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Powering Science-based innovation: Exploring the need and role of a Network of Innovation Centres in the UK and Ireland

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Powering Science-based innovation:

Exploring the need and role of a Network of Innovation Centres in the UK and Ireland

This report was prepared for the Institute of Physics by the Enterprise Research Centre. The principal authors were Stephen Roper, Carol Stanfield, Jane Bourke (University College Cork), Stephen Brosnan (University College Cork) and Christopher Haley, with support from Anne Crean and Danielle Rawlings of the IOP.

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EXECUTIVE SUMMARY

- This report explores the role of Innovation Centres in supporting innovation and commercialisation in physics-based companies across the UK and Ireland. Such support is likely to be important in encouraging physics-based firms, especially when the firms are young and/or small.

- Both the UK and Ireland have well-developed innovation ecosystems comprising a wide range of diverse Innovation Centres and related accelerators and business incubators. However, the Irish and UK innovation ecosystems have rather different characters: in the UK, especially England, there has been relatively little attempt at nation-wide planning or system co-ordination (although this may mean that the resulting ecosystem is in some ways more resilient). In Ireland the innovation ecosystem has had more top-down curation.

- Innovation Centres are difficult to define, and the distinction between these and other innovation support organisations (such as incubators, accelerators, science parks) is not clear-cut. We suggest that Innovation Centres may be identified by a focus on supporting the development of either individual businesses or their technologies; a mix of technological development support alongside business development support; and a focus on later-stage technologies (i.e. higher Technology Readiness Levels) than other support organisations.

- However, this still admits a wide-range of organisations, with significant diversity amongst their services, disciplinary focus, customer base, catchment area, business model, and other dimensions. (Interestingly, several organisations encountered during our research described themselves as both an 'innovation centre' *and* another type of organisation, such as an accelerator, test facility or laboratory complex, suggesting that they felt the term insufficient to capture their activities.)

- Although indicative only, we find that within the UK, Scotland has the greatest number of Innovation Centres, followed by the South East of England and the North-West. In Ireland, the Dublin region has by far the greatest number of Innovation Centres relevant to physics-based firms, followed by the South West of Ireland.

- Comparing the distribution of Innovation Centres with the distribution of physics-intensive firms, we suggest that Scotland and Wales are relatively 'well supplied', whilst London, East of England and West Midlands have fewer Innovation Centres per physics-based start-up, and so might be more likely to have unmet needs.

- However, we also note that this finding conflicts somewhat with the 'Paradigm Shift' survey of physics-based businesses in late 2021. That survey found that innovators in Scotland and Wales were *more* likely than average to report being hampered by improper equipment, machinery or space, whilst those in London were *less* likely to report this.

- Taken together, these results may suggest that the reported lack of facilities might actually reflect a lack of *signposting* to facilities, or, alternatively, a need for more *local* facilities. It may also suggest that firms in some regions are more *able to travel* to other areas (e.g. London firms travelling to Oxford or Cambridge) to access facilities.

- UK and Irish firms' views of their ability to access support from across the ecosystem differed markedly. For UK firms, the support system often appears complex and inaccessible with services seen as of variable quality and public grant support important but inconsistent.

- In Ireland a more consistent pattern emerged with most interviewees highlighting the important role of Enterprise Ireland Development Advisors in supporting them and helping to access ecosystem resources. Possibly because of the relatively small size of the Irish innovation ecosystem, and the co-ordinating role of Enterprise Ireland, the reported need for additional signposting was weaker.

- All Innovation Centres reported being members of various networks, often a combination of national (e.g. UKSPA) and regional. These networks were seen as important both in order to support their clients, as well as to learn and adopt best practices. In Ireland, Enterprise Ireland was identified as being especially important in organising training and networking.

- Among UK ICs there was also an appetite for additional networks or working groups linked to specific physics-based technical challenges (e.g. recycling, battery materials), which were seen as a mechanism to maximise the value of existing 'innovation assets'.

- However, many Innovation Centres reported being unable to collaborate more closely with others, often due to differing funding arrangements and contractual restrictions associated with that funding.

- It was apparent from primary research that Innovation Centres were seen (both by firms and the Innovation Centres themselves) as a partial solution to a skills gap amongst firms - namely, a lack of commercial acumen, entrepreneurial awareness or commercialisation training amongst technical staff.

- Other key functions included the provision of affordable access to equipment for small start-up businesses and the availability of specialist scientific skilled people.

CONTENTS

SECTION 1: AIMS AND OBJECTIVES OF THIS REPORT

1.1 Introduction

This report explores the role of Innovation Centres in supporting innovation and commercialisation in physics-based companies across the UK and Ireland. It is well-known that innovative firms play a vital role in improving productivity and solving societal challenges, and for that reason are integral to the Government's Industrial Strategy. However, it is also well-established that, particularly during the early years of their development, the survival and success of innovative companies depends strongly on external support. For example, the formation and growth of university spin-outs often relies heavily on the assistance they receive from their Technology Transfer Office and other networks. Understanding the availability and appropriateness of support structures for innovative firms is thus of great importance.

In addition, the dominant mode of thinking about growth policy and the creation or support of young firms has, in the past decade or so, moved increasingly towards an *ecosystem* model, which focuses less upon 'transactional' support and more upon 'relational' issues, such as the interconnection of components and the ease with which entrepreneurs can navigate this network.[1] Accordingly, the degree to which Innovation Centres are part of a wider ecosystem, and are well-connected with other key nodes, is also of particular interest.

This report therefore addresses a series of research questions, including:

- *Effectiveness*: How effectively does the current network of Innovation Centres support physics-based innovation across the UK and Ireland? Is there a need for further development of the support infrastructure for physics-based innovation?

- *Accessibility*: How accessible is the current support infrastructure for physics-based innovators? Is there a need for better signposting of existing support infrastructure to firms?

- *Geography*: Are there gaps in the current support structure for physics-based innovation? Does access or effectiveness of provision differ across different parts of the UK?

[1] Mason, C and Brown, R (2014) 'Entrepreneurial Ecosystems and growth-oriented Entrepreneurship', https://www.oecd.org/cfe/leed/Entrepreneurial-ecosystems.pdf

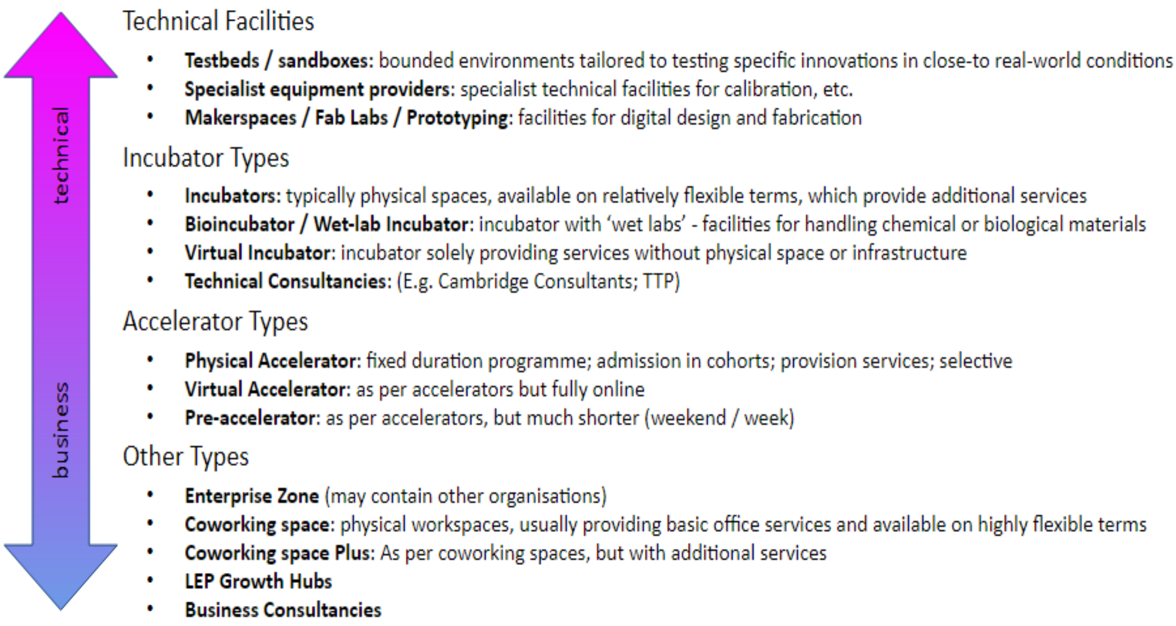
- *Connectivity*: How well-connected are innovation centres? Do they function as a coherent system, and as part of a larger support ecosystem? Is there a need to improve coherence and network-building?

Whilst the report provides an overview of the current availability of Innovation Centre support for physics-based innovation across the UK and Ireland, it does not aim to be a comprehensive survey of innovation centres, and should be taken as indicative only.

1.2 Definitions and Classifications

The focus of our report is the notion of an 'Innovation Centre'. This term is currently used by a number of organisations which typically provide a mixture of business support and technical support to start-ups or other firms. However, it is clear that there exists a wide spectrum of organisations which adopt this label, ranging from more technical types of support (such as specialist calibration facilities) to more business-oriented support (such as accelerators and coworking spaces):

Figure 1.1: Illustration of support types



We also reviewed the academic literature. While the research literature on innovation ecosystems and policy support is extensive, relatively few studies focus specifically on Innovation Centres. Where studies have been undertaken they have tended to be (i) case studies of individual ICs; (ii) analyses of specific subtypes, such as accelerators; or (iii) examinations of some specific aspect of IC intervention such as the business support services they provide. Nevertheless, one working definition of an 'innovation centre' is offered:

> *'An innovation centre provides services and support to new companies that develop (or wish to develop) and sell new products or technological processes whose markets involve a high degree of risk. The objective of the centre is the creation and development of businesses in high technology sectors. The centre can provide services and support in a wide variety of areas: finance; marketing; technology; administration. Sometimes the innovation centres form an integral part of a larger project of the science park type'.*[2]

This definition suggests both the wide range of services and support which may be provided by an Innovation Centre (IC), the potential diversity of the client base of an IC, and the importance of the position of any IC within associated ecosystems and networks. This definition would also likely encompass accelerators, incubators and a number of other start-up support programmes.

In many situations, being overly prescriptive about what is and what is not an IC is probably not useful. However, the definition above might be *too* broad for some purposes, and we note that the proposed working definition largely precedes the rise of start-up accelerators and related support mechanisms. In our view, there may be value in separating accelerators and incubators from other types of support organisation, and hence adopting a slightly narrower definition based on functional characteristics. We suggest that the following three characteristics may be helpful in defining ICs and distinguishing them from other actors within the innovation ecosystem:

- First, an Innovation Centre is focused on supporting the development of either individual businesses or their technologies. This is likely to involve working closely with individual businesses over an extended period of time. In this sense ICs differ from innovation intermediaries which are often focused on developing inter-organisational networking activities or partnerships. This network-building activity may be part of the IC offering but only as part of a broader package of support for business or technology development.

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[2] Source: Science Park Consultancy Scheme. Core Specifications. SPRINT Programme, DGXIII, European Commission, Luxembourg, 1994, cited in Escorsa, P and Valls, J 'A Proposal for a Typology of Science Parks' in The Science Park Evaluation Handbook, Technopolis 1996

- Second, at least in the context of physics-based innovation considered here, ICs are likely to have a focus on technological development alongside business development. This differs from most incubators and accelerators where the primary focus is on supporting business rather than technological development. It also suggests a difference between ICs and organisations such as the Catapults where the primary focus is on solving particular technological problems or developing sectoral capacities.

