Innovation Caucus

UNDERSTANDING CLUSTER GROWTH POTENTIAL – Part 1: Place Based Innovation in the UK: Synthesis Report

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About the Innovation Caucus

The Innovation Caucus supports sustainable innovation-led growth by promoting engagement between the social sciences and the innovation ecosystem. Our members are leading academics from across the social science community, who are engaged in different aspects of innovation research. We connect the social sciences, Innovate UK and the Economic and Social Research Council (ESRC), by providing research insights to inform policy and practice. Professor Tim Vorley is the Academic Lead. The initiative is funded and co-developed by the ESRC and Innovate UK, part of UK Research and Innovation (UKRI). The support of the funders is acknowledged. The views expressed in this piece are those of the authors and do not necessarily represent those of the funders.

About this Document

This report is the first of two for the Understanding Cluster Growth Potential project the second part is Place based Innovation in the UK: Case Studies

Contents

Place-based innovation and policy

The Build Back Better Plan for Growth (HM Treasury, 2020), R&D Roadmap (HM Government, 2020), Innovation Strategy (Department for Business, Industry and Industrial Strategy, 2021), and Levelling Up White Paper (HM Government, 2022) all emphasise the importance of strengthening research and innovation as mechanisms for the UK to increase productivity and prosperity, and to boost left behind places. These principles are further enshrined in strategic delivery plans across government departments such as the recent UKRI Five-year Strategy (UKRI, 2022). These strategies recognise that the UK's competitive advantage derives from innovative places and that delivering impact across the country requires support to unlock innovative potential and to sustain and grow innovative places.

These shared objectives have led to a strong focus on clusters and place-based innovation strategies more broadly. Consequently, there is strong demand for tools, and an evidence base, to understand the future growth opportunities related to place-based innovation, which investment strategies should be deployed where to boost the contribution of innovation to local GVA, and how these can serve the levelling up agenda.

A first phase of this project concluded in 2022 and culminated in the *Understanding Cluster Growth Potential* report (Nelles *et al.,* 2022). In this research, we developed a framework to understand future growth opportunities and the aspects that merit further focus to strengthen a place's contribution to economic growth. The framework was constructed based on a literature review on the elements of clusters, their life cycles, and the relationship between absorptive capacity and cluster growth. The report included three case studies, selected in consultation with Innovate UK, on which the framework was applied in practice – East Midlands medical technologies, Solent marine and maritime, and Belfast cyber security. The cases were selected to represent industries at different evolutionary stages, based on very different technologies and industries, and located in different parts of the country in order to test and refine the framework across a diverse range of contexts. This initial set of cases demonstrated the potential of the framework and showed how even when case studies are quite diverse across a number of variables, there is considerable scope to generate comparative insights.

Given the demonstrated value of the first phase of research, the project was extended for a second phase designed to apply the framework to additional case studies. This research was conceived, in line with the previous report, to assist policymakers and their delivery agencies to frame and design their strategies for place-based development. Innovate UK has used the framework proposed in the previous report, and applied again here, to learn more about cluster maturity and to identify growth considerations across the place axis. They work with many actors to effect change and growth of clusters across the UK. This research provides more context and insight to further that agenda and to serve as a common frame of reference for cross-departmental discussions around place-based development. This time, we aimed to build on the insights of the original report and focused on the following questions in each case:

- Could we evidence a cluster (or some sort of significant place-based innovation occurring) in this place? If so, what is it?
  This question arose out of our observation that very few of the cases that we studied in the first report fulfilled the criteria that we outlined as the characteristics of clusters. However, in all cases, there was significant and interesting innovative activity taking place that could be nurtured and supported to increase growth. See a more detailed discussion of our

observations and how that has affected our approach to this report in the "definitions" section, below.

- What is the growth potential of the cluster?
  While in the previous report we focused on clusters at different life cycle stages, this research concentrated more specifically on places and industries that Innovate UK felt were emerging. Whether these were older industries adopting new technologies or responding in innovative ways to new pressures or relatively new industries building novel technologies, the case studies were intended to reveal potential clusters in the making and use the framework to think critically about what kinds of support might launch or accelerate a growth cycle.

- What technologies and trends are driving innovation? Do they seem sustainable and to what extent are they aligned with current Innovation Strategy objectives?
  The first wave of studies suggested that enabling technologies, such as digital and AI, were influencing innovation trajectories. Understanding what kinds of core technologies might be driving innovation and assessing whether the places studied have access to the resources, skills, and networks necessary to leverage them is crucial to evaluating growth potential and assessing interventions. Policy trends and conditions, such as Net Zero and changes arising from the UK's departure from the European Union, are also stimulating innovation and challenging industries to develop creative responses. If patterns are evident across case study, this could be useful to inform policy development.

- What kinds of supports (if any) are needed to accelerate growth?
  While case studies often differ substantially in many ways, some challenges are common. This research focuses on understanding how interventions might need to be tailored to individual contexts while also seeking lessons about what types of support places might require to leverage place-based innovation to level up.

This report has two parts: Part I, this document, outlines our approach and offers a synthesis of observations and insights from the case studies. Part 2 is an annex that compiles all of the case studies with a short introduction. In Part I, we clarify key definitions and summarise our methodology (outlined in more detail in Part 2). This is followed by a section of short summaries of the case studies, that provides a preview of what is contained in Part 2 and context for the synthesis that follows. The "Lessons" section is the core of this report. It focuses on a selection of the most interesting findings - commonalities or contrasts - from the case studies. The report concludes with a summary of core lessons and their policy significance.

Our most important takeaway is that while our cases differ substantially - in terms of geographies, maturity, core technologies, and industrial structures - they share many commonalities. These are significant as where we found intersections between cases; these might also be areas where national political attention might benefit the evolution of place-based strategies. A second high level observation is that these common themes do not diverge significantly from tensions and debates highlighted in the literature on place-based innovation. In short, while the experiences of each of these cases differs on some levels, they are not unique.

We conclude by suggesting that more research applying this framework to cases at differing scales and in different industries, in different places, will continue to deepen our understanding of place-based innovation dynamics. In addition to broadening this research to different and more varied industries,

future studies might also consider exploring different industries in the same places to compare experiences and geographies of innovation. More work could also be done to explore the linkages between case studies in different industries to better understand knowledge flows. Furthermore, one of the biggest blind spots in this study was our inability to directly include the experiences of firms in our analysis. Future research would benefit greatly from seeking more industry input. Finally, there are currently various efforts to quantify and map clusters in the UK. Consequently, there is an opportunity to use research such as this to vet and check the results of other methodologies and to seek other synergies between them.

Defining place-based innovation (or, why this isn't a study of clusters)

The first *Understanding Cluster Growth Potential* report specifically adopted the innovation cluster as its frame of reference, but clusters are far from the only configuration of place-based innovation. Other and related concepts capture these kinds of localised advantages include national (Freeman, 1995, Lundvall, 2008) and regional innovation systems (Asheim and Coenen 2005, Cooke *et al.*, 2011; Asheim, Smith & Oughton, 2011), agglomeration economies (Duranton & Puga, 2004; Combes, Duranton & Gobillon, 2011; Porter, 1996) and innovation and entrepreneurial ecosystems (Granstrand & Holgersson, 2020; Oh *et al.*, 2016; Stam & Spigel, 2016; Spigel, 2020). All attempt to capture the factors that combine to characterise innovative places and catalyse growth, entrepreneurship and centre on the idea that a critical mass of collocated firms in related industries can yield stronger innovation outcomes compared to more dispersed and diverse local economies.

Clusters are industry or sector specific. Nelles *et al.* (2022) defined these as a group of firms and intermediary organisations involved in related activities and that derive individual and collective benefits from collocation with each other such as through access to shared knowledge bases, labour markets, specialised services, infrastructure, support services, training and other industry-specific pooled resources. At their most basic, clusters can therefore be identified by three criteria that groups of firms must possess in order to be described as a cluster:

- Interaction and collaboration between actors within the group (e.g. firms, knowledge producers, industrial and support organisations, local authorities, etc.);
- Engaged in related activities, for example within the same value chain or producing similar products;
- Spatial co-location.

From this definition, a cluster is more than just a critical mass of "the right ingredients" – such as firms and assets – but is also a function of networked relationships and flows and exchange of resources between firms, and other localised assets. In other words, agglomeration alone is not a guarantee that the particular types of benefits associated with clusters will materialise or be optimised.

Adopting this definition has two important implications - the first is that identifying and understanding cluster dynamics requires in-depth qualitative analysis to confirm that network effects are being generated in areas with critical mass and industrial co-location. Secondly, it assumes that places that lack one or more of these characteristics do not have as much policy interest as those that do. This is problematic, as places that have not fully developed clustering dynamics are the ones in which public intervention may have the greatest impact. However, even more crucially, a focus on clusters risks missing the potential advantages of other types of place-based innovation strategies such as smart

specialisation (Grillitsch and Asheim 2018). A focus on clusters may also overlook innovation dynamics by looking for or trying to catalyse them at the wrong geographies rather than taking advantage of dynamics that might be occurring at smaller or larger scales.[1] Finally, focusing exclusively on clusters also potentially limits consideration of interventions that might catalyse place-based innovation. Where clusters are specific industrial groupings, innovation (eco)systems are more generalised and can benefit multiple types of economic activity.

