



INNOVATION &
RESEARCH
CAUCUS

Understanding Geographies of Innovation:

Research agglomerations, knowledge networks,
and implications for place-based innovation.

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About the Innovation and Research Caucus

The Innovation and Research Caucus supports the use of robust evidence and insights in UKRI's strategies and investments, as well as undertaking a co-produced programme of research. Our members are leading academics from across the social sciences, other disciplines and sectors, who are engaged in different aspects of innovation and research system. We connect academic experts, UKRI, Innovate UK and the Economic and Social Research Council (ESRC), by providing research insights to inform policy and practice. Professor Tim Vorley and Professor Stephen Roper are Co-Directors. The Innovation and Research Caucus is funded by UKRI via the Economic and Social Research Council (ESRC) and Innovate UK, grant number ES/X010759/1. The support of the funders is acknowledged. The views expressed in this piece are those of the authors and do not necessarily represent those of the funders.

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Executive summary

Background

This project aims to contribute to our understanding of place-based innovation by exploring localised and system-level innovation dynamics in the UK. Recent research, such as the Innovation Cluster Map (DSIT 2024), focuses on local dynamics, mapping clusters of business activity. However, maps such as these only show one part of a complex and not entirely localised innovation system. This project builds an additional layer to the cluster map by exploring the relationship between concentrations of business activities and other parts of the system that underpin them.

This project maps research, innovation projects, commercialisation activities, and related support infrastructures relative to clusters of businesses to explore how knowledge might flow from research assets to commercial applications within specific places. This helps build a *localised* picture of the collocation of innovation activities at different points of the value chain. A study of a selection of knowledge networks provides a vantage point on the relationship between places to better understand *system*-level implications and impacts of place-based investments at different value chain stages.

Situating localised specialisms within broader knowledge and innovation systems adds nuance to the contention inherent in clustering and place-based innovation literature that concentrations of activities (e.g., research) generate localised spillovers that confer specific advantages to stakeholders in those places. This relational approach proves that spillovers and knowledge diffusion are not exclusively and may not even be mainly localised. This raises questions and suggests future research pathways on place-based innovation support policies.

Approach and Case Selection

- » We evaluate place-based innovation activities using an encompassing clustering approach. This method allows us to examine how activities are co-located geographically, their functional relationships within the innovation value chain, and the potential institutional linkages between localised research and innovation actors.
- » Unlike traditional analyses, focusing on employment concentration and business units in specific sectors, our approach considers broader spans across administrative locations and aspects of the innovation value chain.
- » The study focuses on (non-health) engineering biology, identified as a critical technology in the [UK Science and Technology Framework](#). It analyses four data sources with geo-located data covering information on academic publications, publicly funded projects, patents, and business activities. This helps identify research, development, and commercialisation hotspots, and the corresponding infrastructure supporting these activities.
- » The research maps the UK's engineering biology business clusters by considering their internal characteristics and their connections to other business activities or technologies¹. It also explores the relationships between locations with high levels of engineering biology

¹ Business clusters were identified using Real Time Industrial Classifications (RTICs) in collaboration with The Data City Ltd.

activity through a network analysis of co-authorship networks and publicly funded project participants (proxied by Innovate UK funded projects database), highlighting collaboration in research and knowledge production, as well as in the development phases of innovation.

- » This holistic approach aims to provide insights into how place-based innovation can be embedded, generate knowledge flows, and operate within broader collaboration networks. It offers recommendations for achieving balanced economic benefits from innovation activities across the national engineering biology ecosystem.

Findings

The findings highlight that business activities tend to be localised and are often collocated with other activities (such as research and innovation projects). While this research does not explore the relationship between those activities across the value chain, it does explore how they unfold over different geographies. Rather than being geographically restricted, innovation activities take place through multiple pathways and network relationships across geographical boundaries. We build this argument by mapping and analysing hotspots, business cluster locations, characteristics, and knowledge networks.

Research, innovation projects, and commercialisation hotspots

- » Every UK region has non-health engineering biology research, innovation, or commercialisation expertise.
- » Non-health engineering and other main biology hotspots tend to collocate.
- » While hotspots generally cooccur with the commercialisation infrastructure support for engineering biology, causation is unclear; for example, some hotspots, such as those in Northern Ireland, the South West, and eastern Scotland, lack nearby infrastructure.
- » The commercialisation infrastructure types differ across the country; some areas, like Cambridge, Norwich, and Manchester, have a range of infrastructures supporting various stages or types of innovation activity, while others have infrastructure limited to specific types of activities.
- » Distribution reflects a diversity of regional strengths or specialisations (e.g., research-focused hotspot in Newcastle or commercial-focused hotspot in Oxford). Future research may further explore these spatial distributions.

Business cluster location

- » Our analysis identifies eight engineering biology business clusters across the UK.
- » Non-health engineering biology business clusters vary in size and scale. While Oxford hosts two small business clusters, the largest business cluster links the geographies of Manchester, Birmingham, and Swindon.
- » Business clusters and areas of research and commercialisation excellence tend to be geographically collocated, but spatial overlaps are not perfect.
- » There were some cases with significant non-health engineering biology research and commercialisation activity in Norwich and Bristol without a corresponding business cluster. This could be because those clusters are still emerging and host too few businesses that

meet our criteria for inclusion. Currently, non-health accounts for a minority of engineering biology business activity in those places.

Business cluster characteristics

- » Localised business clusters are composed of businesses with multiple technological activities (identified through RTICs), indicating distinctive specialisms. Examples include:
 - Oxford clusters: life sciences, omics, net zero, and clean tech.
 - Cambridge cluster: health-related technologies like biopharmaceuticals, pharma, and AI.
- » Larger clusters might indicate the presence of specialised subclusters due to their diverse composition.
- » Word clouds show clusters' distinct orientations. For example, Oxford clusters focus on environment and sustainability, with digital keywords like "platforms" and "machine learning." London, Manchester, and Cambridge clusters highlight "manufacturing," suggesting a focus on engineering biology production activities.

Knowledge networks

- » Exploring knowledge networks can help us understand how and where knowledge that fuels innovation is generated.
- » Different engineering biology research collaborations across the UK are seen in co-authorship (university-based) relative to Innovate UK projects (wider variety, including private sector).
- » We find evidence of internal collaboration in both non-health engineering biology publications and Innovate UK projects, but external collaborative relationships dwarf this.
- » Significant regional variations exist in intraregional (internal) vs. interregional (external) collaboration in non-health engineering biology applications. Places with large research universities have lower (but still significant) external collaboration rates. In contrast, places like Doncaster, Blackpool and Shetland have high external co-authorship and partnership networks in Innovate UK projects.
- » Innovate UK projects have higher external collaboration rates (an average of 94% of external to total dyadic collaborations vs. 68% for publications), partly supported by programmes that enable places to collaborate with peers.
- » While we did not analyse supply chain relationships or interfirm innovation partnerships, we expect that these are similarly distributed.
- » These findings do not challenge the idea that localised relationships are important for cluster formation but emphasise that these occur within a context of extensive intra-regional knowledge flows.

Discussion and insights

The project explores two approaches analysed in place-based innovation policy: optimising localised innovation benefits and maximising system-wide innovation. Our key findings indicate that the

identified patterns in non-health engineering biology innovation show that the spatial distribution of innovation activities around these applications is linked to the location of business clustering and support infrastructures across the country.

- » There is a high spatial concentration of academic research, innovation project grant funding and commercialisation activities in regions with substantial support infrastructure.
- » We found significant interregional collaboration in research networks embedded in academic co-authorship, patenting and innovation grant funding. This means that investments in specific locations can create spatial spillover effects, benefiting other hubs (nodes) in the knowledge network and suggesting potential broader impacts beyond local and neighbouring areas.
- » Our study emphasises the role of place-based strategies given the singularity of the clusters and relationships created between them. However, it is also essential to consider place-based investment strategies around infrastructures and support for research collaboration networks in emerging sectors to enhance regional innovation capacity and localised economic growth.

Our results raise some questions that may be useful in designing the next generation of place-based innovation strategies.

Should we update assumptions about expected impacts from place-based investments? The research revealed a (not unexpected) relationship between research and commercialisation activities and clusters of engineering biology firms. However, much remains to be learned about how these activities influence and interact with each other to support policy goals and missions such as place-based innovation and growth.

How can we encourage collaboration to promote intraregional and interregional spillovers? Our results suggest that opportunities to better connect knowledge and innovation activities across different clusters by understanding their positions within value chains. For example, places specialising in research and development activities may benefit from being connected to those with strong manufacturing bases and capabilities, and vice versa.

What else can we learn about the relationship between innovation infrastructure investment and place-based outcomes? The relatively high correlation between hotspots and infrastructure suggests that infrastructure was developed in places demonstrating research to commercialisation capacity. However, questions remain regarding how much those investments have acted as multipliers for these activities.

How do these insights help to support local commercialisation better? Given their importance, there is an opportunity to invest in infrastructure that supports the commercialisation of place-based research. This includes the creation of incubators, accelerators, and innovation hubs tailored to the needs of local business clusters and localised research activities.

1. Introduction

This research was commissioned to build on recent work on place-based innovation, offering a more rounded perspective on localised innovation dynamics. The Department for Science, Innovation, and Technology (DSIT) recently released the Innovation Cluster Map (DSIT 2024). This interactive tool enables users to explore the geography of business clustering² in various sectors, with associated data about size, turnover, and investment. Around the same time, the Innovation and Research Caucus (IRC) began working with Innovate UK to understand the landscape of commercialisation infrastructure³ for non-health applications of engineering biology in the UK, to identify the gaps in provision, and to provide recommendations relating to investments in new infrastructure or strategies to maximise the value generated from using and exploiting existing infrastructures across the country (Jibril et al., 2024).

These DSIT and IRC projects explore different aspects of localised innovation systems, focusing on the location of business activities and interrogating the infrastructural underpinnings of innovation translation activities. When considered together, they provide empirical evidence that enhances our understanding of how the co-location of businesses and business-support infrastructures boost the knowledge base and contribute to the refinement of place-based strategies.

While these accounts clearly focus on business and business support activities, there is an opportunity to connect these insights to the research and early-stage development landscape to develop a fuller picture of the relationship between knowledge generation and commercial activities in places. To this end, this project maps research, innovation projects, and commercialisation activities relative to clusters of businesses and related support infrastructures to understand better how knowledge might flow from research assets to commercial applications within specific places. A study of a selection of knowledge networks also enables us to move towards understanding the *relationship between places* to better understand the implications and impacts of place-based investments at different stages of the value chain.

Doing so adds nuance to the contention inherent in clustering and place-based innovation literature that concentrations of activities (e.g., research) generate localised spillovers that confer specific advantages to stakeholders in those places. This relational approach offers evidence that spillovers and knowledge diffusion are not exclusively and may not even be mostly localised. Places are not silos or closed systems. Rather, they sit within extensive collaboration networks that offer insights into knowledge flows and innovation dynamics when mapped.

This exploratory research illustrates the value of simultaneously considering localised and systemic spillovers in developing place-based innovation strategies.

