Regional Innovation Ecosystems:

Understanding their nature, identifying their value

A Phase I report for the Local Enterprise Partnerships of Lancashire and Cumbria, to inform the development and implementation of ecosystem approaches to innovation within Local Industrial Strategies.

Chris Ford
Simon Hallam
Ian Convery
Lancaster University & University of Cumbria
November 2019

A research and impact project, sponsored and funded by:

Lancashire Enterprise Partnership
Centre of Nuclear Excellence
North West Nuclear Arc
Cumbria Local Enterprise Partnership
Lancaster University
E·S·R·C Economic & Social Research Council
University of Cumbria

Contents

1. Evaluating ecosystems: our objectives

The pursuit of high performing 'innovation ecosystems' is driven by the belief that if we can connect the right people and organisations in the right ways, we can drive innovation and in turn productivity, not just in one firm but across an entire region. Much research has been carried out on various forms of business-related ecosystems, yet this work is dispersed and often disconnected, spanning many academic traditions. Furthermore, much of what we have learnt has been drawn from contexts that may not lead to useful or readily applicable ideas for policy makers elsewhere.

> The purpose of this research project is to investigate the practical value of ecosystems approaches to innovation-led productivity interventions for policy makers in Lancashire and Cumbria, a study area that we shall refer to as the Northern North West ('NNW').

To address this goal, we developed a series of three interconnected objectives that would guide this research, which were shared with partners in May 2019. These objectives draw together specific research interests from the core funders: The ESRC funding both the Lancashire and Cumbria LEPs to develop the evidence base for Local Industrial Strategies, the Centre of Nuclear Excellence (CoNE), a public-private nuclear sector partnership, and Lancaster University providing funding support through its Impact Acceleration Account (IAA). The over-arching aim of this project, across its multiple phases, is to deliver robust research activities that yield high quality academic publications, and policy-valuable insights that have value regionally, nationally and internationally.

The three objectives are as follows:

1. ***Understand the nature*** of innovation ecosystems in general, and in different regions and economies around the world, as evidenced in academic, policy and business literatures.

2. ***Identify the value*** of innovation ecosystems in these different settings, looking at the role of ecosystem thinking and management in multiple economic and social systems.

3. ***Apply ecosystems knowledge in context***, through the identification of case study sites for deeper investigation in phase two of this research project.

This first phase of the study addresses 1 and 2 above, prior to field-based case study work to tackle ecosystems in context in the NNW. There are two main aspects to this literature review:

- The first ties together various themes from established research, clarifying concepts and presenting a clearer body of knowledge that we can use to understand and then begin to evaluate ecosystems.
- The second presents insights from relevant and useful exemplars, drawn from around the world. From these and other evidence we also consider the different spatial scales over which ecosystems might function.

Our approach does not consider any study area, especially one as large as the NNW, to have 'an innovation ecosystem'. Instead, we suggest that a bricolage of overlapping systems exists: of different sizes, connecting various individuals and organisations in a range of ways, with different

levels of interaction and different economic and social goals. These systems might foster innovation, but we know that this can manifest in ways that escape the usual forms of innovation measurement. Our aim, therefore, is to understand theory (in phase one) then root our more detailed insights in real-world practice (in phase two), as we seek to understand the innovation realities, and potential futures, of selected ecosystems that are of significance to the NNW study area.

The ecosystems we seek to understand may be categorized in a wide variety of ways, and subject to varying forms of influence from different key organisations. In some cases we may be interested in highly managed entities in discrete locations with a specific industrial focus, what we might call 'closed systems', but of equal interest are 'open systems' spanning loosely configured groups of firms, perhaps with little or no attempts at co-ordination (what the academic literature calls 'ecosystem orchestration'). Our goal with this project is to evaluate these systems, according to an evaluative frame that we will develop as the process advances, in order to allow meaningful policy interventions to take place.

The questions we need to ask and answer for effective evaluation focus on three interconnected areas of concern, which to some extent form a logical progression of inquiry:

> **Categorisation:** Can we utilise existing theory to help us classify the existing or emergent ecosystems within the NNW, in order to highlight key features and functions that we expect to see in any well-functioning system of that type?
>
> **Exploitation:** The connectivity that ecosystems promise is only valuable if it can be exploited by those firms within the network, to drive profitability, growth, and increased productivity. Can we identify the practices that support exploitation of each type of system, and identify the extent to which the ecosystems within the NNW support these practices?
>
> **Orchestration:** Policy interventions are only worthwhile if we believe that the ecosystems we study are open to direct management or broader forms of orchestration, to enhance their performance (which itself needs to be defined). Can we identify the openness of ecosystems to different forms of orchestration, and evaluate the potential value (both now and in the longer term) of different managerial interventions?

These goals also need to integrate with local, regional and national policy objectives, and help to find ways to deliver on those objectives. Also, critically, we need to generate new approaches to evaluation that are credible, simple to administer and understand, while holding our innovative communities and policy makers to account so that we can make good long term investments. In this context accountability becomes a complex and multi-dimensional concept, as we seek to understand the multiple ways of valuing different opportunities and outcomes that exist across our communities: from pure economic value, to social and environmental outcomes, or goals of inclusivity of opportunity, economic diversification or other non-financial measures of 'success' or 'value'. We will seek to build on the work already undertaken in this new academic and policy domain: the construction of the Open Valuation Framework, developed by Ford and Mason (2018) and deployed in conjunction with the Cabinet Office Open Innovation Team, was a first step towards an ecosystem evaluation methodology. This now needs to be adapted to reflect the complexities of multi-sector regional innovation ecosystems.

2. Key questions

This report has been structured to give a joined-up flow of ideas, as much as possible, rather than discrete bodies of academic knowledge. There are good reasons why ecosystems approaches to management are challenging: they cover many areas of both academic and practical expertise, ranging from broad-based views about how knowledge is created, how markets emerge and are best exploited, but also about how people learn, collaborate and innovate across multiple boundaries. In the following sections we seek to join up some of these themes, through the following sections:

3. **Ecosystems.**
   What different kinds of ecosystems do we need to consider when seeking to promote innovation? In this section we unpack the different types of ecosystem that support the flow from 'knowledge & ideas' to 'valuable market offerings'. We also consider how economically oriented systems fit with broader areas of social and environmental concern.

4. **Innovation across firm boundaries.**
   How do firms identify, acquire and then translate knowledge or expertise from across an ecosystem in order to drive their innovation-oriented productivity? In this section we draw together key concepts from the absorptive capacity, innovation management and open innovation literatures to better understand how individuals and organisations can fully exploit their positions within ecosystems.

5. **Orchestration.**
   How do policy makers and managers take steps to form, shape and support ecosystem? In this section we explore the concept of 'orchestration': the very challenging work of co-ordinating, cajoling and connecting across different firms, sectors, geographies and social worlds to support value creation, capture and equitable distribution.

6. **Place-based productivity and spatial scales.**
   If we consider innovation ecosystems to be many, varied and diverse in scale and scope then do we need to consider the drivers of productivity growth in the same way? In this section we investigate the notion of place-based productivity drivers, and the link to innovation ecosystems of different shapes and sizes.

7. **Innovation ecosystem case studies.**
   What can we learn from other innovation ecosystems? In this section we look at three quite different settings, in depth, and seek lessons and questions to guide our inquiry.

8. **Conclusions & Phase II studies.**
   Which innovation ecosystems in our region can yield valuable insights for policy and practice? This section proposes case study sites for field-based research.

3. Ecosystems

The term 'ecosystems' has become a popular tool to help us describe, understand and manage geographical clusters of organisations and their wider networks. This is evident in the way the term has become ubiquitous in annual company reports and the top strategy and business journals (Fuller, Jacobides, & Reeves, 2019; Jacobides, Cennamo, & Gawer, 2018). To fully benefit from the research in this domain, and bring it to bear in practice, we need to be clear about the different types of ecosystems, their nature, purpose, benefits, interactions and management challenges. We can then situate this knowledge in our regional context and use it to identify opportunities, gaps and the potential for innovation-led productivity increases through ecosystem-oriented policy making.

3.1 Innovation

Before we consider ecosystems, we need to be clear about the use of the term 'innovation' in this context. We draw on the definition provided by Baregheh, Rowley, & Sambrook (2009) that describes innovation as the bundle of practices and processes that yield new products, processes or services. This definition does not explicitly consider the creation of new markets as part of innovation, but we suggest that this is an important aspect of innovation when thinking about ecosystems: innovation can be the recombining of ideas and technologies from a variety of domains, coming together to generate not only the products for a market, but to shape the market in the process, and the types of business models that might succeed in these changing markets. This accepts multiple outcomes of innovation: sustaining and slightly improving on existing ways of working, the creation of radical new products for existing markets, or entirely disrupting a market or sector through new value offerings.

For policy makers there is then a challenge of understanding innovation at a regional or national level, such that interventions can be created that carefully target the right types of support to different sectors. Measures of innovativeness abound, and it is not our intention here to recap all of these. However, it is important to note that in most cases these measures offer proxies (of various quality) for innovation outputs: for example, R&D spending is an input-based proxy, while patent counting is a process-based proxy. Neither offers any certainty over the effectiveness of the innovation spend, or the quality and potential value of the technology being patented. Furthermore, they offer insights only into industries that record innovative activity in this way.

In this report and the associated research we do not set out to challenge or replace existing innovation metrics. Instead, we seek to focus on a much less explored aspect of regional innovation: the evaluation of existing or emergent innovation ecosystems. Much literature has pointed to the important role played by networks, systems or clusters of firms in accelerating innovative activity. Yet we know little about how organisations determine whether to engage with such systems, and so exploit their innovation-supporting capabilities. We also know little about how such systems can be effectively designed to fit specific contexts, and how the knowledge absorbing capabilities of individuals and firms can be developed alongside ecosystem strategies to support innovation.

3.2 Ecosystem types

In this report we focus on innovation ecosystems, but with the understanding that these are inextricably linked to both business ecosystems and knowledge ecosystems (all three of which we define below). From a purely economic perspective it is the combination of these three elements that can support good policy making, if the goal is to develop network-oriented interventions to support productivity growth and the exploitation of regional innovation assets.

Yet we must also be concerned with society and our environment, and their relationships with the economic. In fact, ecosystems have been traditionally associated with ecology: 'ecosystems' was first used by Ernst Haeckel in 1868 to refer to interdependencies among organisms in the natural world. An Ecosystems approach can describe interacting biological communities and their physical environment (nature-focused), a complex economically-oriented network (business-focused); or people, their life situations, and the behaviours that result from their interaction (social-focused). An entity is both shaped by, but also shapes, the ecosystem it interacts with.

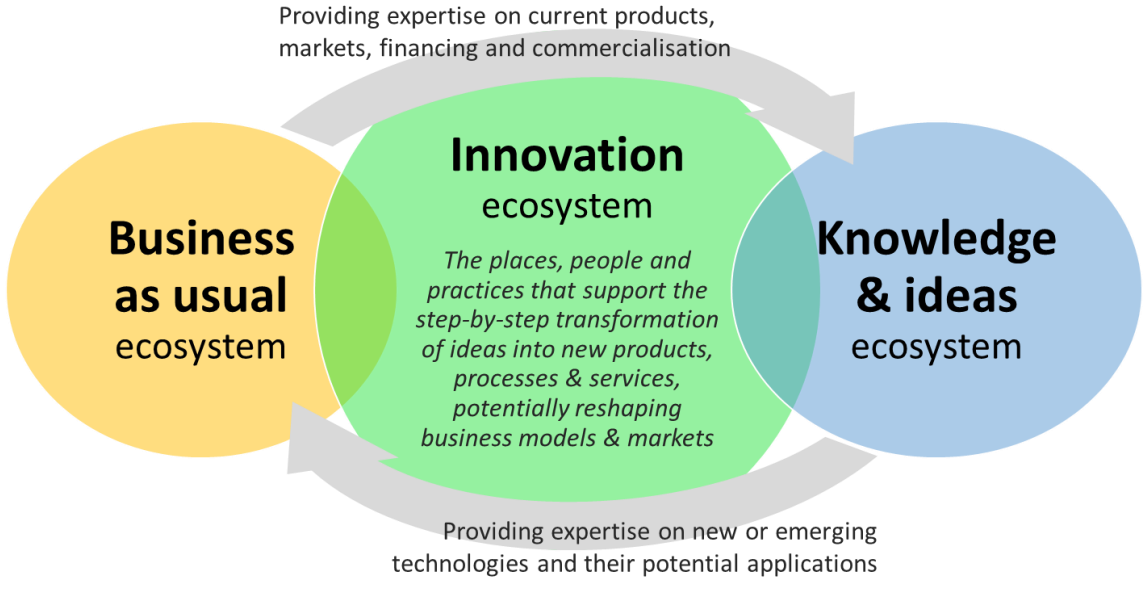
In this report our focus is innovation ecosystems. We see such systems as a sort of melting pot that bubbles together expertise and insight from two different domains, where commercial and market knowledge blend with scientific or technical knowledge. The interactions can be fast or slow, organised or chaotic, but the result is change on both sides as scientists or innovators, equipped with market knowledge, can better focus their energies on valuable solutions, while commercial entities can identify or create new markets for the innovations that are about to emerge. Such change happens through a step-by-step process, with each step revealing the next.

Based on this understanding of innovation and ecosystem interactions, we create our definition:

> An 'Innovation Ecosystem' is a combination of the places, people and management practices that support the step-by-step transformation of ideas into new products, processes & services, potentially reshaping business models and markets.

This is illustrated in figure 1, below.

Figure 1: Overview of economic ecosystems that are spanned by any organisation



The description of innovation ecosystems shown in figure 1 draws on a well-established definition of innovation (Baregheh, Rowley, & Sambrook, 2009) and an understanding that the process requires the choreography of multiple steps and a variety of people and expertise, as science moves from idea to market (Mason, Friesl, & Ford, 2018). This locates the innovation process in an ecosystem that is more than simply a particular place, but rather a network that connects places, people and ways of working. In some settings, this separation into business-innovation-knowledge ecosystems might be very clear cut, for example as different divisions within a firm develop their own specialisations, or individual technology experts seek to start new businesses with support from business mentors, VCs or angel investors, who then bring both business and market-shaping innovation expertise in to the mix. Equally, this separation could be purely analytical, with innovative business owners connecting their own product development ideas with input from their wider business networks. In this case the model helps us to understand the nature of the knowledge and expertise they draw on at different moments in the innovation process.

This innovation process can take many forms: from incremental changes to existing products, through to radical product changes, combined with disruptive new business models that reshape markets and challenge established ways of creating and capturing value.

> For each of these separate innovation goals, which themselves may only be revealed as the process advances, we need different measures to allow us to understand, track, project and evaluate the performance of the innovation process and its unfolding relationships with various ecosystem actors.

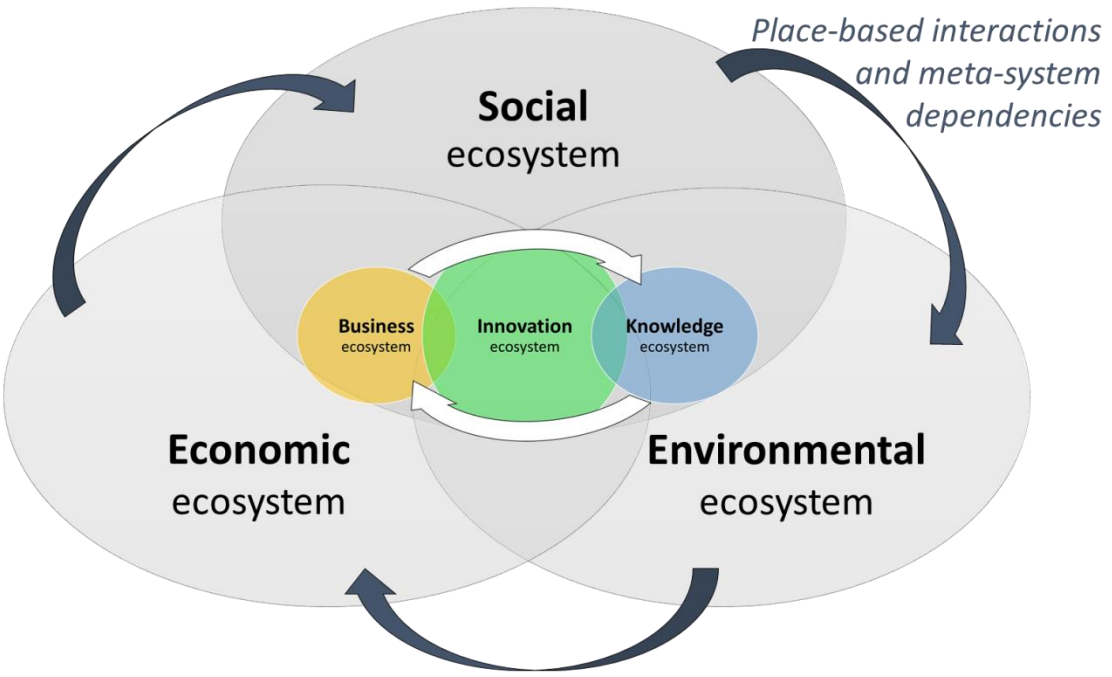
If 'performance' is connected to 'value creation and capture' then we must be aware that in this context the term value has many meanings beyond the financial – for a consumer the value of a product might be its superior functions, its great style or its environmental credentials; for businesses value might be economic or it might be concerned with brand building or expanding its internal knowledge base through the recruitment of valuable staff or the purchase of valuable intellectual property (IP).