Given our approach to case selection, and our findings from previous case studies, we recommended that, rather than assuming the existence of a cluster in our target geographies, we explore the degree to which clustering dynamics were evident and, where the criteria were not completely met, instead explore what kinds of innovation dynamics exist that might be built upon to stimulate growth. This approach aligns more closely with the objective of identifying the characteristics of high growth potential targets for intervention and of learning more about what kinds of interventions might be most effective to boost innovation and productivity.

Methods and methodological considerations

As in the previous report, we relied on discussions with Innovate UK regional managers to select case study industries and geographies. These conversations yielded nearly 30 candidates, which the research team and Innovate UK partners collaborated to narrow down to nine final case studies. Among the considerations for case selection were some degree of geographical variation, so that the study included cases from as many regions as possible. We also aimed for a diversity of urban-centred versus more distributed cases, which also had the impact of creating a variation in the geographical size of the case study areas. These varied from quite large (e.g., medtech in Wales) to the very small (e.g., immersive technologies in Gateshead). While we also aimed for some variation in the ages and types of industries, the range of differences was limited by pairing similar cases (e.g., agritech in Eastern England and in Northern Ireland). By exploring how pairs of industries have evolved in different parts of the country, we were able to investigate similarities that are related to the focus industry as well as differences that might be attributable to specific local contexts.

We opted for this decidedly not data-driven approach for several reasons. First, the *Understanding Cluster Growth Potential* report stressed that while quantitative approaches to defining clusters are frequently sought, it is critical to understand that clusters are more than the sum of their statistical parts. This is among the reasons that data-driven approaches to cluster identification are so difficult. The presence of agglomeration of something (an industry, for example) can be relatively easy to detect. The degree to which that agglomeration is resulting in the clustering dynamics that enhance innovation outcomes is much trickier to determine. Even more difficult is determining quantitatively which agglomerations may have the *potential* to develop those dynamics or are earlier in that evolutionary process. Since the inception of this project, the Department for Science, Innovation, and Technology (DSIT) has sponsored research that will develop a methodology to do this type of quantitative mapping exercise.

[1] For example, at smaller scales in industrial districts (Katz & Wagner, 2014) or activity centres (Loh *et al.*, 2022), or at larger scales in superclusters (Beaudry & Solar-Pellitier, 2020) or connected clusters.

Our approach to selecting cases relied on the observations and experience of (primarily) Innovate UK regional managers, their networks, and local stakeholders. This is particularly useful for pinpointing buzzed about and emerging innovative activities, which we hoped to spotlight in this research. However, it is important to acknowledge that these perspectives are likely to be subjective and may be biased. While we expected that this approach would be effective in identifying areas of developing critical mass and emerging innovations, we knew that the reference industries and geographies were not likely to comprehensively identify fully realised clusters, either in composition or scales. We argue that this finding, however, is an essential and unavoidable part of the assessment process and can help policymakers and their delivery agencies to rethink how to characterise the innovative sectors in place-based economies and their relationships to sectors.

In applying the cluster growth potential framework (Nelles *et al.*, 2022), researchers were instructed to follow the evidence to assess whether their case studies exhibited all of the cluster criteria and, if possible, to discuss whether clustering was occurring at different scales or within different industrial groupings. In the many cases where specific clusters were not identified, researchers focused on describing the innovation dynamics that they were able to observe and make recommendations to enhance and magnify them. We take up a discussion of our findings on these themes in the Lessons section.

Before introducing the case studies themselves, it is useful to highlight the approach we adopted, in discussion with Innovate UK, to data, metrics, and comparison. This discussion is important to understanding how to approach case studies - particularly pairs of case studies - and think about comparison but is also relevant to the broader agendas that are developing in relation to cluster identification, mapping, and comparison.

The interpretive guidelines that accompanied the *Understanding Cluster Growth Potential* report included a list of metrics that might be useful for such a purpose. While these indicators are still relevant, and we include them where appropriate, we stress that they are not suitable for comparative analysis without addressing substantial methodological issues. Because metrics that describe things like industrial growth or employment add important context to the case studies, we have opted to include them where possible. We did not do any of our own quantitative data collection or analysis for this report but instead relied upon statistics published in reports we collected during the desk research process or that were shared with us during interviews. While we cite data sources, it is important to note that they are not always reported at the same geographies that we are studying (we indicate geographies if they differ from our own) and we cannot verify the accuracy of those figures. As such, we emphasise that these figures should only be used to gain an understanding of the individual cases and not be considered for comparative purposes.

Case study summaries

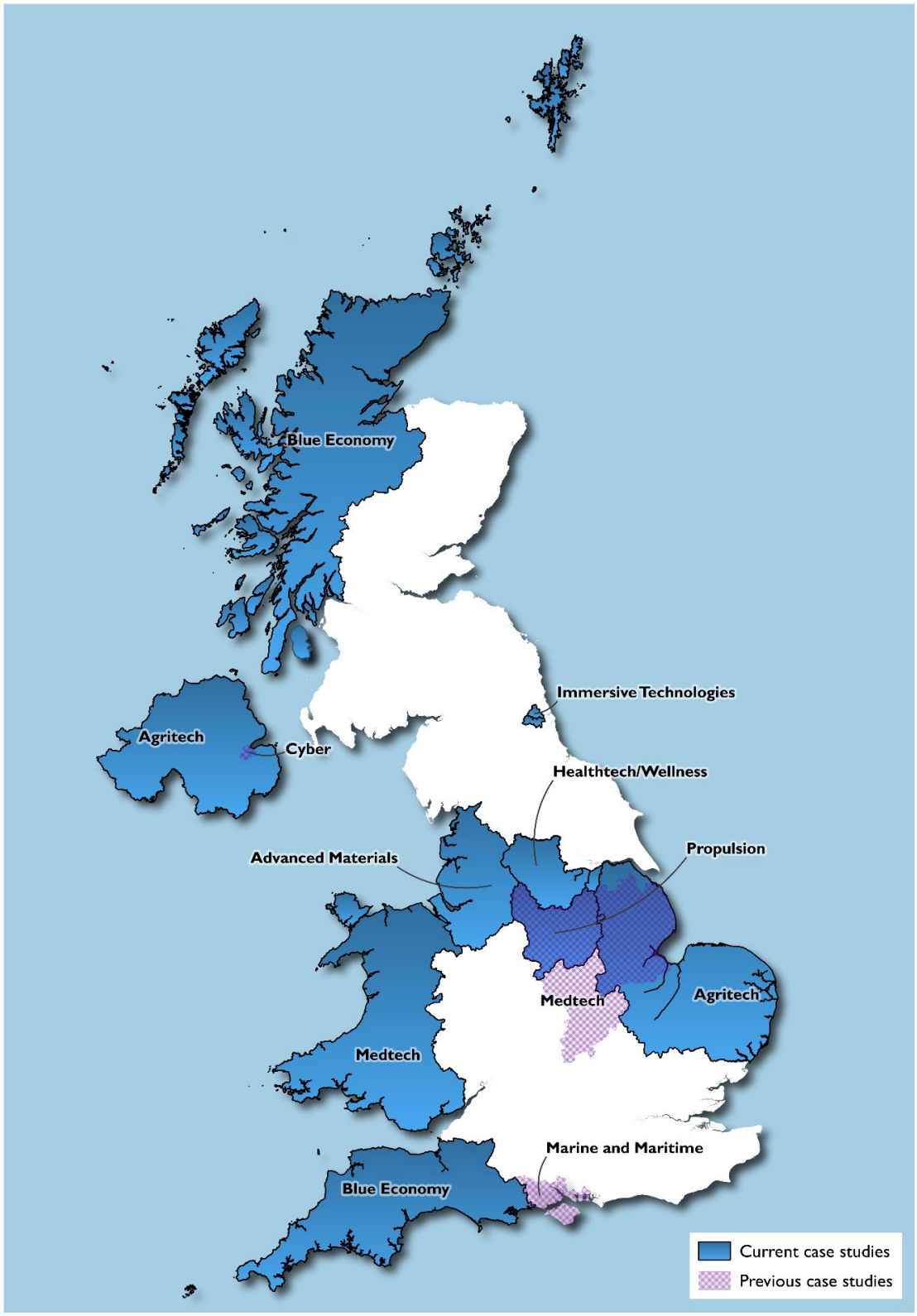

Figure 1: Locations of case studies with cases covered in the current document shown in blue and cases conducted as part of the *Understanding Cluster Growth Potential* report in purple checks.