² Concentration of related firms that cooperate as well as compete in a geographical area (Porter, 1998).

³ Our definition of infrastructure includes both open-access physical assets and 'soft' infrastructure. The latter incorporates institutions and organisations that provide resources, services and networks which support innovation and commercialisation (Jibril et al., 2023).

1.1 Research questions

This project investigates the following questions:

- » Is there evidence of a spatial concentration of research activities in the UK?
- » To what extent are research activities co-located in areas with a critical mass of commercial activity (e.g., clusters)? Are there places with high levels of research activity that do not have business clusters (or vice versa)?
- » How does adopting a systems perspective enhance our understanding of the role of research hotspots within knowledge networks?
- » What implications do these factors have for innovation strategy and investment?

Questions related to the project that were not addressed in this present report include, among others, the specific causal relationships between research hotspots on local clustering and economic growth, quantifying the multiplier effects of UKRI investments in specific places beyond their immediate boundaries (see Ma et al. 2024), and positional analysis of the nodes in knowledge networks.

1.2 Approach

To evaluate place-based innovation activity, we take the cluster approach defined by Michael Porter (1998). We consider that place-based innovation should be analysed by looking into (1) how activities co-locate geographically, (2) their potential functional relationships across the innovation value chain, and (3) the presence of (institutional) linkages between businesses, governmental organisations and higher education institutions.

Much of earlier work in this arena has mainly focused on identifying the concentration of employment and business units in particular administrative areas and officially defined sectors (SIC codes) without considering innovation activities' potential to span administrative locations and industrial value chain segments. The pure industrial location analytical work also downplays some of the localised innovation component, which spans beyond the private sector activity and can be the catalyst for the co-location of research and innovation (i.e., localised scientific production). Our approach uses business activity-level analyses. Therefore, we do not need to pre-establish a particular geographical segmentation; we can identify patterns of firm activity co-location without being confined or delimited within the borders of discrete administrative units (Simpson 2007)⁴.

In addition to identifying clusters, we analyse research and innovation excellence hotspots and their intraregional and interregional relationships to evaluate how spatially connected the innovation system is. Finally, we explore the potential co-location of business, research and innovation activities and their related support (i.e., innovation projects or infrastructure).

To address our research, we focus on a specific sector: engineering biology. This sector was chosen because it was identified as one of the UK's five critical technologies featured in the UK Science and Technology Framework (DSIT 2023). Additionally, it was the subject of a recent IRC report on the

⁴ Our approach is in line with the green paper of the UK Industrial Strategy of considering industrial analyses beyond the traditional SIC codes (UK Government, 2024).

role of commercialisation infrastructure (Jibril et al. 2024). Following the example of the IRC report, we focus on non-health engineering biology activities. This focus allows us to incorporate infrastructure data into our study, build on previous work, and explore a sector that team members have researched previously. While our data focuses on engineering biology as an example, this report aims to draw out lessons likely to hold across sectors and to develop a methodological framework that can be used in other sectors or technological contexts.

First, we identify research, development, and commercialisation hotspots by analysing three data sources: academic publications, publicly funded innovation projects proxied by Innovate UK-funded (IUK) projects, and patents. This rigorous process enables us to identify areas with high concentrations of research, development, and commercialisation activities in the UK, pinpointing top-performing locations and situating the relevant commercialisation infrastructures around them. These are outlined in section 3.

Secondly, we take the identified engineering biology business clusters discussed above (section 4) and map them in relation to the hotspots and support infrastructure outlined in section 3. In section 5, we add nuance to this map by examining the internal characteristics of each cluster, focusing on their overlap or connections to other sectors and highlighting keywords relevant to the businesses operating within these clusters. This approach enables us to differentiate between the clusters and may facilitate the exploration of thematic alignments between research and economic activities. Sections 3 to 5 provide insights into the geographies of innovation in engineering biology. In section 6, we explore the relationships among these geographies. This section includes a network analysis of co-authorship collaborations, participants involved' locations in IUK funded projects to explore how people connect and work together in research and knowledge production.

1.3 Contribution, findings and implications

In this project, we contribute to the literature on the geography of innovation by simultaneously exploring two fundamentally different approaches: (1) encouraging the optimal distribution of benefits from localised innovation activity and (2) maximising system-wide innovation (Shearmur et al., 2016).

Our findings reveal some interesting patterns in the geographies of engineering biology innovation, allowing us to formulate hypotheses about how knowledge networks influence place-based innovation and local development in other industries and contexts.

The findings suggest that the spatial distribution of innovation and research activities is linked to the geographic clustering of business activities and related support infrastructures. The study identifies eight clusters of non-health engineering biology across the country using industry clustering techniques and data from web scraping. These clusters vary in location, size, business innovation potential, and value chain specialisation. Larger clusters, such as those in Oxford and London, may consist of sub-clusters due to their size.

The analysis reveals a high spatial concentration of research, innovation projects, and commercialisation activities in non-health engineering biology. Places excelling in these areas tend to have more significant commercialisation-supporting infrastructure, indicating that areas with strong research and innovation activities are also active in related commercial activities. Every

region in the UK appears to have the expertise and potential to compete in these emerging activities. Still, the most productive areas in research and innovation are those with substantial commercialisation infrastructure.

This raises important questions about place-based innovation policies in the UK, particularly concerning the expected or predicted local impact of innovation investment. By adopting a systems approach – understanding how innovative locations fit into and contribute to knowledge networks – it seems likely that investments in particular places can create spillover and multiplier effects, fuelling innovation at other nodes within these networks. As a result, existing analyses of the local impacts of innovation investments may overlook the benefits that emerge from network relationships in different places.

Additionally, our findings offer some insights regarding the “stickiness” of investments at various points along knowledge and value chains. For instance, our analysis shows a higher degree of interlocal collaboration within research networks, as evidenced by co-authorship, but a much higher degree of external collaboration in innovation projects.

Overall, the study emphasises the importance of both localised and systemic approaches to place-based innovation strategies and the critical role of infrastructure in supporting emerging sectors. It provides valuable insights into how different places can enhance innovation capacity and economic growth through strategic investments in research collaboration with partners outside their immediate areas, developing and enhancing access to innovation infrastructure, and business support.

2. Methods

This report provides a series of nested descriptions that outline the geography of non-health engineering biology innovation. By examining how different activities relate, we define the boundaries of innovation hotspots based on the concentration of activities. We also infer how their co-location may influence localised economic growth and development. Crucially, we do not make any claims of the causality of these processes. Although the proximity of activities might suggest causal relationships, our analysis does not confirm such links. Instead, this study pulls together the building blocks for future analyses and draws out some suggestions for policy implications and research directions.

Sections 3 to 6 present our analytical findings. Each section addresses one of the research questions (see Figure 1) and briefly outlines the objective of the analysis, specifies the data used, summarises the findings, and suggests associated policy implications. The discussion and recommendation section synthesises the findings across these sections and focuses on actionable insights. Since each section includes a detailed discussion of methodological approaches and data used, the remainder of this section will elaborate on case and data selection.

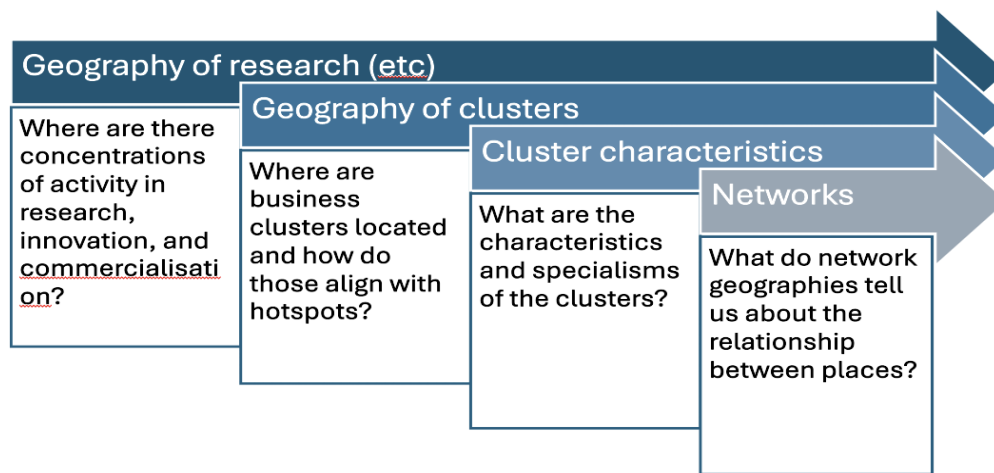


Figure 1: Analytical framework

2.1 Case selection: Non-health engineering biology

Engineering Biology is ‘the application of rigorous engineering principles to the design of biological systems, with the objective of contributing to economic activity and sustainable and resource-efficient solutions to the societal challenges faced in food, chemicals, materials, water, energy, health and environmental protection.’ (Royal Academy of Engineering, 2019, p.3). Engineering biology was one of five priority technologies identified by the UK Government in its 2023 Science and Technology framework, with the Department for Science, Innovation and Technology pledging £2bn in 2023 to support the sector over the coming decade (DSIT 2023).

The UK has made significant early investments in foundational engineering biology research and is now recognised as a global leader in this field. It ranks second only to the US in terms of recorded research output and research grant investment worldwide (CST 2023). The UK has also been relatively successful in translating and commercialising applications of engineering biology research, particularly in relation to human health. For example, advancements in these areas were instrumental in enabling the speedy development and deployment of Oxford-AstraZeneca’s Covid-19 vaccine in 2020.

Despite possessing similar research strengths in the non-health applications of engineering biology, the UK has generally been less successful in translating these strengths into successful commercial outcomes. This has been attributed to various factors, including regulatory uncertainty, insufficient access to scale-up infrastructure, and challenges in attracting investment due to inadequate or impatient venture capital funding (Jibril et al., 2024). Understanding the routes to successful knowledge integration and eventual commercialisation is important because, over the next decade,

non-health applications of engineering biology have the potential to deliver greater commercial value globally relative to human health applications (McKinsey Global Institute, 2020).

Therefore, engineering biology, particularly its non-health component, serves as an ideal case study for exploring the geographies of innovation. It allows us to identify and trace geographical hotspots across the entire spectrum of innovation activities, from foundational research to commercialisation. By building on previous research that mapped out the geographical landscape of research, development and commercialisation infrastructure for non-health engineering biology applications (Jibril et al., 2024), we can gain deeper insights into the dynamics of the UK's knowledge and innovation landscape.

2.2 Data sets and methodological notes

We conducted a detailed investigation of our research questions using various data sets that comprehensively represent research, innovation, and commercialisation activities. These datasets also include information on infrastructure and patterns of business clustering (see Figure 2). We focused on selected data that effectively acted as reasonable proxies or indicators for these specific activities, acknowledging that each has drawbacks. We also incorporated spatial information to determine geolocation. Several datasets also include relational information that was used in our network analysis to uncover connections and relationships within the landscape of research and innovation activities.