- Third, the innovation objective of ICs focuses their activities on the later, near-market (applied, experimental development) elements of the R&D process. This will differ from university-based or independent research centres where more basic or applied R&D is likely to be the primary focus. It is hard to be prescriptive but in terms of Technology Readiness Levels this is likely to mean that Innovation Centres have a focus on levels 6-9, during which products/services move from prototype to a proven market offering.

This slightly narrower definition thus distinguishes ICs from most accelerators and incubators, but still acknowledges that IC's vary widely – with some being more focused on business development, others more focused on technology development – and that the clients they serve will also vary both in their location and support needs. We recognise that, in practice, distinguishing ICs from other innovation support organisations will often be difficult, with differences often more about the emphasis organisations place on different aspects of business and technological development, rather than whether or not they provide relevant services.

Other aspects of ICs' position within the innovation ecosystem are also likely to differ significantly: public or private funding, having a national or regional client base, and a narrow or broadly-defined disciplinary focus will all be potentially important in shaping the contribution of ICs to physics-based innovation.

With regards to the definition of 'physics-based innovation' or 'physics-based firms', we were guided by the list of physics-intensive sectors provided by the IOP, which is included in Annex D; this was used to guide the selection of interview candidates. (However, whether 'physics-based innovation' was a term that was understood or recognised by Innovation Centres is a question which we examine in section 3 below).

1.3 Study approach

Our study builds on the extensive 'Paradigm Shift' survey of physics-based businesses conducted by the IOP in late 2021.[3] This provides data on the barriers to innovation identified by physics-based firms in both the UK and Ireland. Access to facilities and equipment was one of the key issues raised in the survey, and we investigate this further here through a range of secondary and primary research activities.

Phase 1 of the study focuses on exploring data available from existing secondary sources to provide an indicative (rather than comprehensive) mapping of Innovation Centres – and some other related resources – across the UK and Ireland. This mapping of the 'supply side' is then compared to firms' responses from the IOP 'Paradigm Shift' survey to suggest hypotheses which can be explored in the primary research phase of the project. For the UK mapping we draw on UKRI directories and resources, information from the UK Science Park Association and other documentary sources, including the earlier Incubator and Accelerator study undertaken by Nesta.[4] For Ireland, we draw on secondary data provided by Science Foundation Ireland, Enterprise Ireland and various university web-sites.

Phase 2 of the project involves primary research interviews with a small number of Innovation Centres and physics-based innovators across the UK and Ireland, as well as an online survey of UK and Irish Innovation Centres. Key themes for discussion with Innovation Centres included:

- Support and services provided (e.g. physical facilities, mentoring and networking)
- Sectoral focus
- Business model (How are they funded? What is the basis of their engagement with participating firms - e.g. do they take equity?)
- Delivery and network partners
- Links to other elements of the innovation ecosystem

[3] CBI Economics (Oct 2021) 'Paradigm shift: Unlocking the power of physics innovation for a new industrial era'. Available online at: https://www.cbi.org.uk/media/7318/21-10-01-institute_of_physics_final_october-2021.pdf

[4] Bone, J., Allen, O., Haley, C. (2017) *Business Incubators and Accelerators: The National Picture*, BEIS Research Paper 7. London: BEIS / Nesta

- Entry and exit criteria, length of residency
- Geographic location and catchment area

Essentially similar themes were covered in the online IC survey with a focus of obtaining broader geographical and disciplinary coverage than was possible in the interviews.

For physics-based innovators we were interested in understanding:

- Technology readiness level (TRL)
- Stage of business development, financing and IP protection
- Age and growth rate
- Locational choice and what governed this (e.g. role of specific premises/equipment, regional and ecosystem factors, proximity to universities etc)
- Experience / engagement with innovation centres (e.g. Choices to locate within a centre or not, and the experience of this engagement.)
- Previous support (i.e. what assistance had firms received, from whom, and the impact of this support, if possible to determine).
- Their perceived primary needs in order to scale (e.g. access to infrastructure, access to capital, access to markets, access to talent)

1.4 Overview of the report

The remainder of this report is organised as follows:

- Section 2 focuses on the indicative mapping of IC capacity across the UK and Ireland based on secondary source material and the comparison with data on the needs of physics-based innovators.
- Section 3 focuses on the results of the interviews and on-line survey with Innovation Centres in the UK and Ireland and their perceptions of related innovation ecosystems.
- Section 4 reports the main findings from the interviews with physics-based innovators and their assessment of met and unmet support needs

SECTION 2: MAPPING INNOVATION CENTRE CAPACITY AND DEMAND

2.1 Introduction

In this section we explore the distribution of innovation centres and physics-based innovators in the UK and Ireland, and compare these distributions with data from the 'Paradigm Shift' survey of physics-based businesses, relating to access to facilities and unmet needs. We divide our analysis into separate sections for the UK and Ireland, recognising differences in the structure of each nation's innovation ecosystem, support infrastructure and geo-spatial scale. The IOP 'Paradigm Shift' survey provides a useful comparison point, covering both physics-based firms in both the UK and Ireland.

2.2 Innovation centres and support needs across the UK

2.2.1 UK Physics-related Innovation Centres

Innovation centres relevant to physics-based innovators are identified here using several secondary sources:

i) The UK's Research and Innovation Infrastructure Portal (RIIP): this site is a catalogue of the UK's publicly funded research infrastructure that are open to use and collaboration. We only selected those ICs which explicitly state they make facilities available to industry, as opposed to other academics (see full list in Annex A).

ii) The UK Science Park Association (UKSPA), filtering for members which stated they have specific physics facilities/capabilities (Annex B).

iii) A broader search of physics-linked innovation facilities, including Catapults, innovation networks and other research centres not listed in the above sources.

Table 2.1 below reports the indicative mapping of physics-related ICs across UK regions. We emphasise that this is indicative only and very unlikely to be complete.

The greatest number of physics-related Innovation Centres identified through the UKRI RIIP portal are in Yorkshire and Humber followed by Scotland and the North West. In contrast, there are apparently no physics-linked Science Parks in Yorkshire and the Humber. Conversely, the South East has by far the highest number of Science Parks likely to be physics-linked, whilst the East of England has only one which appears to have an explicit physics link. After including other Innovation Centres, e.g. Catapult centres and other physics research and innovation centres identified through internet searches, we find Scotland has the highest number of innovation centres identified, followed by the South East, North West and Yorkshire and Humber.

Table 2.1: Indicative number and ranking of physics innovation centres: UK regions

	No. of research centres open to industry (RIIP)	No. of Science Parks with Physics link (NSPA)	Other innovation centres	Total of innovation centres	Rank of innovation centres
South East	2	9	5	16	2nd
London	2	2	2	6	8th
East of England	0	1	3	4	10th
North West	5	3	5	13	3rd
West Midlands	1	2	2	5	=9th
South West	3	4	2	9	5th
Yorks and Humber	8	0	2	10	4th
East Midlands	0	5	2	7	=6th
Scotland	6	3	9	18	1st
Wales	1	4	2	7	=6th
North East	1	1	3	5	=9th
N Ireland	0	1	0	1	12th

Source: ERC analysis

2.2.2 Physics-based businesses

To determine the corresponding demand for services, we identified physics-related firms based on the Business Structure Database, which covers all UK firms and a previous sectoral classification developed by the IOP[5].

Table 2.2 shows the UK regional distribution of 142,074 low, medium and high intensity physics-related firms. The table shows that a higher proportion of physics-related firms are found in London, the North West, East and South East. This largely mirrors the regional profile of all firms, except there are rather fewer physics-based firms in London than one might expect if physics-related firms followed the same distribution as all firms (i.e. 19.2% of all firms were based in London in 2019, but only 12.7% of high-intensity physics firms are located there). Correspondingly, every other region has a slightly higher proportion of

[5] Turner, J Nana-Cheraa, R and Roper, S (2021) 'Profiling firms in high, medium and low physics-intensity sectors: innovation, growth productivity and skills use', ERC report for IOP, June 2021.

physics-based firms than of all firms. There is also no obvious difference in terms of the distribution of firms in high-physics intensity sectors within the individual regions. However, for the South East region, there is a slight difference of about 3 and 4 percentage points respectively between high/low intensity use and medium/low intensity use.

The 2021 ‘Paradigm Shift’ survey of physics-based businesses provides more detailed information on the factors which limit firms’ ability to undertake innovation and their difficulty in accessing appropriate facilities. Regional analysis of the survey data suggests some significant contrasts (Table 2.2):

Table 2.2: Regional distribution by physics intensity, 2018 (BSD)

Region	Low intensity # firms: 640,201	Medium intensity # firms: 404,056	High intensity # firm: 142,074
East	9.3%	10.4%	10.6%
East Midlands	6.9%	7.1%	7.7%
London	14.3%	15.8%	12.7%
North East	3.2%	2.7%	3.1%
North West	10.1%	9.6%	10.5%
Northern Ireland	3.5%	2.5%	1.9%
Scotland	8.0%	6.7%	6.9%
South East	13.2%	16.8%	15.8%
South West	10.3%	9.3%	9.1%
Wales	5.3%	4.0%	4.0%
West Midlands	8.1%	7.9%	9.8%
Yorkshire and The Humber	7.9%	7.3%	7.9%

Source: Turner et al. (2021)

Table 2.3: Reported factors which limit the ability of physics-based companies to undertake R&D/innovation (% firms)

	Suitable facilities (buildings and space)	**Access to laboratories**	**Access to physical testing equipment**	**Access to demonstration space / equipment**	***Base no. of interviews***
East Midlands	31	9	16	16	*39*
East of England	31	19	33	19	*39*
London	22	17	10	15	*51*
North East	31	23	31	39	*18*
North West	26	19	23	16	*53*
Northern Ireland	0	0	14	0	*9*
Scotland	35	17	10	21	*39*
South East	32		18	18	*75*
South West	28	10	10	18	*51*
Wales	33	22	33	22	*24*
West Midlands	21	11	7	18	*35*

Source: 'Paradigm Shift' survey

- When asked to report what limited the firm's ability to undertake R&D/innovation activity, 39% of physics innovators in the North East and 29% in Yorkshire and the Humber reported difficulties accessing demonstration space/equipment, compared with just 14% among all UK and Ireland physics innovators.

- 33% of firms in the East of England and in Wales were concerned with access to physics testing equipment, compared with 20% among all physics innovators.

- 23% of physics innovators in the North East, 22% in Wales and 21% in Yorkshire and Humber were most likely to be concerned with a lack of access to labs. These results are shown in Table 2.3.

- Additionally, the survey showed regional differences in the proportions of physics innovator firms which reported a lack of equipment, machinery or space as one of the most significant challenges to undertaking R&D activities. 30% of physics innovators in Yorkshire and Humber cited this, followed by 29% in North East, shown in the graph below.

These differences underscore the importance of understanding the role and distribution of ICs across the UK and Ireland.