This simple diagram can also help us to visualise the attributes of individual organisations. For example, an early stage start-up may have some great technology and a good knowledge network, but no understanding of how to connect this to a market, so therefore no links within either an innovation or a business ecosystem. Meanwhile, a large manufacturing firm with significant internal R&D activity would operate across all three of these ecosystems, and would most likely have developed in-house expertise in supporting and shaping innovations as they progress from idea to market. Different individuals within that firm would then connect in to different networks, as parts of these overlapping ecosystems, for example their R&D teams may have university links and cross-industry collaborations within their science-specific knowledge ecosystem.

For the purpose of this report, there are two core challenges that we need to think about in relation to the ecosystems presented in Figure 1:

- How does each of these three ecosystems function – what are the key attributes that underpin their ability to perform, and are these connected in any way?
- How does knowledge move through these inter-connected systems – what are the key processes at play and how can we evaluate them?

Figure 2: locating innovation ecosystems within a meta- ecosystems framework



However, the economic imperative driving our interest in innovation exists within a broader framework of concern. There are other dimensions that need to be central to our decision making: the social and the environmental. For economic strategy to be sustainable and acceptable within the community it serves, we must take these into account at all stages, not only in terms of impact, but also to better understand the resources available. Certainly concerns about evironmental issues, and increasing interest in social innovation, suggest that these dimensions can provide a stimulus to new innovation practices, with goals that blend economic, social and environmental prosperity.

In the following section we unpack the key features of the ecosystems described above: first we focus on the knowledge, business, and innovation ecosystems that together constitute our economic system; then we consider the social and the environmental systems, and how these relate to the economy in both policy and practice.

3.3 Knowledge ecosystems[1]

Localized knowledge hotspots, often centred on a university, public research organisations or R&D intensive large firms, can be termed knowledge ecosystems. Such systems have a well-documented positive effect on innovative start-ups[2], as well as ongoing innovation in more established firms. However, these ecosystems are not focussed on commercialisation, but rather on enabling the advancement of science and technology. The performance of such systems does, however, often require input from both commercial and public entities and clearly the goals of each may be quite different but well aligned: for example in the Lancaster University 5GRIT project[3], academics may be

[1] [2] This overview draws from the literature review authored by Clarysse, Wright, Bruneel, and Mahajan (2014), synthesising insights from Agrawal and Cockburn (2003); Baptista (1998); Boltanski and Thévenot (2006); Powell, Packalen, and Whittington (2010); Whittington, Owen-Smith, and Powell (2009).

[3] Full details of this 5G Rural Integrated Test Bed project can be found at http://www.5grit.co.uk/

interested in creating new 5G technologies and testing their functionality, while businesses seek to understand how the use cases being tested could lead to commercial opportunities.

In other settings such as large, R&D intensive organisations, the movement of a new product from knowledge ecosystem through to business ecosystem and the ultimate launch of a new product may be viewed through the lens of stage-gate process models, or advancing levels of technology readiness. In the early stages the scientists controlling the research will be embedded in very different networks, attending different types of events or conferences and reading very different materials, to the individuals responsible for commercialisation of tested and market-ready products. So, while the product itself may reside entirely within a single organisation, the networks that shape its progress will change as the innovation process unfolds and the science is connected to markets.

Three key features are considered to be central to the development of a well-functioning knowledge ecosystem:

Anchor institution. In knowledge ecosystems the anchor institution(s), often a university or government research organisation, plays a key role in creating and shaping interactions between ecosystem members, producing basic and applied research, and catalysing industrial innovation through R&D collaborations.

Diversity. The ecosystem contains a wide range of different organisational forms, most likely including universities or public research organisations, small entrepreneurial firms and established companies that span different parts of their respective value chains, venture capitalists or other funders. This diversity ensures that there are many different value systems in operation: individuals and firms that have different motives and different criteria for gauging success. This allows them to share knowledge and collaborate productively through the alignment of goals, whilst each collaborator captures different forms of value in the process.

Cross-realm transposition. This is the process by which knowledge is moved from one 'social world' (Clarke & Star, 2008; Star & Griesemer, 1989) to another, from where it has been developed to where it can be adapted, assimilated and exploited. This is a critical, but often underestimated, process that requires individuals to learn how to work effectively across the boundaries of different worlds, each with its own language, value systems, ways of working and ways of understanding success.

There is good evidence that without the processes in place to support this last function of the knowledge ecosystem – the sharing and reshaping of knowledge at the boundaries of firms and their particular realms – it is unlikely that diversity and the presence of an anchor institution will lead to the development of a thriving innovation ecosystem.

This highlights the importance of individuals as well as organisations when we think about knowledge ecosystems and their impact on innovation: it is individual as well as organisational networks that deliver the ability to connect to new sources of knowledge, and individual boundary spanning capabilities that form an essential component of an organisation's absorptive capacity (see section 4, below).

When all three factors are present – anchor institution(s), diversity, and effective cross-realm transposition - the system is better able to exploit its sum of knowledge because of:

1) the ease with which tacit knowledge flows around the system, and
2) the low-cost of mobility of personnel between organisations.

Both of these factors facilitate rapid collective learning, as ideas diffuse across the ecosystem and allow new forms of knowledge co-creation to take place.

For individual firms, strong ties to wider, global research networks can partially substitute the value gained from being located within a knowledge ecosystem. However, research has shown that the best predictor of high performance is still location within a dense knowledge ecosystem.

3.3 Business ecosystems

Two distinct conceptualisations of the business ecosystem have emerged from the literature: "ecosystem-as-structure" and "ecosystem-as-affiliation" (Adner, 2017). Each has a very different character, delivering different opportunities to firms and regions in very different ways. We consider them in turn.

The Extended Enterprise (ecosystem-as-structure)

The structure perspective assumes ecosystems are constructed around a specific value proposition (Adner, 2006, 2017). For this value to be delivered to the end user or customer, a network of interdependent firms linked by a multiplicity of formal and informal ties needs to function collectively as a system. These ties reflect the co-evolution of capabilities around an innovation as firms shift from a randomly structured group to a more structured community (Moore, 1996). What separates this from a simple value chain as a tool for analysis is that in these situations those ties cannot be reduced to a simple set of bilateral relationships (Adner, 2017): there are many and varied links between ecosystem members, that generate a complex variety of dependencies.

In the context of city governance the term *extended enterprise* is used by Visnjic, Neely, Cennamo, and Visnjic (2016) to describe the delivery of a core product or service that relies on co-ordination and integration across an ecosystem of complementary products and strategies. What separates this form of business ecosystem from a knowledge ecosystem is that here the motivation is the creation of a viable customer proposition, rather than the development of knowledge, and the central anchor in this case tends to be a large company with a direct, commercial interest in shaping and delivering that value proposition (Clarysse et al., 2014). This anchor firm takes a leading role, orchestrating contributions from across the network, drawing together disparate elements to create new and valuable economic communities (Moore, 1996; Williamson & De Meyer, 2012).

The Platform Market (ecosystem-as-affiliation)

When discussing platforms we typically turn to internet-enabled technology for our examples, yet there are ecosystem examples based on platform strategies that existed well before the emergence of the internet, such as the case of the tyre industry studied by Adner (2017). A platform might be a digital space where transactions occur, but equally it could be a physical place where people come together, or a common set of components or design principles that exist as a specific product platform for the mass customisation of other products. There are two predominant types: internal company or product platforms, and external or industry platforms that act as the foundation upon which external innovators from a range of companies can thrive, as an innovative ecosystem (Gawer & Cusumano, 2014).

Internal platforms such as those that now dominate the automotive industry or home appliances industry allow a core systems architecture based on common elements to be exploited across multiple products and sites of production, delivering operational flexibility as well as economies of scope and scale products (Jiao, Simpson, & Siddique, 2007; Lampón, Frigant, & Cabanelas, 2019; Worren, Moore, & Cardona, 2002). Whilst such platforms fall under the control of single organisations, these internal platforms can extend beyond the boundaries of the firm, and create an extended ecosystem through the supply chain. These 'supply chain platforms' depend on tight specification and integration of supplier products into the platform owner's final product or service (Gawer & Cusumano, 2014). The notion of affiliation here looks, in fact, much more like the ecosystem-as-structure model where the anchor organisation has a great deal of control.

External platforms are those that have gained the most popular attention, and these theories offer real promise to policy makers investigating the functioning of towns or cities. The most common exemplars are, of course, those that create virtual market places, such as Amazon and Ebay, or those that exploit the sharing economy through platforms models such as AirBnB or Uber. These commercially oriented platforms create highly functional and scalable spaces that connect participants, allowing the platform owner to capture some of the value created through their particular platform model (Constantiou, Marton, & Tuunainen, 2017).

> The key descriptive features of any such platform revolve around their role as a place where multiple other firms and individuals can come together and trade, joined through some kind of platform infrastructure and rules.

The platform then manages the flows of commercial activity and perhaps ensures some level of trust or accountability to support people's faith in the platform as a place to do business. In both research and practice, platforms are being explored in a multiplicity of ways beyond the B2C internet giants.

In the context of city governance the term *platform market* (Visnjic et al., 2016) describes an ecosystem of independent interactions between customers and complementors - those organisations or individuals who offer products and services via the platform, which in this case is the city itself. Governing the platform hub means creating and controlling the specific architecture and interfaces to allow those on both sides of the market to benefit from its reach, range and value (Visnjic et al., 2016, p114). Platform performance is centred upon the growth and sustainability of the platform itself, and its ability to command a strong position against other platforms.

Unlike the extended enterprise version of an ecosystem, in this setting the focus is no longer on controlling core decisions about the construction of value for a specific customer group. Instead the platform orchestrator focusses on much broader aspirations of connectivity, knowledge exchange, and innovation across multiple sectors. In this mode the role of orchestrator is to shape a platform such that it encourages affiliation (Adner, 2016), with the orchestrator in a non-competing role, acting more as an anchor for a diverse range of other organizations (Clarysse et al., 2014). In our recent studies set in the NNW we seek to extend the the city-based work of Visnjic et al. (2016) and town centre experience work of Hart, Stachow, and Cadogan (2013) to consider towns as platforms through which multiple organisations can create a diverse range of value offerings. This perspective sheds new light on the performance of towns as economic, social and cultural spaces.

3.4 Innovation ecosystems

The strength of interest around innovation ecosystems, in both policy and practice, has given this term great significance despite a relative lack of clarity or rigour over the way it is actually used (Oh, Phillips, Park, & Lee, 2016). When a business ecosystem is being studied in the context of firms specifically seeking to develop innovative products or processes, Adner and Kapoor (2010) use the term *innovation ecosystem*. However, what this approach to defining an innovation ecosystem can too easily ignore is the importance of understanding the multi-stage process through which novel ideas become valuable products, services or processes (Baregheh et al., 2009): what Clarysse et al. (2014) term *cross-realm transposition*. This movement of ideas and emerging innovations across firm boundaries is a key element in any innovation ecosystem, it defines the shift from purely knowledge-based sharing to the creation of valuable outcomes for business and society.

This movement of innovative ideas beyond a single firm has been the subject of another influential and growing body of literature: that of open innovation (Chesbrough & Crowther, 2006; Chesbrough, 2003). This literature has very much encouraged academics to look more closely at the role of networks, and the ways in which we study innovation ecosystems in general (Feldman, Siegel, & Wright, 2019). Open innovation is too expansive an area to cover in detail here, but importantly this body of research has its roots in the study of innovation strategies of very large, stable organisations, in contrast with the literature looking at entrepreneurial innovation ecosystems. Combined, these diverse studies can be drawn on as we progress our research in the NNW, to seek exemplars, frameworks or particular challenges that are relevant to specific contexts.

One common concern emerging from these literatures, however, is that of performance measurement, due to the complexity of the interactions and longevity of the timescales of network-enabled innovation (Feldman et al., 2019).

> As innovation ecosystems emerge and grow, the firms within them develop new ways of creating and capturing value that may be hard to measure, or certainly to attribute to system effects rather than business-as-usual firm effects.

If an ecosystem has grown organically, without policy intervention or government investment, its performance as a system is probably not subject to any measurement or governance (this does not preclude measurement, if a better understanding of system performance becomes of interest). However, if we move from the 'invisible hand' of evolution to the 'visible hand' of policy intervention then the returns on the resources being used to feed the system need to be understood and evaluated.

This is a common challenge for innovation ecosystems, in particular those that emerge from the creation of new platforms such as science parks, digital networks or other connecting and catalysing spaces. For those investing in such platforms there is a need to suspend disbelief: seeking to identify relevant metrics for success gradually, as the processes that support good outcomes are understood, without rushing to implement KPIs that could be counterproductive (Ford, 2017).

What the ecosystems governance literature does make clear, though, is that if such systems are to be created or augmented then a holistic governance approach that integrates multiple activities and interests is essential in order to facilitate co-creation (Colombo, Dagnino, Lehmann, & Salmador, 2019; Stam, 2015). The goal, then, is to identify particular innovation ecosystems that are emergent and which already benefit from some of the social connectivity that supports collaboration and

innovative co-creation (Leyden, Link, & Siegel, 2014). It is then a policy decision to determine how and where to invest in order to scale and share the subsequent benefits, and how to govern this particular "bottom-up-top-down" innovation ecosystem.

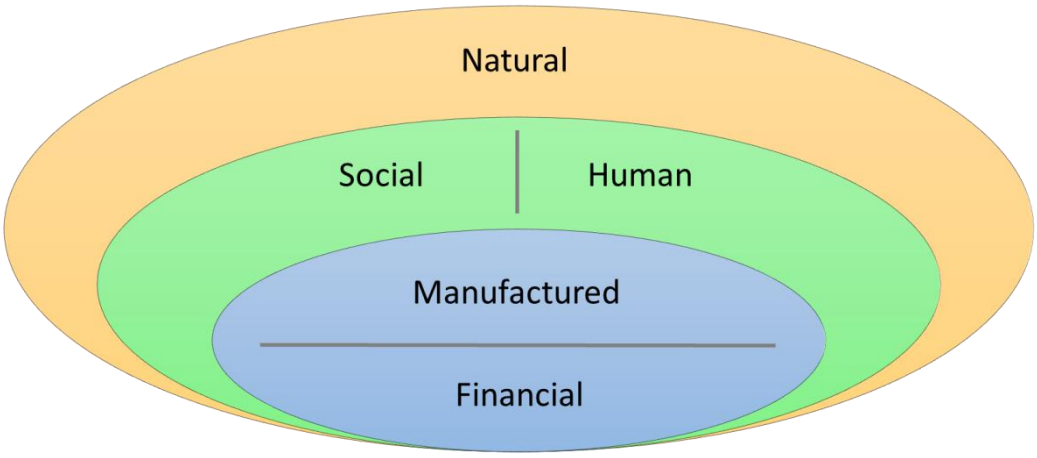
3.5 Ecosystems and sustainability

The concept of sustainability or sustainable development has been with us for some time (most commentators would use the 1987 World Commission on Environment and Development report as a contemporary starting point), and the basic premise is one of intergenerational equality and balance across key sectors of human activity, most notably the environment, economy and society. Sustainable development should '*meet the needs of the present without compromising the ability of future generations to meet their own needs'* (WCED, 1987).

More recently, and in alignment with ecosystem thinking, the United Nations have agreed a set of 17 Sustainable Development Goals (SDGs), which emphasis connectivity and interactions across various forms of social, economic and environmental activity. As Pradhan et al (2017) note, the SDGs look ahead to 2030 and transformative global change by ensuring, simultaneously, human well-being, economic prosperity, and environmental protection.

The concept of natural capital and the rise in importance of natural capital accounting are practical and politically useful ways of translating these broad global goals into more fine-grained monitoring and evaluation processes, leading to better informed strategic decision-making. As we seek to understand and develop our innovation ecosystems, we need to also consider the wider implications of such economic activity. One particular approach to the challenge of mapping such dependencies is through the use of the Five Capitals Model (Ellis, 2000, Forum for the Future, 2018, Coulson et al, 2015, Davenport et al 2019). This provides a basis for understanding sustainability (across economic, social and environmental domains) in terms of the economic concept of wealth creation or 'capital', but linked across these three domains (see figure 3 below). Any organisation will use five types of capital to deliver its products or services; financial, manufactured, human, social, and natural.