Eastern England Agritech

The agritech sector encompasses connected technologies originating from a variety of industries and across different platforms designed to aid and transform agricultural activities. In this case, we interpret the geography of "Eastern England" as encompassing a core set of counties - Lincolnshire, Norfolk, Suffolk, and northeastern Cambridgeshire - while acknowledging that agricultural activities, supply chains and synergies also extend south into Essex, west into Hertfordshire and Bedfordshire, and northwest into the East Midlands. Our research suggests that the area has particular specialisms and growth potential in crop and biosciences underpinned by strong research capacity in universities and research centres; food and beverage processing, with a large sectoral presence and recently established research centres; controlled environment farming (including vertical farming); and sensors, robotics, and automation. It is difficult to describe agritech in Eastern England as a cluster, because of the distributed geographies that it inhabits, the wide variety of activities that fall under its umbrella, and the current state of development of synergies between them. The area has many of the raw materials to fuel that growth and to seize emerging market opportunities. The sector will benefit from ongoing national attention to net zero goals, rethinking regulations on gene editing post-Brexit, and investments and initiatives in the space sector, which will likely improve downstream applications. Engaging closely with LEPs, Agritech-E, and research organisations around the area will be crucial to coordinating activities in the cluster and designing effective interventions.

Northern Ireland Agritech

Northern Ireland has existing strengths in several areas of agritech with potential for future growth including data and digitalisation, earth observation, AI-enabled technologies, optics and sensors, nutrition and food quality, agri-engineering, and farm equipment manufacturing. Agritech in Northern Ireland has many of the right ingredients to be a successful cluster but has not, as yet, coalesced as such. While there are strong capabilities, and industrial identities, around agriculture, food and beverage and agrifood, there is not yet clear cluster leadership in agritech. The research infrastructure and support streams are not as numerous as in some other agritech clusters, but it is well-established, well-resourced, and developing and supporting world-leading innovations. While higher education and publicly funded research are spearheading important knowledge generating projects, the role of the further education college, CAFRE, in providing skills, training, business support, knowledge exchange, and promoting innovation adoption should not be overlooked. There is an emerging consensus that the single most impactful intervention to accelerate cluster development would be the creation of a cluster leadership organisation - or the adaptation of an existing structure - to strategise beyond agrifood, advocate more effectively within the fragmented Government structure, increase international visibility, and establish a shared identity for the sector.

Great South West Blue Economy

The Great South West is an amalgam of three Local Enterprise Partnerships (LEPs) in the South West: Cornwall and Isles of Scilly LEP, Heart of the South West LEP, and Dorset LEP with approximately 700 miles of coastline. Areas of expertise in the blue economy are emerging and consolidating around offshore wind, oceanic environment monitoring, autonomous vessels, surveillance and maritime security, and marine science and research. While these may be regarded as core competencies, other related industries are as diverse as boat building (specifically race and pleasure craft) and fitting, satellite applications, digital and data, and logistics. Spatially, blue economy activities are distributed across a broad geography with notable concentrations in and around major urban areas and port facilities. Additionally, given the diversity of blue economy activities and industries it is hard to describe the

current configuration as a cluster in the technical sense. There are, however, synergies that seem to be evolving between different blue economy subsectors described here and it is not too difficult to imagine that with further evolution these industries may converge further and create meaningful spillovers that will act as innovation multipliers. While processes are underway to develop a stronger identity for the sector in the area, there is not yet a collectively shared vision. The area is also facing skills shortages that might constrain growth.

Scottish Highlands & Islands Blue Economy

The Highlands and Islands area is home to emerging expertise in the blue economy with a focus on offshore energy, aquaculture, and marine biology, monitoring, and engineering. The various industries that make up the blue economy tend to operate in silos and are sometimes competitive over marine resources. As such, this is currently less of a coherent cluster than a set of industries, activities, and assets that could potentially be more effectively connected to maximise opportunities for knowledge synergies. For a large, in many cases remote and sparsely-populated area, the Highlands & Islands has a rich foundation of core assets in the blue economy. Industries with large multinational anchor firms and growing international investment, well-established and well-connected research programmes in universities and independent research organisations, specialised infrastructure, and active and engaged supportive organisations mean that the area has a lot of expertise and engagement to build on. While how to best coordinate the blue economy in the Highlands & Islands remains an open question, it is clear that the area has a strong foundation to grow its various industries. Targeted investment could help to overcome challenges - particularly related to skills - and create conditions to ensure that the benefits of growth are effectively captured in order to fuel the development of local innovation systems.

Yorkshire Healthtech

Healthtech in Yorkshire comprises both emerging and established clusters. In the West, Leeds has a relatively mature and dense network of firms related to digital healthcare, personalised medicine, tissue regeneration and wound care, and wellbeing (nutrition, wellness, mental health, sleep). These appear to be centred around research centres of excellence as well as strengths in related fintech and software industries and underpinning assets such as IT infrastructure, and a legacy of manufacturing strength. In the South, Sheffield has some large healthtech anchors and evidence of startup activity, although this is a more recent development than the West. Beyond these two centres, there are other distinct pockets of healthtech activity, each building on local assets and legacies such as textile industry in Huddersfield which has translated into woundcare technologies, and Bradford establishing a Digital Health Zone linked to the local university and proximate to the Wolfson Centre for Applied Health Research. As such it is not appropriate to view Yorkshire as a healthtech cluster, although this presents an opportunity, already appreciated by the respective Combined Authorities who are coordinating to better integrate complementary strengths across the region. For example, South Yorkshire has the opportunity to be more applied in the wellbeing space by drawing on the data infrastructure and architecture in West Yorkshire, enabling both regions jointly build digital health solutions.

Wales Medtech

The medtech sector encompasses diagnosis and treatment devices to improve health and wellbeing. As such it has links to technologies employed in a range of industries including pharmaceuticals, electronics, manufacturing, software and data analytics, all of which have presence in Wales. In this case we include the whole of Wales while recognising this region may have distinctly separate areas

of activity with limited interaction between each other and strong connections to regions outside Wales. The north of Wales appears to interact with industry in assets in Liverpool and Manchester, and the south of Wales has better infrastructure and network connections with Bristol and surrounds. Therefore, it is difficult to describe medtech in Wales as a cluster, although the area has many of the knowledge and support assets to fuel growth. The sector will benefit from the unique position of having a strong voice from a national devolved administration, enabling a more direct policy focus on some of the regulatory changes that affect the medical sector post-Brexit. However, threading the needle of access to international markets for Wales based firms requires engagement and coordination with those proximate regions such as Northern Ireland and the Republic of Ireland, where market activity has grown in recent years.

East Midlands Energy/Propulsion

The propulsion cluster in the East Midlands, centred around Derbyshire and Nottinghamshire, is an established cluster since important anchor firms have been active in these regions for decades (e.g., Rolls-Royce, Alstom, Toyota). However, the green industrial revolution has brought a new dynamic to this area. Due to the fact that within these regions, a variety of cutting-edge low-carbon propulsion technologies (e.g., electric, hydrogen, alternative fuels, nuclear) are being developed, serving multiple sectors of the economy (e.g., trains, vehicles, aerospace, submarines), a strong regional absorptive capacity has been created in energy research in general, and in propulsion and engine systems engineering, in particular. Although it can be considered as an existing cluster, it has been formed as a set of separated interconnected sub-clusters on a sectoral basis (train cluster, vehicles cluster, etc.) rather than an overall, coherent propulsion cluster. The area is uniquely positioned to play a central role in the research and development of propulsion technologies and engine systems engineering globally, since it has access to a significant, broad pool of specialist abilities and skills across all alternative propulsion technologies, providing efficient low-carbon energy solutions for all means of transportation. The long-term, strong, and continuous commitment of the government to the potentiality of the cluster along with the creation of an organisation that could lead, coordinate, and coherently represent the cluster in its entirety are two of the most important areas of potential support that emerged from our interviews.

North West Advanced Materials

Advanced materials innovation is fundamental to the economic development of the country and its net zero strategy. This has been duly recognised by the UK government (Department for Business, Industry and Industrial Strategy, 2021) which highlights innovation in advanced materials as an area of strength and opportunity for the country. The North West region of England has one of the largest combinations of advanced material development and application companies in the UK, as well as world-leading material science research institutions. The North West can leverage its strong asset base to take advantage of the global focus on net zero and decarbonisation and turn the area into an advanced materials innovation and manufacturing powerhouse. Our research suggests that the sector would benefit from closer collaboration between the various stakeholders and strong leadership that can help formulate and drive the industry strategies. Closer engagement between the different administrative authorities such as LEPs and combined authorities would be essential to the coordination of strategic interventions and other activities aimed at realising the objectives of the UK's national innovation strategy and other initiatives.