2.2.3 Comparing Innovation Centres and business needs

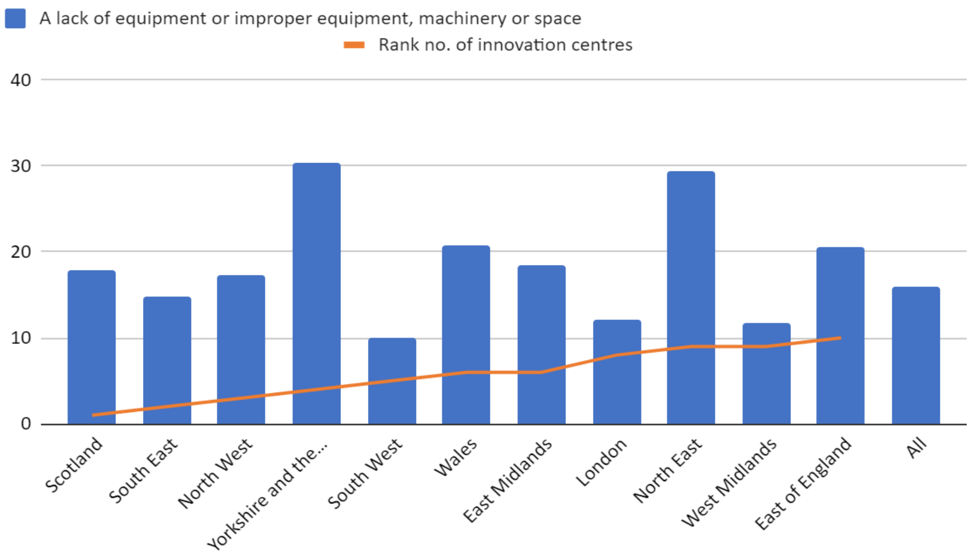
How does the regional distribution of Innovation Centre capacity compare to the distribution of physics firms and their need for facilities? Table 2.4 compares the distribution of high intensity physics firms, in order of the regions with the greatest proportion of these firms, compared to the total number and ranking of innovation centres. It is clear from the table that the regions with the highest proportions of high intensity physics firms are not necessarily those with a high number of physics-linked Innovation Centres. At the top of the table, the South-East has the highest proportion of high intensity physics firms and ranks second in our count of physics-linked Innovation Centres. At the bottom, Northern Ireland has the lowest proportion of firms and lowest number of innovation centres. The South West, North West, Yorkshire and Humber, North East, East Midlands and Northern Ireland are at the same or similar ranking on both employment and Innovation Centre measures. London, East of England and West Midlands rank higher on the proportion of high intensity physics firms distribution than on Innovation Centre count suggesting the potential for unmet needs for support, while Scotland and Wales rank higher on number of Innovation Centres than proportion of firms.

Table 2.4: Comparing high intensity physics-based firms distribution with number and ranking of physics innovation centres

	Location of high intensity physics firms	No. of research centres open to industry (RIIP)	No. of Science Parks with Physics link (UKSPA)	Number of other innovation centres	Total of innovation centres	Rank of innovation centres
South East	15.8%	2	9	5	16	2nd
London	12.7%	2	2	2	6	8th
East of England	10.6%	0	1	3	4	11th
North West	10.5%	5	3	5	13	3rd
West Midlands	9.8%	1	2	2	5	=9th
South West	9.1%	3	4	2	9	5th
Yorks and Humber	7.9%	8	0	2	10	4th
East Midlands	7.7%	0	5	2	7	=6th
Scotland	6.9%	6	3	9	18	1st
Wales	4.0%	1	4	2	7	=6th
North East	3.1%	1	1	3	5	=9th
N Ireland	1.9%	0	1	0	1	12th

Source: ERC

Figure 2.1: Proportion of physics innovators reporting lack of facilities as one of the most significant challenges to R&D and ranking of number of innovation centres



Source: IOP Survey

Comparing the proportion of firms reporting lack of facilities as a barrier to innovation with the ranking of regions by their number of innovation centres shows little obvious linkage (Figure 2.1). The highest proportion of firms reporting lack of facilities as a barrier in the North East and Yorkshire and Humberside are regions with contrasting high and low numbers of Innovation Centres.

All of the survey measures, relating to difficulties in access to facilities, are most commonly reported in the North East, Yorkshire and Humber, Wales and the East of England, regions which rank 9th, 4th, =6th and 10th, respectively, in our count of innovation centres in those regions. This suggests there might be specific issues in these regions. From the survey data we might have expected firms in West Midlands and London to also be more likely to report issues with access to facilities, however, this is not the case.

We suggest that further work may be required to reconcile these apparently conflicting results. Taken together, these results could suggest, for example, that the reported lack of facilities might actually reflect a lack of signposting to these facilities; or, alternatively, a need for more *local* facilities. It may also suggest that firms in some regions are more able to travel to other areas (e.g. London firms travelling to Oxford or Cambridge) in order to satisfy their needs.

2.3 Ireland

This section provides an overview of the innovation centre landscape in the Republic of Ireland. Here, reflecting the specifics of the Irish context Innovation Centres are defined in three ways:

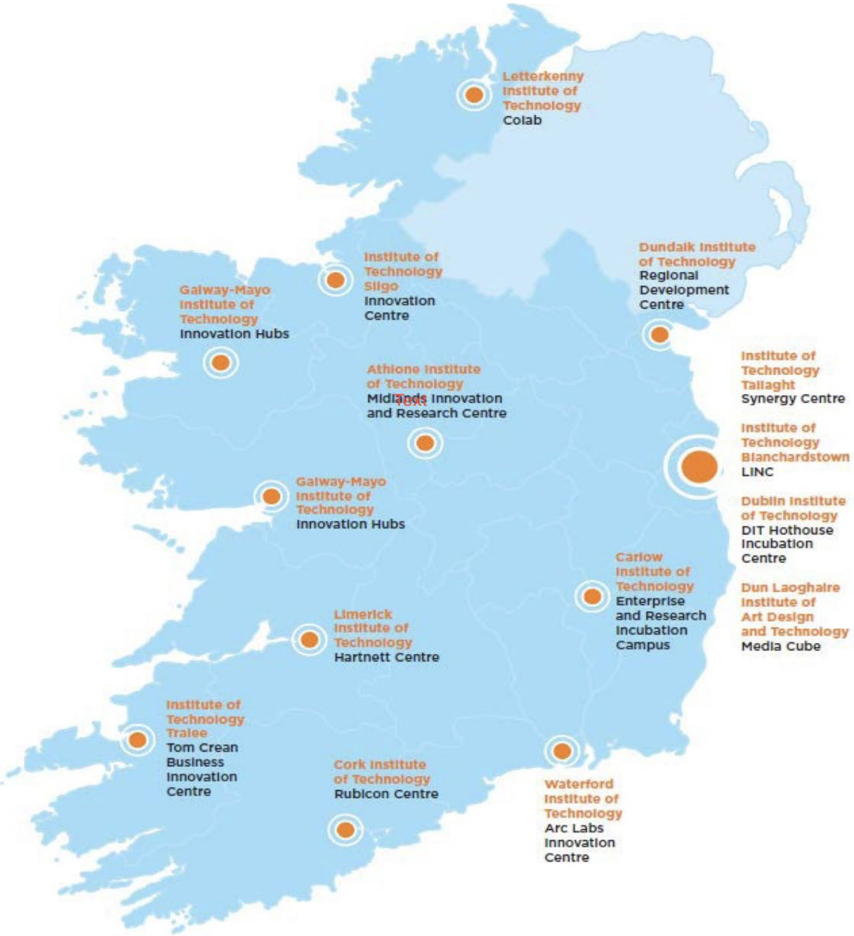
- As physics related research centres identified from Knowledge Transfer Ireland's Directory of Research, Development and Innovation Supports for Enterprise. The directory provides overview of the research, development and innovation supports available to companies provided by State bodies, and an overview of the Higher Education Institutions, industry- focussed Centres, Gateways and other research centres of scale that are supported by the Department of Enterprise, Trade and Employment (DETE) and the Department of Further and Higher Education, Research, Innovation and Science (DFHERIS).

- Members of Enterprise Ireland's New Frontiers programme, the national entrepreneur development programme for early-stage start-ups. It is based in 16 campus incubation centres across the country. The thematic areas of the centres are closely aligned with Ireland's Research Prioritisation Strategy.

- Broader search of physics linked innovation facilities not listed in the above sources.

Figure 2.2 shows the geographical distribution of Enterprise Ireland's network of campus-based incubation centres. The centres are strategically located throughout the country with the aim of accelerating the development of sustainable early stage businesses across the country which have strong employment and growth potential. These centres provide access to both research facilities and expertise within their host institution and also Enterprise Ireland's Technology Gateway programme, comprising 15 gateways with each focused on key technology areas aligned to industry needs.

Figure 2.2: Distribution of National Network of Incubation Centres



Source: *Enterprise Ireland (2015b)*

Table 2.5 provides an overview of industry-focused innovation centres across NUTS3 regions in the Republic of Ireland (see also Annex C). Reflecting the broader concentration of economic activity in Ireland physics-related ICs are concentrated in Dublin and the South West of Ireland albeit with a presence of one or more physics-related ICs in each of the other NUTS3 regions.

Table 2.5: Number of Innovation Centres in Ireland, by NUTS3 Region

Region	Highly unlikely to be physics (no lab space)	Labs but no stated physics links	Most likely to be physics
Dublin	18	8	22
East Midlands	1	1	4
South-East	0	0	1
South-West	5	3	8
Mid-West	0	3	5
West	1	2	3
Midlands	0	0	5
Border	0	0	2

In a final piece of analysis, we explore data from the IOP/CBI survey and specifically the results for physics innovators to explore the extent to which innovation centres impact on their business. First, the Paradigm Shift survey refers to the broad industrial sectors that best describe the activities of physics-based innovators. The results suggest physics-based innovators in Ireland are considerably more concentrated in Computer/electronics (27.6%) compared to UK (10.9%). Furthermore, the rate of Irish physics-based innovators operating in the construction sector is more than double that of physics innovators in the UK (5.6%).

The survey also asks respondents to identify the challenges facing their companies in relation to undertaking R&D/ innovation activities. The results suggest that physics-based innovators in Ireland have more difficulties accessing finances (42.9% vs 31.6% in UK) and face greater uncertainties in relation to undertaking R&D (60.7% vs 46%) relative to firms in the UK. Furthermore, challenges associated with accessing external expertise is identified by more than double the rate of Irish respondents compared with the UK (28.6% vs 14.8%). However, physics-based innovators in the UK identify issues accessing physical testing equipment (21% vs 8.7%) and the ease of navigating available supports (28.5% vs 8.7%) much more frequently than firms in Ireland.

SECTION 3: UNDERSTANDING INNOVATION CENTRE PROVISION

3.1 Introduction and evidence base – UK and Ireland

In order to build upon the IOP-CBI survey, we conducted a range of interviews with Innovation Centres and physics-based companies across the UK and Ireland. This was complemented by an online survey (distributed to around 100 innovation centres but receiving only 9 responses).

UK Innovation Centres varied quite widely in nature, although all had some form of interest and relevance to establishing physics-based firms. They included a specialist physics-based university research centre (RC); a public sector research establishment (PSRE); three Catapult-type centres, referred to here as 'translators'; and four generic science parks with links to physics departments or housing parts of the physics innovation ecosystem, e.g. public funded research labs. Six Irish ICs were also interviewed; these centres were all hosted within universities or Institutes of Technology, and were located across the main geographic regions of Ireland.

Firm interviews were targeted at those firms for which physics technologies were central to their operations, they were undertaking physics-R&D, and were less than ten years old. Smaller firms were also targeted as these are more likely to require external support of the sort which might be offered by Innovation Centres. In collaboration with IOP, a selection of Innovation Centres with an interest in supporting physics-based firms were also identified and approached for interview.