Figure 3: Visual representation of the Five Capitals Model



Natural capital accounting gained increased attention following its inclusion in important policies such as the Clean Growth Strategy (2017) and the Government's 25-Year Environment Plan (2018), along with recent consultations for Net Gain and the Environment Land Management Scheme (ELMS). Paragraphs 170b and 171 of the 2018 National Planning Policy Framework requires that both plan-making and decision-taking by Local Planning Authorities must recognise and enhance natural capital (CIEEM, 2019). This focus on natural capital is both important and timely given current concerns regarding environmental degradation and the 'climate crisis'.

The significance of this policy shift transcends traditional environmental concerns, and points to the need for a new kind of knowledge economy, one that is rooted in place and reflects local knowledge and expertise. In particular, the UN Sustainable Development Goals highlight the benefits of community engagement and stresses the need to empower local communities to get involved in natural ecosystem initiatives. There is a clear opportunity for regional innovation, technology and environmental partnerships to respond to these complex challenges.

The study of ecosystems and the development of natural capital management approaches are well aligned, although to date very little academic work has been carried out to connect these broad-based concepts. Ground breaking work coming out of Lancaster University in recent years (Ivy, McKeever, & Perenyi, 2018; McKeever, Anderson, & Jack, 2014; McKeever, Jack, & Anderson, 2015) has shown the significance of social capital (Coleman, 1988) within tightly-knit communities in driving innovation.

> This innovation and entrepreneurship research suggests counter arguments to the assumption that an anchor institution needs to be present to drive innovation, instead emphasising the role played by communities that are motivated, well-connected and deliberately self-supporting.

More work needs to be done to usefully join up these concepts: we see innovation ecosystems as the purposeful connections that allow new combinations of human, financial, natural and other capitals to be explored and exploited for sustainable development and economic growth.

4. Innovation across boundaries

To unlock the potential value of being in any ecosystem, an organisation needs to know how to access and make use of the expertise around them. This ability to move knowledge across the boundary of the firm has been investigated by academics for over fifty years, with early studies looking at the key role played by individual 'boundary spanners' (Allen & Cohen, 1969; Tushman, 1977; Tushman & Scanlan, 1981). This term has become central to all manner of inter-organizational research, and brings into focus the importance of individual-level capabilities and networks when studying business-level outcomes.

Absorptive capacity

Possibly the most significant body of literature to emerge from these initial studies of boundary work is that related to 'absorptive capacity', which represents "*the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends*" (Cohen & Levinthal, 1990, p128). This capacity is important when firms consider engaging in any activity that involves the sourcing of external technologies for internal or co-operative exploitation.

Theories of absorptive capacity have developed as various academics have sought to deconstruct this concept[4], but for our purposes the critical features of absorption include:

1) Sufficient internal, expert knowledge to know what you need, where to look for it, and how to accurately value it (for its technological contribution to your work) when you do find it.
2) The ability to acquire the knowledge you need – either through purchase, licencing, or some form of collaborative venture.
3) The ability to transform and assimilate the new knowledge such that it generates new capabilities.
4) The ability to fully exploit these new capabilities in the creation of new opportunities for product, process or business model innovation.

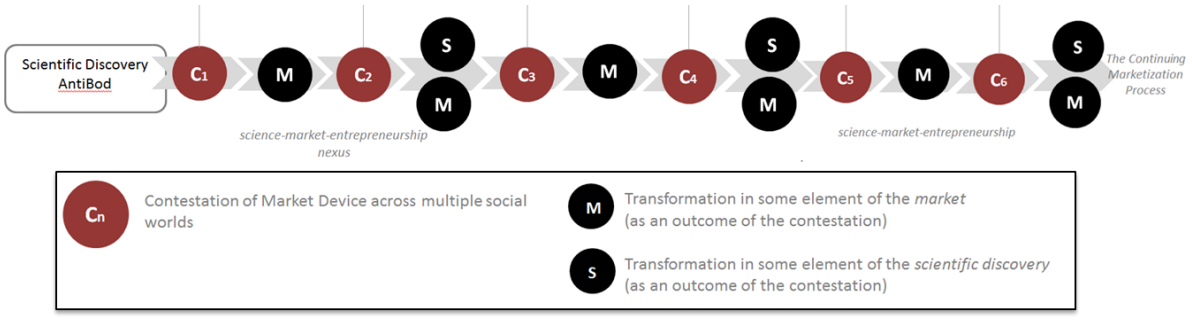
These four elements highlight the fact that immersion in a network is a necessary, but not sufficient, condition for regular and productive knowledge flows to take place. Furthermore, the skills required to carry out thee four steps are quite different. While large firms may have separate technology scouts (step 1), IP and legal experts (step 2), R&D heads with deep experience of these processes (step 3), and commercialisation experience across multiple markets (step 4), for SMEs this full-spectrum of absorptive capabilities is unlikely to be present. This is why science and technology incubators, for example, often employ experienced entrepreneurs in residence to help those with a predominantly technical background with the assimilation and exploitation of more business-oriented knowledge.

[4] The progressive works on absorptive capacity have generated a range of process diagrams, new or adapted constructs, paired constructs, and evidence to support the validity of each new variation. We do not present a full review of that literature, but draw on: Cohen and Levinthal (1989, 1990, 2000); Lane, Koka, and Pathak (2006); Lane and Lubatkin (1998); Todorova and Durisin (2007); Zahra and George (2002).

Boundary work at the nexus of social worlds

Our studies of boundary work in high innovation setting reveals the critical role played by these catalysing and connecting individuals. Even in large firms there are capability gaps that can be filled by experts with the ability to work across different domains, or social worlds. These individuals can deploy not only their networks, but also their deep understanding of what motivates a venture capitalist or a large organisation to collaborate with an SME or start-up, and can begin to prepare the ground for productive encounters. They also know when to call in the IP specialists, how to build a compelling business proposition, or where to look for further sources of market expertise. Importantly, they cannot 'dump' all of this knowledge onto an innovator in one go – they support the sequencing of events. This process can be illustrated as shown in figure 3, below.

Figure 3: Progressive boundary work that reveals and creates value (Mason et al., 2018)



What this picture describes is a real sequence of contestations followed by a scientist, guided by an innovation manager. The term 'contestation' describes a meeting or event when key people from different social worlds come together to work out what is valuable, what the next steps are, and who to next get involved in the innovation process. At the end of each contestation there are two kinds of outcomes: new understanding of potential markets for the innovation, and new insight into how the science needs to be progressed in order to be ready for this market. In each contestation the innovation manager, perhaps supported by others such as a business mentor or entrepreneur in residence, acts as a connector and translator across social worlds. For example, they may help a scientist understand the need for IP protection and support them in negotiations with the university where they did the original work, bring in product experts to help them understand the scale and scope of markets they didn't even know existed, or create safe spaces for discussions with potential purchasers and collaborators about how to best push the science forwards.

Whilst this example comes from inside an incubator, similar processes are seen in more open systems where the innovation manager or similar individual is working with dispersed communities of innovators. Critically this process has two purposes for most first-time entrepreneurs: to ***advance the science*** or technology, whilst also ***socialising the scientists*** into the multi-faceted world of commerce. To allow smaller firms to work productively with anchor institutions in any ecosystem, such differences in collaboration capabilities need to be understood and carefully addressed.

This is one example of an innovation process where new technologies are brought in to new commercial domains. Other examples exist, and the journey of a new discovery may begin with peer networks or customer-driven innovation. We need to understand context to be able to understand the roles played by boundary spanners, catalysts, and those individuals located at key nodes in the network. That will be the role of the field work, to be undertaken in the next phase of this project.

5. Orchestration

Orchestration is the proactive exercise of leadership in a network by a central individual or organisation, operating beyond the boundaries of their own firm and therefore without the authority or control that comes through hierarchy (Dhanaraj & Parkhe, 2006; Giudici, Reinmoeller, & Ravasi, 2018). Whilst every ecosystem is likely to require different forms of co-ordination, depending on those involved, their shared and separate goals, and the resources they can draw upon to achieve these goals, there are certain common themes that underpin the work of orchestrators. According to Dhanaraj and Parkhe (2006), when we consider innovation ecosystems in particular, these themes are:

- **Knowledge mobility.** Orchestrators support the ease with which dispersed knowledge is shared, acquired and deployed across a network. This, in turn, underpins the success of that network in generating increased levels of innovation output.

- **Innovation appropriability.** Orchestrators ensure that there are appropriate 'regimes of appropriability' (Cohen & Levinthal, 1990; Zahra & George, 2002) in place as knowledge and innovations flow across the ecosystem, and as individual firms seek to capture the value of their innovation investments rather than allow too much of this to 'spillover' for the benefit of others.

- **Network stability.** Orchestrators seek to keep the networks stable in a potentially highly dynamic setting. Their work accepts that network members may change over time, and that there will be active participation of network members in shaping their own futures based on a diverse heterarchy of values, orders of worth, and authority structures (Boltanski & Thévenot, 2006; Stark, 2009).

These themes are relevant to all systems, and their generic nature makes them useful as a broad analytical guide but without much clear direction for specific place-based policies. We can, however, start to refine these ideas by looking at the nature of systems and the type of orchestration that might be required. A useful start point is the work of Giudici et al. (2018), who seek to make a much clearer distinction between closed-system orchestration and open-system orchestration.

The closed-system approach to orchestration positions a hub firm at the heart of an ecosystem that is focussed on the delivery of a specific product/market combination, as described in the 'ecosystem-as-structure' perspective (see page 9). Here the orchestrator, which is generally the anchor business with strong commercial interests in the success of the innovation, takes responsibility for the selection of partners and the integration of capabilities from across the network. They take responsibility for evaluating each potential partner in turn, to establish their potential to make a positive contribution to value creation and capture.

This form of orchestration can create shared value in a number of ways, although two particular approaches are identified by Nambisan and Sawhney (2011): 'innovation integrators' and 'platform leaders'. The first of these sees the orchestrator firm as the creator of a basic product architecture, which is then completed and shaped into a final product-market offer through the integration of trusted partner expertise and technologies. The second, the 'platform leader' approach, sees the hub firm take sole responsibility for the creation and distribution of the core offering, then seek to build an ecosystem of firms around that core product. These other firms in the ecosystem develop

complimentary products which then make the core offer more attractive, such that the scale and scope of their combined ecosystem can increase.

The open-system approach to orchestration contrasts with the above because the orchestrators are seeking to support a much broader base of decentralized, entrepreneurial activity (Giudici et al., 2018). This orchestration approach fits with the 'ecosystem-as-affiliation' model where the central organisation is not seeking to profit from the system, necessarily, but rather is taking the role of catalyst as it seeks to support growth, collaboration and increased affiliation (eg membership or inward investment) with the innovation community. In the previous section (see page 15) we described the critical role of such orchestrators at the boundary of diverse social worlds: helping both large organisations and smaller entrepreneurial start-ups to establish ways of sharing ideas and creating innovations that rely on their combined technology and market expertise.

For SMEs the presence of orchestrators can replace the need for significant investments in learning and capability development. Becoming expert at working across boundaries, and becoming embedded in multiple different networks (legal, venture capital, international markets, advanced manufacturing processes, …) can be both daunting and extremely time consuming for an entrepreneur. Furthermore, such investments are a dangerous displacement away from their core competency: the development of some innovative science, process or technology. Whilst universities might tend to advocate the importance of innovation training and support for SMEs and start-ups, we must also acknowledge that sometimes learning is slow and distracting. In contrast, absorption of tacit knowledge through real-time business development alongside an external innovation manager may be the best course of action in some situations.

Evaluating ecosystem orchestration

In previous sections we have identified a number of ecosystem types, spanning different economic, social and ecological priorities and a variety of more or less centrally controlled approaches to creating, delivering and capturing value. Above we describe some priorities for orchestrators, and set out how different broad-based approaches might link to different ecosystem types. This provides a theoretical launch point for research: seeking to work out how we can understand ecosystems in context and how specific orchestration approaches can be tailored to those systems to allow them to deliver productivity gains in to the regional economy.

At present the academic and more practice-oriented literature tells us little about is how ecosystems can be evaluated prior to the creation of orchestration approaches. Often orchestration is a 'punt' based on the belief that 'something should be done'. This is perhaps acceptable for well-funded private sector firms with an appetite for business model experimentation; for the public sector with an eye on its own accountability to both central government and local stakeholders, having a little more evidence to underpin such 'leaps of faith' would be useful. If we wish to develop place-based policies that augment the innovation capabilities of networks, not just single firms, then we need to know if we can treat these collectives as functioning ecosystems that would benefit from orchestration, and if so, what form that leadership and informal control should take.

Beyond this initial evaluation of openness to orchestration, we need to determine process and outcome priorities for ecosystems that can be aligned with the goals of multiple organisations, and delivered through new orchestration approaches. These, again, need to be open to evaluation and an approach to measuring and managing the value coming from collaborative innovation needs to be developed. This may require extended time scales and very broad-based engagement with stakeholders whose needs are being met, or could be met, through these more joined-ip innovation approaches.

6. Place-based productivity & spatial scales

An ecosystems-oriented approach to regional innovation has to be based on a belief that it will yield economic gains. Whilst some of these benefits will naturally spill over in to neighbouring regions, or extend out to national or global supply chains, the focus has to be on supporting innovation-led productivity growth alongside real-terms revenue growth within the specific LEP area. We know that innovation performance is an important driver of productivity growth, and that increasing UK productivity performance is a central objective of the UK Industrial Strategy. From a NNW perspective we therefore need to pay particular attention to place-based drivers of productivity: the opportunities and challenges that we specifically face.

The descriptions of knowledge, business and innovation ecosystems presented in section 3 make clear that there is no specific spatial scale over which any of these networks might operate. The regular, almost daily contact that comes with the tight clustering of firms inside a single building or science park is one of many spatial scales on which an innovation ecosystem could thrive. In contrast, An example of a globally distributed yet highly collaborative innovation ecosystem is the Internet Engineering Task Force (IETF), which effectively controls the way in which the internet works, using open processes to develop open standards[5]. In research looking at collaboration among the worlds' 13 largest telecoms firms, seeking to shape their entire global supply chains through network virtualization[6], Ford and King (2013) saw first-hand how communities that are encultured into online collaborative working can operate smoothly across multiple time zones, whilst collectively developing highly technical documents or ideas. This example illustrates the task-focussed nature that we might expect of global innovation systems, which bring together subject-area experts to develop very specific knowledge outputs.

To understand the productivity enhancing benefits of innovation systems, we need to unpack the place-based features that drive existing innovation and collaboration behaviours. This is essential given our already stated belief that we have not one, but rather a bricolage of innovation ecosystems spanning the NNW, operating across different geographies and likely to respond to different forms of intervention or orchestration.

Place-based Productivity

Productivity performance is driven by the activities of individuals, firms, supply chains, sectors and the spatial arrangement and relationships between collaborating firms, their markets, and their key resources. Understanding the spatial drivers of productivity is especially important given the requirement for Local Enterprise Partnerships (LEPs) to produce evidence-based Local Industrial Strategies (LIS), and the renewed emphasis on place-specific policy interventions for regions such as the NNW, with its widely dispersed areas of industrial expertise. These challenging geographies can, however, provide fertile ground for innovation through the harnessing of digital technologies that

[5] For a full description of the work of the IETF and an insight into their global scale, and volunteer workforce, visit https://ietf.org/about/

[6] The NFV White paper published in October 2012 is possibly the most significant yet unreported document relating to the Internet of Things. The pressure on telecoms networks brought about by the exponential growth in demand for services forced them to come together and co-create a plan, in collaboration with HP and Intel, to radically change the hardware and software platforms upon which all global telecommunication is based, deliberately creating new global software markets to service as-yet-imaginary new software requirements. The white paper can be read here: https://portal.etsi.org/NFV/NFV_White_Paper.pdf

have the potential to intimately link together firms in new techno-economic ecosystems. Understanding the processes of innovation-led productivity growth is therefore vital.

Spatial differences in productivity are typically determined by two factors: the sectoral structure of the economy, and variations in productivity performance of the same sector in different locations. These intra-sectoral differences in productivity will reflect a combination of skill levels, business specialisms, the types of products/services being produced, and the markets firms operate in. For example, a large consultancy firm located in a big city serving a range of specialist markets and clients is likely to have higher productivity than a small consultancy serving local markets. This in part explains why productivity tends to be higher in urban areas than in rural ones.

Research by ONS analysing regional and city-level productivity across the UK found that firm-level productivity was the most important determinant of spatial productivity levels and growth. Sectoral structure was a much less important driver of productivity differences.[7] These findings have important implications for regional policy: They suggest that efforts to improve productivity by growing high-value sectors, and thus changing the industry structure of the economy (which has been a long-standing feature of regional and local economic strategies), need to be paired with place-based approaches to enhancing innovative potential. This emphasises the need to address firm-level productivity, and we propose that ecosystem-based approaches are a key tool.