Gateshead and Newcastle Immersive Technology

The immersive technology sector focuses on technologies that can transform users' digital experience by combining the virtual experience with users' sight, sound, and touch. The aim is to create an artificial, simulated environment applicable to a variety of industries and platforms. The immersive technology industry in the North East is currently emerging around Gateshead and its surrounding area alongside the River Tyne in Newcastle. The Gateshead Council and North East LEP recognise the potential development of the cluster and its application that may spread across the wider local authority areas of North East England, which comprise the urban centres of Tyneside, Wearside, and Teesside and the local authority areas of County Durham, Gateshead, Newcastle, North Tyneside, Northumberland, South Tyneside and Sunderland. Our research suggests that the industry grew from particular specialisms of entertainment and gaming. However, opportunities arising during the pandemic have allowed for a wider range of industries to realise the potential that immersive technologies could bring to business, in areas such as advanced manufacturing, crisis and hazard management, skills training, and education. We see immersive technology in the North East as an emerging cluster, centred on Gateshead, with national and international interconnections due to the virtual nature of immersive technology and the wide variety of applications that it is currently connected to and may connect to in the future. A major strength of the emerging cluster is its high potential opportunity (HPO) status for immersive technology, conferred by the Department for International Trade (DIT). Challenges remain in the limited talent pool, access to funding to scale up firms, and education initiatives affecting the potential that immersive technology offers. Support needs to be given in increasing awareness among existing entrepreneurs on the wide application of immersive technology, as well as among clients who are adopting immersive technology. The sector will also benefit from attracting investors into the region and growing the local private funding community.

A synthesis of lessons from cases

A significant takeaway from this analysis is that the observed challenges associated with place-based development align with existing literature. It should be noted that the insights are drawn from a limited sample of case studies (nine, or twelve if the previous report is included), chosen with a specific focus. As such, these findings may not be representative of the full range of experiences of UK place-based innovation dynamics. Nevertheless, the commonalities and contrasts among the case studies offer some indication of what can be anticipated and could facilitate the development of policy and research agendas related to place-based innovation.

Geographies and characteristics of place-based innovation

One of the most striking, but perhaps not surprising, findings to come from this research is that very few of the places we identified exhibited all of the qualities of a cluster as we have defined them.[2] The case studies in larger geographies - such as agritech in Eastern England and Northern Ireland, medtech in Wales, the blue economy in both the Highlands and Islands and in the Great South West - were least likely to look, feel, and behave as cohesive clusters. In part, this was because they tended to be more dispersed, which suggests that while larger geographies might make sense from a policy perspective, they do not necessarily effectively describe industrial clustering dynamics. In some of the places we studied, for instance the Highlands and Islands, the distance between points is both significant and travel times between them are such that it is difficult to make the case for any significant degree

[2] This is likely a bias related to our case selection process, which focused on cases where clusters may or may not be emerging that would be of interest to Innovate UK as targets of intervention.

of industrial co-location at that scale. This lesson reflects debates in the cluster literature (e.g. Asheim *et al.*, 2006; Boschma & Kloosterman, 2005; Martin & Sunley, 2003) about the appropriate spatial definition of a cluster. Some research suggests that the boundaries of a cluster are perhaps better determined by analysing interactions and relationships (Reid *et al.*, 2008) than using political demarcations.

However, geography is not totally to blame. Many of the industries we studied were also relatively fragmented - meaning that while they may share some thematic or value chain relationships, the cognitive distances between some of the component industries were quite large. In agritech, for example, remote crop surveillance by satellite and cell and gene editing intersect on the farmer's field, but typically do not otherwise have strong innovation-catalysing connections. This is not to say that the agritech industry does not hold as a concept, but highlights the difficulty in bringing together actors that consider themselves core participants in other sectors (or clusters) - such as space and biosciences, respectively - to participate in networks to drive innovation around agriculture. We see similar cognitive distances in other cases as well, in the gulf between medical imaging and advanced materials innovation for prostheses; and between offshore energy and aquaculture. In these gaps, however, lie important opportunities. The following section on related variety, enabling technologies, and trajectory evolution picks up this point in more detail.

We did see some important spatial patterns. The smallest and newest case study - immersive technology in Newcastle - is a potential cluster emerging out of a comparatively geographically tiny innovation district. Its newness and spatial concentration made it easier to understand its evolution and the scope of its knowledge exchange networks. Also notable about this case is that its members are developing a technology product that, while it may have multiple and varied applications, is built using similar digital technologies. As a result, cognitive and spatial proximity is quite high and highly conducive to the spillover dynamics that fuel clustering. Respondents in the Yorkshire healthtech case argue that there are, in fact, two separate clusters in the area centred on West and South Yorkshire. Here, the relationships and characteristics of those two urban poles were stronger internally than connections between them. Because there are clear complementarities between the groupings of firms in both areas, it appears as though there might be strong, if yet unrealised, potential to bring firms and industries in these two places closer together.

The propulsion industry in the East Midlands[3] illustrates how networks and identities can exist simultaneously at multiple scales. In this case, there is some cohesion and knowledge exchange between firms in different modes - trains, vehicles, aerospace, submarines - around the science and engineering of converting energy into motion, which is continuing to translate into partnerships as the energy transition unfolds. Equally, however, these different transport sectors have strong sub-clusters. This dual-characterisation of actors - as members of a propulsion cluster from one perspective, and a rail cluster from another (for instance) - does not necessarily create conflict, but it does present complexity and demonstrate how industrial classification is often in the eye of the beholder. Many of the members of the propulsion cluster, or rail cluster, could potentially alternatively be grouped with a different set of actors as an alternative energy cluster (with a mobility sub-cluster). This suggests that the point of departure, for research and for policy making, will strongly determine what we look for

[3] Note that even though there is a relatively strong sense of clustering in the East Midlands, the propulsion cluster in Derbyshire and Nottinghamshire is arguably part of a bigger cluster that includes thousands of firms and extends to the whole of the Midlands.

and find. And that, perhaps from a developmental perspective, there are many different ways to perceive, frame, organise, and catalyse place-based innovation.

We see similar patterns play out spatially. The medtech industry in Wales is concentrated into northern and southern poles. Agritech actors in Northern Ireland and Eastern England, as well as blue economy actors in the Great South West, aggregate in larger cities that are relatively spread apart. This creates an interesting tension. Does cognitive proximity - e.g., participation in the broader medical industry - mean that clustering dynamics can exist without (or in the context of weak) spatial proximity? What are the limits of co-location for innovation? While this is certainly not a new question for agglomeration theory and scholarship, it is not one that has been effectively resolved in practice. Some research suggests that we can think of clusters at the national scale as composed of more or less well-networked and spatially concentrated nodes (Vorley *et al.*, 2021). Others suggest that many of the benefits of agglomeration (co-location) decay significantly over very short distances (Figueiredo *et al.*, 2015). Still others argue that different industries experience spatial and cognitive (and other forms of) proximity very differently (Rosenthal & Strange, 2020).

Alternatives lenses to place-based innovation

While this study is not in a position to definitively answer these questions about the dynamics of innovation and space, it can propose some interpretations. First, while clustering and various types of agglomeration externalities are useful policy objectives, the absence or weakness of obvious clustering dynamics should not dissuade researchers or policy makers from seeking to understand how innovation may be occurring in geographically concentrated industries. In short, *clusters are not the only game in town*. Many places and industries, including all of the cases in this report, are reportedly relatively innovative. These cases should arguably be of more interest to research, innovation, and levelling up policy, as those places perhaps stand the most to gain and may be where thoughtfully designed interventions may have the most impact. In some cases, encouraging different types of activities and injecting support may catalyse cluster growth. In other cases, reframing geography or industrial definitions might reveal more appropriate ways of defining and developing specialisms.

In yet other cases, the scales, target industries, or local conditions mean that cluster strategies might not be appropriate. Focusing on clustering (i.e. a concentration of related industrial activity) as the ideal outcome risks ignoring how other types of interventions may be more effective at accelerating growth. This echoes lessons from the French experience (Duranton *et al.*, 2011) and empirical literature which is critical of the benefits of clustering (e.g. Huber, 2012). We argue that where we have identified gaps in spatial or cognitive proximity - where geographies and/or industries have been very broadly defined - there may also be opportunities. In cases where there are spatial gaps, it might be more appropriate to focus on developing more localised innovation systems (see Martin & Simmie, 2008), seeking areas of unique intersection between local industries and research and then plugging that specialism into a broader network of clusters in the region. Where there appears to be greater cognitive distance, seeking and developing opportunities at technological intersections can help to grow unique and world-leading capabilities to anchor growth (e.g. see Delgado *et al.*, 2014). Sometimes both approaches might prove valuable. In each instance, the strategy of bridging these natural distances goes beyond a traditional clustering approach to build on existing innovation activity, borrowing from tactics of smart specialisation, distributed knowledge networks, and agglomeration economics.

Related variety, enabling technologies, and trajectory evolution

In all of our cases, the emerging and evolving market opportunities revolved around combining different types of emerging technologies with foundational technologies to increase efficiency, access new markets, and respond to emerging challenges (see the section on innovation drivers, below). The similarity of experiences, from marine and maritime to medical technologies, was notable. Each of the industries was evolving to incorporate some or all of the following technologies or practices: artificial intelligence (AI), autonomous robotics and platforms, remote sensing, and digital/big data data analysis and exploitation. The degree to which these have become fundamental to such a wide range of activities suggests that these are a new generation of enabling technologies. Also mentioned, but not yet at the point of widespread adoption, were alternative fuels and battery technologies. Identifying these key enabling technologies is important because empirical literature suggests that specialising in these technologies leads to increased economic activity, especially in less innovative regions (Evangalista *et al.*, 2018).