Across the UK, thirteen firms were interviewed located in the South, Wales, Yorkshire and Humber and Scotland. The firms included both university spin outs and businesses started by people working in industry, and operated in a range of areas of physics ranging from enabling technology, quantum, semiconductors, RF and microwave, graphene, imaging, medical devices, specialist scientific instruments and a firm which both produced medical devices and provided consultancy support to other firms. Six Irish firms were also included in this phase; these firms were located across Ireland, and across a range of sectors including SpaceTech, Industrial Technologies, Manufacturing, and Health/Medical technology.

3.2 UK Innovation Centres' perspectives

3.2.1 Overview of UK ICs

The Innovation Centres interviewed for this research had very different funding models. The university research centre (RC) was government funded. Two ICs had some core government funding, one for fundamental research and regulatory activities, the other for supporting commercialisation activities with business. Their income was supplemented by collaborations to bid for other government research funds and/or commercial income streams - providing services and expertise to businesses. Other ICs generated income through renting office and lab space, including to universities or in collaboration with universities and local authorities. One was entirely self-funded but acknowledged the contribution made by being within an Enterprise Zone (EZ), as they seek to develop a life-sciences cluster.

Performance measures across the ICs tended to be based on capacity for those mainly generating private rental income, although there tended to be restrictions on what type of firm could locate on a science park or some vetting of companies that translators would work with. For example, the goal of one science park was to develop a life sciences cluster, and so its targets and performance measurements were based on this. Another IC's role in the local ecosystem was to grow businesses, so expanding businesses moved on, preferably to another local authority-owned site in the vicinity. Another IC had allowed smaller businesses to grow within and take more unit space, suggesting different operational and strategic goals. Publicly-funded translators had broader economic and societal goals through commercialising relevant research and also building up innovation ecosystems in the UK, through growing businesses and seeking to connect them to UK funders – implicitly to try to keep the IP in the UK.

The services provided by the ICs also varied widely, mapping on to different groups of TRLs. The research centre, which took discoveries to TRL 3, opened their facilities to collaborations with other academics and signposted some queries 'which made sense' to a related innovation centre. Translators were positioned at different stages of TRL. One described themselves as in the 'new product/new market' quadrant; another was at TRL 4-7, with a focus on proving there is a verified design, technical or assembly process and the third described themselves as 'very small r and large D', meaning 'for us, innovation is the art or science of taking existing ideas and inventions and applying them in new ways in the market in such a way that we actually create innovations that generate value'. The latter two offered access to equipment to realise the product, whilst the former did not have equipment but focussed on sharing their expertise to develop a Minimum Viable Product (MPV).

Two of the translators facilitated access to private funders, the third did not see that as part of their role. Only one had recently branched out into providing entrepreneurship skill development, and were looking to develop more in this area aimed at universities and businesses, recognising it as a skill deficiency within their labour market. The others did not provide such training, and training provided tended to be on use of equipment.

The PSRE offered a commercial service and collaborated to bid for government research funds. As seems to be the case with expensive equipment, they would conduct tests on samples, but did not allow external partners to access labs and equipment due to the level of expertise required to operate the equipment to the necessary quality. The PSRE and one of the translators administered government funds to work with businesses – either themselves or with academics.

Science parks had physics-appropriate lab space available for rent and those with closer links to universities or public research facilities had access to specialist equipment available. One noted the importance of its positioning on sandstone and access to power as important for physics research. Another noted the importance of Innovation Centres to be constructed flexibly – with power and water cooling and modular building to reflect industry and regulatory changes.

All science parks could facilitate access to business development support, either through the park managers or signposting. They also facilitated access to private finance or public funding. One, as part of its objective to become a life sciences cluster, intended to develop its own investment network and had been in dialogue with the British Business Bank about this.

With regard to social networking, science parks more usually provided networking opportunities, informally through the space and the possibility of 'corridor conversations', or more formally through organising events and opportunities for business owners to share ideas.

In terms of skills development, we found a mixed picture: few of the innovation centres interviewed offered much in the way of skills development as a specific offer, although 8 of the 9 online respondents claimed that this was one of their services provided to firms (the most common service reported). Those on science parks facilitated discussions between firms and local educational institutions (one IC saw this as an important function they had recently taken on, working with the local LEPs) or referred on to an associated university or other provider. One trained embedded company in use of the equipment on site. One science park had provided an ERDF funded leadership development course, but had not generated sufficient interest for a course without public support. The PSRE offered free and paid-for training in their area of expertise and, internally, had 200 PhD students working there and employed a mix of Apprentices.

3.2.2 Client profile and services

Those ICs offering paid-for consultancy services worked with any client whom they could support and was able to pay the fee. Most consultancy services might only require a day or two time and expertise, including testing samples, the longer ones might be around a week. Most of those with a greater proportion of public funding did not open facilities to clients, but undertook this work on their behalf. Another model was having PhD students work at the facility – they were trained to operate the equipment and could do this for the partner university. Occasionally, a company might also be involved in the student's project.

The PSRE reported how specific government funding (Measurement for Recovery) had enabled micro and small businesses to work with them to test ideas and enable them to progress to the next stage. This might be just equivalent to a day or two of consultancy time but made the difference. Barriers to entry were low with applicants only required to submit a video explaining their problem, which was assessed by scientists.

Translators tended to think in terms of numbers of projects rather than numbers of clients and this varied according to their own staffing levels and capacity. They varied in whether they served a regional clientele or more broadly. The IC interviewed in Scotland did mainly support Scottish businesses due to the funding sources; others were situated within existing clusters, but did not exclusively serve them. Two of the non-science parks had multiple sites around the country and outreach centres. Online respondents principally reported serving firms within their same region, with two reporting that their clients were from across the whole UK.

Science parks reported in terms of tenants, again varying according to the size of the park. Science parks housing parts of the physics ecosystem would work with off-site clients. As noted under 'Funding Models', most science parks had some sort of criteria for businesses locating there. In addition to the examples cited above, one tended to have just pre-commercial firms on the site, so small firms were constantly growing at the centre.

3.2.3 Clients' needs

One of the main needs reported by innovation centres interviewed in the UK was the need for better education and training on commercial acumen to physicists. This would help to identify if their idea had a commercial application and value, as illustrated in this quotation from one interviewee:

> *'Our academic sectors are probably the finest in the world. The ideas that they produce are amazing, but the skill-set required to take those ideas through into commercial products is not what is taught'.*

This need was echoed within those innovation centres seeking to develop entrepreneurial skills training, not just of academics, but a more broadly observed trend. There were also some concerns regarding the talent pipeline and whether enough scientists were coming through, and how employable graduates of physics degrees are given how theoretical courses tend to be – with placements tending to be more expensive to provide. Quantum physics was identified as an area where there is a particularly high demand at the moment, including internationally, and insufficient supply of graduates.

As noted above, small firms often need a relatively small amount of resource to help test or discuss a specific aspect of their work, but without public funding, they find access to the human and physical resources prohibitively expensive. One noted that to achieve the 2.4% target, there is a need for government to match this funding because physics-based research (through access to expertise and equipment) is expensive.

3.2.4 Networks

Innovation Centres used networks in at least three different ways: (i) to find clients; (ii) to 'refer onwards' clients for services which they could not serve themselves, or which outgrew their space, or were a poor fit; and (iii) to identify and share good practice.

All innovation centres that were interviewed reported being able to draw on various networks. Formal networks included UKSPA or more local/regional innovation centre networks, sometimes co-ordinated by LEPs. Innovation centres also frequently networked with ‘sister’ organisations – which might be related because they receive government funding from the same body (e.g. through Enterprise Zones or Science and Technology Funding Council); or have similar activities and services (for science parks, these are more commonly networks linked by provision of business advice, for others, the common feature was their scientific specialism e.g. Medilink Midlands). Knowledge Transfer Networks, Innovate UK and Scottish Edge were also mentioned as sources of support.

In terms of finding clients, academic networks and entrepreneurship-related networks were reported (at least, by online respondents) as being the most important sources of deal-flow; in addition, most online respondents reported both signposting clients to other innovation organisations, and having other innovation organisations signpost clients to them. Every single online respondent reported sharing good practice was one of the principle benefits of network membership.

Respondents did not think there were specific gaps in the ecosystem and they used both formal networks and a vast expanse of informal international networks, and their own contacts and knowledge, to support their own work and in offering advice and support to business. With regard to networks, one respondent noted: ‘Formality gives structure and confidence; informality gives pace.’

3.2.5 Perceived gaps and capacity issues

The gaps and capacity issues identified by ICs reflect those of physics-based companies: - entrepreneurial and commercialisation skills; affordable access to equipment for small start-up businesses and availability of specialist scientific skilled people. There is also a need for a diverse range of qualification levels and a need to encourage different ethnic groups and women into science. Other issues identified included an overvaluing of IP by universities, which made collaboration difficult. It was frequently reported that universities did not have a sense of the expense of moving beyond invention.

Collaboration between innovation centres and other research centres and/or companies was made problematic, if not impossible, by funding regulations. Despite the will to collaborate, one respondent reported that attempts to do so are stymied by the regulations. With differing funding arrangements across different centres, combined with varying rules associated with different pots of funding, collaboration becomes contractually impossible. Whilst these rules may have originated with State Aid requirements, this seems to be a particularly complex set of arrangements which are constraining collaborative innovation.

One respondent noted that cost sharing models would significantly help new Innovation Centres, but presumably, the funding framework would need to support this.

It also appears that the UK, unlike other countries such as Germany and US, are funding fewer ‘national laboratories’, with such facilities increasingly expected to generate commercial income, putting at risk much of the research and innovation which takes place at these institutes. Yet this collaboration, and access to such facilities, can help overcome the barriers to innovation presented by established manufacturing processes, with manufacturers unable to test new processes which may impact on production and/or inventors being anxious to share what they are testing too widely.

A few respondents referred to the need for patient capital at the point of moving from research to manufacture, but few commented specifically on this as they did not tend to operate at this level. Where this might apply a little more - on science parks - they would use networks to refer businesses to specialist support or funders, as they did not want to duplicate the activities of, e.g. Growth Hubs.

The facilities to pilot at scale were referred to by one respondent who noted this at a general issue:

> ‘*if you wanted to do something at middle size, make a few thousand or something a few thousand litres of something, quite often that's not there and, industry …[are not] going to turn that off to try, your material out. So the gap really is what we would call sort of innovation assets.’*

However, rather than just viewing this problem across the board, there is a need to identify what the priority segments are, e.g. specific issues around recycling composites or battery materials, for example, where this general issue could be tackled.

On the whole, it was reported that there was a high number of institutions/programmes in the innovation ecosystem, and that this was necessary, as illustrated in the following quote:

> *’… a new idea emerges and suddenly there are five initiatives to help support that idea. You know, graphene emerges as a wonder material, and suddenly there's all sorts of programs to help you with graphene. And it just gets very, very complicated…..and it's gonna remain that way I think because I don't think you will get a universal innovation model because we're not developing the same thing all the time and different innovations require different elements of support*.

Arguably, what this does lead to is a situation where it is difficult for firms, and their advisers, perhaps even in Technology Transfer Offices, to know where to go for support :

> ‘*People don't see the wood for the trees, so they may miss things like the catapult. They may miss things like IUK programs because they're trying to process too much’.*

One respondent referred to IOP’s map of the physics infrastructure which has the potential to help in this regard.