When considering any interventions, we need to be clear about the goals and timescales within which they might be achieved. The ONS research also suggested that firm characteristics such as size, location, age, and the structure of ownership are important determinants of productivity. Larger firms, those that are part of international supply chains and those operating in wider geographical markets (in which competition is typically more intense than in local markets) typically have higher than average levels of innovation, management practice, are more likely to adopt new technologies, and are better able to access new geographical and product/service markets. These factors all drive firm-level productivity performance – and so any one of these might be seen as a goal of orchestration (for example, building an ecosystem with sufficient scale and reputation to attract trade visits from potential international collaborators).

Innovation and the flow of ideas between firms takes place across a wide range of locations, spatial scales and economic geographies. These can include: single buildings (typically referred to as innovation hubs or centres); single sites (such as innovation campuses located on or near to universities); dedicated areas either in or out of towns and cities (innovation quarters or parks); between towns/cities containing complementary economic assets (tangible and non-tangible) linked by major transport routes (known as innovation corridors or, in a coastal setting, innovation arcs); and across much wider and harder-to-define geographical areas (ie. the concept of fuzzy geography which informed the development of city-region economic analysis).

One key question is the extent to which concentrations of innovation activity can or should be thought of as innovation ecosystems, and what geographical distribution or industrial variation of these organisations can justify the 'ecosystem' moniker? In other words, when does the value of the whole become significantly greater than the value of the parts?

An example of this in Cumbria and Lancashire is the nuclear sector, which may be seen as fitting in to at least three different ecosystems: 1) a geographically limited ecosystem centred on Sellafield and West Cumbria, incorporating a well networked supply chain and associated business service providers, 2) an arc spanning from North Wales to North Cumbria (the "North West Nuclear Arc"), including major research institutions and nuclear sites, or 3) if there is strong policy interest in

[7] ONS, *Understanding Spatial Labour Productivity in the UK* (2019) - https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/labourproductivity/articles/understandingspatiallabourproductivityintheuk/2019-05-03

exploring the value of knowledge sharing across something that might be termed the "clean-energy sector"[8], then nuclear in Cumbria and Lancashire connects to hydrogen in north Lancashire as well as offshore wind, battery/solar, biomass and other emerging technologies. The rationale for treating this last group of organisations and technologies as an innovation ecosystem may not even be the connectivity of the primary actors, but rather the potential value of more purposefully connecting the engineering, robotics, advanced manufacturing and other complimentary bodies of expertise from nuclear, with early stage technologies offering new challenges and new markets.

Critically, for all three of these potential ecosystems, we need to establish the realities of these networks before we can claim them to be innovation ecosystems, worthy of policy-led interventions.

This highlights the role of public authorities in innovation ecosystem facilitation, management and orchestration, either in specific locations or wider economic areas. Our analysis concentrates on this aspect of ecosystem development, particularly in relation to boosting productivity through system orchestration, given that it is a key objective of UK economic policy.

Innovation Ecosystem Spatial Scales

Innovation ecosystems can operate at a wide range of spatial scales, often determined by the partners involved, the scale of aspirations of policy makers, and the types of collaborations the system seeks to support. This variability presents a challenge of where to draw ecosystem boundaries, and how to map which actors operate inside and outside of any system.

Moonen and Clark (2017) identified nine typologies of "innovation location formats", which offer a useful way of considering where, why and how innovation takes place. The analysis concentrates on urban areas, where most innovation activity is concentrated, and identifies examples of each type of innovation location format. The authors do not define these locations as innovation ecosystems in their own right, rather they consider them as part of wider innovation ecosystems.

We have grouped these into four broader categories, and drawn together insights from different cases of each type, from around the world. In some cases, these developments reflect specific attempts by the public sector to create an innovation ecosystem, whilst in others public agencies have sought to build on existing innovation activity. We do not offer any judgement here on the appropriateness of policy intervention at these spatial levels, or their particular applicability in the NNW study area, but rather we seek to illustrate the range of ways in which ecosystem thinking and purposeful action is being deployed to support innovation activities. The four categories are:

Innovation Hubs - *Single innovation centre buildings, usually close to or at universities, centred around specific sector or related sectors, and with easy access to nearby funders.*

Innovation centre developments tend to be led by the private sector or non-profit organisations with a strong private sector oversight (eg. Board Members), with a financial model based on generation of rental income. Success depends upon collaboration between innovators, mentors, investors and businesses and on the hub/campus being part of the local community. Examples include MaRS

[8] The term 'clean energy' has been used to describe only renewables, or to include these as well as nuclear. We include nuclear in our definition of the term, but acknowledge that this is contested. The most recent analysis of energy production reflects the concerns of some groups about the status of nuclear and so uses three categories: renewables (currently producing around 40% of UK energy), fossil fuels (currently 39%, primarily from gas), and nuclear (currently 19%). For further information see: https://www.carbonbrief.org/analysis-uk-renewables-generate-more-electricity-than-fossil-fuels-for-first-time

(Toronto, Canada), based on health, cleantech and ICT, and SUP46 (Stockholm, Sweden), based around mobile media and gaming.

Innovation Sites - *Innovation on university campuses or former industrial sites typically led by local authorities or property developers, or in suburban or out-of-town sites.*

Former industrial sites benefit from having existing infrastructure systems (road, rail, utilities), although often require public sector leadership and/or funding to make sites investment-ready and attractive enough to make them appealing locations for newer businesses. Examples include Berlin TXL (Germany) on a former airport site and focused on smart city solutions and Brooklyn Navy Yard (US), which is based around electronics, clothing and digital industries. Innovation campuses seek to leverage university assets to support innovation in the local economy, known as the anchor-plus model (Katz and Wagner, 2014 & 2016). Examples of campuses include Paris-Saclay (France), focusing on smart energy, aerospace and advanced manufacturing and Cardiff Innovation Campus (Wales), which is based on chemicals, life sciences, ICT and social sciences. The Health Innovation Campus development at Lancaster University represents an intended example of this type of innovation ecosystem.

Innovation Zones - *Innovation quarters, usually close to major transport hubs, districts on brownfield sites, suburban innovation parks in which access to urban centres is less crucial, or out-of-town innovation zones developed on greenfield sites.*

Innovation Quarters tend to have a mix of sectors, and include Kings Cross (London, UK) and Werksviertel (Munich, Germany). Districts include Barcelona 22 (Spain), which has a focus on ICT, medical technologies, energy, design and media, and South Lake Union (Seattle, US), based on IT and life sciences. Suburban innovation parks include Herzliya (Tel Aviv, Israel), centred on IT, software and cybersecurity and One North (Singapore), which features a mix of social science and media activities. Out of town innovation zones include Suzhou Industrial Park (China), which is based on advanced manufacturing and engineering, biotech, nanotech and digital design, and Manchester Airport Enterprise Zone (UK), which includes advanced manufacturing, creative industries and logistics.

Linked Innovation Areas - *Innovation triangles or corridors, connecting two or more separate cities or towns, usually linked by major transport routes, and with complementary sector specialisms, clusters and supply chains.*

Innovation Triangles include the North San Jose Innovation Triangle (California, US), based on ICT, and the Twente Innovation Triangle (Netherlands), focused on advanced manufacturing and nanotech. A key challenge is ensuring sufficient grow-on space for businesses along the connecting infrastructure routes. Innovation Corridors include London-Stansted-Cambridge (UK), mainly based on biotech, ICT, cleantech and agritech sectors and the cross-border Cascadia Seattle-to-Vancouver corridor (US-Canada), based in ICT, digital media and life sciences.

Innovation corridors do not necessarily have to be straight line developments. For example, Innovation Arcs have similar features to Innovation Corridors, with centres of innovation linked along a shared, curved coastline. Examples include Bothnian Arc (Finland-Sweden), which is discussed further in the next section of this report. The Lancashire-Sheffield Advanced Manufacturing corridor and North West Arc (clean growth) represent local examples of innovation linked areas, with these links spanning multiple administrative boundaries.

Key Spatial Scales Insights

The benefits of being embedded in a functioning innovation ecosystem can be experienced across a wide range of spatial scales, from the very local to the multi-state network. These economic geographies are rarely aligned with administrative boundaries, and across different industries or sectors the innovation geographies are also likely to differ. For these reasons it is hard to try and define any single Cumbria innovation ecosystem or Lancashire innovation ecosystem. Rather, each LEP area will contain within it several distinct innovation ecosystems that may be clearly defined, or may only exist as embryonic, imagined concepts, waiting for greater orchestration. Furthermore, some cross-border innovation ecosystems may span or link parts of both LEP areas, or connect them up as part of broader sectoral networks such as the North West Coastal Arc Partnership.[9]

The fact that systems span administrative boundaries creates challenges for local, regional and national policy makers in terms of identifying priorities, resources, outcome goals and delivery timescales. Nevertheless, public policy can (or at least may be able to) foster innovation ecosystem development, by identifying and supporting separate high functioning systems, or embryonic systems worthy of investment, whilst taking lessons from them to other locations and systems. For each ecosystem the rationale for public sector involvement, and the roles of public partners, may differ. Knowledge of the underpinning socio-economic conditions that support orchestration and sustained innovation will allow the public sector to establish its best potential interventions.

Questions for Phase II

The findings contained in this chapter leads to a number of key questions for the next phase of our work which focuses explicitly on the NNW region. The answers to these questions may vary, depending on the nature of the innovation ecosystem being investigated:

- **Rationale for intervention.** Is it possible to identify public interventions that are most impactful in specific innovation settings, including in embryonic innovation ecosystems?
- **Ecosystem evaluation.** Can we value innovation ecosystems, and the role of orchestration?
- **Strategic approach.** Is it possible to develop a set of generic governance and orchestration strategies, which can be scaled through regional or national replication?
- **Knowledge sharing.** How do we evaluate this aspect of sectoral productivity impact?
- **Linking urban and rural innovators.** What role can improved knowledge sharing and cross-firm innovation play in closing the productivity gap between urban centres and rural hinterlands?
- **Approach to generating growth.** What is the right balance between top-down innovation strategy and support for bottom-up actions?
- **Additional funding and policy instruments.** Are additional funding and policy instruments required to support and provide incentives for innovation across different regions (eg. LEP areas and between English LEP areas and Welsh regions)?
- **Alignment with broader policy.** Are ecosystems best supported through targeted interventions, or complementary actions relating to labour markets, land use, housing, transport etc?

[9] The NW Coastal Arc emerged from the 2015 Science and Innovation Audits, and brings together a consortium led by Lancaster University, including all the region's LEPs (Cumbria, Lancashire, Cheshire, Liverpool City, Stoke-on-Trent and Staffordshire), the North Wales Economic Ambition Board and the Mersey-Dee Alliance, together with companies of all sizes, and ten regional universities. See http://www.northwestcoastalarc.net/

7. Innovation ecosystem case studies

Headline Insights

Each of the three ecosystems examined has very different drivers and rationale for public investment. In the Bothnian Arc and Aosta Valley, policymakers have specifically sought to increase innovation performance and to create an identifiable innovation ecosystem, whereas in Boulder, policymakers have sought to strengthen an already high-performing, recognisable innovation ecosystem. There are different pathways to innovation ecosystem creation and growth and the relationships and interaction between public and private partners.

The Bothnian Arc has successfully stimulated increased cross-border collaboration and open innovation. This policy-driven approach to create an innovation ecosystem spanning border regions of Sweden and Finland has successfully fostered greater cross-border HEI co-operation and development of open innovation projects between universities and businesses. Increasing the scale of these collaborations and securing greater involvement of SMEs in the innovation ecosystem is required if a step-change in innovation performance is to be realised.

In Aosta Valley, public authorities have sought to boost collaborative innovation through targeted interventions aimed at addressing key societal challenges. The authorities in this Italian region have used pre-commercial public procurement and living labs to successfully stimulate new collaborations between SMEs, research institutions, public sector end users and the acceleration of roll-out of new smart energy and intelligent mobility technology solutions. The challenge remains to increase awareness of these opportunities across a wider range of end users and SMEs.

Boulder has a varied innovation ecosystem in which entrepreneurs, large firms and public R&D labs all play important roles. Whilst the growth of Boulder (US) as an innovation hub does not appear to have been the result of any highly orchestrated stakeholder strategies or actions to create a culture of collaboration, different partners have had important inter-related and complementary roles. Large technology firms, universities and a network of Federal R&D labs provided useful anchors for entrepreneurial activity, contributing to Boulder's high business start-up rates and strong entrepreneurial ecosystem.

Over the past decade, policymakers across the globe have taken a strong interest in the geographical and spatial drivers and characteristics of innovation, spurred on in part in the UK and the rest of Europe by the development of the Smart Specialisation approach to regional and local economic development and an increased emphasis on place-based decision-making.

Since 2011, The European Commission (EC) has sought to encourage Local Enterprise Partnerships (LEPs) in England and regional development agencies across the European Union (EU) to adopt policies consistent with the principles of Smart Specialisation,[10] an approach endorsed by the UK Government.[11] Under the Smart Specialisation approach, regions should seek to invest in existing economic strengths and assets and develop proposals to enhance local innovation capacities and

[10] https://ec.europa.eu/jrc/en/research-topic/smart-specialisation

[11] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/436242/bis-15-310-smart-specialisation-in-england-submission-to-european-commission.pdf

capabilities, thereby strengthening innovation ecosystems. This includes a focus on social innovation: increasing innovation whilst also meeting a defined social need. It is assumed that all of this will, in turn, stimulate increased business investment and strengthen supply chains. A key question for Smart Strategies is the extent to which they can help to increase knowledge connections and flows in peripheral and rural areas, and help to overcome the absence of agglomeration effects and major economic centres.

In this chapter, we examine three locations where partners have either adopted ecosystem approaches to support innovation and economic development, or where place-based ecosystems have formed more organically, yet in locations outside of major urban areas:

- **Bothnian Arc.** A large predominantly rural cross-border area (Bothnian Arc) that performs well on innovation metrics and is home to some important innovation assets, but with limited relationships between them.
- **Aosta Valley.** A location with a poorer long-term innovation performance that has adopted a specific targeted approach to foster innovation links between local partners and improve rates of innovation whilst addressing major societal challenges.
- **Boulder.** A semi-rural tech hub with a strong entrepreneurial and innovation culture and a high quality natural environment and quality of life, but which now faces the challenge of how to continue to promote economic growth whilst protecting the natural environment.

We focussed on just three case studies and subjected them to in-depth scrutiny, rather than seeking to maximise the quantity of locations covered. One of the major challenges in identifying exemplar innovation ecosystem is a lack of impartial, objective evidence. Often what is presented is a superficially positive, post-hoc rationalisation of economic performance and policy impact, rather than robust evaluation. Instead, we have sought to unpack the ecosystem-oriented activities and outcomes with greater care, to identify insights for our phase II work, looking at case studies within our own regional context.

Selection Process

We sought to identify insights into how towns, regions or countries have sought to create and/or foster growth through innovation ecosystems and, where possible, evaluate the impact of the related interventions. The intention was not simply to look at regions that have the same/similar economic and demographic characteristics to Cumbria and Lancashire. Rather, we wanted to examine innovation ecosystems covering a range of regional economic geographies, performance on innovation metrics, and policy contexts, which also have at least some innovation challenges in common with Cumbria and Lancashire. This helps to generate transferrable lessons for local partners. We identified innovation ecosystems that:

- Spanned a range of sectors
- Included a diverse range of innovation actors from the public and private sectors
- Sought to evaluate ecosystem impact in a range of different ways
- Adopted novel approaches to innovation and policy-led practice
- Had some specific innovation challenges that are also present in Cumbria and Lancashire
- Generated enough publicly available information (eg. research, consultancy and policy reports) to enable us to carry out our desk-based analysis.

Based on these criteria we identified a wide range of locations through a review of available literature, and selected the three cases of Bothnian Arc, Aosta valley, and Boulder. Other locations that were considered, and which could be studied further at some future point in time, included:

- Castila-La Mancha (Spain) - innovation in a rural, agricultural region
- Cairns (Australia) – building an innovation ecosystem round a university anchor institution in a remote location
- Northwest Germany and US Great Lakes region – innovation in wind energy and associated sectors
- Styria, Austria – innovation in greentech
- Douro and Aveiro (both Portugal) - innovation in tourism in rural areas
- Vila Real de Santo António (Portugal) - innovation in urban and coastal tourism.

The different approaches to ecosystem evaluation are of particular interest in each of these cases. Given that our research aims to unpack the productivity-enhancing potential of innovation ecosystems, we need to draw out lessons on measurement and evaluation from other such interventions around the world. The case for action is stronger if system change can be measured robustly, and the impact of public actions can be evaluated and easily communicated.

The precise metrics used to evaluate innovation ecosystems should reflect partners' objectives (Millard, 2018)[12] and a range of other factors, such as the scale of the system, its maturity, the levels of investment made, and perhaps some reference to peer communities (as used to evaluate Boulder) or performance benchmarks. It is a complex and challenging task to quantify the synergistic interactions between innovation actors and the positive spillovers/externalities that these relationships generate. With value creation and capture taking place over broad spatial and temporal dimensions, the data capture challenges are significant.