Figure 2: Key datasets used in mapping exercises

2.2.1 Research, innovation projects, and commercialisation in non-health engineering biology

We use the terms “research, innovation, and commercialisation” to describe a bundle of activities that typically occur upstream in knowledge and value chains. In this context, we differentiate between academic research, collaborative innovation projects involving universities, public research organisations (PROs), and/or businesses of a more applied nature, as well as commercialisation activities in which innovations are prepared for the market. We used the following datasets as indicators for these activities:

Publications: We retrieved publications from UK affiliations from the Web of Science (WoS) covering five years from 2019 to 2023. We searched in the *Title*, *Abstract*, and *Keywords* fields using the same engineering biology keywords as in the report of Jibril et al. (2024) (see Appendix A). Our dataset includes 78,823 publications, of which 5,872 are classified as non-health and health engineering biology. In total, 189,019 unique authors contributed to the overall publications. Researchers at academic institutions largely authored these publications, although 29% of authors have affiliations outside academia.

IUK-funded projects: We downloaded all the Innovate UK-funded projects (UKRI, 2024a) from the UKRI website. Then, using the keyword list from Appendix A, we searched in the *Project Title*, *Public Description*, and *Public Summary* of projects whose *Project Start Date* was between 2019 and 2023. While data on the whole population of UKRI-funded projects is available online at the Gateway to Research (GtR) portal (UKRI, 2024b), we opted to use the IUK dataset because it had complete and more reliable spatial and relational data. The GtR data lacks analytical spatial information (such as postcodes). The IUK dataset contains information about 3,343 projects, of which 455 were categorised as non-health and health Engineering Biology. In total, 4,575 unique organisations participated in this set of projects.

Patents: Although patents may not perfectly measure the commercialisation of innovations, they are probably the most frequently used indicator of technology output. Patents cover a broad range of technologies and provide valuable detailed information, including important spatial and temporal coverage. Additionally, as an input to innovation, they are closely linked to innovative products and services, even though not all innovations derive from patents. In contrast, not all patents are used for industrial or commercial purposes (OECD, 2009).

Initially, we identified non-health engineering biology patents published between 2019 and 2023, with at least one applicant from the UK. This was done by searching the *Title*, *Abstract*, and *Claims* fields within the Espacenet portal, using the same keyword list as the previous data sources (European Patent Office, 2024). However, since Espacenet did not provide the applicants' spatial information (e.g., postcode), we had to match the patents exported from Espacenet with those included in the OECD's REGPAT database (OECD, 2024). This database contains applicants' data with spatial information, including postcode, even though we could match only a subset of the patents found in Espacenet (around 40%).

Of 1,227 matching patents, we classified 617 as non-health engineering biology patents. Overall, we found 588 unique organisations listed as applicants for the patents.

2.2.2 Infrastructure

We base our identification of innovation and commercialisation infrastructure on Jibril et al.'s (2024) previous work built on an infrastructure framework developed by Jibril et al. (2023). Our definition of this support infrastructure includes both open-access physical assets and 'soft' infrastructure. The latter incorporates institutions and organisations that provide resources, services and networks that support innovation and commercialisation.

For emerging technologies such as engineering biology, the research and commercialisation value chain can be divided into several stages: early-stage research, industrial translation, demonstration, commercialisation of new products and scaling up. Both physical and soft infrastructure can support different stages of the innovation and commercialisation processes (see Jibril et al., 2023).

To reflect the various types of organisations supporting engineering biology in the UK, we categorised soft infrastructure into three broad categories and physical infrastructure into four categories, each aligned with different Technology Readiness levels (see Table 1).

Table 1: Categories and Definitions of Innovation and Commercialisation Infrastructure

Soft Infrastructure	Physical infrastructure
Research and Innovation Ecosystem Enabling Organisations (EEOS), e.g., DSIT, UKRI, Innovate UK	Research and Translation (R&T) infrastructure, supporting basic research and proof of concepts (TRL1-TRL 3)
Strategic Coordinating Organisations (SCOs), e.g., Knowledge Transfer Networks (Business Connect)	Translation and Demonstration (T&D) infrastructure, supporting prototype development (up to TRL 5),
Industry and Research Networks, e.g. industry associations	Demonstration and Commercialisation (D&C) infrastructure are larger scale facilities, supporting pilot scale activity (up to TRL 9)
	Commercialisation and Scale-up (C&S-up) facilities, supporting commercial scale production.

Source: Adapted from Jibril et al. (2024)

Engineering biology infrastructure organisations were identified by searching the UK and international repositories of engineering biology facilities. We reviewed previous government and other stakeholder reports on engineering biology and consulted with numerous stakeholders (Jibril et al., 2024). For data on physical infrastructure, we additionally gathered information from the following sources: i) Capacitor, a directory of global fermentation facilities; ii) Pilots4U, a European database of biotechnology semi-pilot, pilot and demonstration scale facilities; and iii) Infraportal, a UK database for research and innovation infrastructure.

2.2.3 Clusters

This report uses non-health engineering biology businesses listed in The Data City's database to construct business clusters using a methodology similar to that used in the DSIT cluster mapping project. We define a business cluster as a geographically localised group of firms performing activities with similar technological, skills, and innovation bases.

2.2.3.1 Identification of engineering biology businesses

Identifying engineering biology businesses in the UK using standard industry classifications is challenging, as engineering biology serves as a platform technology with applications spanning multiple sectors and continuously evolving application areas. Below, we outline our methodology for identifying these firms and analysing the UK non-health engineering biology business landscape.

As previously discussed, our focus is on non-medical engineering biology applications, i.e., in the areas of agri-food, chemicals, materials, and the environment. These are areas in which the UK has existing strengths or key potential for commercialisation and which align broadly with three of the Four Missions outlined in the *National Engineering Biology Programme* (NEBP): Food Systems, Clean Growth, and Environmental Solutions⁵ (see Annex 1 in Jibril et al., 2024 for a detailed background to the choice of these applications). To identify engineering biology companies, we collaborated with the UK Department for Science, Innovation, and Technology (DSIT) and The Data City, a commercial data provider. The Data City employs web scraping and machine learning algorithms to create Real-Time Industrial Classifications (RTICs) that serve to group companies based on their activities and technologies as described on their websites. The taxonomies and keywords for identifying engineering biology companies were developed by DSIT's Engineering Biology team and included input from scientific experts and various government stakeholders. In July and August 2023, IRC and The Data City created a bespoke Engineering Biology RTIC. They searched through 1.7 million UK businesses from Companies House, resulting in an initial list of about 21,000 companies. Following thorough manual checks, the final RTIC identified 1,744 companies. Among these, 86 were categorised within the defined engineering biology application areas, and an additional 14 were sourced from the Bio-Industry Association's 2022 directory. This combined effort resulted in a total of 100 companies for our analysis.

2.2.3.2. Identification of spatial clusters

Our geographical cluster exercise aims to identify concentrations of non-health engineering biology applications in certain areas of the UK. The analysis uses the HDBSCAN technique, a clustering algorithm well-suited for varying densities of geographical distributions. This method effectively identifies both dense clusters, like those in London, and more dispersed clusters, overcoming the limitations of other techniques that usually highlight dense urban areas due to their socio-economic networks.

HDBSCAN is a clustering algorithm developed by Campello, Moulavi, and Sander (2013). It stands for "**Hierarchical Density-Based Spatial Clustering of Applications with Noise.**" It is designed to identify clusters of varying shapes and densities, making it particularly effective for analysing complex systems.

One of the key advantages of HDBSCAN is that it does not require users to specify the number of clusters in advance. Instead, it builds a hierarchical structure and applies cluster similarity (stability-based) techniques to extract the most meaningful clusters. In simple terms, like density-based

⁵ Recent reports have identified key UK strengths or potential in Agriculture and Food (EBLC, 2021, CIIP, 2023), Chemicals and Materials (EBLC, 2021, CST, 2023), and Biofuels and Renewables (environment) (CST, 2023)

algorithms, this technique identifies concentrations of points (in this case, engineering biology businesses) within the data. Then it uses a hierarchical approach to determine whether to subdivide a cluster into its subclusters or keep them whole.⁶ This makes HDBSCAN highly adaptable and capable of handling datasets with clusters of a variety of sizes and business densities. Its ability to identify patterns in real-world data without strict assumptions about cluster structure makes it a robust and reliable clustering tool for various domains.

Using these five different data sources, we were able to conduct our cascading analysis. First, we identified research, innovation project, and commercialisation hotspots and their alignment with support infrastructure (section 3). Then, we mapped business clusters and considered these geographies relative to hotspots (section 4). We further analysed the characteristics of those clusters (section 5) before exploring a selection of knowledge network geographies (section 6).

⁶ For a more detailed explanation of this process see Berba (2020).

3. Research, innovation project, and commercialisation hotspots

Every region has a non-health engineering biology hotspot and supportive commercialisation infrastructure.

3.1 Objective

A first step in understanding ‘geographies of innovation’ involves identifying where key research and development activities are taking place. In this section, we aim to analyse the locations of research, innovation projects, and commercialisation in non-health engineering biology in the UK. The places mapped in Figure 3 exhibit a high concentration of all three metrics. Using three different indicators of knowledge generation at varying stages of the value chain enables us to capture places of interest where significant spillovers might occur more confidently. This approach also helps account for time lags. Additionally, the map illustrates the location of commercialisation infrastructure, allowing us to explore the relationship between innovation support and research, innovation projects, and commercialisation activities.

3.2. Data used

We used a keyword list (see Appendix A) for all of the following metrics to identify relevant data. For instance, we used the identified non-health publications listed in Web of Science 2019-2023 as our proxy for research activity (see [section 2.2.1](#) for details about this dataset). This dataset predominantly captures academic articles produced by university researchers and public research organisations, although it occasionally includes authors from industry. This should, therefore, be considered an indicator of early-stage Technology Readiness Levels (TRL) and blue-sky research.

For innovation projects, we used publicly available data on projects funded by Innovate UK from 2004 to 2023 (see the discussion of data used and its caveats in [section 2.2.1](#)). These projects, with an innovative nature, may involve academic institutions, public research bodies, and industry partners, serving as an indicator of efforts to translate research into practical applications. Regarding patents, we used a combination of data from both Espacenet and OECD REGPAT databases (see [section 2.2.1](#) for a discussion of sources and their limitations). Patents serve as one measure of commercialisation activity. Figure 3 illustrates the top performers based on their positions in the top half on each of our metrics. Additionally, the map contains an inset showing all (health and non-health) engineering biology hotspots. This helps readers contextualise non-health activities within the broader landscape of engineering biology in the UK, following the methodological framework developed by Jibril et al. (2024).

3.3. Findings

- » The hotspots in Figure 3 show that **every region in the UK has some expertise in non-health engineering biology** research, innovation, or commercialisation activities.
- » Considering the map and inset together, there are also **spatial correlations between the location of non-health and all other engineering biology hotspots**. This demonstrates the close relationship and often overlap between non-health and other (predominantly health)

engineering biology activities. While the geographies are quite similar, the inset shows that some places appear to specialise in health-related engineering biology (notably in northern Wales and South West England).