3.3 Irish Innovation Centres’ perspectives

3.3.1 Overview of Irish ICs

Six Irish ICs were included in this study. These centres were all hosted within universities or Institute of Technologies and were located across the main geographic regions of Ireland. The centres were established between 1989 and 2016, with workforces ranging from 1 to 15 staff members. Each participant described their organisation as a business incubator, while highlighting other supports available such as technology transfer funding, accelerator programmes and links to host institutions technical facilities. There was significant variation in the extent to which organisations were focused on supporting physics-based projects or businesses, ranging from less than 5% to 40% of businesses having a physics dimension. Many respondents required further clarification on what constitutes ‘physics-based businesses’, "physics-based innovation, just wondering what the target of that is?"

Some diversity was identified across funding models employed by the Irish ICs. The majority of centres noted that they operated a mixed funding model, however differences exist in terms of the percentage breakdown of funding, sources of funding etc. Public funding generally makes up a larger percentage of IC funding, with host universities and Enterprise Ireland (EI) being identified as important sources of funding. ICs generate some private funding through partner companies paying fees for collaboration, spin-outs, rent and licencing technologies. However, these fees tend to be relatively small compared to public funding.

ICs identified a large diverse range of KPIs for measuring organisational performance. Occupancy rate was identified as the most common KPI for measuring IC success. The majority of participants (67%) indicated that their organisation is running at maximum capacity around 90% of the time. The reasons provided for why organisations were not operating at maximum capacity was the result of recently acquired additional space and differences in relation to how maximum capacity is measured. One IC hoped to achieve their targets on a cumulative period based on their funding cycle, as opposed to measuring capacity at a given point in time.

Many centres identified the importance of EI in guiding performance metrics for Irish ICs. Under the New Frontiers programme, EI supports a network of seventeen ICs located within universities and institute of technologies in Ireland. The New Frontiers supports over 500 participants per year in the establishment of a new business (Stage 1) with the expectation that close to 130 will progress to Stage 2, many of whom may later be able to receive investment funds from the LEOs or EI.

Participants identified a number of KPIs across key thematic areas:

- Clients: number of enterprises incubated, number of collaborative projects, value of collaboration projects, number of consultancy projects
- Financial: amount of investment raised (public and private)
- Intellectual property: number of patents filed, number of patents granted, number of licences, options, assignments, number of invention disclosures
- Gender: number of female entrepreneurs assisted

Furthermore, many participants outlined the importance of collaborating with companies designated High Performance Start-Up Companies (HSPUs) by EI i.e. companies with potential to reach sales of over €1 million and employ 10+ people after three year period.

3.3.2 Client profile and services

Participants identified a range of services provided by ICs in Ireland. All participants indicated that the services provided by their organisation were predominantly business services, as opposed to technical services. Although it can vary from client to client, participants estimated that business services made up between 90 and 100% of total services provided. Each IC included in the study provided their clients with shared workspace, access to funder networks, access to funders networks, knowledge-services e.g. advice and support around managing a business, access to skills and training, access to social capital networks and mentoring programmes. Other services provided included transnational events with network of ICs, international market links, equipping companies with latest tools and methodologies e.g. lean start-ups, customer discovery.

Some key differences emerged in relation to the provision of direct finance, lab space and technical equipment. Three ICs (50%) offer rentable lab space and specialised equipment to industry clients, primarily through linkages to university research facilities. One participant noted that while their organisation does not provide lab space per se, access arrangements may be provided for an additional cost to IC clients.

The majority of participants (83%) indicated that their organisation does not provide direct funding to companies and do not take an equity stake “we never have and we never will”. The only exception is that ICs will take an equity stake for spin-out companies from their host university where the equity stake is determined by the university’s IP policy. One IC does provide direct finance to their industry clients but does not take an equity stake in the companies post-incubation.

The number of clients hosted within ICs varied from 19 to 55 companies. Some ICs described their client base as “sector agnostic” but the majority of IC clients operate in sectors closely aligned with the six broad strategic areas outline in the Research Prioritisation Strategy. These sectors are deemed the most likely to deliver the greatest economic and societal impact. All participants identified standard licensing fees as the most common cost for industry clients, while additional services may be provided through negotiations and agreed fees e.g. consultancy services, access to lab space, access to technical expertise etc.

Most participants indicated that their organisation accepts companies at all stages of business development, from pre-revenue to established companies. Spin-outs from host universities were identified as companies most likely to be pre-revenue while typically companies would at a minimum need to have a good understanding of the market, have a viable product developed and on the cusp on earning revenues.

Many participants highlighted additional entry criteria employed when selecting which companies to host within the IC. Participants noted that it was important that their organisation was considered more than a provider of office space and emphasised the importance of linkages between incubated companies and researchers within their host institution - “We don't just want to be a renter of office space because we probably can't compete on that in the market and there is no real benefit going back to the university by doing that"… link in university supports, add-value by engaging in Student placements and graduate placements, guest lecturing.

Participants highlighted the importance of accepting companies that would be eligible to receive additional funding in the future from EI. As such, the entry criteria is similar to the criteria for receiving EI funding "We use similar criteria to EI and LEO […] Companies need to be eligible to receive EI support i.e. engaged in manufacturing or internationally traded services, planning to grow to scale of 10 or more people, five years old".

3.3.3 Clients' needs

Participants identified access to expertise, access to capital and business services as the common needs of physics-based companies. They highlighted challenges in relation to understanding the fundamentals of customer development, managing customers, and raising finance (particularly private funding e.g. through venture capital and/or angel investment. While acknowledging physics-based companies tend to be very strong on the technical side, challenges emerge in relation to commercial acumen, developing a business plan, and preparing financial forecasts. Furthermore, participants indicated that the capital intensive nature of physics-based companies means that it is challenging for physics-based start-ups to have all the required equipment or they lack the resources to make that investment themselves. Therefore, ICs provide a vital service for physics-based companies by providing access to research facilities, expertise and equipment.

Most participants (67%) indicated that the desire for lab space is the most commonly requested service from physics-based companies that oftentimes cannot be accommodated by ICs in Ireland. Given the majority of ICs are hosted within academic institutions, lab space designated towards teaching and research activities is given priority over incubated companies so oftentimes there is excess demand for these services. Furthermore, access to specialised equipment was identified as being problematic, particularly across the life sciences.

One participant identified providing certification as a gap in the services offered by the IC that were regularly requested by clients - "Certification in Ireland is limited, only one or two places can certify. In order to get certified need to go across to UK and additional expenses associated with it and if it doesn't work out additional expenses again. We can do some testing but cannot provide certification. We would link them in with organisation that provide certification but it is limited in Ireland".

Most participants identified the lead times for bringing a product to market and the associated challenges of raising finance as the key challenges inhibiting growth in deep-tech start-ups.

> *"One of the key challenges is financing - for deep-tech projects there is long lead in time so having sufficient runway from a financial perspective or a funding perspective is critical"*

> *"I think probably the biggest challenge for deep-tech takes number of years to bring product to market is primarily investment and finance. So much investment needs to go in, it is relatively easy to get seed investment but next stage of growth -where does that come from when you are still pre revenue and you still need deeper investment before you can bring a product to market"*

3.3.4 Networks and gaps

Participants identified EI (83%), industry groups (83%) and Local Enterprise Offices (66%) as the most important networks that their organisation participated within. EI was identified as being important for providing funding, organising training and networking events, and enabling access to overseas markets. The key benefits for participating in these networks is that it allows ICs to enhance their "profile to industry partners, gain an idea to what local government direction is from strategic point of view, how to support local industry, knowledge and insight into potential funding coming down the line, hot topics - sustainability, renewable energy - keeps the finger on the pulse. It keeps is up to speed what can be available so this improves the support we provide". Furthermore, many participants outlined the importance of these networks for signposting clients to their organisations "we are well connected with EI. That's how we get message out. We support LEO and emphasise additional supports we provide".

Every participant indicated that their organisation would be willing to signpost companies to other innovation organisations within the ecosystem. Participants stated that the size of the innovation system, linkages across universities, and industry groups means ICs are well aware of the services provided by other innovation organisations in Ireland - "Ireland's really small, we are only four million people. I know we think we are giant country but we are only two or three degrees away from people"

Most participants indicated that they were satisfied with their membership within networks and could not point to any gaps in relation to functionality, geographic scope and sectoral focus. However, the lack of physics-specific networks was highlighted by a number of participants as an area that could be improved in the future.

> *"In some ways I'm not aware of things going on in physics area. It seems to me that there is more software and IT groups and even life sciences tend to be well coordinated. In some ways, physics is so crosscutting in so many areas it is hard to group them together but in that way doesn't tend to be specific industry events and networks directed towards physics".*

Some participants highlighted the diversity of sectors supported by physics research as a key challenge in efforts to develop physics-based networks *"It's very difficult when you're talking about physics industries - two microscope companies but not enough to create microscope network so they come under general life sciences networks"* while others questioned the appropriateness of the terminology involved *"I haven't heard your language of physics-based companies being used at any point during my time involved here because nearly everyone else in the start-up landscape talks about the sector a company fits into".*

3.4 Summary and conclusions

Our interviews included discussions with 19 physics-based R&D performing firms and 24 Innovation Centres (9 via online survey instruments) across the UK and Ireland. The interviews aimed to provide more detail on the support needs of physics-based firms, building on the IOP/CBI survey results discussed in Section 2, and capture the views of a small number of Innovation Centres. It is important to note that given the relatively small group of interviews the views reported are not necessarily representative.

One of the key observations from the interviews is the huge diversity which exists within the group of physics-based companies as well as their supporting Innovation Centres. An element of this diversity relates to the wide variety of physics technologies which span quantum, semiconductors, RF and microwave, space technologies graphene, imaging, medical devices, and specialist scientific instruments. Businesses also vary significantly in their TRL and maturity, with differing resource requirements and requiring different types of external advice and support at different stages of development. Similar diversity was evident in the Innovation Centres we interviewed with different centres playing very different roles in physics-based innovation. Research centres – with a more technological focus – are complemented by 'translators' of technology and incubators/accelerators and science parks with a stronger focus on business development. This diversity maps onto the TRLs with Research Centres focussed on TRL 1-3 and ‘translators’ on TRLs 4-7.

The diversity of focus of Innovation Centres is also evident in their funding with UK Centres combining a range of regional and national public funding with some income through paying fees for collaboration, spin-outs, rent and licencing technologies. A similar funding mix was evident in Irish ICs. However, greater diversity was evident among the funding models adopted by the UK ICs due partly to their varied public funding sources and the lack of any consistent national model or programme in the UK which supports Innovation Centres. By contrast in Ireland the, Enterprise Ireland funded, New Frontiers programme has provided support for a network of seventeen ICs across Ireland and providing support to around 500 early stage businesses each year. This scheme has led to more consistency of approach across Ireland reflected in a common focus on business development (rather than technical services) and common KPIs. Where Irish ICs did offer rentable lab space or specialised equipment this was in partnership with their host university. In the UK, ICs based on science parks had physics-appropriate lab space available for rent and those with closer links to universities or public research facilities also provided access to specialist equipment available.

Innovation Centres were asked specifically about their access to networks. UK ICs are strongly networked both through formal networks such as the UKSPA, or more local/regional innovation centre networks, sometimes co-ordinated by LEPs. In Ireland, Enterprise Ireland was identified as important in organising training and networking events. In both countries participants indicated that they were satisfied with their network linkages and could not point to any gaps in relation to functionality, geographic scope and sectoral focus. No physics-specific networks were identified by participants, however, and a number of Irish participants felt that this was an area that could be improved in the future. Innovation Centres used networks in at least three different ways: to find clients; to ‘refer on’ clients; and to identify and share good practice. Among UK ICs there was an appetite for working groups linked to specific physics-based technical challenges (e.g., recycling, battery materials). These were seen as a mechanism to maximise the value of existing ‘innovation assets’.