The case studies below have all adopted different approaches to these evaluation challenges. In each case we present an overview of key geographic and economic features, describe the objectives and performance, then set out the various measurement and evaluation approaches.

Presented below are some key insights from our three case studies. The full case studies are attached as appendices to this report, and provide a much more detailed analysis of the individual ecosystems. Two of the three case studies (Bothnian Arc and Aosta Valley, both in Europe) provide examples of interventions by policymakers specifically intended to increase innovation performance and to create an identifiable innovation ecosystem. The other case study (Boulder, in the United States) provides an example of a successful innovation ecosystem that has grown organically, and which partners in the public and private sectors have subsequently sought to strengthen further through orchestrated strategy and actions.[13]

[12] https://masschallenge.org/article/startup-innovation-ecosystem-explained.

[13] The case studies described in this chapter draw together insights from a wide variety of academic, policy and thinktank reports. Further details and a full citation list is available for each of the three case studies in their respective appendices and report References.

Bothnian Arc (Sweden-Finland)

Bothnian Arc is a cross-border coastal area around the Gulf of Bothnia at the northernmost end of the Baltic Sea in north-west Finland and north-east Sweden, similar in geography to the North Wales-North West England coastal arc.

Geographic and economic overview: Bothnian Arc encompasses an area approximately 800km x 70km (500 miles x 45 miles) along the upper Bothnian Bay with a population of around 710,000 (compared to 498,400 in Cumbria and 1,490,500 in Lancashire) and an annual GVA of around £25bn (roughly twice the size of the Cumbria economy and around 85% of the size of the Lancashire economy). Geographically, the area includes six Swedish municipalities, three Finnish sub-regions and two Finnish cities. The three largest cities of Oulu in Finland (population 203,750) and Swedish cities Umea (83,249) Lulea (43,574) are the main centres of innovation in the Bothnian Arc, where key innovation assets in the private and public sectors are located.

Ecosystem features and activities: This case study is an example of a policy-driven approach to the creation of an innovation ecosystem and whereas the North West Nuclear Arc seeks to drive innovation and collaboration in the nuclear sector, partners in the Bothnian Arc have sought to boost innovation and collaboration to support diversification of the economy away from traditional sectors. A further objective was to promote a Bothnian Arc brand and use this as part of marketing efforts to increase inward investment. A multi-partner Bothnian Arc Association was created in 2012 to promote co-operation in new business creation, innovation, education, training and R&D.

There have been some notable successes, for example, fostering of greater cross-border co-operation between the main universities, and development of open innovation projects between universities and businesses in three core areas (internet research, printed electronics and international business). However, most activity to date has been on individual projects based on small-scale initiatives from HEIs and local authorities. Increasing the scale of these collaborations and securing greater involvement of SMEs in the innovation ecosystem is required if a step-change in innovation performance is to be realised. Additional policy levers and funding may be required to enable the Bothnian Arc Association to play a leading ongoing role in innovation system co-ordination and facilitation/orchestration.

Evaluation: Bothnian Arc authorities have developed their evaluations of performance by utilising the innovation indicators published for administrative regions that map most closely to the Bothnian Arc area, from both Sweden and Finland. This enables tracking of performance over time and comparisons with other regions, but does not necessarily evidence the direct impact of ecosystem oriented activities orchestrated through the Bothnian Arc association. Performance evaluations incorporate data on tertiary educational attainment, R&D personnel, high-tech manufacturing employment, employment in knowledge-intensive services, R&D expenditure, business R&D expenditure, patents. The broader northern Sweden and northern Finland regions in which the Bothnian Arc sits are both in the “Innovation Leaders” category (top of four broad categories) according to the 2019 EU Regional Innovation Scoreboard. No specific data or evidence on the value of the innovation ecosystem or on the impact of policy interventions has been published.

Aosta Valley (Italy)

Aosta Valley is a sparsely populated mountainous region in the north west of Italy with consistently has low rates of innovation (compared to the Italian average).

Geographic and economic overview: Aosta Valley is a semi-autonomous mountainous region in northern Italy, located on the western side of the Alps, bordering France and Switzerland. The region's capital, the town of Aosta, is around 120km (75 miles) north of the major Italian city of Turin. The main transport route is the Autostrada A5 motorway, which connects Aosta Valley to Turin (south) and France (north). Aosta Valley has the lowest population density of any Italian region (39 residents per km^2 in 2017). The region covers an area of 3,263 km^2 (slightly larger than Lancashire and just under half the size of Cumbria). The region's population in 2017 was estimated at 126,883, of whom 34,008 lived in Aosta Town. The GVA for the Aosta Valley is around £3.4bn per annum.

Ecosystem features and activities: This case study is an example of public authorities seeking to create an innovation ecosystem through targeted interventions. In 2012, as part of an EU cross-border innovation programme, the regional government introduced a scheme combining pre-commercial public procurement and Living Labs, which sought to increase local SME innovation capacity and capabilities. This approach extends the "community wealth building" model, which involves local public organisations using their purchasing power to strengthen local supply chains through purchasing goods and services. In Aosta Valley, the regional government has taken this one step further by acting as "first buyer" for new and emerging technologies in priority areas of smart energy and intelligent mobility. The objective is to increase the ability of local businesses to develop, test and validate and roll-out new innovative products and services to meet identified societal challenges, consistent with the concepts of Smart Specialisation and open innovation.

This approach has successfully stimulated new collaborations between SMEs, universities and end users (eg. schools) and the acceleration of new technologies and solutions being brought to market. The different prior experiences of partners in living labs and the challenges in developing common information sharing platforms did provide some delays to real-life prototype testing. This points to the need for awareness raising across the innovation ecosystem to increase the efficiency and impact of such approaches to increase SME R&D and innovation.

Key wider challenges being tackled include: under-representation of employment in high technology sectors; low educational attainment; a proportionately low share of graduates in technical and scientific disciplines; under-representation in advanced manufacturing and high-value service sectors; fewer firms reporting "innovation activities" than the Italian average (40% versus 45%); and fewer enterprises reporting process and/or product innovation (28% vs 34% nationally).

Evaluation: Overall, the programme (and the innovation ecosystems it sought to create) leveraged some 1.1m euros of private sector R&D, from a public investment of around 1.3m euros. R&D intensity has increased in Aosta Valley since the introduction of the PCP/Living Lab experiment (although there is no quantitative evidence on the proportion of this increase that is attributable to the scheme). However, the region still underperforms the Italian average. By 2015 the total R&D expenditure was only 0.7% of the regional GDP (compared to 0.5% in 2011 before the programme started), still well below the Italian (1.3%) and European average (2.0%).

Boulder (US)

Boulder is a small city in the United States, in the north of the State of Colorado. It is located in the foothills of the Rocky Mountains, around 25 miles from Denver, the State's Capital and largest city.

Geographic and economic overview: The City of Boulder is the 11th largest municipal area in the State, with a population of around 107,125 in 2017, up from 97,385 in 2010 (10% increase), with the wider Boulder County being home to 322,514 residents. The city is 5,430 feet (1,655 m) above sea level. Boulder's population is equivalent to one-seventh of the population of the state capital, Denver, which in 2017 was 704,621. Between 2010 and 2017, Denver's population grew by 17% and it is currently the 12th largest US city. Boulder is easily accessible by the US highway network. Denver International, the US's fourth-largest airport, is the main passenger airport serving Boulder. Boulder County GDP in 2017 was around $25bn. Boulder is home to the main campus of the University of Colorado, with around 35,000 students enrolled for the 2019 Fall Term.[14]

Ecosystem features and activities: Boulder has a varied innovation ecosystem in which entrepreneurs, large firms and public R&D labs all play important roles. The city's high quality natural environment and quality of life has attracted many young, highly-educated entrepreneurs to move to Boulder and start up their own businesses. Boulder has been called a "creative class" city[15]. It has a very high concentration of high-skilled workers and entrepreneurs. Whilst the growth of Boulder (US) as an innovation hub does not appear to have been the result of any highly orchestrated strategies or actions to create a culture of collaboration, a range of partners have had inter-related and complementary roles.[16] Large technology firms, universities and a network of Federal R&D labs provided useful anchors for entrepreneurial activity, contributing to Boulder's high business start-up rates and strong entrepreneurial ecosystem.
In recent years, there has been a more strategic approach to ecosystem orchestration through the creation of the Boulder Economic Council, the economic development arm of the local chamber. Overall, there are a number of drivers Boulder's economic success and its record of collaboration and innovation: entrepreneurs play a strong role in setting the economic agenda, with high levels of commitment from government, universities, and large corporations; strong commitment of entrepreneurs and business owners who have run businesses in Boulder for many year, and are well known and trusted; inclusivity, which means that anyone who wants to participate in the ecosystem is welcome; high quality business and partner engagement events; and a vibrant, risk-taking community of venture capitalists and accelerators.

Evaluation: The 2017 Boulder Innovation Venture report[17] compares Boulder's position on a range of innovation, entrepreneurial and economic indicators with eight "peer communities" across the US. Boulder performs very strongly on a range of innovation and entrepreneurial indicators. It is not possible to attribute the impact of any one initiative or partner to Boulder's performance: the evaluation seeks to establish the performance of the city as a whole. It is the richness of the innovation ecosystem and its deep-rooted impact on the city's economy and culture, that generate strong economic performance.

Some key features are:

- Over 60% of residents in the Boulder metropolitan area have a degree (higher than any of the peer communities and one of the highest rates anywhere in the US).
- The City of Boulder's employment jobs density (employment as a proportion of the resident

[14] https://public.tableau.com/views/alltotal/CampusTotal-Summary?%3AshowVizHome=no.
[15] This term was coined by Richard Florida in his 2002 book, *The Rise of the Creative Class*.
[16] Budden and Murray (2019) drew similar conclusions about Silicon Valley and Greater Boston, two of the most celebrated innovation ecosystems.
[17] Boulder Economic Council (2017).

population) is two-to-three times larger than those of peer communities
- A high concentration of Science, Technology Engineering and Math (STEM) occupations (15%, some 2.5 times the US average and second of all the peer communities)
- Since 2012, 41% of all venture capital funding in Colorado was invested in Boulder start-ups.
- Boulder has the second-highest per capita levels of venture capital investment of peer communities.

Policy insights across the cases

The three ecosystems examined have different drivers and rationales for public investment. In the Bothnian Arc and Aosta Valley, policymakers have specifically sought to increase innovation performance and to create an identifiable innovation ecosystem, whereas in Boulder, the ecosystem had grown organically over many years and recent policy interventions have only sought to strengthen this high-performing location. Yet the level of innovation performance in the three cases suggests a much closer link between the Bothnian Arc and the city of Boulder, as compared with the Aosta Valley and its consistent underperformance, according to national innovation data. This perhaps also explains the investment approach adopted in Aosta: the ecosystem activities extended beyond network building and the creation of new collaborations, making deliberate and significant use of public funds to directly support innovative firms.

This highlights different approaches to the creation and growth of innovation ecosystems and to the orchestration of the relationships, and interaction between public and private partners. As discussed in the previous chapter, solely top-down efforts to create innovation ecosystems are likely to fail unless the underpinning economic conditions for innovation exist and innovation assets are present.

Policy makers can facilitate innovation between innovation assets by providing funding, infrastructure, strategic procurement and by promoting collaboration between innovation actors, for example universities, entrepreneurs, business accelerators, venture capital, large firms, and consultants (Sun, Zhang, Cao, Dong and Cantwell, 2019). Drawing on a literature review of nine previous studies, Durst and Poutanen (2013) identified a range of factors that support ecosystem facilitation and orchestration:

- Resources (management, allocation and availability)
- Governance (eg. clarity of roles, support for interaction between partners)
- Strategy and leadership (eg. clarity of purpose)
- Organisational culture (eg. risk-taking, trying out new ideas)
- Human resources management (innovation as a core job requirement)
- People (access to R&D community)
- Partners (quadruple helix – communities, businesses, academia, public authorities)
- Technology (development, adoption and diffusion of new technologies)
- Clustering (fostering cross-sector collaboration between firms and organisations with complementary expertise).

In practice, the importance of these factors may vary from place to place depending on the nature of the innovation ecosystem and the specific factors at play. For example, in Aosta Valley, the regional government demonstrated strategic leadership by identifying the potential to increase the region's low rates of innovation and R&D. The government provided dedicated resources to local SMEs to

develop new technological solutions, and changed organisational culture in the public sector to foster their adoption. In the Bothnian Arc, the emphasis has been on developing a governance function through the creation of an innovation agency, which has sought to create closer partnership working between firms and universities in common areas of expertise. This agency has also sought to foster more innovation-focussed communication and collaborative working across the national and regional governments that constitute the Arc.

Boulder already had strong underpinning institutional foundations for innovation and entrepreneurialism (eg. a strong university presence, government R&D labs and presence of large companies), with the private sector, through the local chamber, taking a strong strategic lead. Public sector partners are playing an increasingly important role linking private entrepreneurs with the federal labs.

Questions for Phase II

The analysis contained in this chapter leads to a number of key questions for the next phase of our work which focuses explicitly on the NNW study area:

- **Links between entrepreneurial and innovation ecosystems.** What are the interactions between entrepreneurial ecosystems in which new businesses are launched and the innovation ecosystem in which they operate?
- **Leadership.** Which organisation(s) should lead innovation ecosystems and under what conditions?
- **Partners.** Which partners need to be involved in the innovation ecosystem to ensure ecosystem growth?
- **Vision.** How can varied stakeholders with their own (and sometimes competing) priorities be brought together to agree on innovation ecosystem vision and priorities and to support implementation?
- **Tension.** What are the tensions in partner relationships, and does it matter if some stakeholders within the innovation ecosystem are less engaged than others?
- **Sustainability.** To what extent can innovation ecosystems be made self-sustaining, and what underpinning factors and infrastructure are necessary?
- **Smart Strategies**. To what extent can Smart Strategies can overcome “lock in” (ie. absence of agglomeration effects and major economic centres) in more rural locations?
- **Public sector as purchaser of innovation**. Under what conditions can public procurement of innovation provide a more effective way of both addressing major societal challenges and boosting local economic competitiveness and productivity than other forms of funding/intervention?

8. Conclusions & Phase II studies

In this Phase I report we have set out some of the most significant and current bodies of knowledge relating to innovation ecosystems. These are summarised below, along with the details of the next phase of this work, which comprises two field-based studies across the NNW area.

The nature of innovation ecosystems

We have highlighted the critical role that innovation ecosystems play as a bridge between knowledge and commercial exploitation of that knowledge. We also show that there are differences between knowledge, business and innovation ecosystems in terms of the resources they bring to bear, the goals of anchor organisations, and the geographical distributions of the system members. Geography and the spatial arrangement of organisations has historically been seen as a barrier to innovation, with the development of clusters seen as perhaps the only antidote. Yet the rise of new communication technologies and the greater mobility and flexibility of work forces can, perhaps, overcome geographic concerns when other factors that support collaborative innovation are strong. Critically, in any context we need to look closely at the nature of the different business, knowledge and innovation ecosystems in place, and we cannot assume that simply because we have one type of ecosystem, we have all three.

Across different business ecosystems we also see variation between those structured around a core product/market offer and supporting technologies, and those ecosystems that operate as platforms for much broader forms of connectivity. When looking at the NNW region and the desire to see greater spillover benefits from core industries such as advanced manufacturing or nuclear, these difference in ecosystems characteristics become important. To generate these broader-based entrepreneurial networks we need to identify mechanisms to connect structured ecosystems to peripheral or emerging technologies that might benefit from these established and rich seams of expertise. Yet we cannot underestimate the task here: the broader our aspirations the more challenging it becomes to move and translate the necessary expertise across organisational or social world boundaries; This makes the connecting and catalysing role of the orchestrator critical.

Ecosystems and Capitals

There may be a role to be played by a deeper understanding of the relationships between natural and social capital and ecosystems, particularly for the NNW. We intuitively know that these are good places to live, to raise a family, to spend time at work and at leisure, but have we done enough to map and measure the ways in which we purposefully deploy our natural and social capital? We do not necessarily need to use the language of 'capitals' to describe the value and impact of these factors on economic performance. However, as natural capital accounting becomes more commonplace, utilising this as a tool for the measurement and communication of activity places this broader notion of capitals at the front of intervention decisions. This is quite different to undertaking natural capital impact assessments after core decisions have been taken. This may not always be necessary, but for certain settings the ability to weave social, cultural and environmental concerns into economic decision making could allow us to leverage our investments to support multiple, longer-term innovation objectives.