And these enabling technologies do not exist in silos. They, too, intersect and interact to enable even greater innovation. AI is now being used as a tool to extract insights from large digital datasets to generate predictive models, assist with more efficient use of resources, and to detect flaws and threats. AI can help farmers decide where to fertilise and when, make it easier for doctors (and vets) to detect sickness in individuals or communities, facilitate the coding of complex software, and model wave and wind patterns to optimise placement of offshore assets. Autonomous vehicles and robots remove humans from dangerous environments (e.g., servicing undersea cables or offshore wind pylons), low-skill repetitive tasks (e.g., cleaning fish pens or harvesting vegetables), or ones requiring a high degree of precision (e.g., surveying or precision manufacturing) - operations that are only possible because of access to and fast processing of vast amounts of real-time data. The reduced cost of access to satellite technologies is generating huge amounts of this data and, parsed with the right tools, can provide valuable insights for industries. Closer to earth, sensors are also multiplying and generating feedback that enable people to act more quickly, efficiently, and precisely.

That these key enabling technologies have permeated every case study demonstrates the transformative power of technology adoption and its innovative potential. While all of our cases benefit from these technologies, not all of them appear to be fully leveraging the advantages of related variety. Theories of relatedness (Frenken *et al.*, 2007; Cooke, 2012) suggest that the innovation profiles and trajectories of places will tend to evolve through the (re-)combination of technologies in which it is specialised, and even more so through cognitively proximate industries (Kogler *et al.*, 2013). Thus, it is not surprising to see that highly agricultural economies are the places where agritech is evolving or that places with strong healthcare assets are also centres of medtech innovation. From this perspective, the places that are likely to be best positioned to innovate are those in which combinable specialisms are co-located. So, those places that have evolved expertise in robotics and agriculture, such as the area around Cambridge and Lincoln, may be more likely to generate advances in agricultural robotics. Note that while this discussion is couched in the language of technological relatedness, the same principles hold for skills relatedness, or shared supply chains, where knowledge may flow, and be combined, more readily between industries with similar skill sets.[4]

Notably, where places lack localised specialisms in, for example, robotics - such as many parts of the Highlands and Islands - they are not precluded from developing those capacities and innovating through

[4] Note that technological and skills relatedness may differ substantially from one another in the same place, adding more and different vectors of localised knowledge recombination.

adoption. However, when both local specialised industries and expertise in an enabling technology are present, the probability of innovation through recombination increases. This same approach holds that places without specialisms may find it more difficult to generate innovative clusters of industries.

Levereging relatedness and the cognitive proximity between industries creates opportunities to develop new specialisms and new growth trajectories. But where places have specialisms in some areas and not others also creates space for the bridging connections described above. There may be a potential for areas with strong localised specialisms to connect with areas with complementary specialisms and develop synergies despite spatial distance. In some cases, this may be a more viable approach than trying to develop complementary specialisms from scratch locally. Enabling technologies can also function as a bridge to link cognitively separated industries. For instance, aquaculture and offshore wind are only grouped together because their activities take place in aquatic environments. Other than their use of maritime infrastructure, they have very little in common. Lessons about designing, siting, building, maintaining, monitoring, crewing, and protecting offshore infrastructure, however, might be transferable. Emphasising and enhancing those connections can help both industries develop. Among enabling technologies, the development of maritime autonomous vessels and platforms, for instance, could create more opportunities for greater collaboration and knowledge exchange between these industries and potentially drive the evolution of a localised specialism in maritime automation. In several cases, we suggest how focusing on those potential intersections might be a strategy to catalyse greater cohesiveness and generate unique local industries.

Knowledge exchange and proximity

One of the greatest challenges in applying the cluster framework in this project was the limitation on the number of interviews we were able to conduct per case study. This meant that we couldn't speak with firms directly to understand their experiences and knowledge exchange practices. While our methodology enables us to get a reasonably high level understanding of knowledge flows, these are necessarily anecdotal and from the perspectives of specific actors, such as industry associations, support structures, universities or research institutes, and the like. As such, our understanding of knowledge exchange should be considered impressionistic.

Given that in most cases we were able to speak with representatives of most of the main organisations in the research community and business associations, we do have a relatively clear understanding of how these actors perceived the importance of proximity and knowledge spillovers in their areas. First, formalised relationships between local higher education and research communities were typically characterised as quite strong and close. Researchers from different local institutions reported that they network, communicate, and collaborate with one another. However, their most important partners were definitely not exclusively, or even mostly, local. In many cases, their most significant collaborations were in other parts of the country or world.[5] For many research institutions with global reputations (or ambitions), their focus in developing networks and recruiting talent was more likely to be international than local.

However, two interesting patterns appear to be emerging. First, with respect to spatial proximity, many of the external research partners and influential sources of research that were most frequently mentioned were located *just outside* of the study area. This is evident on the maps of case study assets,

[5] This echoes the responses from the small number of representatives from firms that we were able to speak with, who also reported choosing partners primarily based on fit for purpose rather than location.

where almost every case has dots indicating important research sources beyond the case study boundaries. For instance, in Eastern England, Rothamsted Research, located in Hertfordshire, was considered an anchor by actors located as far away as Lincoln and Norwich. Important advanced materials research outside of the North West takes place in Sheffield. Research actors in the propulsion industry are located throughout the Midlands. While these patterns might signal a misalignment in our case study geographies and firm locations and knowledge flows, it may equally speak to a more common pattern where specialised research institutions exist in broader geographies than the core industrial specialisation, such that a broader penumbra of research expertise feeds a denser core of economic activity. This supports the idea that the benefits of proximity may function at different scales for different types of activities and effects - e.g., knowledge exchange, labour markets, etc. - and, if so, this may have implications for thinking about boundaries, assets, and market participants in place-based innovation strategies. Furthermore, because these "external" actors are often located in neighbouring geographies - LEPs, regions, etc. - it suggests that, where these patterns are evident, strategies should perhaps recognise the potential value of cross-boundary collaboration.

A second observation from many of the cases is that even though localised research networks tend to be relatively strong, they are often quite siloed. This is particularly observable in cases with highly fragmented industries - such as agritech, blue economy, medtech, and propulsion. In both blue economy cases, there was limited (although not zero) interdisciplinary interaction between researchers from cognitively more distant departments. Marine biologists and environmental scientists were not, for instance, as closely linked into blue economy networks that focused more on marine engineering and automation. This was also reflected in business networks. However, in our case studies, we suggest that there might be benefits to bringing these disciplines together more explicitly and that linking them through emerging and enabling technologies might be a mechanism to increase knowledge flows. These conversations are beginning to happen, but silos are still the default in most cases.[6]

Enhancing knowledge flows from higher education and research institutions appears to be one area of potential intervention. While most respondents cited their research infrastructure as a core asset we were not able to rigorously evaluate degrees of impact and embeddedness in local ecosystems. The Yorkshire healthtech network between academia, industry and local government (Medilink, ABHI, and YHAHSN) and the Leeds Academic Health Partnership (universities, NHS, councils, colleges, and third sector) provide strong examples of knowledge sharing and broad based collaboration. Such networks exist in many cases but while each institution was able to point to success stories, they also admitted that they could potentially extend their impact and that their observations were based on the firms that they do have relationships with and that they could not comment on other firms' experiences. In some cases, impressions were not so favourable. For instance, in the Northwest advanced materials case, anecdotal evidence suggested that firms avoided partnering with universities over differences in approaches to managing and owning intellectual property. In other instances, relationships with higher education were complicated by a lack of capacity within business to engage in collaboration and differences in expectations. These findings are largely consistent with the literature on the experiences of university-industry collaboration (see Rose *et al.*, 2013; Nsanzumuhire & Groot, 2020).

[6] One caveat here is that encouraging these interdisciplinary connections might be useful to leverage the benefits of related variety. However, in some of these cases it might be more appropriate to first strengthen (potential) subclusters versus forcing a broader industrial identity in these spaces.

Anchor firms can also be a significant source of knowledge spillovers but, as these cases demonstrate, the presence of large international companies does not guarantee strong flows. The East Midlands propulsion case highlighted that while many anchor firms were very R&D active, those activities were not always local. For instance, Alstom and Toyota do not have significant R&D departments in the region. The blue economy in the Highlands and Islands is also dominated by large multinationals in both the aquaculture and offshore energy industries, with notable implications for knowledge circulation within the region. Even where some R&D might happen locally, larger firms typically have distributed global research networks and knowledge may be more likely to flow out than spillover within the region. The effectiveness of interfaces between global knowledge pipelines and local networks of diffusion can vary significantly from firm to firm and industry to industry (Bathelt, 2007), depending on the quality of social cohesiveness in the region (Morrison *et al.*, 2013). This highlights the not at all new challenge of extracting localised benefits from the presence of globally oriented anchor firms.