- » There appears to be a **spatial association between hotspots and engineering biology commercialisation infrastructure locations**. It cannot be determined by this data alone whether the infrastructure was placed in known hotspots, whether the presence of infrastructure has increased or stimulated activity over time, or if the relationship is more complex.
- » **There are a few outlier locations to consider.** For instance, certain hotspots, such as Northern Ireland, the South West, and eastern Scotland, lack nearby supporting infrastructure. In contrast, Western Wales has two facilities but does not qualify as a hotspot based on our methodological approach.
- » As the commercialisation infrastructure report (Jibril et al. 2024) notes, the **types of commercialisation infrastructure are not evenly spread across the country** or within hotspots. Some places – like Cambridge, Norwich, and Manchester – have a mix of infrastructure types, but other hotspots only have one variety. This distribution could reflect different functions or strengths of places. For instance, research-focused infrastructure in Newcastle could indicate that it is a particular strength or aspiration. In contrast, the presence of scale-up infrastructure in Oxford could be a signal of more commercial activities. Future research may explore those connections and spatial correlations in more detail.

3.4 Insights

- » The diversity of places where hotspots appear signals that non-health engineering biology is a vibrant and emerging industry in the UK.
- » The relatively high association between hotspots and infrastructure suggests that infrastructure was in places that demonstrate research and commercialisation capacity. Still, the degree to which those investments have acted as multipliers to these activities is unclear (e.g., does infrastructure investment help to make places more attractive and “stickier” to research and early innovation activities?).
- » There is an opportunity to understand the relationship between the spatial distribution of types of infrastructure and localised research and infrastructure strengths.
- » The relationship between non-health and health engineering biology activities may present opportunities to design interventions that support both branches (as well as potentially other emerging technologies related to activities within agritech, materials, or net zero).

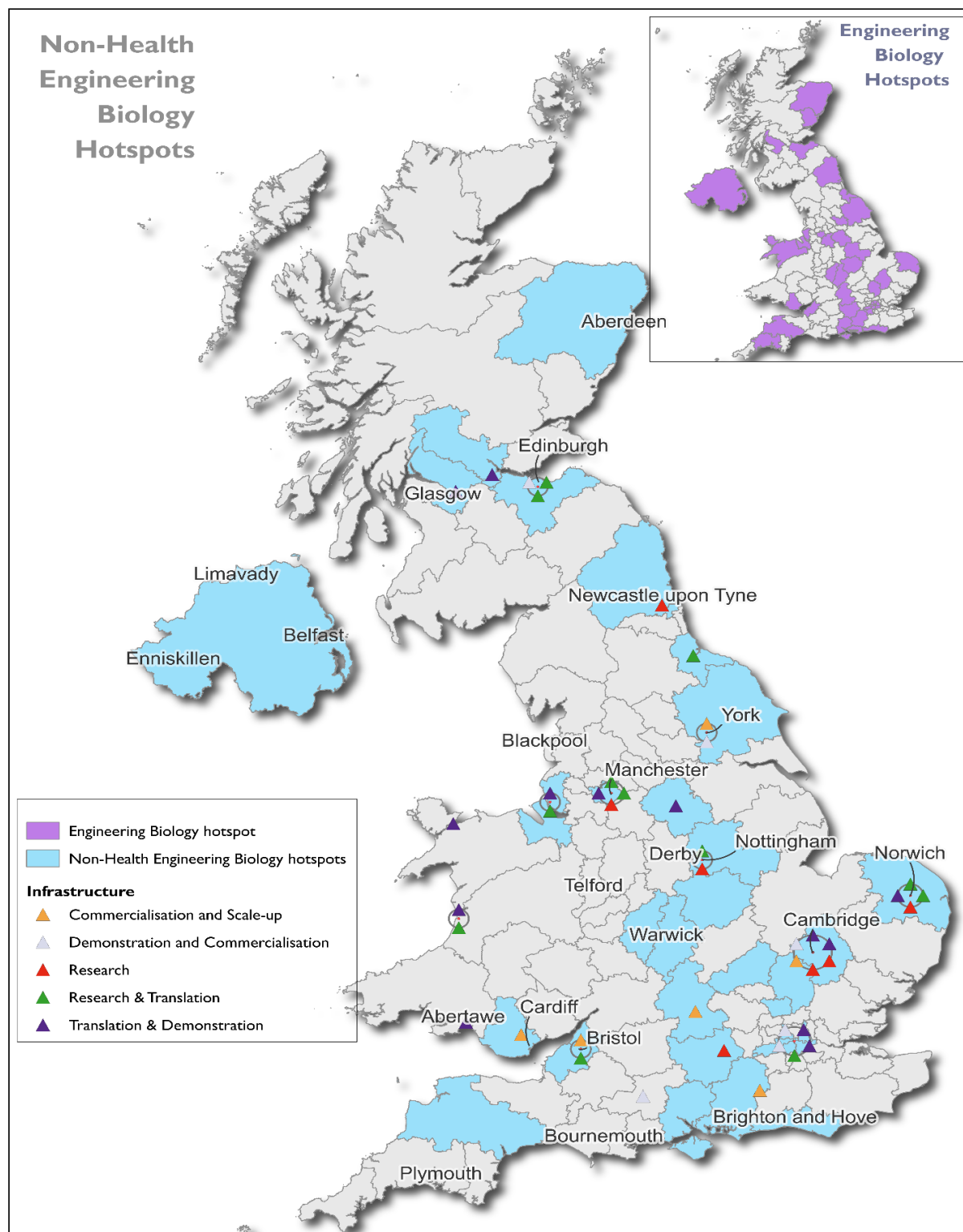


Figure 3: Non-health engineering biology hotspots and infrastructure with an inset showing hotspots for the whole engineering biology industry for reference.

4. Locating engineering biology business clusters

Research, commercialisation, and business clustering happen at different scales and geographies.

4.1 Objective

One of our research objectives was to understand the spatial relationship between concentrations of firm locations – known as business clusters – and the hotspots of research and commercialisation activities described in the previous section. We define a business cluster as a geographically localised group of firms that engage in activities with similar technologies, skill sets, and innovation bases. It is important to note that the correlation between these different measures of specialisation does not necessarily indicate that the co-location of these activities causes the formation of engineering biology firms. However, the overlaps suggest that there may be synergistic dynamics worth further investigation.

4.2 Data used

To identify these clusters, we used data on firm locations and specialisations from The Data City Engineering Biology Applications RTIC (RTIC0085), which includes nine industry categories (see [section 2.2.3](#) for more information on this dataset and its limitations). For this project, we focused on all categories except "Agriculture / Eco-Friendly Agrochemicals" and "Health & Life Sciences."⁷

This focus allowed us to create a targeted perspective on the non-health engineering biology sector for this research. To define the boundaries and compositions of each cluster, we employed the Hierarchical Density-Based Spatial Clustering of Applications with Noise (HDBSCAN) algorithm, which is specifically designed to handle data with varying densities (see an explanation of the HDBSCAN method in [section 2.2.3.2](#)). Consequently, some clusters consist of tightly packed data points, while others are more spread out. This presents a challenge for standard clustering algorithms that assume uniform density across clusters. We set the minimum firm count of 11 for our analysis.

It is important to note that while this approach is effective for identifying patterns of spatial relationships, it does not reveal or imply specific relational characteristics. From this map, we may *intuitively* suggest potential synergistic relationships and spillovers between firms within the community, but we cannot definitively conclude that these relationships exist. As such, these geographies and their implications should be treated as indicative rather than conclusive.

Figure 4 displays the geographical locations of the eight non-health engineering biology clusters relative to the hotspots mapped in the previous section. It is important to highlight that we used

⁷ For this project, we focused on the following RTICs: Agriculture & Food - Foods (such as alternative meat/protein/fat), Biofuels & Hydrogen, Biological Materials & Reagents - Nucleotide synthesis & sequencing, Chemicals & Materials - Biosensing, Chemicals & Materials - High Value Compounds, Chemicals & Materials - Products (such as biobased/degradable products & sustainable fashion), and Environment & CO2 capture - Bio Energy & Carbon Capture.

different techniques to identify clusters and hotspots. While clusters use the HDBSCAN method, as previously explained, the hotspots were determined based on postcode area boundaries.

4.3 Findings

- » Using the approach described above, we identify **8 non-health engineering biology clusters** across the UK.
- » These **clusters vary in size and scale**, with several locations containing more than one distinctive grouping⁸. For instance, Oxford hosts two of the smallest clusters, while the largest cluster consists of a corridor linking Manchester, Birmingham, and Swindon.
- » **There are correlations between these clusters and areas recognised for research and commercialisation excellence; however, these correlations or spatial associations are not perfect.** The hotspots map highlights areas of concentrated research and commercialisation, primarily in parts of London, Cambridge, and Oxford, closely aligned to the identified clusters. Additionally, the map reveals a significant corridor of research and commercialisation excellence that extends from Sheffield to Oxford.
- » **The clustering algorithm revealed outlier geographies with significant economic activity**, particularly extending slightly westward from Manchester to Swindon. Furthermore, there are significant pockets of research and commercialisation activity around places like Norwich and Bristol, which the algorithm did not identify as business clusters. This oversight occurred because the concentration of non-health engineering biology firms fell below the threshold level used in our approach, although these places appear to have higher concentrations of health-focused businesses.

4.4 Insights

- » These findings illustrate a relationship between research and commercialisation activities and clusters of engineering biology firms. However, there remains much to learn about how these activities influence and interact with one another to support policy goals such as place-based innovation and growth.
- » Revealed differences in the scale and geography of these activities suggest that policy initiatives should be cautious about assuming that investments in these activities will directly result in economic activities such as firm formation, job generation and growth in the same location.
- » While there may be similarities in the types of environments that foster excellence in both research and firm formation, the specific conditions and geographical contexts are unlikely to be identical.
- » To effectively support innovation and growth objectives in specific locations, it is essential to understand the resources required by stakeholders, such as businesses either already

⁸ HDBSCAN identifies clusters based on density, allowing multiple groupings within the same area. In locations like Oxford and Greater London, distinct high-density regions of firms can form separate clusters if local density exceeds the algorithm's threshold, even when geographically close.

located there or considering a move. Establishing effective connections between these stakeholders and relevant local or external resources is crucial.

- » Consequently, clustering strategies that focus broadly on stimulating activities across different parts of the local knowledge and value chains often fail to connect these elements. They may not recognise that spillovers and synergies can influence different geographic scales. As a result, these strategies risk emphasising individual ingredients rather than the overall recipe. This highlights the value of adopting a systems perspective to understand the geography of innovation.