In the context of consistent reports of skills shortages by physics-based firms, another area of specific interest discussed with the ICs was their involvement in skills provision and development. Both UK and Irish firms emphasised the lack of a strong technical talent pipeline and a lack of entrepreneurial skills among physics PhDs. Few of the UK innovation centres interviewed offered much in the way of skills development as a specific offer. However, those on science parks facilitated discussions between firms and local educational institutions or referred on to an associated university or other provider. Others provided technical training for the equipment on site. In Ireland, access to basic leadership training was provided as part of the range of business support services with firms signposted to other EI training programmes where more in-depth training was required.

UK ICs identified a range of 'gaps' in the ecosystem relating to - entrepreneurial and commercialisation skills; affordable access to equipment for small start-up businesses and the availability of specialist scientific skilled people. These closely reflected the key challenges identified by UK firms. The complexity of the system was also noted by some UK participants with a suggestion that better signposting to aspects of the physics infrastructure would be useful to firms and technology transfer offices. Perhaps because of the relatively small size of the Irish innovation ecosystem, and the co-ordinating role of Enterprise Ireland, Irish IC participants saw less need for additional signposting measures.

SECTION 4: PERCEPTIONS OF PHYSICS-INTENSIVE FIRMS

4.1 UK physics-based firms' perspectives

4.1.1 Overview of UK firms

Thirteen firms were interviewed across the UK. Firms' location was largely dictated by historical ties – either the university they had spun out of, or where the founders lived. One firm had recently expanded to a new office in Yorkshire where they were taking advantage of the local ecosystem, another had made a similar move earlier - leaving the university town they had spun out of to locate where there was funding and support available. Firms were all less than 10 years old although an exception was a firm which had been founded 60 years ago, but had fallen into financial problems and relaunched within the last 10 years. It remained in family ownership from the original industry founder. Another was founded in the last 10 years, but was a service and R&D off-shoot of a larger, older parent company. Most firms employed fewer than 10 people, but two employed 10-24, one employed 25-49; two more over 50.

The firms varied also in terms of their stage of development. Most were pre-profit, if not necessarily pre-revenue. Those generating revenue tended to be selling products for research purposes, to varying scale, or had had one earlier larger sale and were continuing development or were generating revenue through consultancy or service work.

All were growing or planning for growth, either organically or more aggressively. For example, the largest firm interviewed was ready to move to the manufacturing stage and seeking a suitable site UK site (see Gaps below) and the older firm was also planning for growth into a new market, expanding their physical space in the same location, increasing staff and a target to increase turnover by 50% in 3 years.

4.1.2 Attracting staff and the skills pipeline

Many respondents noted a shortage of staff with the skills required in all parts of physics – and noted that there is competition for those available, and wages commanded in the market at the moment are beyond the reach of these SMEs. Many are employing engineers rather than those with specialist physics knowledge because they are not available. A lack of a talent pipeline and an inability to celebrate the achievements and everyday application of physics throughout education was highlighted by one respondent as a particular issue

However, there were also issues with a lack of preparedness amongst Postdocs for entering start-up firms, associated with the range of skills needed in start-up – where people need to be able to do more than one job – and a mindset of resilience and willingness to take risks. One respondent noted that PhD students are not exposed to entrepreneurship, and that more broadly, PhD students are not exposed to the possibilities of working in start-ups. This respondent also acknowledged that people prepared to take those risks and with the right mindset needed to be compensated for this. They were exploring share options for staff, citing the example of John Lewis as an employee-owned business as a model to aspire to.

One firm also reported struggling to hire quality business development managers (BDMs) – if those skills are not within the founding team - in part because they are less confident in what they are looking for. Thus, there is both an issue of a lack of skills and perhaps a lack of confidence or ability amongst founders to recruit the right people.

Location was important, as illustrated by one firm which selected location on basis of being similar firms in the same area – and a pool of potential talent - *we're pirates and take our prisoners and give them interesting and creative jobs that they can't get if we were to release them to these other firms.* This contrasted with a firm in Sheffield which did not have that ecosystem and would be competing with the university for staff.

4.1.3 Facilities and Funding

A number of issues were raised with regard to access to space or equipment. All firms worked with universities to some degree in deriving knowledge from the university. Accessing facilities and equipment in universities can be prohibitively expensive for small firms. A lack of funding for maintenance of this expensive equipment, once installed, and the need to pay for operator time means that even it is known about, it is difficult to use.

Some commented that while there were spaces available for R&D, it was not necessarily suited for physics R&D. And one firm, seeking a UK manufacturing space, noted that the space they needed, with the infrastructure required – e.g. electricity – was not available, or available in parts of the country (e.g. former steel works) where there were not the skilled staff. By and large, it would appear from the interviews that, in the words of one respondent, *'it's business development that's needed – equipment is secondary'.*

All firms had at some point received public funding from Innovate UK for their R&D – and most still were. The extent to which they were currently reliant on this funding varied considerably. The support was largely welcomed and necessary to survival of these small firms, as noted by one which had received initial funding but then had been unsuccessful in recent rounds of UK public funding. They were now devoting their time to seeking investment and funding, in contrast to those with the investment who can focus on the R&D. Another had benefited from Innovate UK's Covid Recovery Grant which was vital at a time when no orders were being generated due to lockdowns.

On the whole, public funding was largely necessary to enable access to early-stage private investment and most firms had gone on to successfully secure private Angel investment– either in UK, US or Europe. But this investment tended to fall away at the time most significant investment was needed – at higher TRLs. A few commented on the 'Valley of Death' – the lack of transitional investment needed to test and produce at scale, the lack of large-scale public and private investment.

Most commented it had not been easy to access the right private finance, indeed this took considerable time and resource (funded by public support). One noted that they did not have their ideal investors, and that patient capital was difficult to come by.

Another noted that countries like the US, Malaysia and Singapore had better all-round support packages to the UK, such as better tax incentives, grants, physical locations and the know-how to develop a business. These were all felt to be lacking in UK public institutions. One respondent noted the complexity of applying for R&D Tax Credits and especially Patent Box, and that some help with issues like these and regulatory matters would be useful.

All firms had some form of IP, however, one respondent was sceptical about the value of IP, commenting that it was only useful to use as a marketing tool for investors. As a small firm, they would not be able to defend any breach, and the additional 'cost' is revealing their science. This tended to be one area where the firms were happy with the quality of advice from TTOs, or where others had drawn on their own experience to access the lawyers they needed.

4.1.4 Networks and access

Access to communities and networks facilitated by private investors was noted as invaluable to those who had secured such financing for their R&D. They introduced potential customers and other investors. Although based on only a few interviews, this seemed to be particularly the case in the US. Firms tapped into both local general business support networks (e.g. SetSquared) or more specialist national/international networks, such as Innovate UK Edge, European Innovation Council, IMechE, the Royal Academy of Engineering and P4. Attendance of events/seminars within specialist physics areas was also common.

Support does not appear difficult to find, those interviewed knew where to go for support, but it does seem more difficult to *get* that support or get the support at the necessary quality, presenting a qualitative issue more than a quantitative one: '*too many people provide support, but nevertheless, we don't get enough support'.* Location helped some firms by allowing them to use local personal networks to access financing and business support, e.g. one respondent used local networks to identify legal advice for IP and to make links to a Dutch bank which provided investment.

Firms interviewed did not, by and large, seem to expect to raise financing locally. Indeed, we have seen some firms interviewed gain US investment. One respondent noted '*finance is global'*.

4.1.5 Business support and development, Intellectual property

Non-university spin outs were less likely to have received business development support, and tended to need this less, having previous industry experience to draw on. All university spin-outs had some experience of business development support in universities, and their perceptions were generally negative or that there was a limited value of the support from universities.

A number of issues were raised in the research in terms of business support and 'spinning out' a company from a university:

- Over-valuing of the original IP by the university;
- A failure by universities to recognise that the success of a start-up comes *after* the generation of the idea, when the work of successfully taking a product to market has been done - a skill universities were universally reported not to have;
- Variation in the proportion of shares taken by different universities and in the IP terms offered – and in contrast to some institutions in the US which do not take any share;
- Technology Transfer Offices were reported to be understaffed and staffed by people very eager to help and support, but who did not understand the nuances of the markets the firms were seeking to reach. One reported that, in hindsight, they might have been better off not engaging with the university TTO but seeking Angel

Investment straight off themselves, describing their engagement with the TTO (and other public sector funded business support schemes) as 'inefficient', while another described them as *'a hindrance'*.

- TTOs themselves are '*all being pestered by an army of CEOs for hire – consultants – whose expertise is also questionable'.*
- A mindset gap between academia and industry was occasionally cited by respondents, with universities offering stability - the converse of what an entrepreneur needs to have.
- One noted that universities are not set up to deal with companies, beyond spin out. They note that different parts of the institution might be very supportive, where supporting companies is within their job role, but others less, so, e.g. contract teams can be risk averse, and staff within the Schools might be reluctant to facilitate access. There is a lack of consistency in university policy.

However, a couple had benefited from ICure and one found this particularly helpful, providing the resources to be able to engage with customers. Other business support models were also more favourably mentioned, such as the then-ESPRC funded Quantum Technology Enterprise Centre in Bristol (now QUEST, funded by the University) and the Creative Destruction Lab. These are characterised by the input of expert business mentors and training in aspects such as markets and value propositions. KTNs were also cited as valuable sources of business development support, providing training in making pitches and competitive opportunities to pitch to investors. One respondent noted: *'Catapults are reasonable, not stellar examples',* being too similar in ethos to universities.

4.2 Irish physics-based firms' perspectives

4.2.1 Overview of Irish Firms

Six Irish firms were included in this study. These firms were located across the main geographic regions in Ireland, and across a range of sectors including SpaceTech, Industrial Technologies, Manufacturing and Health/Medical. Firms were established between 2014 and 2020, with workforces ranging from 2 to 21 full time employees.

These firms included spin-outs from third-level institutes, a family business, a business started to meet an existing business need and a business started by former colleagues. Some firms considered themselves 100% physics-based businesses, while others are users of physics-based technologies. All firms categorised themselves as R&D intensive. Some firms are involved in the development of one product, while other firms are producing a range of products. The Technology Readiness Level (TRL) of these products ranged from 3 (applied research) to 9 (full commercial application).

In terms of business development stage, the firms ranged from pre-seed to established. Of the firms which were revenue generating, turnover was generally less than €1m, with one firm generating more than €5m. With respect to customer-base, most firms are, or expect to be, selling largely to international markets. However, one firms currently only serves the Irish market. Growth ambition ranged from organic to aggressive growth plans, with some firms stating a preference for organic growth without securing private investment, while others are very eager to scale-up, "as a high tech start up, it's important to scale as fast as possible".

4.2.2 Attracting Staff and the Skills Pipeline

Firms had varying experiences with respect to attracting staff. For instance, one firm reported no problem in attracting physicists given the leading-edge nature of their work, but find it more difficult to hire engineering staff and, in particular, software developers who have many employment options. While another firm stated "access to sufficient talent is our main issue", and highlighted the limited hands-on industry experience of physics graduates up to and including PhD level. One participant stated:

> "*physics as a discipline has kind of shot itself in the foot. Needs to look to electrical engineering, for example…. physics graduates need to be more business aware. Physicists…all think they will become professors; they think they won't be academically challenged outside of academia but that's not the case at all. Career development needs to start from the first day in University"*.