We know that the concept of social capital, which describes the bonds of trust and mutual support that connect individuals and groups, is well embedded in entrepreneurship research. Social capital has also been invested in by organisations such as the World Bank, and underpins the workings of

microfinance initiatives across the globe. In the NNW we too have well connected communities, and whilst there are concerns in some areas about the ability to attract talent, that workforce tends to be more stable once in place. Can we see this accumulation of place-based social capital as an innovation asset, a network of connections that can be repurposed through well-developed orchestration? If so then we need a language to support the systematic evaluation and communication of social capital related interventions.

Orchestration and evaluation

If we wish the see policy interventions in ecosystems, then we first need to establish that innovation gains are possible through more structured and purposeful system-level leadership. This requires us to develop some mechanism or toolkit for innovation ecosystem evaluation, prior to investments in orchestration.

Such evaluations can build on the work already undertaken in our open innovation research across bioscience and central government, where we sought to unpack the ways in which value is created, captured, and accounted for to multiple stakeholders. The framework we need for regional ecosystems evaluations has to be capable of mapping the purposes, resources and ways of working embedded in each key stakeholder, then visualising how these can be connected and supported through collaborative innovation.

Alongside such evaluations we need to think carefully about longer term accountability. Supporting the growth and prosperity of an ecosystem may span the life of multiple administrations, and the recording of value being created may not be straightforward. This creates a double challenge: how does an ecosystem oriented innovation strategy yield sufficient evidence of 'success', when success is delivered to disparate communities and understood in many different ways? And what is this sufficient level of evidence, if it must ensure that the strategy in place is seen as more than the 'pet project' of a single visionary?

The three case studies described in this report, and in detail in the appendices, highlight some of the opportunities and challenges faced by policy makers seeking to harness the value of innovation ecosystems.

In the Bothnian Arc we see large-scale public investment in ecosystem architecture, while in Aosta Valley we see public sector organisations being willing to co-create innovations through active risk taking as early stage technology purchasers. In contrast, in Boulder we see actions taken some 50 years ago to draw in a core of government agencies alongside a thriving university act as the seed for what then appears to be an entirely entrepreneur-led ecosystem that is perhaps the envy of the world. This has led to Boulder being able to exploit the natural capital of the region to attract and retain a deep pool of human capital, whilst the social capital of the innovation ecosystem supports good behaviours and allows ideas to flourish, and the financial capital of funders but also university and government research centres support the rapid growth of successful start-ups.

The theory and the case studies presented here give us sufficient insight to create a research approach to look at innovation ecosystems in the NNW study area of the UK. The cases we propose are discussed below.

Clean Energy Innovation Ecosystems: Phase II Research Outline

This field-based research will look at the potential for ecosystem interventions to support innovation in the clean energy sectors of Cumbria and Lancashire. The study will look at ecosystem establishment and resilience through the lens of managerial beliefs about ecosystem benefits, the requirements they would place on orchestrators, and the ways in which they evaluate ecosystem gains in order to justify their sustained commitment.

We want to understand the unfolding process of ecosystem affiliation, the ways in which managers value emergent ecosystems, and evaluate their potential role within them.

We cannot assume that organisations with already established ways of working will place any value on the supposed benefits that ecosystem membership might bring, or are willing to subject themselves to some level of external, ecosystem co-ordination. Yet for the networked innovation benefits of ecosystems to be realised, some level of purposeful open system orchestration is needed. This, in turn, requires organisations to be open to orchestration taking placing. But what value do different organisations seek from ecosystems? Which kinds of ecosystems do they most value, and why? And critically, how do they want the orchestrators to account to them for this value, both in the formative stages and as the system evolves, to support their own decision making?

Our setting is a broad geographical cluster with a strong emphasis on clean power generation, seen as a combination of nuclear, wind, solar, hydrogen, and more experimental technologies such as biodigesters and solar-battery. The highest value concentration of activity surrounds the nuclear industry, which can be seen as potentially connecting to at least three different ecosystems:

1. The recently created North-West Nuclear Arc, which at this stage is an organisation in formation, based on shared goals, but which seeks to connect the leading industrial players, government entities, and research institutions in an arc from North Wales to West Cumbria.
2. The nuclear related industries, such as advanced robotics, which currently form a relatively tightly connected group that functions as an extended supply chain to the power generators.
3. The various renewable power industries, including nuclear, operating at radically differing scales, levels of investment, and positions within their technology lifecycles.

Across all three groups regional policy makers are interested in understanding whether improved connectivity and collaboration may lead to higher levels of innovation-led productivity growth. Yet little is known about whether managers in these industries see any of these three imagined, embryonic or existing networks as the basis of a viable and thriving innovation ecosystems.

This research sets out to investigate the perceptions of such managers, and in particular to discover:

- the value they place on various existing or potential ecosystems, and the ways in which they evaluate and account for engagement with them
- the innovation enabling practices they would expect to see orchestrators adopting
- the information they need from ecosystem facilitators/managers/orchestrators in order to begin or extend their engagements with or through the ecosystems

The inclusion of three potential ecosystems allows insight into the various ways they attribute value to different innovation-oriented opportunities. To ensure that this research remains manageable in scope, our focus will be on senior managers with decision making powers. Very roughly, at this stage, the aim would be to interview 30-40 managers in total, spanning the different industries and possible ecosystems. In addition, we would seek to conduct interviews with at least 10 policy makers, at chief officer or senior management level.

Rural Town Innovation Ecosystems: Phase II Research Outline

This field-based research will investigate the relationships between people, place and ICT-driven innovation (Internet and Communication Technology). We will explore the motivations for investment in this ecosystem at three levels - investors, current workforce, and future workforce. In this way, we will unpack the overlapping economic, social and environmental ecosystems that enable or constrain the potential for sustained, high value economic activity in this sector.

There are fledgling communities of technology firms across the NNW study area, exploiting the mobile nature of their work while maximising lifestyle ambitions alongside the development of their businesses. As highlighted by the IPPR (Cox and Longlands, 2016), small cities and larger towns can be perceived as offering many lifestyle advantages over large cities: lower house prices, lower population density and a resultant easing of infrastructure pressures, good access to countryside and national parks, higher quality schooling, and other factors that lead to higher levels of self-reported wellbeing, and lower levels of anxiety, than in major urban centres.

Whilst evidence still suggests that ICT focussed organisations thrive best when embedded in urban clusters, the automatic assumption that this will provide a higher quality of life for the entrepreneurial business owner is questionable: this is an assumption that Amartya Sen characterises as "*a confusion of wellbeing with being well-off*" (Sen, 1999; cited by Cox and Longlands, 2016). In fact, preliminary interview data captured for this project reveals several technology firms making explicitly lifestyle-oriented decisions to locate in well-connected but rural settlements, and grow their business here.

What is less clear is precisely how business owners make decisions about locating in rural settlements, and the ways in which multiple overlapping economic, social and environmental factors can support growth in these fledgling technology-enabled business ecosystems. What encourages these organisations to move to, then 'put down roots' in, rural settlements? Can these individual innovators be better networked to enable increased knowledge sharing, and innovation-led productivity growth? Moreover, how does a region traditionally struggling with talent retention and attraction ensure that there is a sufficiently skilled workforce available to support the growth of this potentially high value ecosystem?

To answer these questions we adopt a broadly three-level approach, gathering qualitative data through interviews and focus groups with: 1) inward investors (the business owners of ICT oriented firms); 2) current workforce (those employed by such firms); and 3) future workforce (young people of school age within the region, who need to be retained or attracted back early in their careers).

This case study looks closely at a single rural town, Penrith in Cumbria. This single centre approach is important in the first instance because of the need to understand the ways in which place-specific value is understood, and to develop conceptualisations of this value that span social, business and environmental systems, and that extend through time. A feature of this work will be the relationship and connectivity between the town and the nearby Lake District National Park, which is increasingly expected to take a role in the social and economic wellbeing of communities[18]. This relates to our interest in how, in practice, the town is connected to both nearby and more remote natural and cultural assets, and the role these play in shaping key individuals' value judgements about whether to live, work or invest here.

[18] The Glover 'Landscapes Review' published in September 2019 highlights the need for national parks to actively foster economic and social wellbeing, both within the parks but also in surrounding areas, whilst enhancing access for young people and giving communities greater voice in decision making. Downloaded at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/833726/landscapes-review-final-report.pdf

References

Adner, R. (2006). Match your innovation strategy to your innovation ecosystem. *Harvard business review, 84*(4), 98.

Adner, R. (2016). Navigating the Leadership Challenges of Innovation Ecosystems. *MIT Sloan Management Review, 58*(1).

Adner, R. (2017). Ecosystem as structure: an actionable construct for strategy. *Journal of management, 43*(1), 39-58.

Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. *Strategic management journal, 31*(3), 306-333.

Agrawal, A., & Cockburn, I. (2003). The anchor tenant hypothesis: exploring the role of large, local, R&D-intensive firms in regional innovation systems. *International journal of industrial organization, 21*(9), 1227-1253.

Allen, T. J., & Cohen, S. I. (1969). Information flow in research and development laboratories. *Administrative science quarterly*, 12-19.

Almirall, E., Wareham, J. (2011). Living Labs: Arbiters of Mid- and Ground- Level Innovation. Technology Analysis and Strategic Management, 23(1), 87-102.

Baptista, R. (1998). Clusters, innovation and growth: a survey of the literature. *The dynamics of industrial clusters: international comparisons in computing and biotechnology*, 13-51.

Baregheh, A., Rowley, J., & Sambrook, S. (2009). Towards a multidisciplinary definition of innovation. *Management decision, 47*(8), 1323-1339.

Bilgram, V.; Brem, A.; Voigt, K.-I. (2008). User-Centric Innovations in New Product Development; Systematic Identification of Lead User Harnessing Interactive and Collaborative Online-Tools, in: International Journal of Innovation Management, Vol. 12, No. 3, pp. 419-458.

Boltanski, L., & Thévenot, L. (2006). *On justification: Economies of worth* (Vol. 27): Princeton University Press.

Budden, P., & Murray, F. (2019). MIT's stakeholder framework for building & accelerating innovation ecosystems. MIT's Laboratory for Innovation Science & Policy Working Paper.

Chesbrough, H., & Crowther, A. K. (2006). Beyond high tech: early adopters of open innovation in other industries. *R&d Management, 36*(3), 229-236.

Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*: Harvard Business Press.

Clarke, A. E., & Star, S. L. (2008). The social worlds framework: A theory/methods package. *The handbook of science and technology studies, 3*, 113-137.

Clarysse, B., Wright, M., Bruneel, J., & Mahajan, A. (2014). Creating value in ecosystems: Crossing the chasm between knowledge and business ecosystems. *Research Policy, 43*(7), 1164-1176.

Clermont, F. and Fionda, F. (2016). A modern approach for procuring research and innovation: The pre-commercial public procurement. European Procurement & Public Private Partnership Law Review 11 (2), 88-96.

Cohen, W. M., & Levinthal, D. A. (1989). Innovation and learning: the two faces of R & D. *The economic journal, 99*(397), 569-596.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative science quarterly, 35*(1).

Cohen, W. M., & Levinthal, D. A. (2000). Absorptive capacity: A new perspective on learning and innovation *Strategic Learning in a Knowledge economy* (pp. 39-67): Elsevier.

Coleman, J. S. (1988). Social capital in the creation of human capital. *American journal of sociology*, S95-S120.

Colombo, M. G., Dagnino, G. B., Lehmann, E. E., & Salmador, M. (2019). The governance of entrepreneurial ecosystems. *Small Business Economics, 52*(2), 419-428.

Constantiou, I., Marton, A., & Tuunainen, V. K. (2017). Four Models of Sharing Economy Platforms. *MIS Quarterly Executive, 16*(4).

Cox, E. & Longlands, S. (2016). *The role of small and medium-sized towns and cities in growing the northern powerhouse*. IPPR.

Dhanaraj, C., & Parkhe, A. (2006). Orchestrating innovation networks. *Academy of management review, 31*(3), 659-669.

Durst, S., & Poutanen, P. (2013). Success factors of innovation ecosystems: Initial insights from a literature review

Feld, B. (2012). Start-up communities: Building an entrepreneurial ecosystem in your city. John Wiley & Sons.

Feldman, M., Siegel, D. S., & Wright, M. (2019). New developments in innovation and entrepreneurial ecosystems. *Industrial and Corporate Change*.

Fionda, F. (2012). The Aosta Valley case study on precommercial public procurement and Living Labs. Presentation to EcoProcura 2012.

Ford, C. J. (2017). *Business performance management: when not to measure*. Retrieved from London:

Fuller, J., Jacobides, M. G., & Reeves, M. (2019). The Myths and Realities of Business Ecosystems. *MIT Sloan Management Review, 60*(3), 1-9.

Gawer, A., & Cusumano, M. A. (2014). Industry platforms and ecosystem innovation. *Journal of Product Innovation Management, 31*(3), 417-433.

Giacometti, A., Teräs, J., & Aalto, H. (2019). Social and economic resilience in the Bothnian Arc cross-border region. Prepared on behalf of the Nordic Thematic Group for Innovative and Resilient Regions 2017–2020, under the Nordic Council of Ministers Committee of Civil Servants for Regional Affairs.

Giudici, A., Reinmoeller, P., & Ravasi, D. (2018). Open-system orchestration as a relational source of sensing capabilities: Evidence from a venture association. *Academy of management journal, 61*(4), 1369-1402.

Graham, R. (2014). Creating university-based entrepreneurial ecosystems. Massachusetts Institute of Technology Skoltech Initiative.

Hart, C., Stachow, G., & Cadogan, J. W. (2013). Conceptualising town centre image and the customer experience. *Journal of Marketing Management, 29*(15-16), 1753-1781.

Hugosson, J., Olmsäter, G. & Hallin, T (2012). Towards a borderless innovation system in the Nordic region: Final report from the evaluation conducted by Interreg IVA Nord.

Isenberg, D. J. (2010). How to start an entrepreneurial revolution. Harvard Business Review, 88 (6), 40-50.

Ivy, J., McKeever, E. G., & Perenyi, A. (2018). *The Role of Social Capital within Local Business Networks in a Low-trust Transitional Environment.* Paper presented at the Academy of Management Proceedings.

Jacobides, M. G., Cennamo, C., & Gawer, A. (2018). Towards a theory of ecosystems. *Strategic management journal, 39*(8), 2255-2276.

Jiao, J. R., Simpson, T. W., & Siddique, Z. (2007). Product family design and platform-based product development: a state-of-the-art review. *Journal of intelligent Manufacturing, 18*(1), 5-29.

Katz, J., & Wagner, W. (2016). Innovation districts.

Katz, J., & Wagner, W. (2014). The rise of innovation districts: A new geography of innovation in America

Lampón, J. F., Frigant, V., & Cabanelas, P. (2019). Determinants in the adoption of new automobile modular platforms. *Journal of Manufacturing Technology Management*.

Lane, P. J., Koka, B. R., & Pathak, S. (2006). The reification of absorptive capacity: A critical review and rejuvenation of the construct. *Academy of management review, 31*(4), 833-863.

Lane, P. J., & Lubatkin, M. (1998). Relative absorptive capacity and interorganizational learning. *Strategic management journal*, 461-477.

Leyden, D. P., Link, A. N., & Siegel, D. S. (2014). A theoretical analysis of the role of social networks in entrepreneurship. *Research Policy, 43*(7), 1157-1163.

Mason, K., Friesl, M., & Ford, C. J. (2018). Markets under the Microscope: Making Scientific Discoveries Valuable through Choreographed Contestations. *Journal of Management Studies*.

McKeever, E., Anderson, A., & Jack, S. (2014). Entrepreneurship and mutuality: social capital in processes and practices. *Entrepreneurship & Regional Development, 26*(5-6), 453-477.

McKeever, E., Jack, S., & Anderson, A. (2015). Embedded entrepreneurship in the creative re-construction of place. *Journal of business venturing, 30*(1), 50-65.

Moonen, T., & Clark, G. (2017). The logic of innovation locations: Understanding the drivers that enable cities to host innovation economies.

Moore, J. F. (1996). *The death of competition: leadership and strategy in the age of business ecosystems*: HarperBusiness New York.

Nambisan, S., & Sawhney, M. (2011). Orchestration processes in network-centric innovation: Evidence from the field. *Academy of management perspectives, 25*(3), 40-57.

Nauwelaers, C., Maguire, K., and Marsan, G. A., (2013). Regions and Innovation: Collaborating across borders, OECD reviews of regional innovation. OECD Publishing.

Oh, D.-S., Phillips, F., Park, S., & Lee, E. (2016). Innovation ecosystems: A critical examination. *Technovation, 54*, 1-6.

Pallot M. (2009). Engaging Users into Research and Innovation: The Living Lab Approach as a User Centred Open Innovation Ecosystem. Webergence Blog

Powell, W., Packalen, K., & Whittington, K. (2010). Organizational and institutional genesis: the emergence of high-tech clusters in the life sciences. Queen's School of Business Research Paper No. 03-10.

Pose, A., & Wilkie, C. (2017). Institutions and the entrepreneurial discovery process for smart specialisation. Governing smart specialisation, 34-48.