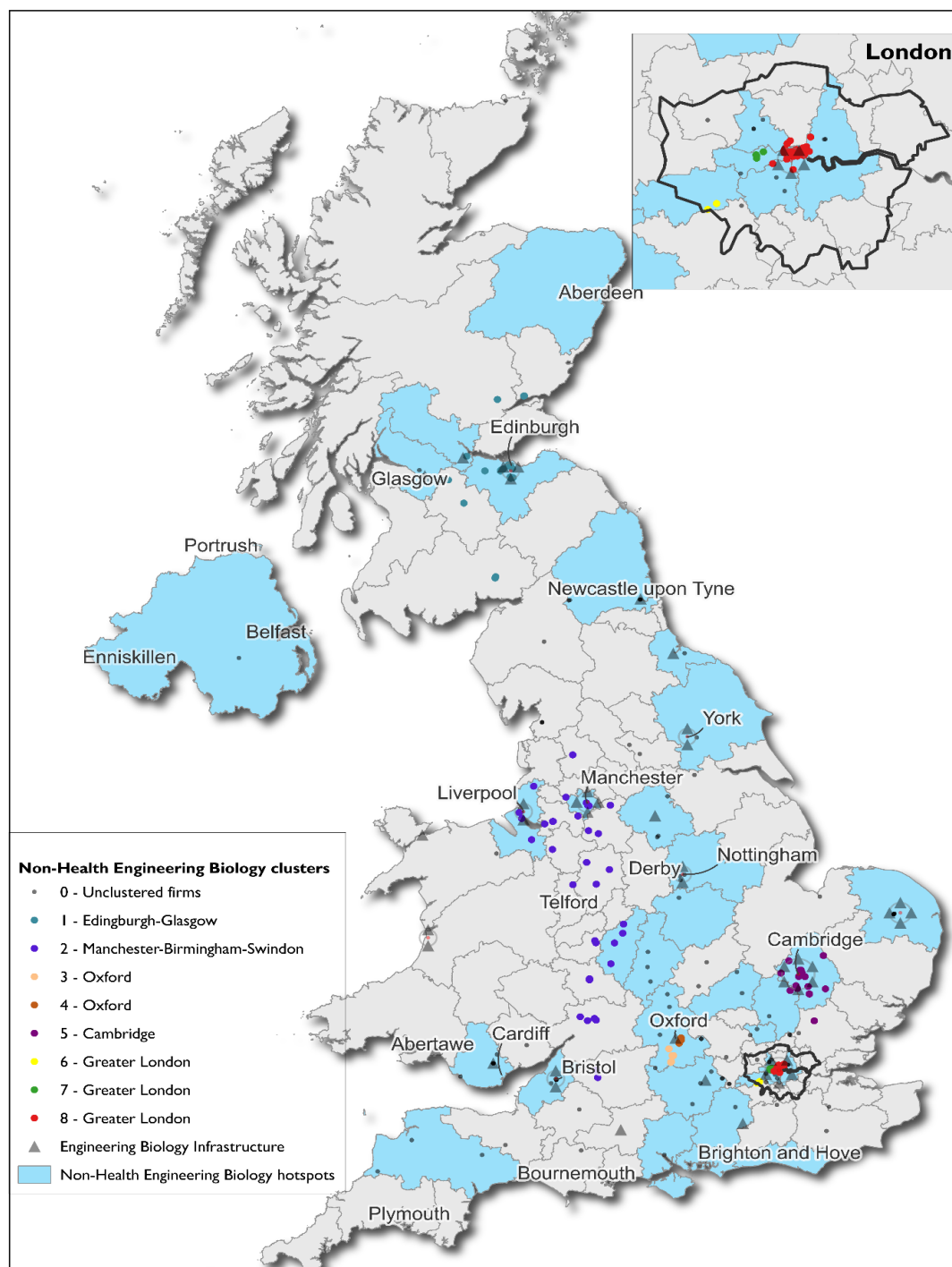


Figure 4: Non-health engineering biology clusters mapped against hotspots. Coloured dots represent engineering biology businesses. Dots of the same colour are part of the same cluster. Grey dots are “noise” points not assigned to a cluster. Hotspots are indicated in blue at the level of postcode areas.

5. Characteristics of engineering biology business clusters

Business clusters in non-health engineering biology have distinctive specialisations that can inform spatial innovation strategies.

5.1 Objective

The previous section identified all non-health engineering biology clusters; however, it is important to consider that these clusters are not identical. While there are similarities and overlaps among them, businesses in different places may specialise in different subsectors or occupy different parts of the value chain. This section aims to highlight these differences to build a clearer picture of geographies of innovation and to provide a stronger evidence base for exploring relational activities.

5.2 Data used

The cluster map in the previous section was constructed using firms assigned a set of RTICs specifically related to non-health engineering biology. However, The Data City allows businesses to be coded with multiple RTICs. Exploring these additional classifications helps us to develop a richer picture of the specialisations and sub-specialisms that differentiate non-health engineering biology business clusters. For this analysis, we used the additional RTIC data associated with the businesses identified in the previous section, which is illustrated in Figure 5.

Table 1 describes the different non-health engineering biology clusters based on the number of establishments and firms, the average firm size (employment and turnover), their average growth and innovation performance, and financial investments. Additionally, The Data City database includes short descriptions of business activities sourced from their websites. By analysing word frequencies, we can also generate word clouds for each cluster (see Figure 6). The word clouds were created using the online tool Wordclouds.co.uk, which allows for the visualisation of the most frequently occurring terms.

5.3 Findings

- » **Every cluster is made up of businesses with multiple RTICs assigned.** A cursory glance at Figure 5 shows how different the RTIC profiles for each cluster are and begins to make the case that they have distinctive specialisms.
- » **Some clusters are more diverse than others.** The Oxford clusters, for instance, have fewer RTICs than others. Businesses in the first cluster specialise in life sciences and omics, and the second one combines life sciences, net zero, and clean tech. By contrast, businesses in the Cambridge cluster have a much higher diversity of assigned RTICs with a comparatively greater focus on health-related RTICs such as biopharmaceuticals, pharma, and AI. The fact that the (spatially and numerically) larger clusters are more diverse could be a function of their size but could also indicate the presence of specialised subclusters.

- »» The **composition of the business clusters** (see Table 2) shows that the UK is home to several engineering biology clusters, each with unique characteristics and varying sizes. These clusters show diverse economic activities, employee numbers, and turnover rates.
- »» **Size and Scale:** Clusters vary significantly in size. For example, the Oxford and Cambridge clusters show a mix of small and large establishments, while the Manchester-Birmingham-Swindon cluster forms one of the largest clusters.
- »» **Employment and Turnover:** Employee numbers and turnover rates vary widely across clusters. Larger clusters tend to have higher average turnovers, reflecting significant economic activity, such as Manchester-Birmingham-Swindon, which reported substantial turnover figures.
- »» **Growth and Innovation:** Growth rates and innovation scores indicate the vitality of these clusters. Most clusters report positive growth rates, with substantial variation reflecting different stages of development and economic health. Innovation is generally strong across clusters, supported by Innovate UK funding.
- »» **Funding and Collaboration:** Innovate UK funding is pivotal for innovation across these clusters. Funding levels vary, with some clusters receiving substantial support, driving higher innovation scores and growth.
- »» **Business Transactions:** Deal Room activity, representing business transactions and investments, varies across clusters. Higher Deal Room averages in certain clusters like Oxford indicate significant business transactions, while others show moderate activity.

Overall, these clusters highlight the dynamic and varied landscape of engineering biology in the UK, with each region uniquely contributing to the sector's growth and innovation. The presence of both large and small firms, significant funding, and robust innovation activities underscores the importance of these clusters in driving the engineering biology sector forward.

- »» The **word clouds further reinforce the contention that clusters are differentiated** and add some context to the RTIC breakdowns. For example, the word clouds reveal that the two Oxford clusters are both oriented around problems related to the environment and sustainability and keywords such as “platforms”, “machine learning”, “data centre”, and “software” suggest that businesses are also digital. By contrast, London, Manchester, and Cambridge feature the keyword “manufacturing” more prominently, suggesting that businesses in this cluster are more oriented towards engineering biology production activities.

5.4 Insights

- »» The findings support our argument that clusters are not internally homogenous and can vary significantly between locations. A single location can be the host of more than one cluster, indicating that a “one size fits all” approach to stimulating growth in the industry is likely to be less successful than cluster-based or cluster-sensitive strategies that focus on the unique specialisations of each cluster.

- » This also suggests that there are opportunities to better connect activities across different clusters by understanding their positions within value chains. For example, places that specialise more in research and development side activities may benefit from being linked to those with strong manufacturing bases and capabilities, and vice versa.
- » There is an opportunity to explore the degree to which research, innovation projects, and commercialisation activities align thematically with cluster specialisation.
- » There is an opportunity to gain a deeper understanding of cluster phenomenon by individually analysing how these localisation, formation, specialisation and development processes occur in each location, along with the narratives that drive these evolutionary processes.

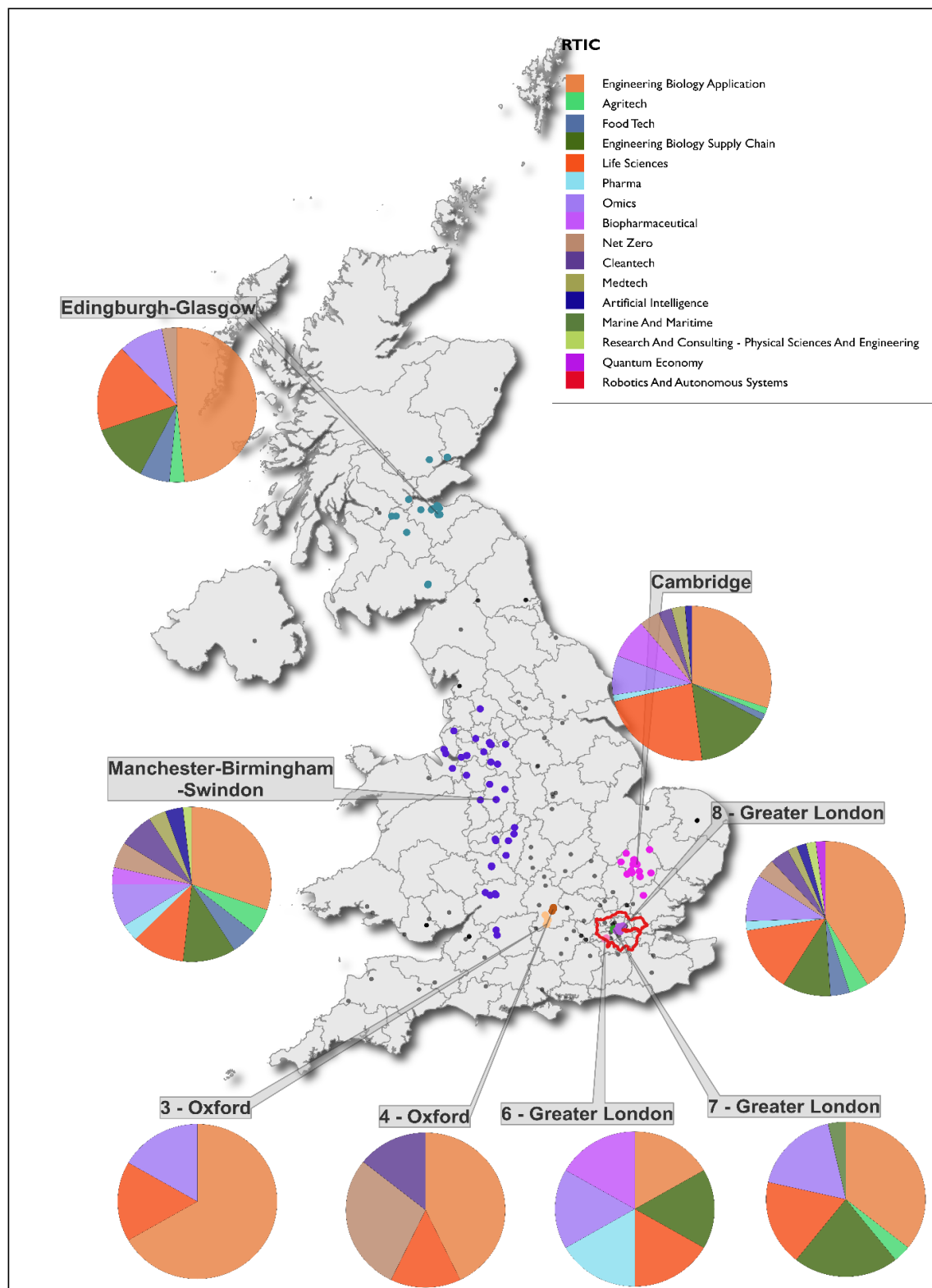


Figure 5: Real time industrial classification (RTICs) distribution across clusters