This view was largely shared by another participant: "we find that physicists have fundamental deep knowledge and understanding, and when they apply that deeper knowledge, deeper awareness to hard engineering challenges, they progress quite quickly in terms of picking up these skills. We would love to see a bit more of cross-pollination between the two disciplines, physics and engineering, across third level, and that would be very valuable". This participant went on to stress the importance of industry working more closely with third level institutes to support skills training and the need to consider other models, such as apprenticeships.

Another participant commented that it is generally non-nationals working in the research labs, and at present they seem happy to work and live in Ireland, but if that changes, that will create challenges.

4.2.3 Facilities and Funding

Firms had accessed support and funding through a variety of avenues. Most firms had received initial support from their Local Enterprise Office (LEO), and subsequently from Enterprise Ireland (EI) through the New Frontiers or the High Potential Start-Ups (HPSU) programmes. One participant described this support as "More business model development…. the strategy side of things…how to pitch your business. Very much funding focused." There was general agreement that it is business development where support is needed rather than technological support, e.g. "business development leadership is what we need…. strategy and planning". Participants spoke of the steep learning curve when moving from a research-orientated unit to being more commercially orientated.

Most participants highlighted the important role of their EI Development Advisor (DA) in supporting them. The proximity of the DA and the LEO to their businesses was seen as important by some participants, with one participant suggesting more visits by the DA to the business - "they need to come out to you as much as possible…. I would say twice a year to each client". Although most participants had engaged virtually with their DA over the course of the pandemic and felt that worked as well as face-to-face meetings.

Having experience of starting a business in Ireland and the UK, one participant stated that "at the start, it was much easier to see what was available in Ireland….. Irish pathway is a lot clearer…..and all grants build on top of each other". Another participant with prior experience with start-ups in Germany, the US and UK felt that the "start up support by EI is second to none". Many participants spoke about the positive exposure for their products from winning awards and competitive funding through support agencies such as EI and InterTrade Ireland. Firms saw the PR generated and marketing as a crucial benefit in this regard.

Some firms have also benefited from large grants from the Disruptive Technologies Innovation Fund and European grants via Horizon2020 and the European Space Agency (ESA). A number of participants had come through the ESA's Business Incubation Centre (BIC) at Tyndall National Institute, describing it as 'very helpful' and 'very important'. Many participants spoke about the important role of third-level Universities and Research

Institutes, particularly in the earlier stages of the business/research and in relation to funded postdoctoral work, e.g. Marie-Curie awards.

In addition, some firms have accessed co-funded equity through EI's HPSU scheme and/or secured private investment via Angel Investors and Venture Capitalists (VCs). However, financing in terms of scaling up is generally seen as a challenge, with one participant stating "financing is difficult in Ireland…. it's easier in the US". Another participant, with experience in the UK market also, said there was more of a focus on attracting VCs there than in Ireland. However, one participant who is currently transitioning to raising Series A funding for larger manufacturing capacity said "while access to finance is a challenge, it is also attainable".

4.2.4 Business support and development, Intellectual property

Most participants identified areas where they could use additional support, such as project management, sales, marketing and grant writing. However, it should be noted that there was little consensus here, most likely due to the heterogeneity of these firms, in terms of their products and markets. This suggests the importance of targeting support based on individual firm needs.

One participant with a number of businesses stated that "*project management is a key skill being ignored… for a really successful project, a strong project manager makes all the difference. I believe that this is a skill that can be learnt.*". The same participant identified sales as the "*single most important process"* for his company, and something that his firm needs help with – "*companies fail because they can't sell*". Marketing was identified as one of the main challenges for many firms, with participants highlighting the important role of support agencies in this regard. Another participant highlighted that employing an agency to assist with grant writing was "*the most important thing to happen for this firm*", stressing this was a skill they didn't have in-house.

Intellectual Property (IP) protection was generally seen as important, for example "*existence of company hinges on how well we protect ourselves in that regard*", but challenging, for example "*companies need help in this area"*. Some firms did not know if they needed to go down the patent route, while others felt it was not the right approach for their products. One firm had employed the services of an IP lawyer based in Dublin for their expertise and this assisted greatly in terms of successful patent applications. In some instances, patents were granted at earlier research stages (prior to spin-out), with some firms using technologies under license from third-level institutes.

4.2.5 Networks and access

Most firms were involved in several national and international networks, and considered themselves well served by these networks. One participant suggested the potential for a network of physics-intensive firms to showcase their products where physics employers/employees could develop relationships. One participant highlighted the importance of their informal network, developed over 20 years, in successfully setting up the firm.

4.3 Conclusions

UK and Irish firms' views of their ability to access support from across the ecosystem differed markedly. For UK firms, the support system often appears complex and inaccessible with services seen as of variable quality and public grant support important but inconsistent. UK respondents had benefitted from ICure, and other business support models were also more favourably mentioned, such as the then-ESPRC funded Quantum Technology Enterprise Centre in Bristol (now QUEST, funded by the University) and the Creative Destruction Lab. KTNs were also cited as valuable sources of business development support, providing training in making pitches and competitive opportunities to pitch to investors. In Ireland a more consistent pattern emerged with most participants highlighting the important role of their EI Development Advisor (DA) in supporting them and helping to access ecosystem resources. Having experience of starting a business in Ireland and the UK, one Irish participant stated that "at the start, it was much easier to see what was available in Ireland….. the Irish pathway is a lot clearer…..and all grants build on top of each other". Another Irish participant with prior experience with start-ups in Germany, the US and UK felt that the "start up support by EI is second to none".

One other interesting aspect to our discussion with firms was the value seen by Irish firms in the positive exposure for their products from winning awards and competitive funding through support agencies such as EI and InterTradeIreland. Firms saw the PR generated and marketing as a crucial benefit in this regard.

SECTION 5: CONCLUSION

5.1 Introduction

In this project we aimed to address four main research questions related to: the effectiveness of Innovation Centres in providing support for physics-based innovation in the UK and Ireland; identifying accessibility and any gaps in provision; and examining connectivity. Our interviews with Innovation Centres in Ireland and the UK emphasise the differences in provision between the two countries, and suggest a number of potential steps to support physics-based innovation.

Section 5.2 provides an overview of our findings in terms of current Innovation Centre support in the UK and Ireland and identifies a number of gaps in current provision. Section 5.3 provides some suggestions for future research.

One limitation of our analysis is worth emphasising at this point. While a number of our UK respondents mentioned the importance of local factors in shaping the support available by Innovation Centres we did not pursue these geographical variations in support in any great detail. We therefore make no specific suggestions for spatially specific initiatives over and above the distinction between the UK and Ireland.

5.2 Assessing Innovation Centre support for physics-based innovation

Both the UK and Ireland have well developed innovation ecosystems comprising a wide range of diverse Innovation Centres and related accelerators and business incubators. Due to the very different process of policy development in the two economies, however, the Irish and UK innovation ecosystems have rather different characters. The UK system has largely developed or evolved as a result of individual actors' decisions and initiatives. For example, individual universities have established their own incubator, accelerator and/or Innovation Centre ecosystems often with other local partners. In the UK, there has been relatively little attempt at nation-wide planning or system co-ordination (although the resulting ecosystem may arguably be more resilient with somewhat fewer single-points of failure). This is most evident in England, with some more system-wide planning evident in Scotland. In Ireland by contrast, centralised and significant state funding of key elements of the innovation ecosystem have led to a more strongly curated and uniform innovation ecosystem, with common elements across different regions and university contexts. For example, the, Enterprise Ireland-funded *New Frontiers* programme has provided support for a network of seventeen ICs across Ireland. The common funding for the scheme has led to more consistency of approach across Ireland reflected in a common focus on business development and common Innovation Centre KPIs. An essentially similar, curated approach has been adopted by Science Foundation Ireland (SFI) over the last decade in their strategic funding of a series of thematic Research Centres.

These contrasts in funding mechanisms and objectives have significant implications in terms of networking and collaboration between Innovation Centres. Innovation Centres in both countries reported extensive networking and sign-posting of clients from one organisation to another. Network benefits in terms of sharing and developing expertise were commonly reported across both the UK and Ireland. In Ireland, collaboration between Innovation Centres was facilitated by Enterprise Ireland and enabled by common KPIs and funding models. In the UK, however, collaboration between Innovation Centres was said to be more difficult due to conflicting funding requirements and objectives.

Reflecting differences in the nature of IC provision in the UK and Ireland, the IOP-CBI survey suggested significant differences between the UK and Ireland in the extent to which firms felt that the network of Innovation Centres meet their needs. This result was strongly echoed in our discussions with businesses. In short, while physics-based innovators in Ireland felt well supported by the Irish Innovation Centre network, firms in the UK were often critical of both their ability to access appropriate services and in some cases the quality of the innovation support services that they were able to access. This reflected a number of information failures or weaknesses in the UK physics innovation ecosystem. These include but go beyond the availability of services from Innovation Centres:

- There was said to be a lack of awareness of the existing physics infrastructure and of the various business advisory services available amongst scientists. This was attributed by some to the complexity of the UK innovation ecosystem, arising through the complex nature of innovation and activity at each TRL, which results in their being many different players and pots of funding, but little overarching clarity on what is optimal and valuable.

- This situation was often compounded by a poor understanding of the markets for physics innovations at universities and of the cost of further research and development leading to overvaluation of invention and a lack of incentivisation for spin outs. In some case this led to poor or inconsistent quality in the services received by firms with little clear route through which firms could assess quality before engaging with service providers.

- University facilities were often reported to be costly to access even where external funding was available and a number of publicly funded facilities listed on the UK's

Research and Innovation Infrastructure Portal, identified a number of facilities which were not available for industry use.

5.3 Suggestions for Further Research

As indicated in the introduction, this study was indicative only: it did not aim to produce a comprehensive map of innovation centres, nor did it aim to survey a large proportion of such organisations. As a result, there are various questions which cannot be answered definitively by this study, but which may benefit from further research.

For example, since this work was not able to survey all ICs concerning their funding source, we are unable to comment on the reasons for, and consequences of, the relative 'over-representation' of ICs in Scotland and Wales which was discussed in section 2.2.3. It would be interesting to ascertain whether such ICs are being consciously used for economic regeneration, or are a function of relative proportion of public/private expenditure in the regional economies, or are required in greater numbers as a consequence of geography and more difficult travel (in comparison with the London and the South East, say).

We also suggest that further work is needed to understand why firms in some regions reported in the Paradigm Shift study that a lack of facilities was one of the most significant challenges to R&D, yet the regions concerned seem to be relatively well-represented by innovation centres. As discussed above, there could be several reasons for this, including difference in signposting of facilities, differences in geography, and ease of to travel to other areas (e.g. London firms travelling to Oxford or Cambridge).

That said, 'under-' or 'over-representation' is a relatively crude measure, which does not take into consideration the *relative fit* of centres with firms: many ICs perform highly-specialist functions which might be essential to one firm yet irrelevant to another. It may therefore be worthwhile to undertake a more fine-grained mapping by sector or TRL, in order to provide a more detailed view of gaps.