Sen A (1999). *Development as Freedom*, Oxford University Press

Stam, E. (2015). Entrepreneurial ecosystems and regional policy: a sympathetic critique. *European Planning Studies, 23*(9), 1759-1769.

Star, S. L., & Griesemer, J. R. (1989). Institutional ecology,translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social studies of science, 19*(3), 387-420.

Stark, D. (2009). The Sense of Dissonance: Accounts of Worth in Economic Life.

Testoni, C., & Boeri, A. (2015). Smart cities: public policies and business models for a sustainable development, stakeholder networking and innovative public procurement in Italy.

Todorova, G., & Durisin, B. (2007). Absorptive capacity: Valuing a reconceptualization. *Academy of management review, 32*(3), 774-786.

Tushman, M. L. (1977). Special boundary roles in the innovation process. *Administrative science quarterly*, 587-605.

Tushman, M. L., & Scanlan, T. J. (1981). Boundary spanning individuals: Their role in information transfer and their antecedents. *Academy of management journal, 24*(2), 289-305.

Van den Broek, J., Eckardt, F. and Benneworth, P. (2017). The transformative role of universities in regional innovation systems. CHEPS Working Papers 201705, University of Twente, Center for Higher Education Policy Studies (CHEPS).

Visnjic, I., Neely, A., Cennamo, C., & Visnjic, N. (2016). Governing the city: Unleashing value from the business ecosystem. *California management review, 59*(1), 109-140.

Whittington, K. B., Owen-Smith, J., & Powell, W. W. (2009). Networks, propinquity, and innovation in knowledge-intensive industries. *Administrative science quarterly, 54*(1), 90-122.

Williamson, P. J., & De Meyer, A. (2012). Ecosystem advantage: How to successfully harness the power of partners. *California management review, 55*(1), 24-46.

Worren, N., Moore, K., & Cardona, P. (2002). Modularity, strategic flexibility, and firm performance: a study of the home appliance industry. *Strategic management journal, 23*(12), 1123-1140.

Zahra, S. A., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *Academy of management review, 27*(2), 185-203.

Appendix I – Bothnian Arc: An Innovation Ecosystem Case Study

Factor	Description
Location	Cross-border coastal area in north-west Finland and north-east Sweden, rich in natural resources, at the northernmost end of the Baltic Sea.
Infrastructure Connections	Large area with limited connecting infrastructure (motorways, railways and direct flight connections), which makes connections difficult and time consuming, especially during winter. Cross-border co-ordinated approach required to develop solutions (eg. easier train/bus travel across the border).
Type of Innovation Ecosystem	Bothnian Arc is an Innovation Arc spanning the Gulf of Bothnia, with centres of innovation linked along a shared, curved coastline. This case study is an example of a policy-driven approach to the creation of an innovation ecosystem. The concept of the Bothnian Arc was created in the late 1990s by policymakers, which have specifically sought to increase innovation performance and to create an identifiable cross-border innovation ecosystem. A further objective was to promote a Bothnian Arc brand and use this as part of marketing efforts to increase inward investment. Despite being remote and having very low population densities, both regions of the Bothnian Arc were already among the better performing regions in terms of innovation performance (according to the EU Regional Innovation Index), due to the presence of universities, technical research organisations and major technology and advanced manufacturing employers including Nokia in Finland. The region also benefits from high levels of public sector investment on both sides of the border in innovation activities (van den Broek, Eckardt and Benneworth, 2017). The main universities in the area had previously collaborated on innovation-related projects. Partners wished to develop partnership working beyond ad hoc projects and try to strategically co-ordinate and orchestrate innovation-driven collaboration, within and across the cross-border region.
Spatial Scale	Bothnian Arc encompasses an area approximately 800km x 70km (500 miles x 45 miles) along the upper Bothnian Bay with a population of around 710,000. Geographically, the area includes six Swedish municipalities, three Finnish sub-regions and two Finnish cities.[19] The three largest cities of Oulu in Finland (population 203,750) and Swedish cities Umea (83,249) Lulea (43,574)[20] are the main centres of innovation in the Bothnian Arc, where key innovation assets in the private and public sectors are located. These are regarded as "anchor cities", providing geographical focal points for innovation and the development of a cross-border ecosystem.
Key Drivers of the Innovation Ecosystem	The 1996 Regional Innovation Strategy for Northern EU sought to develop stronger cross-border linkages. The local authorities of Oulu, Lulea and Umea in the northern Sweden-Finland border areas subsequently worked closely together to identify how cross-border joint working an initiatives could help to increase economic competitiveness.

19 https://www.programmemed.eu/fileadmin/PROG_MED/capitalisation/OECD_Regions_Collaborating_Across_Borders.pdf

20 United Nations data estimates for 2019.

	One outcome of these discussions was the creation, in 1988, of the Bothnian Arc, a coastal area centred around three cities, which partners believed had the greatest potential for innovation-driven economic growth. It is in this area that the majority of the region's major companies, universities and technical research institutes are located (Hugosson, Olmsäter & Hallin, 2012). The University of Oulu and Lulea University of Technology were already collaborating in cross-border projects, including those funded by European Union Interreg programmes (Nauwelaers, Maguire and Marsan, 2013). In 2002, local authority partners created the Bothnian Arc Association, to co-ordinate, facilitate and fund cross-border innovation activities. The main vision of the Bothnian Arc is *"To become the most functional and integrated border region in Northern Europe – with strong economic growth, high-quality social welfare and a sustainable, clean environment".*[21] The broad overarching objectives of the Bothnian Arc are to: ▪ Promote economic diversification away from traditional sectors (mining, forestry and metal manufacturing) ▪ Increase business-start up rates and the stock of SME businesses and reduce dependence on large firms ▪ Better connect innovation assets in the research/business base to create an internationally renowned "technology hub of the north" [of Europe] ▪ Combine resources to generate economies of scale in provision of innovation services, enhance collaboration and increase access to wider business and knowledge networks ▪ Create an innovative, competitive region to overcome the challenges presented by its peripheral location and declining older industries. ▪ Develop a "borderless innovation system" in the Nordic region. The whole of the Bothnian Arc is currently contained in a European Territorial Co-operation programme aimed at supporting transnational co-operation among regions in northern Europe, titled Northern Periphery and Arctic 2014-2020.
Sectoral/ Technology Specialisation	Both sides of the border are specialised in the following sectors: electronics; software technology; metal industry; forestry; wood processing/paper; mining; space technology; and environmental technology. Higher-value added sectors (ICT, high-tech manufacturing, Knowledge-intensive services, creative industries and life sciences) are concentrated in and around the two main cities in the Bothnian Arc. The ICT sector in Oulu includes Nokia's R&D Centre, whilst Facebook's data centre is located in Luleå.

[21] https://www.bothnianarc.net/-en/.

Key Innovation Actors	**Cross-Border** ▪ Bothnian Arc Association (promotes co-operation in new business development, innovation, education, training and R&D) ▪ Local authorities (funding and strategic leadership) **Finland** ▪ Business Oulu: support to companies ▪ Nokia, Nokia-Siemens, Polar, Elektrobit, Itella ▪ University of Oulu; Oulu University of Applied Science; Kemi-Tornio University of Applied Science; Lapland University; Kokkola University Consortium Chydenius ▪ Oulu Innovation Alliance: strategic alliance between the city of Oulu, the University of Oulu, the Oulu University of Applied Sciences and the VTT Technical Research Centre of Finland ▪ Technopolis Science Park ▪ Digipolis Kemi Technology Park **Sweden** ▪ Lulea University of Technology ▪ Large ICT companies with headquarters outside of the region, including TeliaSonera, CapGemini and Google; Steel company SSAB; Metal manufacturer MEFOS ▪ Energy Technology Centre in Piteå and the Solander Science Park ▪ Innovation Office North, located in Umea in collaboration with Luleå ▪ Krenova, incubator for creative industries ▪ Aurorum Science Park ▪ LTU Innovation ▪ Internet Bay Business development company LNAB
Outcomes and Impacts	The Bothnian Arc is a deliberate attempt to reframe and reposition a region, to put it on the map and give its existing innovation efforts a promotional boost. It also shows commitment and vision from policy makers, which can make inward investors feel more confident about investing in the region. The Bothnian Arc has successfully stimulated increased cross-border collaboration and open innovation, for example, fostering greater cross-border co-operation between the main universities, and development of open innovation projects between universities and businesses in three core areas (internet research, printed electronics and international business). Partners have had several notable successes (Nauwelaers, Maguire and Marsan, 2013), including: ▪ Increasing the propensity for co-operation between the University of Oulu and the Luleå University of Technology (the two universities have long-standing record of partnering in cross-border projects), including developing join courses and R&D projects. ▪ Creation of the Oulu Innovation Alliance, a “triple helix” partnership promoting open innovation in three core areas (internet research, printed electronics and international business). No specific data on the value of the innovation ecosystem or on the impact of policy interventions have been published. Data collected is at the level of the administrative regions of Finland and Sweden that most closely map onto the Bothnian Arc area. This includes data on tertiary educational attainment, R&D

	personnel, high-tech manufacturing employment, employment in knowledge-intensive services, R&D expenditure, business R&D expenditure, patents. The broader northern Sweden and northern Finland regions in which the Bothnian Arc sits are both in the "Innovation Leaders" category (top of four broad categories) according to the 2019 EU Regional Innovation Scoreboard.
Success Factors	Nordic regions have a long history of collaboration. In addition, Bothnian Arc areas have many things in common, and their labour markets and industries are largely complementary (Giacometti, Teräs & Aalto, 2019). Other key success factors identified are (Nauwelaers, Maguire and Marsan, 2013): ▪ Engagement and commitment of major companies ▪ Strong mandate given by local authorities to the Bothnian Arc Association to emphasise innovation issues ▪ Clear prioritisation of innovation activities in areas that are already strongly performing and/or have main innovation assets
Innovation Ecosystem Challenges	Nauwelaers, Maguire and Marsan (2013) also identified some challenges: ▪ The Bothnian Arc Association has limited resources (staff and funding) and can only play a limited role in innovation system co-ordination and facilitation/orchestration. ▪ No dedicated policy instruments exist to implement the Bothnian Arc vision. Most activity to date has been small scale projects based on local initiatives from HEIs and local authorities ▪ Lack of involvement of firms in developing the cross-border vision and financing actions. ▪ Whilst HEIs are involved in specific projects, they also do not contribute to the vision or strategy of the cross-border region Increasing the scale of these collaborations and securing greater involvement of SMEs in the innovation ecosystem is required if a step-change in innovation performance is to be realised. Partners could also look to extend the model of the Oulu Innovation Alliance partnership over the border, aiming at developing a "Bothnian Arc Innovation Alliance", develop business support programmes focusing on mutual cross-border major sectors and roll-out joint funding programmes for R&D projects in areas of shared expertise.
Key themes for further investigation in Cumbria and Lancashire	**Governance.** What is the right balance balance between formal governance structures and informal networks? **Linking urban and rural innovators.** What role can improved knowledge sharing and cross-firm innovation play in closing the productivity gap between urban centres and rural hinterlands? **Approach to generating growth.** What is the right balance between top-down innovation strategy and support for bottom-up actions? **Additional funding and policy instruments.** Are additional funding and policy instruments required to support and provide incentives for innovation across different regions (eg. LEP areas or Wales-England) **Vision.** How can varied stakeholders with their own (and sometimes competing) priorities be brought together under a shared vision?

Appendix II – Aosta Valley: An Innovation Ecosystem Case Study

Factor	Description
Location	Aosta Valley is a semi-autonomous mountainous region in northern Italy, located on the western side of the Alps, bordering France and Switzerland. The region's capital, Aosta, is around 120km (75 miles) north of the major Italian city of Turin.
Infrastructure Connections	The main transport route is the Autostrada A5 motorway, which connects Aosta Valley to Turin (south) and France (north) through the Mont Blanc Tunnel.
Type of Innovation Ecosystem	Since 2012, public authorities in Aosta Valley have sought to boost collaborative innovation through targeted interventions aimed at addressing key societal challenges. That year, Aosta Valley launched a pilot open innovation scheme involving a combination of pre-commercial public procurement (PCP) and Living Labs, in which the public sector would procure innovation and research & development (R&D) services from private businesses with the objective of stimulating prototyping and experimentation of new products and services not yet available in the market.[22] The rationale for this approach is that by acting as first buyer, public authorities can trigger the development of new and novel solutions to deliver more efficient and higher quality public services, address major economic, social and environmental challenges, whilst creating opportunities for local businesses to become leaders (domestically and internationally) in new markets. PCP is an approach to public procurement of R&D services that seeks to stimulate innovation and economic competitiveness by enabling the public sector to steer the development of new technological solutions directly towards identified strategic needs (eg. economic, environmental, social). Prototypes are developed, whether for a single or group of final users for experimentation and validation in a Living Lab environment. Public bodies buy R&D from several competing private sector suppliers in parallel to compare alternative solution approaches and identify the best value for money solutions that the market can deliver to address their needs. R&D is split into phases (solution design, prototyping, original development and validation/testing of a limited set of first products), and after each R&D phase, the number of competing/participating R&D firms is reduced.[23] A Living Lab is a real-life user-centred, open-innovation ecosystem (Almirall and Wareham, 2011), which seeks to promote and integrate R&D and innovation processes (Bilgram, Brem and Voigt , 2008), within a public-private-people partnership (Pallot, 2009). There are no fixed boundaries to the Living Lab. The lab could be a single building, a campus, a city or a wider region. It is up to partners to define the scope, aims, objectives, duration, partner role and physical/geographical boundaries of the Living Lab.[24] The approach supports the principle of Smart Specialisation,[25] a place-based approach which identifies strategic areas for public sector intervention based on evidence-based economic strengths (current and potential). Smart Specialisation

[22] https://s3platform.jrc.ec.europa.eu/documents/20182/84453/Regional+Innovation+Ecosystems/48ab5553-489b-4c41-89b4-5c897e3ef066.
[23] http://www.picse.eu/pre-commercial-procurement-pcp.
[24] https://fissacproject.eu/en/living-labs/.
[25] https://s3platform.jrc.ec.europa.eu/what-is-smart-specialisation-.

	involves an Entrepreneurial Discovery Process, under which participants from different environments (policy, business, academia) work together to identify R&D and other innovation-related priorities (Pose & Wilkie, 2017).
Spatial Scale	Aosta Valley has the lowest population density of any Italian region[26] (39 residents per km^2 in 2017, compared to 73 residents per km^2 in Cumbria and 484 residents per km^2 in Lancashire).[27] The region covers an area of 3,263 km^2 (slightly larger than Lancashire and just under half the size of Cumbria). The region's population in 2017 was estimated at 126,883 (compared to 498,400 in Cumbria and 1,490,500 in Lancashire). Aosta Town is the largest urban centre, with a population of 34,008. Aosta Valley annual GVA is around £3.4bn. The pilot scheme was funded by the EU Alcotra Italy-France 2007-2013 territorial cross-border cooperation programme, which included partner regions of Rhône-Alpes and Provence Alpes Côte d'Azur (both in France), Piedmont, Liguria and Turin (all Italy).[28] The programme sought to introduce an experimental element into these regions' innovation policies and actions.
Key Drivers of the Innovation Ecosystem	The project sought to create and develop a culture of collaboration and open innovation among the public sector, universities and private sector to enhance innovation capacity and capability, stimulate greater R&D activity and boost international competitiveness. Previously, regional public and private investment in R&D in Aosta Valley was very low compared with the Italian and European averages (just 0.57% of regional GDP in 2011 before the programme commenced).[29] By adopting pre-commercial procurement locally, public sector bodies can play the role of first buyer and acquire innovative prototypes at lower-than-market prices.[30]
Sectoral/ Technology Specialisation	Testoni and Boeri (2015) describe in detail the process by which innovation services were procured and new solutions developed and tested. The steps were: 1. Programme partners from across the whole Alcotra project area jointly identified via economic analyses two thematic areas which would be subject to an open call for ideas/tenders (to firms and research bodies): **Smart energy;** and **Intelligent mobility.** 2. Consultation with local public sector partners and local communities/stakeholders – including a survey to identify the needs and expectations of the local community, by consulting local public authorities and institutions (eg. schools, hospitals), civic bodies and community groups.[31] 3. A call for ideas from businesses, research bodies and universities to find possible innovative solutions to the identified challenges facing the Aosta Valley region. Following completion of the tendering process, successful suppliers had six

[26] https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/base-profile/aosta-valley.
[27] Data for UK are for 2017, provided by ONS.
[28] https://ec.europa.eu/regional_policy/en/atlas/programmes/2007-2013/crossborder/operational-programme-italy-france-alps-alcotra.
[29] https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/base-profile/aosta-valley.
[30] https://s3platform.jrc.ec.europa.eu/documents/20182/84453/Regional+Innovation+Ecosystems/48ab5553-489b-4c41-89b4-5c897e3ef066.
[31] https://s3platform.jrc.ec.europa.eu/documents/20182/84453/Regional+Innovation+Ecosystems/48ab5553-489b-4c41-89b4-5c897e3ef06

	months to undertake R&D and prototyping activities and a further six months to test the prototypes in a Living Lab setting. During 2012, the regional public authority awarded five contracts: • Two in Smart Energy (hydrogen energy back-up systems and school energy management systems) • Three in Intelligent Mobility (electric bike sharing, traffic control and management of tourism-related traffic) The prototypes developed were tested during 2013.
Key Innovation Actors	Fionda (2013) identified five key partners (or groups of partners involved in the programme: • **Region Aosta Valley:** the regional government managing the pre-commercial procurement process and the Living Lab • **Businesses.** SMEs taking part in the programme, undertaking innovation and R&D activities and developing prototypes to be "experimented, tested, improved and validated within the Living Lab" • **Universities and research centres**. Knowledge-based institutions (including the University of Valle d'Aosta and Polytechnic Institute of Turin) collaborating with private companies on R&D, innovation and product experimentation/testing • **Public sector end users.** Local authorities/councils, community organisation and other public bodies, such as schools, taking part in prototype testing. • **European Union.** Funding the pre-commercial procurement and Living Labs via the cross-border Alcotra Interreg programme
Outcomes and Impacts	Testoni and Boeri (2015) identified some broad positive impacts from the programme. They found that it had successfully fostered a multidisciplinary approach to the development of new technology solutions by bringing together partners with complementary skills and expertise, thereby creating new innovation ecosystems. The programme also stimulated participation among communities and parts of the public sector that had not previously been involved in innovation. It also stimulated cross-border strategic thinking and strengthened links between SMEs, universities and end users of technology solutions. Overall, the programme leveraged some 1.1m euros of private sector R&D, from a public investment of around 1.3m euros.[32] Clermont and Fionda (2016) identified the following programme achievements: • 7 new products/services in Smart Energies and Intelligent Mobility, with a direct impact on: • 11 business contractors, mostly SMEs; • 5 research centres participating in R&D projects • 6 co-operation initiatives between enterprises and research centres • 4 Living Labs • 120 high-school and university students participating in the Living Labs • 50 civil servants from the local authorities participating in the Living Labs.