Table 2. Business Clusters Description

	Mean	Std. dev.	Min	Max	N	Determinant	Mean	Std. dev.	Min	Max	N
Cluster 1: Edinburgh-Glasgow											
No. Establishments					32	No. Firms					19
Employees	182.579	508.563	0.000	1945.000	19	Innovation Score	1.400	0.894	1.000	3.000	5
Turnover (in million)	80.735	238.315	0.000	802.977	19	IUK funding	1463236	2371427	0	8519354	12
Growth	0.190	0.269	-0.068	0.712	12	Deal room	7.850	17.118	0.000	72.680	19
Cluster 2: Manchester, Birmingham, Swindon											
No. Establishments					45	No. Firms					24
Employees	161.375	455.232	0.000	1945.000	24	Innovation Score	1.000	0.000	1.000	1.000	8
Turnover (in million)	2262.1	10746.140	0.000	52703.77	24	IUK funding	895242.6	918046.8	136995	3054577	11
Growth	0.372	0.712	-0.382	2.509	16	Deal room	2.54625	8.231507	0	31.4	24
Cluster 3: Oxford											
No. Establishments					17	No. Firms					11
Employees	151.454	417.891	0	1403	11	Innovation Score	1.333333	0.5	1	2	9
Turnover (in million)	31.148	75.53456	0	242.1162	11	IUK funding	1093183	1476867	22357	3973820	6
Growth	-0.011	0.3066865	-0.471	0.3325	5	Deal room	145.0118	441.3295	0	1473.51	11
Cluster 4: Oxford											
No. Establishments					11	No. Firms					10
Employees	160	438.3834	0	1403	10	Innovation Score	1.111111	0.333333	1	2	9
Turnover (in million)	25.775	76.07845	0	242.1162	10	IUK funding	243025	42091.04	199230	283175	3
Growth	0.4929	0.2538019	0.231	0.774	4	Deal room	155.318	463.4765	0	1473.51	10
Cluster 5: Cambridge											
No. Establishments					37	No. Firms					32
Employees	202.94	470.3044	0	1945	32	Innovation Score	1.153846	0.375533	1	2	13
Turnover (in million)	150.55	493.9758	0	2653.36	32	IUK funding	485758.5	453490.4	0	1518370	16
Growth	0.2472	0.3852696	-0.104	1.561	18	Deal room	54.215	260.3316	0	1473.51	32
Cluster 6: Greater London											
No. Establishments					11	No. Firms					11
Employees	66.091	112.8117	0	292	11	Innovation Score					0
Turnover (in million)	4.8657	8.297372	0	22.35296	11	Innovate UK funding	305988.3	409872	16165	595811.6	2
Growth	0.5095	0.9060642	0	2.5085	7	Deal room	8.210909	27.2325	0	90.32	11
Cluster 7: Greater London											
No. Establishments					12	No. Firms					11
Employees	21.182	44.5978	0	153	11	Innovation Score	1	.	1	1	1
Turnover (in million)	1.5048	2.343024	0	7.768852	11	IUK funding	973536.9	1206432	286010	2775725	4
Growth	0.2365	0.4012374	-0.194	0.826	7	Deal room	1.760909	4.289379	0	13.59	11
Cluster 8: Greater London											
No. Establishments					38	No. Firms					34
Employees	17.382	23.03359	0	98	34	Innovation Score	1.1875	0.403113	1	2	16
Turnover (in million)	1552.0	9038.294	0	52703.77	34	IUK funding	927589.4	753944.7	50000	2377556	14
Growth	0.5364	0.5914992	-0.382	1.739	19	Deal room	7.037059	15.86866	0	61.43	34

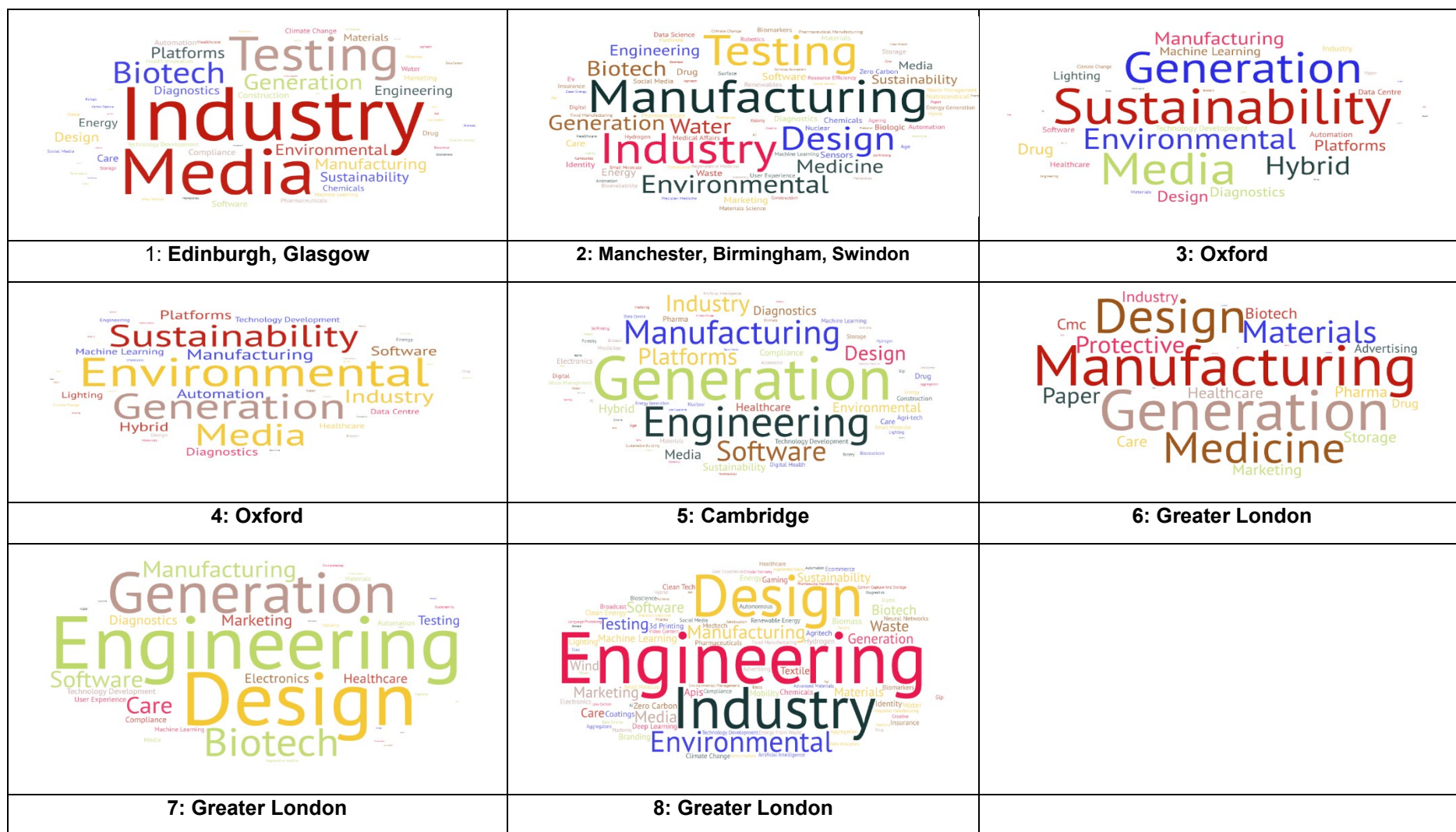


Figure 6: Clusters keyword analysis

6. Knowledge networks

6.1 Objective

Up to this point, we have focused on understanding the extent to which activities are co-located and their significance. The previous section shows that clusters appear to be differentiated, suggesting they may perform different functions within knowledge networks and value chains. This section will explore this possibility by mapping the relationships between various locations as part of our effort to move beyond a localised innovation focus and towards a system approach. By exploring the geographies of knowledge networks, we provide evidence that spillovers and knowledge diffusion can occur over long distances. Although this finding is not unexpected, it raises important questions within the context of place-based innovation support and cluster policy.

6.2 Data used

In order to depict potential science-technology-innovation collaborations across space, we analyse spatial connections among co-authors in research and co-applicants in IUK projects (innovation projects), as these data sets are sufficiently large and provide the most reliable relational data⁹. Although this approach may present some analytical gaps, these networks offer valuable insights into the relational dynamics within the non-health engineering biology sector.

The circles (nodes) in Figures 7 and 8 are positioned at the centre of each postcode area. The thickness of the lines connecting these areas indicates the number of collaborations (either co-authorships or IUK collaborations) between them. In addition, the size of the circles represents the number of unique authors participating in publications for each postcode area or the number of unique organisations participating in IUK projects, respectively. Finally, to aid ease of interpretation and legibility, the maps show only the **top 10% of pairs of postcode areas** with the highest number of research collaborations.

We also present data on internal versus external collaborations for a selection of nodes to examine the localisation of these partnerships (see Table 3). Specifically, Table 4 displays the number of collaboration pairs for publications and IUK-funded projects in the top 10 most collaborative postcode areas, categorised as internal and external. Internal collaborations within a postcode area consist of collaborator pairs (e.g., authors) that originate from the same area, while external collaborations involve one collaborator from a different UK area. Places are ranked in the tables by the overall number of collaborations.

6.3 Findings

- » Both maps show that places are highly interconnected within knowledge networks.
- » Distinct geographies of collaboration emerge in co-authorship and IUK project networks. This differentiation makes intuitive sense: co-authorship networks primarily link researchers in universities, while IUK projects involve participants from a broader range of organisations, including the private sector. The strength of relationships between nodes in the Golden

⁹ We avoided including a patent network map due to the very low number of collaborations among UK organisations found in patent data compared to other sources. While the average number of UK collaborators per publication is 4.61 and per IUK project is 1.86, this ratio is only 1.1 for patents. This element, combined with the relatively limited number of patents included in our dataset (1,227 patents vs 78,823 publications and 3,343 IUK-funded projects), doesn't allow for the creation of an informative patents' networks map.