In most cases, these anchors are supported by a value chain at least partially made up of local firms and knowledge sharing and flows are more likely to be realised through those relationships than collaborative R&D arrangements. And there is evidence that these relationships are encouraging some local innovation. For instance, in the Highlands and Islands aquaculture industry, a few local firms have developed innovations to more efficiently and effectively inoculate fish against illness, a breakthrough that will be relevant to fish farming operations globally. However, many of the support firms for that industry are in logistics and food processing and are not headquartered in the region. Because of limited manufacturing capacity, offshore energy supply chains are also currently international. While there are plans to address those gaps, for the moment the opportunities for local firms to participate are mostly in construction, maintenance, and support and not in higher value added areas where industry leading engineering or technological innovations are most likely to occur. While this pattern appears to be more common in the extractive industries in our sample, the challenge of how to effectively leverage globally connected anchor organisations to build a vibrant and innovative local industry across the value chain is common across cases.

One common benefit of anchor organisations, that is reflected to differing degrees across our case studies, is the impact of embodied (tacit) knowledge transfer through labour market churn. As workers flow through different firms and roles in the ecosystem, their knowledge travels with them. Arguably, this is one of the most effective and powerful mechanisms of knowledge transfer as, with sufficient firm and labour market density, flows will be constant and transfer does not rely on more complex formalised partnerships. Human capital mobility has also been documented as a driving force behind industrial path development and diversification (Neffke & Henning 2013) as where skills spaces are characterised by higher degrees of relatedness - e.g., multiple industries share related skill sets - labour (and knowledge) flows not just within but between industries. This was beginning to occur in the blue economy as oil and gas workers moved into evolving hydrogen and offshore wind industries, in the healthtech cases where workers in digital and ICT are now contributing to the health sector. Furthermore, in the propulsion cluster, the high degree of relatedness of the skills associated with engine systems engineering for every propulsion technology (i.e., internal combustion engines, electric, hydrogen, alternative fuels, nuclear) and means of transportation produces significant benefits to the various, separated, sectoral sub-clusters (i.e., train cluster, vehicles cluster, aerospace cluster, submarines cluster), since workers and experts move easily and naturally from one sub-cluster to another accumulating, synthesising, and diffusing relevant knowledge. This relatedness is the glue that binds those sub-clusters and it is actually the primary reason that the propulsion cluster is conceptualised by some as a cohesive cluster even though it is not organised and managed as such.

Finally, informal knowledge (e.g., serendipitous and interpersonal) exchange appeared to happen within quite small geographies. For instance, stakeholders in West Yorkshire described that they existed in a "small world" where informal relationships were common in contrast to South Yorkshire, where these relationships were less common. The immersive technology community was also described as relatively tight knit, partly due to the convening and networking power of PROTO facility and the currently small size of the industry. In other, more geographically dispersed cases, this kind of highly informally connected community was described around specific facilities - notably labs or incubators designed to bring together firms, research, and support actors - but this phenomenon did not appear to hold at larger geographies. In those cases, it is helpful to have formal organisations performing that bridging role in networks and encouraging interaction.

Skills gaps

If there was a single common theme that came out across all of the case studies, it was that accessing the appropriate skills to fuel growth and innovation was a challenge. While each industry had some unique gaps to fill, it was striking that despite their differences, industries were often struggling to find similar skills.

For instance, digital and data analytics skills were in high demand across all cases driven by an increasing reliance on digital technologies across the board. While this was not surprising in fields such as medtech or immersive technologies, established marine and maritime and agricultural industries were also competing for digital skills. In the latter industries, which have ageing workforces, these pinch points were particularly acute and retaining and reskilling to respond to these challenges - as well as laying appropriate foundations for future talent flows - was a high priority. Competition for skills was also being felt across the engineering professions where interviews revealed that lack of a sufficient pipeline of appropriately qualified engineers was creating disincentives for businesses to invest in training due to concerns about poaching.[7] Managerial skills were another common gap across cases. Respondents in many of these industries felt that managers required both training in business and management and a specific understanding of the industries themselves - a combination that was quite difficult to find in some cases. Specialised knowledge of these industries was particularly important for resource deployment decisions and fundraising activities that enable innovation.

However, it is not just skills in leadership and "high skill" positions that are constraining growth and innovation. Shortages of labour in a wide variety of occupations such as technicians, welders, farm workers, drivers, and warehouse workers, among others, are also creating challenges. Some of these are being exacerbated by an overall reduction in the numbers in the UK labour force with these skills. While as we note later, these shortages are also creating incentives to innovate and transition to automated or robotic solutions, these transitions are not adequately supported or happening quickly enough in most industries.

In most cases, local higher and further education institutions are aware of key skills shortages and are working on addressing those needs. However, the agility and effectiveness of responses varies. In many cases, the most acute skills gaps do not require university or full college degree programmes and so these institutions are not always well positioned to provide appropriate training. In those cases, more might be accomplished with less by bringing together skills providers with employers in more flexible

[7] This was also a theme in our previous report, particularly in the marine and maritime and in the cybersecurity cases.

forums to co-design and deliver programmes. Here, Institutes of Technology (IoTs) and apprenticeship programmes are also assets, but it is likely that even more flexibility will enable more agile responses. In newer industries, such as immersive technology, higher and further education provision reportedly lags behind demand. In these cases, employers will likely have to lead programme design efforts and may struggle, at least initially, to secure the resources to produce those skills locally. In this vein, the case of Rolls-Royce in the propulsion cluster is interesting: Rolls Royce took matters into its own hands and established the Nuclear Skills Academy in collaboration with the University of Derby and supported by Nuclear AMRC, the National College for Nuclear, and other experts. The academy started to operate in September 2022, offering more than 200 apprenticeships, designed to match the needs of the nuclear industry, as those needs are shaped mainly by Rolls-Royce and other anchor organisations. Nevertheless, unless appropriate talent pipelines are developed, talent shortages may create significant constraints at a formative stage of cluster evolution.

Even where appropriate skills are being developed locally - through the efforts of higher/further education or employer training - retention was cited as an issue in several cases. In the North West advanced materials case, respondents reported that they found it difficult to compete with higher salaries that were luring local graduates out of the region. The blue economy cases, located in more peripheral areas, also faced these kinds of challenges, where young people were more likely to move out of the area than remain after graduation. In both regions, the natural and quality of life attractiveness of the area has created an influx of more experienced and older workers, but these were often not significantly fueling the growth of local industries. Rather, and particularly post-pandemic, transplants were often workers seeking more comfortable and affordable places to work flexibly for firms located elsewhere and were therefore not effectively stemming the talent drain. Significantly, this phenomenon was perceived as increasing challenges around talent attraction and retention, since it has affected the housing market and increased costs of living in some places. While this was mentioned in several of the cases, it was unclear how large or influential the influx of flexible workers actually is on the ability of regions to attract and retain labour.

In Yorkshire, stakeholders reported that they were forced to import talent from other parts of the country and internationally. However, they reflected that this was not necessarily a negative for the sector. In fact, they argued that it presents an opportunity for the region to continue to attract top talent from around the world, further strengthening its position as a leader in the healthtech industry, and demonstrating to local skills providers the demand for courses to develop this talent locally. This is an important reminder that labour markets are not local. Companies are prepared to recruit from anywhere in the UK and in some situations from other countries depending on the level of skills and experience required. While having a local skills pipeline is an advantage for both the industry and employment prospects for local residents, there are equally advantages in attracting talent globally. As with knowledge flows, the goal should be to ensure flows from both local and external sources - the former to ensure that local residents capture the benefits of innovation and the latter to connect local industries to new ideas and transmit tacit knowledge generated elsewhere.

Our finding that across diverse regions and industries, skills challenges and demands are similar may seem surprising, however the findings reflect recent empirical cluster literature on the intersection between skills and key enabling technologies. In regions endowed with key enabling technologies there is an increased demand for both a higher level of education and for "a wider, and more exclusive, set of occupations, tasks, and skills" (Antonietti *et al.*, 2023, p. 103). Since our cases identified common key enabling technologies including AI, autonomous robotics and platforms, remote sensing, and digital/big data data analysis and exploitation, it follows that the cases face demands for similar skills.

This has important implications for innovation policy. It suggests that whilst an economy comprised of diverse, resilient and innovative regions may seem on the face of it to require diverse localised skills provision plans to support innovation, there is a strong role to play at a national level to develop a base of talent with skills appropriate to key enabling technologies across the UK.

Convening and strategic entities

Porter (2007) highlights that public policy for clusters starts with identifying cluster members and, if the private sector has not already done so, establish a convening organisation. If convening organisations exist, government needs to become an active participant. While the presence of a dedicated cluster convening organisation is not a necessary condition for cluster formation, as clusters evolve they typically do so with the assistance of such an organisation. These entities bring actors together around a shared identity to create a basis to organise and strategize and to function as a beacon for talent and investment. Their networks catalyse important informal relationships and opportunities for knowledge, expertise, and information sharing. The most effective can advocate for the group to affect government policy and secure resources, and represent it on the global stage. Such entities can also be vital to representing the collective voices of industries that, as many do, transcend the usual administrative boundaries of economic development to carve out a place and extract support from patchworks and hierarchies of local economic plans.