[32] https://s3platform.jrc.ec.europa.eu/documents/20182/84453/Regional+Innovation+Ecosystems/48ab5553-489b-4c41-89b4-5c897e3ef066.

Success Factors	Clermont and Fionda (2016) identify five key factors that have fostered an increase in innovation in the Aosta Valley utilising the PCP/Living Labs approach: 1. **Clarity of scope of R&D.** Clearly defined, fundable R&D activities 2. **Risk sharing between partners.** Sharing of risks and benefits between public sector procurer and commercial enterprise 3. **Sound competitive process.** Open, competitive procurement process in line with State Aid requirements. 4. **Real-time lessons learnt.** Performance evaluation in real operational settings via the Living Labs 5. **Engaging public sector in innovation.** Early involvement of public sector authorities in the process of innovation.
Innovation Ecosystem Challenges	Capello[33] identified four main challenges that the scheme encountered: 1. **Management influence.** Project managers were recruited from outside the managing authority, who had limited ability to influence political decision makers and strategic decision making 2. **Mapping innovation actors and assets.** Insufficient time was given to identifying innovative actors in the region and the sectors chosen reflected top-down priorities. 3. **Securing stakeholder engagement.** Some stakeholders and SMEs in the region were unwilling to take part, 4. **Creating cohesive Living Labs.** It was hard to define a common set of tools to deploy across the living labs because partner regions had different levels of familiarity (or none at all in some cases) with either the concept of Living Labs or experience of working in them. A further challenge relates to internal capabilities. Delivery of PCP requires new competences and new processes to be embedded in the organisation. This, in turn, needs organisational development based on a clear strategic vision. Without long-term commitment, the inherent risk of innovation procurement are increased due to a lack of procurement expertise R&D intensity has increased in Aosta Valley since the introduction of the PCP/Living Lab experiment (although there is no quantitative evidence on the proportion of this increase that is attributable to the scheme). However, the region still underperforms the Italian average. By 2015 the total R&D expenditure was only 0.7% of the regional GDP, still well below the Italian (1.3%) and European average (2.0%).[34] Key wider challenges for policymakers and partners to address include: under-representation of employment in high technology sectors; low educational attainment; a proportionately low share of graduates in technical and scientific disciplines; under-representation in advanced manufacturing and high-value service sectors; fewer firms reporting “innovation activities” than the Italian average (40% versus 45%); and fewer enterprises reporting process and/or product innovation (28% vs 34% nationally).

[33] https://www.slideshare.net/construcaosustentavel/paola-capello-alcotra-innovazione.
[34] https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/base-profile/aosta-valley.

Key themes for further investigation in Cumbria and Lancashire	**Mitigating against sparsity.** To what extent can PCP/Living Labs help to overcome the rural/peripheral absence of agglomeration effects? **Leadership.** Which organisation(s) should manage/oversee the implementation of PCP/Living Labs type approaches? **Knowledge flows.** Can PCP/Living Labs help to increase connectivity and flows of knowledge in rural areas and between urban/rural locations? **Economic impact.** Are there certain conditions under which PCP/Living Labs provide an alternative to, or complementor to, other funded activities that seek to address both societal and economic challenges?

Appendix III – Boulder: An Innovation Ecosystem Case Study

Factor	Description
Location	Boulder is a city in the United States, in the north of the State of Colorado. It is located at the bottom of the Rocky Mountains, 25 miles northwest of Denver, the State's Capital and largest city.
Infrastructure Connections	Boulder is easily accessible by the US highway network. U.S. Highways 36 and 93 allow easy access to Colorado's major north-south (I-25) and east-west (I-70) interstates. Denver International, the US's fourth-largest airport, is the main passenger airport serving Boulder.[35]
Type of Innovation Ecosystem	Boulder has a varied innovation ecosystem in which entrepreneurs, large firms, universities and public R&D labs all play important roles. Whilst the growth of Boulder (US) as an innovation hub does not appear to have been the result of any highly orchestrated strategies or actions to create a culture of collaboration, a range of partners have had inter-related and complementary roles. Large technology firms, universities and a network of Federal R&D labs provided useful anchors for entrepreneurial activity, contributing to a high business start-up rates and a "dymanic entrepreneurial ecosystem".[36] Entrepreneurial ecosystems refer to the human, financial and professional resources and institutional environment which support and nurture new ventures in specific locations (Graham, 2014; Isenberg, 2010). In this respect, the growth of the Boulder economy and innovation ecosystem has followed a similar path to that of other renowned US centres of innovation, such as Silicon Valley or Greater Boston, neither of which were initially orchestrated, nor was there any obvious attempt to create a network of engaged stakeholders (Budden and Murray, 2019).[37] The authors did note that the more recent growth in the innovative biotech cluster in Greater Boston reflected was more strategically orchestrated. In recent years, there has also been a more strategic approach to ecosystem orchestration through the Boulder Economic Council,[38] the economic development arm of the local Chamber [of commerce].
Spatial Scale	The City of Boulder is the 11th largest municipal area in the State, with a population of around 107,125 in 2017[39], up from 97,385 in 2010 (10% increase), with the wider Boulder County being home to 322,514 residents. The city is 5,430 feet (1,655 m) above sea level. Boulder's population is equivalent to one-seventh of the population of Denver, which in 2017 was 704,621. Between 2010 and 2017, Denver's population grew by 17% (from 600,158), and it is currently the 12th largest US city. The City of Boulder's employment base of about 100,000 jobs is between two and three times larger than the vast majority of cities in United States of a similar population size.[40] Boulder County GDP in 2017 was around $25bn. Boulder is

[35] Boulder has a small airport, mainly used for recreational flying, rather than commercial passenger flights.
[36] https://issuu.com/boulderchamber/docs/innovation_venture_report_v26?e=33607933/61913820.
[37] Budden and Murray concluded that Silicon Valley "evolved from a confluence of actions, accidents and subsequently increasing returns over a period of many decades".
[38] http://boulderеconomiccouncil.org/.
[39] United States Census Bureau.
[40] https://issuu.com/boulderchamber/docs/innovation_venture_report_v26?e=33607933/61913820.

	home to the main campus of the University of Colorado, with around 35,000 students enrolled for the 2019 Fall Term.[41]
Key Drivers of the Innovation Ecosystem	For more than half a century, Boulder's high quality natural environment and quality of life has attracted many young, highly-educated entrepreneurs to move to Boulder and start up their own businesses. Boulder has been called a "creative class" city[42]. The city's development as a centre of innovation and R&D started in the 1950s when the city's residents raised funds to buy land on the edge of the city,[43] on which the National Institute of Standards and Technology (NIST) chose to locate a new laboratory. There are now some 17 federal R&D labs located in the City of Boulder, covering as wide range of scientific disciplines, including environmental sciences, telecoms and IT. These labs employ a high volume of high-skilled researchers. Between the 1960s and 1980s, the first wave of entrepreneurs moved to Boulder, attracted in part by the climate and lifestyle on offer. Computer storage was one of the key sectors for new businesses. Growth in this sector, combined with investment in Colorado's telecommunications infrastructure, helped to attract further high-skilled entrepreneurs and workers, and led to Boulder emerging as early leader in internet-oriented businesses in the 1990s. Since the mid-2000s, public and private partners have sought to support local entrepreneurs through Accelerator programmes. These programmes provide fast-growth start-ups with access to mentors, investors and other types of support) In addition, Boulder has benefitted from investment by major Silicon Valley-based IT firms. Google, Uber, and Twitter have all purchased Boulder-based start-ups, boosting the Boulder economy and enhancing the city's reputation as an innovative technology hub.
Sectoral/ Technology Specialisation	Boulder has been described as an "entrepreneurial powerhouse"[44], especially with regard to the technology sector. By 2010, the city had six times more high-tech start-ups per capita than the nation's average[45] and twice as many per capita as the next-best location, San Jose-Sunnyvale in California. Boulder also has a much more diverse industry base than is typically found in cities of this size and location (ie. just outside a much larger city). Major sectors include aerospace, bioscience, energy, IT-software, natural products, outdoor recreation). In terms of new starts, high-tech traded sectors (including manufacturing, IT, professional, scientific and technical services; and management of companies and enterprises, accounted for 43% of Boulder's new businesses between 2010 and 2016. [46]
Key Innovation	As noted, entrepreneurs, large firms, universities and public R&D labs all play important roles. Key actors are:

[41] https://public.tableau.com/views/alltotal/CampusTotal-Summary?%3AshowVizHome=no.
[42] This term was coined by Richard Florida in his 2002 book, *The Rise of the Creative Class*.
[43] https://www.atlanticcouncil.org/blogs/futuresource/boulder-colorado-innovation-in-a-small-town-and-a-big-state/.
[44] https://www.inc.com/magazine/201312/boulder-colorado-fast-growing-business.html.
[45] https://www.kauffman.org/-/media/kauffman_org/research-reports-and-covers/2013/08/bdstechstartsreport.pdf.
[46] https://issuu.com/boulderchamber/docs/innovation_venture_report_v26?e=33607933/61913820.

Actors	• **University of Colorado.** The main campus of the University of Colorado is located in Boulder. A source of spin outs and high-skilled employment. • **Major technology-based employers.** IBM has a large presence in the area, with several thousand employees working in Boulder. Other tech companies with operations in the region include Oracle and Seagate Technologies. • **Boulder Economic Council.** The economic development arm of the **Boulder Chamber of Commerce**. • **City of Boulder Council.** Local authority, which has developed an Economic Vitality Strategy to promote innovation, competitiveness and entrepreneurship in Boulder, supporting the Boulder Chamber and Economic Council • **Federal R&D Centres.** Boulder has 17 federally funded R&D labs[47] key sources of innovation, R&D and high-skilled STEM (science, technology, engineering and maths) jobs. • **Entrepreneurs.** Boulder has a high business start-up rate, especially in the technology sector, and many long-standing business owners with strong commitment to the city • **Risk Capital.** Venture capitalists and private sector Accelerators.
Outcomes and Impacts	Boulder performs very strongly on a range of innovation and entrepreneurial indicators. It is not possible to attribute the impact of any one initiative or partner. It is the richness of the innovation ecosystem and inter-related activities that together generate a strong economic performance. Some key features are[48]: • Over 60% of residents in the Boulder metropolitan area have a degree (higher than any of the peer communities and one of the highest rates anywhere in the US). • The City of Boulder's employment jobs density (employment as a proportion of the resident population) is two-to-three times larger than those of peer communities • A high concentration of Science, Technology Engineering and Math (STEM) occupations (15%, some 2.5 times the US average and second of all the peer communities) • Since 2012, 41% of all venture capital funding in Colorado was invested in Boulder start-ups. • Boulder has the second-highest per capita levels of venture capital investment of peer communities.
Success Factors	Feld (2012) put forward the "Boulder Hypothesis", identifying four key characteristics of the city's start-up ecosystem, which have driven Boulder's economic success and its record of collaboration and innovation: 1. **Lead role for Entrepreneurs.** Entrepreneurs play the lead role in setting the economic agenda and in ecosystem building (Feld describes entrepreneurs as "leaders on the frontlines").

[47] Eleven main labs and six labs which are subsidiaries.

[48] All these metrics are contained in the Boulder Innovation Venture report.

	2. **Leaders embedded in the community**. Long-term commitment of entrepreneurs and business owners who have run businesses in Boulder for many years, who understand the local area (economy, people, priorities) and are well known and trusted 3. **Strong support from government to create the conditions for innovation.** High levels of commitment from government (described by Feld as "feeders" who "set the table" and create the conditions in which innovation can thrive). 4. **Inclusive.** All partners/individuals who wish to be part of the innovation ecosystem can do so, and high quality partner events are held to engage people. 5. **Private funders.** Boulder has a vibrant, risk-taking community of venture capitalists and accelerators. Feld's analysis represented a challenge to the "helix" model, which emphasises the importance of public authorities, universities and industry in ecosystem orchestration. However, Feld's analysis arguably downplays the role of government, as well as universities and large firms. 'Feeders' is a simplification of the key role played by the providers of both human capital and knowledge, both of which are essential to the growth of a knowledge ecosystem. Having a rich knowledge and skills resource base across the universities, federal R&D labs and large technology companies provides the vital ingredients for entrepreneurial activity. In other words, there is a rich knowledge ecosystem within which entrepreneurs can operate. When the knowledge ecosystem is non-competitive, as it would be with labs and universities, these provide useful anchors for entrepreneurial activity
Innovation Ecosystem Challenges	The rapid growth Boulder has experienced is beginning to put a strain on the city's infrastructure. Whilst growth in in-town traffic has remained broadly unchanged over the past 15 years due to a range of green transport options and initiatives, commuter traffic has increased by 35% during the same period. This presents environmental and health challenges, as well as economic challenges congestion presents. In addition, there is a lack of grow-on space for businesses. Denver is becoming a destination for companies looking to expand beyond a small size, due to a lack of grow-on space in Boulder. Denver has greater availability and also lower housing costs, and is rapidly becoming a scaling hub where Boulder start-ups move. However, rather than viewing Denver as a potential threat to the continued economic success of Boulder, partners are seeking to strengthen the links, with Denver providing Boulder firms with an access to infrastructure that more remote cities of a similar size would not have and being viewed as a "landing pad" for successful Boulder firms. The city's innovation partners are seeking to strengthen the links between Boulder and Denver, and to involve the state universities and federal laboratories in the entrepreneurial and innovation ecosystems. To date, the University of Colorado, Boulder, has not been a major source of start-ups. The university is seeking to develop closer relationships with existing organizations such as the Innovation Center of the Rockies, which provides support for research commercialisation and technology transfer. The university has established stronger ties with local federal laboratories through joint research institutes.

	In 2018, Boulder joined the 2018 Start-up in Residence (STiR) programme, as part of a national roll-out of a programme launched in California in 2014. The programme seeks to make it easier for technology entrepreneurs to work with government and to provide government with access new, innovative technology-based solutions to policy challenges. STiR seeks to provide a bridge between entrepreneurs. STiR publishes a list of "government challenges", which start-ups are able to bid for, with successful bidders embedded within public agencies they are working with.
Key themes for further investigation in Cumbria and Lancashire	**Role of entrepreneurs.** Is it possible to create a truly entrepreneur-driven innovation ecosystem? **Links between entrepreneurial and innovation ecosystems.** What are the interactions between entrepreneurial ecosystems in which new businesses are launched and the innovation ecosystem in which they operate? **Leadership.** Which organisation(s) should lead innovation ecosystems and under what conditions? **Partners.** Which partners need to be involved in the innovation ecosystem to ensure ecosystem growth? **Sustainability.** To what extent can innovation ecosystems be made self-sustaining, and what underpinning factors and infrastructure are necessary.