Triangle is obvious and more pronounced in the co-authorship network, whereas the IUK projects reveal more distant connections between places, such as those between Scotland and the South.

- » It is important to recognise that while the maps highlight external relationships, collaboration also occurs within places in both publications and IUK projects, although these internal relationships are less significant than external ones. Tables 3-6 illustrate the ratio of internal to external relationships for the places with the highest total collaborations. For instance, internal collaborations average 42% of the total collaborations, while the average percentage for all locations is 32%. This suggests that co-authors tend to partner more with external partners, although significant activity remains within localised research networks and groups. For IUK projects, this pattern is intensified, where only 8% of total collaborations are internal and an average of 94% are external.
- » However, the significance of internal versus external collaborations varies considerably. Unsurprisingly, locations with large research-intensive universities and/or multiple universities and research organisations tend to exhibit lower external collaboration rates. In contrast, places like Doncaster, Warrington, and Inverness show much higher proportions of external co-authorship collaborations. This trend largely holds for IUK projects as well.
- » IUK projects result in a significantly higher level of external collaboration compared to other research and innovation initiatives. For example, 58% of Oxford's partnerships in publication networks were external, whereas nearly 90% of its partners in IUK projects were external. On average, external collaborations accounted for a relatively high 92% of total collaborations in IUK projects across locations. Notably, while Greater London is involved in the most collaborations, individual postcodes reveal that none from London appear in the top 10 most collaborative areas. This demonstrates a more geographically diverse landscape for IUK project awards.
- » When all postcodes in London are consolidated into one location, it ranks first position in total collaborations and, to a certain degree, normalises its percentage of external to internal partnerships. We conducted this analysis because we noticed that postcodes in Greater London tended to have high numbers of external collaborations, with 68% of West Central London's collaborations in publications being external. We suspected that was reflecting high levels of collaborations between partners *in different parts of London*. By aggregating all London postcodes (see Tables 4 and 6), we effectively counted these intra-London relationships as internal, bringing the percentage of external collaborations closer to the average. At 52% for publications and nearly 91% for IUK projects, these shares are still relatively high, underscoring London's role as a research and innovation hub in the UK engineering biology landscape.

6.4 Insights

- » Innovation activities are often more spatially dynamic than is generally acknowledged in place-based innovation literature. While concentrations of research and innovation projects can benefit the local economy, through networks, they are also highly likely to affect other places. This presents an opportunity to move beyond simply measuring where (and how much) funding for innovation support is allocated and instead focus on understanding how the dynamics of these networks can enable and catalyse spillovers in other locations.
- » Investments at different stages of the value chain have different spatial impacts, and these impacts can vary depending on the characteristics of a given location. For instance, all else

being equal, funding for innovation projects is more likely to generate external partnerships and stimulate knowledge spillovers between different places. In contrast, investment in academic research may more commonly support local knowledge co-production. However, for places with smaller and less research-intensive universities, research investments may actually stimulate greater connections with external partners. This indicates that place-based investments, depending on their position in the value chain, can yield different degrees of local spillover effects compared to broader spillovers. Therefore, it is essential to select investments that align with the spatial objectives of place-based policy.

- » Integrating these insights about networks with an analysis of cluster characteristics suggests that external networks may become increasingly more important further down the value chain as businesses seek partners with diverse capabilities. Here, the opportunity is to learn more about specialisation, where specific activities are happening, and the accessibility to supportive infrastructure. Rather than trying to replicate the assets of successful clusters everywhere, interventions might be more effectively focused on aligning support structures with local specialisations and technological readiness levels (TRL) and facilitating access to networks and assets in other places.

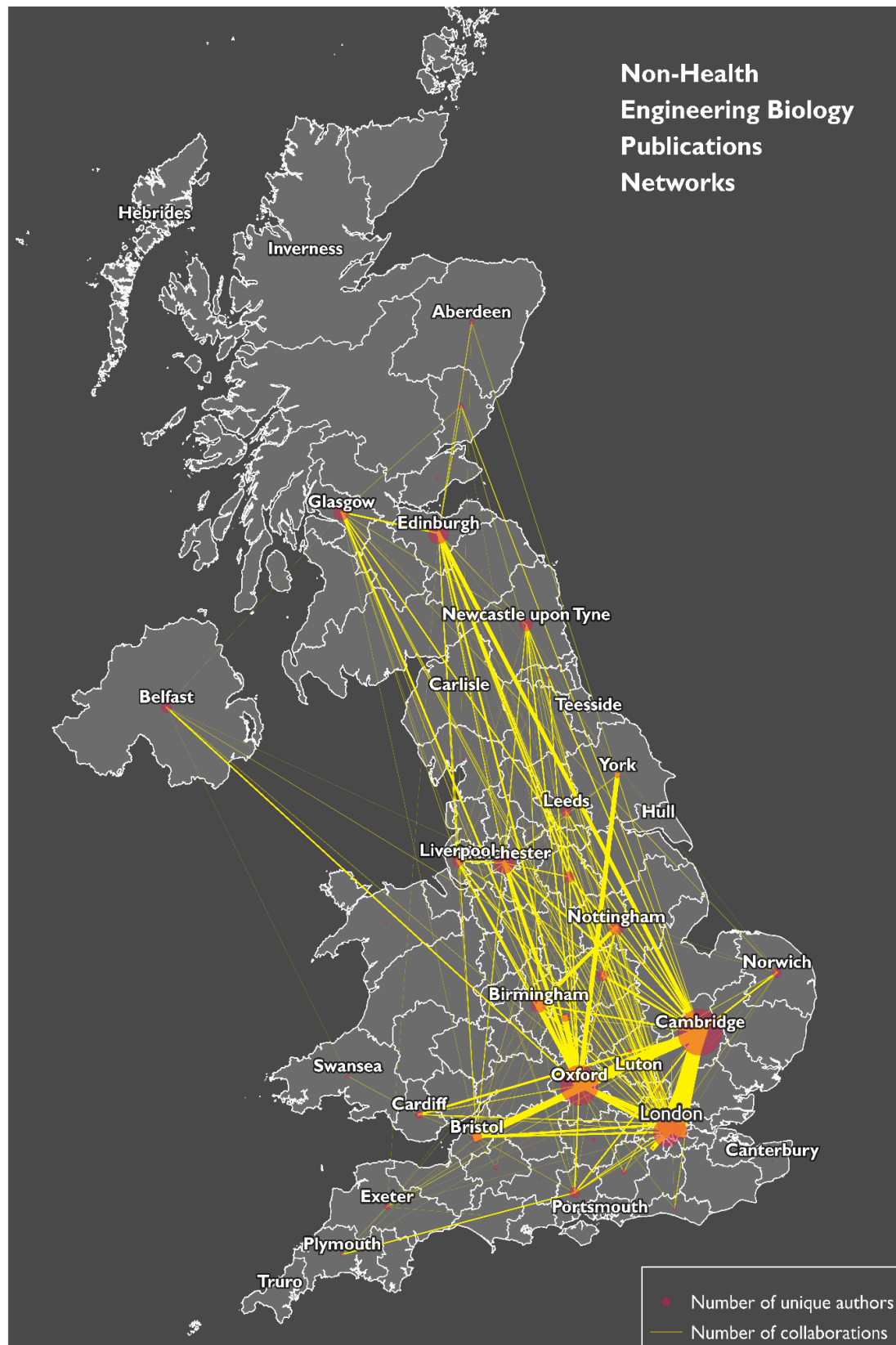


Figure 7: Co-authorship network

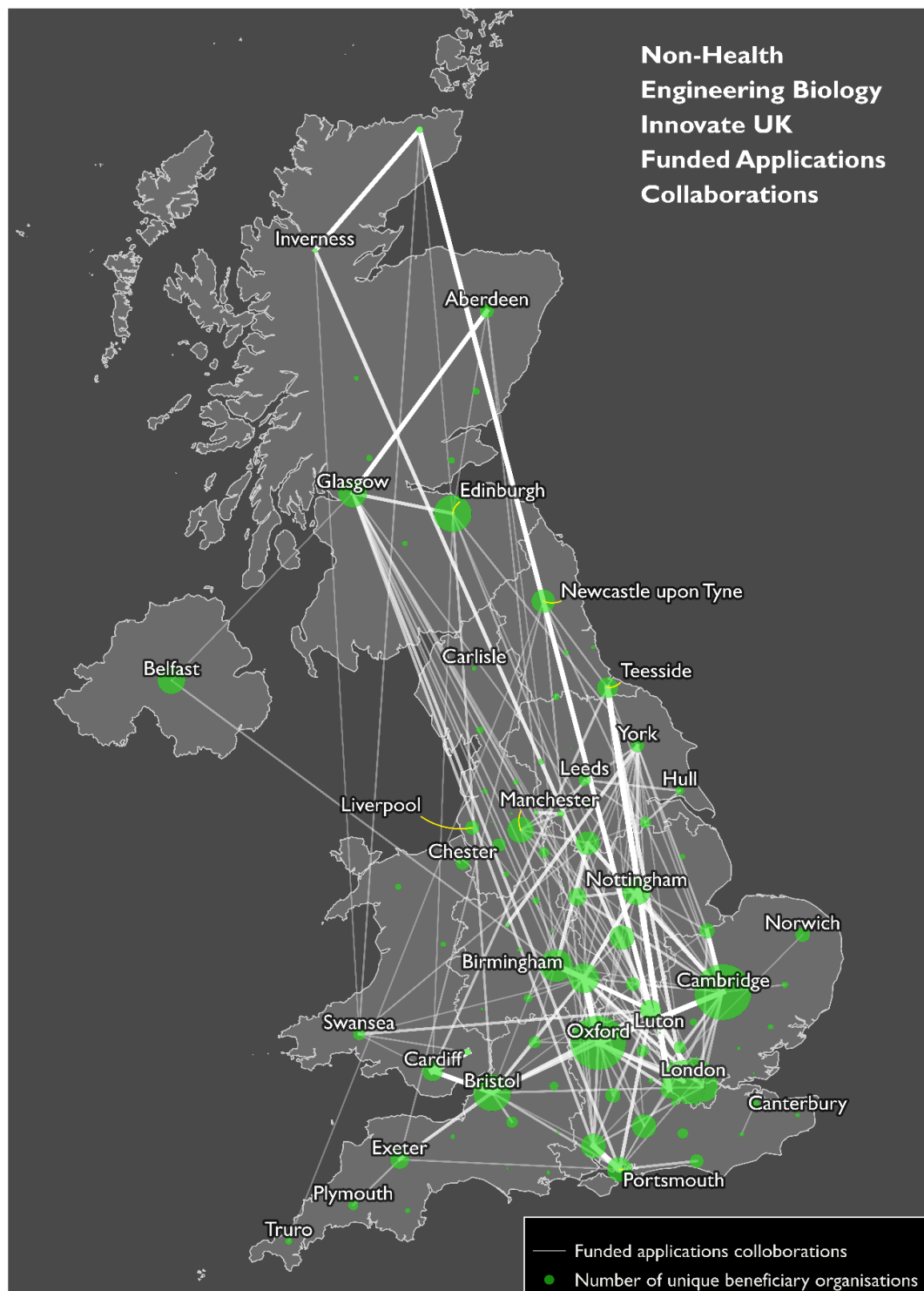


Figure 8: Collaboration network map for participants in IUK projects.