For example, section 2.2.3 found a relatively low concentration of ICs in London. However, we note from other research that London also has a very *high* concentration of accelerators.[6] It is possible, then, that the particular mix of firm support to be found in this region is a consequence of the stage and type of firms (as well as, potentially, the cost of

[6] Bone et al (2017), ibid.

commercial space and, historically, the land-use classes which existed prior to reform in 2020 - both of which may have inhibited development of research facilities near the city).

Somewhat relatedly, it would also be of interest to investigate more deeply which innovation centres truly act as *national* centres of excellence, and how their characteristics may differ from others. From our research, it is clear that some ICs saw the majority of their clients as predominantly of *regional* origin, whilst others saw their clients as coming from all across the UK (or Ireland). One might expect that those ICs with a national catchment area are perhaps more specialist in nature, but it is unclear whether that is the case, or whether these are simply better signposted or otherwise more accessible.

In addition, we suggest that more research is needed to understand better the ecosystem-level functions of such ICs (as opposed to the impact on their clients only). Research on accelerators shows that there are spillover benefits which accrue to other (non-accelerated) start-ups as a result of a programme starting in a particular location, potentially arising from the 'ecosystem co-ordinating' function that such programmes may play.[7] Whether such spillover benefits are also created by Innovation Centres is unclear, but it would seem quite feasible that they exist, particularly if the ICs concerned are well-networked with other types of organisations (e.g. VCs, universities, etc).

Finally, we note that this study did not comment on the issue of quality or effectiveness of individual support organisations. However, it is clear from other studies of the support landscape that not all support programmes are equal: there is significant variance in the quality of business support, as well as variance (at least, perceived variance) in the quality and effectiveness of accelerator programmes, and in *components* of such programmes (such as mentoring). It would therefore be surprising if there were *not* some variance in quality between innovation centres, in terms of the services they delivered to start-ups and other innovative firms. How well clients are able to determine this is unclear, but there may be value in investigating both the actual difference in quality or impact, and in ways in which this can be better signalled to the market.

[7] Bone, J.; Gonzalez-Uribe, J.; Haley, C. and Lahr, H (2019) 'The impact of business accelerators and incubators in the UK' BEIS Research Paper Number 2019/009

ANNEX A: RESEARCH AND INFRASTRUCTURE PORTAL

Indicative analysis of the UKRI Research and Infrastructure Portal for physics-related assets.

	Highly unlikely to be physics (no lab space)	Labs but no stated physics links	Most likely to be physics
N Ireland	Innovationfactoryni (office)		https://wearecatalyst.org/
Scotland	Pentlands Science Park (animal health) Scottish Enterprise Technology Park (tech)	Edinburgh bioQuarter European Marine Science Park Heriot-Watt University Research Park Roslin BioCentre Stirling University Innovation Park	West of Scotland Science Park *(cleanrooms, satellites, laser syst)* Edinburgh Technopole Clinical Innovation Zone,
Wales	AberInnovation	Cardiff Medicentre	Cardiff University Innovation Campus M-SParc OpTIC Technology Centre Institute of Life Science
East Midlands	Enterprise Centre, East Northants Mansfield i-Centre Scott Bader Innovation Centre	BioCity life science incubator and business collective.). Dock, Leicester Lincoln Science and Innovation Park (including Sparkhouse incubation Nottingham Science Park	Charnwood Campus (*Scientific R&D, Test Labs)* Silverstone Park Space Park Leicester Loughborough University Science and Enterprise Park University of Nottingham Innovation Park
East of England	Arise (*health, wellbeing, and performance sectors*) Cambridge Innovation Parks *(no labs*) Harlow Science Park *(no labs*) Hethel Engineering Centre *(no labs*) Innovation Centre, Knowledge Gateway *(no labs*) St John's Innovation Centre *(no labs*) University of Essex Knowledge Gateway Ipswich Waterfront Innovation Centre (IWIC) at the University of Suffolk	Babraham Research Campus *(lifescience)* Cambridge Biomedical Campus, Chesterford Research Park *(lifescience)* Colworth Park The EpiCentre Norwich Research Park Scottow Enterprise Park Stevenage Bioscience Catalyst Wellcome Genome Campus	Cambridge Science Park Mill SciTech Park *(life science meets AI)*
South East	BASE Bordon Innovation Centre *(no labs*) Bicester Innovation Centre *(no labs*) Bracknell Enterprise & Innovation Hub (*no labs*) Fareham Innovation Centre	Bucks Health Tech Hub. Discovery Park in Sandwich *(pharma)* Grassroots, Oxford Heyford Park Innovation Centre (biotech) Kent Medical Campus Milton Park BioEscalator	The Science Quadrant/Abingdon Science Park *Oxford University Begbroke Science Park*, Culham Innovation Centre Culham Science Centre Harwell Innovation Centre and Harwell Campus

	Nucleus Business and Innovation Centre Ocean Village Innovation Centre[10] One St Aldates Oxford Centre for Innovation (Set Squared in Surrey) Witney Business & Innovation Centre[10]	Rothamsted Enterprises SETsquared at the University of Southampton Sussex Innovation Thames Valley Science Park (health science labs) University of Southampton Science Park	Oxford Science Park Oxford Tech Park Surrey Technology Centre Wood Centre for Innovation
London		Queen Mary BioEnterprises Innovation Centre	Imperial White City Incubator/White City Campus/Thinkspace Innovation Gateway at Inst of Cancer
North East	National Innovation Centre for Ageing *(no labs)*	Baltic Quarter, Gateshead Wilton Centre	North East Technology Park
North West	Ashton Old Baths Lancaster University Stockport Business & Innovation Centre	Alderley Park Apollo Buckingham Health Science Campus Circle Square Hexagon Tower Innospace Sciontec: Liverpool Science Park Sensor City University of Chester's Thornton Science Park	Manchester Science Park Sci-Tech Daresbury Heath Business and Technical Park Citylabs campus
South West	University of Bath Innovation Centre (setsquared) Taunton Innovation Park Health and Wellbeing Innovation Centre	Bristol SETsquared Centre, Exeter Science Park UWE Bristol campus, Future Space [1] Plymouth Science Park	Bristol & Bath Science Park Gloucestershire Science and Technology Park Porton Science Park Bristol science incubator Unit DX Brixham Laboratory
West Midlands	BCU STEAMhouse Birmingham's Knowledge Quarter, Innovation Birmingham	Birmingham Health Innovation Campus Birmingham Research Park Coventry University Technology Park Keele University Science and Innovation Park University of Wolverhampton Science Park	Malvern Hills Science Park University of Warwick Science Park
Yorks and Humber	Electric Works Round Foundry Platform Sheffield Technology Parks	Advanced Manufacturing Park Technology Centre Nexus Leeds York Biotech Campus York Science Park	

ANNEX B: SCIENCE PARKS AND RELATIONSHIP TO PHYSICS

Region				
	Number of Science Parks	Highly unlikely to be physics (no lab space)	Labs but no stated physics links	Most likely to be physics
N Ireland	2	1		1
Scotland	10	2	5	3
Wales	6	1	1	4
East Midlands	12	3	4	5
East of England	19	8	10	1
London	3	0	1	2
North East	4	1	2	1
North West	15	3	9	3
South East	31	10	12	9
South West	12	3	5	4
West Midlands	9	2	5	2
Yorks and Humber	8	4	4	0

ANNEX C: INNOVATION CENTRES IN IRELAND, BY NUTS3 REGION

	Unlikely to be physics (no lab space)	Labs but no stated physics links	Most likely to be physics
Dublin	Guinness Enterprise Centre Circular Cities ClimAccelerator E-Labs Huckletree D2 I-Cubed Launchbox Trinty Mastercard Start path NadiFin NDRC Propeller Venture Accelerator Rethink Ireland Start-up Boost Start-up Lighthouse Start-up Scaleup - IoT Accelerator - DCU Ryan Academy Tangent Pioneers The Pearse Lyons Accelerator BiOrbic	Accenture - The Dock AgTech UCD Accelerator Founder Institute The Yield Lab Centre for Applied Artificial Intelligence (CeADAR) Food for Health Ireland (FHI) Learnovate	AMBER - Advanced Materials and BioEngineering Research FPC@DCU National Centre for Sensors Research National Centre for Plasma Science and Technology UCD Centre for Physics in Health and Medicine (CPHM) Meat Technology Ireland Irish Manufacturing Research Technology Centre (IMR) CONNECT FutureNeuro iCRAG I-Form CREST Technology Gateway, DIT MiCRA - Microsensors for Clinical Research and Analysis CRANN Advanced Microscopy Laboratory C-Space The UCD Centre for Quantum Engineering, Science, and Technology The Centre for Industrial and Engineering Optics (IEO) Photonics Research Centre The Centre of Micro/Nano Manufacturing Technology NW Centre for Advanced Manufacturing
East Midlands	Insurtech Network Centre (INC)	PMBrc - Pharmaceutical and Molecular Biotechnology Research Centre	Design+ Applied Design Technology Gateway, IT Carlow designCore The SEAM Gateway, Waterford IT TSSG - Telecommunications Software and Systems Gateway
South-East			ESA Space Solutions Centre Ireland - Maynooth

South-West	Propeller Shannnon Cork BIC International Security Accelerator International Security Accelerator RebelBio (SOSV Accelerator) ProtoAtlantic	Shannon Applied Biotechnology Centre Gateway, IT Tralee	European Space Agency (ESA) BIC Ireland Irish Photonics Integration Centre (IPIC) Microelectronic Circuits Centre Ireland (MCCI) ESA Space Solutions Centre Ireland – Tyndall CAPPA Gateway, Cork IT Irish Centre for Composites Research (IComp) Nimbus IMaR Gateway, IT Tralee
Mid-West		Shannon Applied Biotechnology Centre Gateway, Limerick IT SSPC – UL CONFIRM - UL	Lero – UL Dairy Processing Technology Centre (DPTC) Pharmaceutical Manufacturing Technology Centre (PMTC) CONFIRM Lero
West	BioInnovate	Irish Centre for High End Computing Bioexel	CURAM Insight MET Technology Gateway, GMIT
Midlands			Midlands Innovation and Research Centre (MIRC) Centre for Industrial Services and Design (CISD) Enterprise and Research Incubation Campus (ERIC) APT Gateway, Athlone IT COMAND Gateway, Athlone IT
Border			WiSAR Gateway, Letterkenny IT PEM Engineering and Manufacturing Gateway, IT Sligo

ANNEX D: REFERENCE LIST OF PHYSICS TECHNOLOGIES

Aerodynamics	Instrumentation engineering
Aerosols & Dispersion	Lasers / Photonics / Optical Devices
Aerospace & defence	Magnetism
Analytic Science	Materials Science & Technology
Biophysics	Measurement & Sensors
Catalysis	Medical Imaging / Equipment
Climate & Weather Technologies / Research	Microscopy
Combustion	Nanotechnology
Communication & signalling technologies	Physical Science Research
Computer systems & architecture	Physics-related AI / Robotics
Control Engineering	Plasma technologies
Digital signals/ signal processing	Power Distribution
Display Technologies	Power Electronics
Electronics (electronic devices)	Quantum Technologies
Energy Efficiency	Radio Frequency & Microwave Technology
Energy Generation & Related Technologies	Semiconductors / Computer systems & architecture
Energy Storage / Batteries	Shock Waves
Extraction and drilling	Space & Satellites / Telescopes
Fluid Dynamics / Mechanics	Spectroscopy
Gas & Solution Phase Reactions	Tomography / Scanning Technologies
Geophysics / Earth Engineering	Vacuum Technology

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