In our framework, the presence and strength of such an organisation (or several), was an indicator of the degree to which the industry and place, regardless of whether it was a cluster or not, had the potential to coordinate growth. As it turns out, we were not alone; many of the stakeholders that we interviewed actively considered convening organisations important to unlock the next level of growth in their areas and expressed an interest in establishing or strengthening such an entity.

None of our cases had a single entity that both covered the entire geography of the area and represented the breadth of industries within the sector that we were studying. Agritech-E, a representative body for the agritech industry comes closest, but it was constrained by the fact that in attempting to expand its membership and plug into larger national and international networks it now has a vague geography of representation and the struggle to convene a wide variety of cognitively distant industries. The PROTO establishment - founded by a partnership of the LEP, the Gateshead Council, and the Digital Catapult - also comes close. However, it represents a very small geography and it is likely that once the industry expands beyond the kernel of that facility a more expansive group will need to develop.

Some cases have numerous contenders for leadership, but have not yet materialised a core convening organisation that represents both the geography and the industries involved. The Great South West is a partnership between three LEPs and has an interest in promoting economic development in that geography. Maritime UK South West is the localised outpost of the national maritime advocacy group and is a partner in Ocean Futures, a private-public-research partnership that has a united goal to create a global centre of excellence and supercluster in testing, development and manufacture of autonomy, digital and clean ocean technologies for the rapidly growing global ocean economy. While these entities are not openly competitive with each other, none of them has managed to effectively galvanise actors across the blue economy at the scale of the Great South West. The Yorkshire healthtech case is similarly fragmented, with communities of actors developing around the different poles in the area. Given the growing significance of these industries, locally and nationally, there may be a role for the LEPs/Combined Authorities to come together to lead an effort to convene activities and coordinate

their evolving healthtech strategies. This would be especially helpful to more effectively connect the two poles evolving around Sheffield and Leeds.

In other places, industrial silos or strong alternative identities around other industrial configurations creates challenges for coordination. In Northern Ireland, the lack of a clearly central convening entity has diluted the effective development of a genuine agritech cluster. While agrifood has a relatively strong identity and set of linking networks, agritech does not. Stakeholders are united in hoping to develop a cluster organisation to strategise, convene, and advocate for the broader community. In Scotland, Highlands and Islands Enterprise (HIE) seems the obvious candidate and leader to convene the blue economy. However, industrial fragmentation and siloing is a challenge and the idea of the blue economy has so far failed to generate buy in or industry identification. Strong, nationally organised, industry associations complicate this landscape. Stakeholders in the propulsion industry acknowledged that a variety of associations across the different sectors are actively engaged in the region. There are so many diverse though complementary and reciprocally interrelated activities that are taking place in parallel in this area but no clear leader. Theoretically, the ideal would be, a leader that perceived the propulsion cluster as an interrelated, loosely or tightly coupled network of activities built on the knowledge base of propulsion and engine systems that expands into every aspect of transportation and establish an overarching narrative for the cluster and envision and enable potential trajectories of future development. However, there are also arguments for considering it as a network of either geographically or sectorally distinct subclusters. Networking occurs at various scales and within different industrial silos across Wales. One advantage of a devolved administration, such as Wales, is that the national government has many of the levers necessary to be a strong organising force and champion for its leading sectors. As noted above, the Welsh Government has fulfilled this role through strong support for a network of organisations that shape and deliver policies related to medtech. However, there is a leadership gap in bringing these organisations together specifically around medtech as a core capability.

The innovation and product development potential of the advanced materials industry in the North West is significantly constrained by the lack of a recognised governing structure and network that will bring firms together and coordinate their activities. A common theme among respondents was "the lack of leadership". It is striking given the long legacy of advanced materials in the area that there has been very little focus on developing a strong identity or organisation dedicated to enhancing the image of the North West as a leading centre of materials innovation in the UK.

The commonality of experiences across cases - of evolving or "not quite right" scaled or focused convening organisations - raises important questions about whether that is, in fact, a problem and, if so, what can be done. In each case stakeholders argued that place-based innovation would likely be enhanced by (more clear) leadership and explicitly recognised that a convening and representative entity was an important "piece of the puzzle". They characterised the benefits of such an organisation both in terms of its potential strategic and coordinating value within the community, but also for the legitimacy that it would lend to the industry and its aspirations. To many of the stakeholders we spoke with[8], the lack of a clear cluster organisation *was* a problem. And one that could be solved with assistance of public support.

[8] It should be noted that it is possible that stakeholders that we did not manage to connect with could have completely different views that we cannot capture here.

However, two observations stand out. First, the stakeholders we spoke with were unanimous that leadership was essential (in order to develop towards being a cluster). However, they were not unanimous about what scale or form that should take. Secondly, all of these cases have multiple candidate organisations - they're just not designed quite right *for how we have defined these cases*. This returns us to the points raised in the section on geographies of place-based innovation and the tensions it highlights between the spaces within which the ingredients we[9] *think* should combine and the messier and less predictable reality of emergent behaviours.

Interventions to encourage the development of organisations to convene and lead must grapple with which strategy to pursue - either to magnify and consolidate whatever existing geographies and structures of collective action exist or to steer spatial and industrial development towards a differently defined configuration. The former enables and enhances what is already there. The latter sees an opportunity to realise a different potential. Neither is inherently right, nor are they necessarily mutually exclusive. The Highlands and Islands blue economy case illustrates these different possibilities most clearly. Several industries coexist in a relatively large coastal geography. While there is a well-established economic development agency, Highlands and Islands Enterprise (HIE), the industries themselves are more strongly linked into specialised networks that operate at different scales. Several stakeholders described recent efforts led by HIE and through the SIA before that to develop a blue economy strategy as interesting but noted that the process is always challenging as the industries consulted often did not perceive themselves as part of a blue economy collective at this geographical scale. In our analysis, we suggested that the blue economy could be a useful frame and that there were potentially synergies between the different industries that could be encouraged by supporting innovations around enabling technologies. Alternatively, we suggested a more localised and nodal approach which provided support to places within the large geography to develop their own unique mixes of blue economy industries. In either of these alternatives, establishing an identity - such as an industrial niche (e.g., blue economy firms with expertise in AI) or a place (e.g., a port reimagined to support a mix of industries and research) - is crucial to generate the buy-in necessary to structure effective networks. In other contexts, several potential contenders are vying for the role of primary convening organisation and offering their own definitions of the places and industries that should be included (see the blue economy case in the Great South West and in the Solent from the previous report). In yet others, none of the existing convening organisations want to take on the role, although they acknowledge that someone should (see agritech in Northern Ireland).

Given the importance of convening organisations, both in literature on place-based innovation and to stakeholders in these case studies, they rightly occupy a central position in strategic planning in policy and practice. What these cases demonstrate is that there is no one right way to organise these entities and that designing them appropriately requires a detailed understanding of local contexts, players, incentives, and identities.

Funding and finance

The importance of both public and private funding in innovative clusters is well established in the literature (Florida & Kenney, 1988; Sorenson & Stuart, 2001; Cooke, 2002). Explanations for this go beyond direct financial capital provision. Funding influences the type of relationships formed within the cluster (Wältermann *et al.*, 2019) and can enhance regional knowledge spillovers (Padilla-Meléndez *et*

[9] Using this term broadly here to indicate both the Innovate UK stakeholders that helped define the cases, the researchers that interrogated those geographies, and the actors we interviewed that argued for organising at that scale.

al., 2021). In all our cases, we identified important barriers to innovation related to funding and finance. A major issue that emerged for the interviews concerned the difficulty in accessing private funding sources (e.g., angel and venture capital). Agritech and blue economy experts explained that their businesses do not appeal to private funding sources because of their not-so-quick return on investment. These cases, together with the immersive technology case also mentioned difficulties in persuading them about their growth potential, admitting weaknesses in communication and promotion tied to the dearth of specialised managerial talent highlighted above. This limitation in accessing private funding inevitably increases the importance of the role of public funding.

Additionally, observations were that public funding is not designed to accommodate lengthy planning or commitment timeframes adequately, and therefore, cannot provide the certainty required to ensure the completion of a whole innovation cycle. This situation was particularly apparent in the North West advanced materials case but also evident in the Great South West blue economy and healthtech Yorkshire.

Respondents from the North East immersive technology, Wales medtech, healthtech Yorkshire, and Great South West blue economy cases expressed their deep concerns about funding discontinuities and gaps caused by the UK's potential departure from EU funding schemes and uncertainty on the extent to which UK replacements could compensated for this.

Last but certainly not least, a major issue that emerged from almost all the cases has to do with the companies' (especially SMEs') lack of awareness about funding opportunities and expertise in putting together a strong bid, highlighting the important role that the support structures and organisations play in supporting and navigating the members of the industries in their innovation journey.

As a final comment, we would like to emphasise that for the emerging or relatively recent economic sectors that cannot easily prove their credibility and growth potential to private funds (e.g. certain segments of agritech, immersive technology), public funding support programmes become even more important for their growth and prosperity.

Exogenous innovation drivers

Most cases reported either challenges or opportunities inherent in exogenous events, social forces, or challenges. For instance, in many the social, environmental, and policy shifts related to Net Zero and decarbonisation were reported as drivers of innovation. In agritech, firms were innovating to find greater efficiencies in water and fertiliser use to reduce environmental impact. Others were working on using waste products as more sustainable materials. The move towards alternative fuels and battery technology development in the propulsion industry has also been strongly driven by the pressures of decarbonisation. A clear indication of the UK Government's commitment to Net Zero targets, elimination of fossil fuels and decarbonisation was also highlighted as being critical to investments in material research and development at the firm level in the advanced materials cluster. The surge towards a green economy and sustainability mean that organisations are constantly looking for the next material that will give them a competitive edge, which is likely to continue to drive innovation in the advanced materials industry.

While the UK's departure from the EU has had variable impacts on the sectors we studied, its economic effects and uncertainty have also stimulated innovative responses. Labour shortages have created incentives to accelerate investment in automation and robotics for harvesting, cultivation, and

monitoring in both agritech and aquaculture. In the agritech case, a change in legislative stance is creating some important opportunities as researchers in the fields of gene editing and modification, in particular, anticipated a more permissive and innovation-friendly regulatory environment. However, the UK's departure from the EU has created challenges to some industries where innovation has not yet overcome the economics of exiting the EU, such as for the medtech industry in Wales. Because firms are so oriented towards international markets, including the EU, there are likely to be implications for their presence and activities in the UK.

The Covid-19 pandemic highlighted the challenge of distributed global supply chains and has raised concerns about sovereign capability. This has resulted in a national effort to gather economic inputs within the UK rather than importing them from overseas, especially if those inputs are high-tech or related to critical infrastructure (e.g., power plants, grid, nuclear). For example, in the propulsion case, a nuclear expert noted that the nuclear supply chain in the UK is dominated by French firms due to the strong presence of EDF in building nuclear power stations. This situation has led to a discussion at a national level about the possibilities of increasing the participation of British firms, perhaps aided through the efforts of the new Great British Nuclear body, and about how this endeavour could be supported by the existing R&D-intensive organisations of the British nuclear innovation ecosystem (e.g., research centres, universities). While other industries were not as concerned with national strategic dimensions, firms generally are also adapting and seeking opportunities to innovate in light of lessons learned about supply chain vulnerabilities during the pandemic.

The policy lesson here, for those looking to encourage place-based innovation, is to support local actors to transform challenges into opportunities and to exploit advantages that flow from exogenous change. This may involve ensuring that actors share and understand the implications of changes (such as Brexit) or social and policy pressures (such as decarbonisation goals) in order to more effectively adapt. Or it could involve providing challenge funding to accelerate adaptation and stimulate innovation in emerging spaces. Either way, recognising the importance of exogenous factors as both constraints and enablers of place-based innovation is an important aspect of understanding growth potential.

Notes on applying the framework

This project provided further opportunity to apply and reflect on the usefulness of the framework developed in Part 1 of the *Understanding Cluster Growth Potential* project.

Overall, the researchers found it an effective tool to guide discussions and get insights about place-based innovation dynamics. It is comprehensive and effective at provoking critical reflection about the sources of competitive advantage of places and gaps. Researchers also found that the inclusion of many follow up questions enabled them to do deep dives with interviewees with particular expertise or insights about certain areas of the ecosystem – e.g., skills providers. However, the framework is also quite long and required researchers to be disciplined and experienced in order to cover all of the relevant topics. One solution would be to reduce the number of primary questions and move some of what is currently prioritised into the follow-up question section of the topic guide.

The most important limitation in applying the framework is that it is difficult to effectively assess questions around knowledge exchange practices and the funding and finance landscape without connecting with firms directly. Connecting with representatives from research institutions involved in collaborative projects and of representatives from industry associations, who can speak from practice or relay impressions from their interactions with members is a relatively effective way to get a high-

level perspective. However, these can be biased and typically reflect the experiences of firms that are already highly engaged in collaborative relationships or active in industry or cluster organisations. Reflecting the experiences of firms that may be innovative but not as well connected or sharing their challenges with peers is much more difficult. This is a weakness that is not easy to mitigate without a significant expansion of resources or the introduction of a different approach (e.g., surveys).

The outlook for place-based innovation in the UK

Stimulating growth and prosperity through place-based innovation has been clearly set out as a priority for government departments and the funding councils. As different government agencies grapple with this objective, the ability to draw on rich and robust frameworks and evidence bases is vital. This research is one of many efforts to build that knowledge base and to provide timely and thoughtful insights about opportunities and challenges for place-based innovation growth in the UK. The accompanying Part 2 report contains the nine detailed case studies that we drew from to synthesise the insights in this report. While we are transparent about the limitations of this small sample of case studies, which means that we cannot claim to base our analysis on the diversity of UK experiences, we argue that the degree of commonality of experience that we observed across very different industries and places suggests that these lessons will, to some degree, be generalisable.

The degree of similarity between cases is, in fact, one of our most important high level findings. While cases differed in important respects - in terms of geographies, maturity, core technologies, and industrial structures - several common threads ran through each one. In pointing this out, we do not mean to suggest that local differences are not important. On the contrary, each case contains important contextual lessons that should not be overlooked. However, where intersections exist suggests areas where national political attention might benefit the evolution of place-based strategies. A second high level observation is that these common themes do not diverge significantly from tensions and debates highlighted in the literature on place-based innovation. This is good and suggests that the broader lessons that are emerging from this evolving literature do hold insights for the development of UK places.

Lessons and implications:

- **Mature clusters are difficult to identify** - Our observation that none of the cases in our sample is a mature cluster is an important reminder to researchers and practitioners alike to be careful in their use of terminology and to strive for conceptual precision. This is particularly important in the context of our next point.
- **Clusters are not the only environment in which place-based innovation can thrive** - As policymakers explore strategies to enhance place-based innovation, a focus exclusively on clusters can obscure other configurations of spatially anchored innovation dynamics and risks overlooking the places where public intervention might have the greatest impact.
- **Enabling technologies are catalysing innovation and can be the basis for new path development** - Across our cases, technologies like AI, automation, remote sensing (using sensors or satellites), and digital/big data data analysis were being used by the most cutting edge firms to open new markets and drive innovation. We suggest that these technologies could also be leveraged as bridges to generate synergies between industries that are not currently well connected.

- **Knowledge exchange happens at different scales** - While much of the conventional wisdom on place-based innovation focuses on the importance of local knowledge generating assets, it is important not to neglect the importance of external knowledge pipelines.
- **More can be done to leverage innovation gains from globally connected anchors** - These firms and research institutions can generate important knowledge spillovers and connect firms to an international marketplace of ideas. However, sometimes places struggle to effectively capitalise on these assets to fuel local innovative industries.
- **Many of the same skills are in demand across places and industries** - Digital, engineering, and management skills topped the list of most demanded skills across all cases and places. Because labour markets are not local this suggests that a national approach to address these specific gaps could provide broad stimulus and reduce labour-related constraints to growth.
- **Convening organisations are seen as key, but the appropriate scale/focus is not always evident** - Stakeholders across cases saw the value of a convening organisation to represent the community and chart strategies for collective development. However, few had actually developed a leader at the scale of our analysis. This pattern should provoke thoughtful consideration from both local stakeholders and policymakers about the advantages of convening different configurations of industries at different geographical scales and a recognition that multiple scales and identities may be able to coexist.
- **Longer term funding is needed to fill gaps in private finance** - Most of the industries studied here reported a need for funding that enables firms to complete much longer innovation cycles than public resources typically cover. This is particularly the case in areas of innovation that are too risky or long term for private markets.
- **National agendas and social change drive innovation** - All of the industries studied here were in the process of adapting to demands associated with climate change and the drive to Net Zero (among other exogenous influences). While this has created challenges, it has also increased opportunities for innovation to increase the efficiency of resources, reduce waste and impact, and reuse waste for productive purposes. This kind of responsive innovation could be better supported and the power of mission-led innovation leveraged more aggressively (especially where it aligns with emergent behavioural shifts).

In conclusion, we strongly argue that more research applying this framework to more cases, and more places, will continue to deepen our understanding of place-based innovation dynamics. Beyond adding different and more varied industries to the evidence base, future research might also consider exploring different industries in the same places to compare and triangulate results. More work could also be done to explore the linkages between aggregations of industries in different parts of the country to better understand knowledge flows and complementarities. Furthermore, one of the biggest blind spots in this study was that limited resources meant that there was limited opportunity to directly include the experiences of firms in our analysis. Future research would benefit greatly from seeking more industry input. This will require more resources and rigorously considered research design. Finally, there are currently various efforts to quantify and map clusters in the UK. There is an opportunity to use research such as this to contrast with the results of other methodologies and to seek other synergies between them.

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