Table 3: Total and internal vs external connections based on co-authorship networks by postcode area

Area	Internal	External	Total	External Collaborations to Total
Cambridge	43,845	41,582	85,427	48.68%
Oxford ¹⁰	21,811	30,915	52,726	58.63%
West Central London	13,755	29,669	43,424	68.32%
South West London	14,441	23,109	37,550	61.54%
South East London	9,620	16,760	26,380	63.53%
Manchester	14,989	11,152	26,141	42.66%
Edinburgh	10,240	12,957	23,197	55.86%
Birmingham	11,061	11,433	22,494	50.83%
Bristol	6,561	12,169	18,730	64.97%
Nottingham	9,788	8,311	18,099	45.92%

Table 4: Total and internal vs external connections based on co-authorship networks by postcode area with London postcodes aggregated

Area	Internal	External	Total	External Collaborations to Total
London	72,007	78,838	150,845	52.26%
Cambridge	43,845	41,582	85,427	48.68%
Oxford*	21,811	30,915	52,726	58.63%
Manchester	14,989	11,152	26,141	42.66%
Edinburgh	10,240	12,957	23,197	55.86%
Birmingham	11,061	11,433	22,494	50.83%
Bristol	6,561	12,169	18,730	64.97%
Nottingham	9,788	8,311	18,099	45.92%
Glasgow	8,519	8,516	17,035	49.99%
Newcastle upon Tyne	7,125	7,397	14,522	50.94%

¹⁰ We excluded one publication with 477 UK co-authors, out of which 467 were from Oxford, that would have added 108,811 pairs of internal collaborations to Oxford.

Table 5: Total and internal vs external connections based on IUK project applicant networks by postcode area

Area	Internal	External	Total	External Collaborations to Total
Coventry	39	451	490	92.04%
Cambridge	44	432	476	90.76%
Oxford	43	351	394	89.09%
Milton Keynes	19	337	356	94.66%
Bristol	40	284	324	87.65%
York	28	287	315	91.11%
Cardiff	139	143	282	50.71%
Portsmouth	27	255	282	90.43%
Glasgow	19	256	275	93.09%
Southampton	19	253	272	93.01%

Table 6: Total and internal vs external connections based on IUK project applicant networks by postcode area with London postcodes aggregated

Area	Internal	External	Total	External Collaborations to Total
London	104	1,022	1,126	90.76%
Coventry	39	451	490	92.04%
Cambridge	44	432	476	90.76%
Oxford	43	351	394	89.09%
Milton Keynes	19	337	356	94.66%
Bristol	40	284	324	87.65%
York	28	287	315	91.11%
Cardiff	139	143	282	50.71%
Portsmouth	27	255	282	90.43%
Glasgow	19	256	275	93.09%

7. Discussion and Insights

This report aims to understand how various geographical contexts can either promote or hinder the co-location and development of innovation activities. To achieve this, we first identified various locations in the UK that can foster business activity in emerging sectors, such as non-health engineering biology, alongside related supporting infrastructure. Additionally, we analysed the locations across the UK where research (i.e., publications) and innovation (i.e., patent activity) related to these emerging technological fields were produced. Considering the significance of public support for research and development (R&D) and innovation, our analysis also examined the distribution of Innovate UK public-funded projects for these innovation-related initiatives across the country, as well as the location of publicly accessible infrastructure that supports these efforts.

Our exploratory analysis suggests that the spatial distribution of innovation and research in related emerging economic activities appears to be associated with the degree of geographic clustering or 'agglomeration' of business activities and related support infrastructures.

We use industry clustering techniques to analyse place-based innovation in the UK, focusing on emerging areas of activity. Our exploratory work uses business activity data generated through web scraping techniques to identify the locations of business activities in the UK. Industrial geographical clustering is consistently supported by a constellation of infrastructure that fosters the creation and development of industrial activity in different ways. Our application of non-health engineering biology has revealed eight distinct clusters across the country. These clusters differ greatly in terms of location (geographical features), size and scale, business innovation potential, and value chain specialisation. Due to their size in specific locations, the clusters can be divided into two groups, as exemplified by the cases of Oxford and London.

Our exploratory analysis, which examines the locations of research, innovation projects, and commercialisation hotspots in non-health engineering biology, reveals a significant spatial concentration of these metrics. Of interest is that places excelling in research and innovation-related activities in non-health engineering biology also tend to specialise and demonstrate high productivity in engineering biology economic activity. Although our study points to the fact that every region in the UK appears to have the expertise and potential to compete in these emerging activities, the areas that seem more productive in research and innovation are those with extensive commercialisation infrastructure.

Additionally, we conducted analyses to determine whether the economic activity of a postcode area is correlated with its knowledge base metrics. Through regression analysis, we found that economic activity, measured as the count of firms within specific clusters in a locality, is positively and significantly correlated with all the knowledge metrics (including publications, patents, and IUK-funded projects) for both engineering biology and the non-health subsector. This finding corroborates the dominant view that the location of innovative firms is strongly related to the knowledge-generating capacity of places.

Our analysis has some limitations. It is exploratory and does account for the time dimension of the analysed co-located activities we examine. Therefore, we are cautious about suggesting any causal relationships between spatially located business activities and research and innovation outcomes. Additionally, our conclusions regarding the potential association between specialisation in certain areas of the non-health engineering biology value chain and the support provided through Innovate UK or related infrastructure should be interpreted with care. Furthermore, our analysis only partially

explores the interconnections within the UK non-health engineering biology innovation system, as it has not considered social network analysis methods that could provide deeper insights into the relationships between and within specialised UK locations. Finally, our study does not address the role of skills, which play an important role in shaping the location of businesses or infrastructure. Our results raise some questions that may be useful in designing the next generation of place-based innovation strategies.

7.1 Should we update assumptions about expected impacts from place-based investments?

- » The research revealed a (not unexpected) relationship between research and commercialisation activities and clusters of engineering biology firms. However, much remains to be learned about how these activities influence and interact with each other to support policy goals and missions such as place-based innovation and economic performance.
- » Clear differences in the scale and geography of these activities suggest that policy initiatives should be cautious about assuming that investment in innovation activities, such as research and commercialisation, will automatically lead to significant economic outcomes, such as firm formation and economic growth *in the same location*.
- » Supporting innovation and growth objectives in specific locations may be most effective when we understand the resources required by stakeholders (such as businesses) that are either located there or are considering relocating. It is crucial to connect these stakeholders effectively to relevant local resources but also to forge links with external resources.
- » This research cautions against clustering strategies that focus broadly on stimulating activities in different parts of the local knowledge and value chains without properly *connecting* these elements. It also emphasises the importance of recognising that spillovers and synergies can influence different geographic scales. Successful clustering is less about the individual components and more about how well they work together in a cohesive system.
- » Given that innovation activities are often more spatially dynamic than is generally acknowledged in place-based innovation literature, network dynamics show us that there may be advantages to looking beyond simply measuring where (and how much) funding for innovation support is allocated. Instead, there is an opportunity to consider how understanding how the dynamics of these networks can enable and catalyse spillovers in other locations.

7.2 How can we encourage collaboration to promote intraregional and interregional spillovers?

- » Our results suggest there are opportunities to better connect activities across different clusters by understanding their positions within value chains. For example, places that specialise more in research and development activities may benefit from being connected to those with strong manufacturing bases and capabilities, and vice versa.
- » As a result, there is value in fostering interregional partnerships by promoting collaboration between businesses, universities and research institutions to drive innovation on a national scale.
- » Providing incentives for co-authoring research publications and collaborating on projects across different regions can deepen knowledge exchange between places and increase the likelihood of interregional collaboration (and spillovers) on innovation projects.

- » Furthermore, there are opportunities to gain a better understanding of the relationship between research and innovation specialisation within places. This understanding can help generate strategies to enhance localised synergies but also identify opportunities for beneficial external partnerships.
- » Our analysis highlights the fascinating network of relationships and collaborations within the UK's national engineering biology ecosystem. However, additional research is necessary to identify the primary obstacles and opportunities to achieving effective collaboration among various stakeholders in the engineering biology value chain. Ultimately, understanding these barriers and opportunities will pave the way for more effective and innovative collaborations, driving progress in the field.

7.3 What else can we learn about the relationship between innovation infrastructure investment and place-based outcomes?

- » The relatively high correlation between hotspots and infrastructure suggests that infrastructure was deployed and developed in places demonstrating research to commercialisation capacity. However, questions remain regarding the extent to which those investments have acted as multipliers for these activities.
- » For instance, key questions concern whether these investments have helped to further concentrate innovation activities in specific places, causing localised spillovers, or if whether innovation infrastructure is being accessed by businesses from across the country, leading to more spatially distributed spillover effects, or a combination of both.
- » There is also an opportunity to understand the relationship between different distributions of types of infrastructure and localised research strengths and TRLs. This deeper understanding may help forge stronger connections between locations that could benefit from one another's infrastructure and enhance access to important innovation support for firms located elsewhere.
- » Moreover, there are opportunities to better understand and leverage synergies across industries. This research shows that aside from the clear synergies between non-health and health branches of engineering biology, there are also overlaps with net zero, materials, agritech, digital/data, and more. Targeting infrastructure investments at the intersections of these industries may magnify the effects of a single intervention and encourage interactions between industries that can lead to innovation based on recombination and relatedness.

7.4 How do these insights help to better support local commercialisation?

- » Given their importance, there is an opportunity to invest in infrastructure that supports the commercialisation of place-based research. This includes the creation of incubators, accelerators, and innovation hubs tailored to the needs of local business clusters and localised research activities.
- » Greater availability and access to funded grants for research and development projects, particularly in emerging sectors such as non-health engineering biology, can help seed and sustain areas of research expertise that may lead to local spillovers and broader industry impacts.
- » However, it is important to recognise that investments at different stages of the value chain have different spatial impacts, which can vary depending on the characteristics of a specific location. To the extent that the goal of investment is place-based growth, focusing on practical

commercialisation infrastructure that is appropriately aligned with local innovation strengths and Technological Readiness Levels (TRLs) may yield the most direct improvements.

- » There is an opportunity to develop more customised market access programmes to assist non-health engineering biology businesses (or other emerging industries) in entering global markets and providing the necessary support for scaling up.
- » This might involve encouraging public-private partnerships or public procurement to pool resources and share risks in high-potential innovation areas or areas with less specialisation in the value chain.

These questions raised by our research challenge us to rethink our assumptions and learn more about how combining local and systemic perspectives can significantly enhance place-based innovation outcomes across the country. By doing so, we can drive substantial economic growth and unlock the full potential of our innovation ecosystem.



Now you have read our report we would love to know if our research has provided you with new insights, improved your processes, or inspired innovative solutions.

Please let us know how our research is making a difference by completing our short feedback form via this QR code.

Thank you

The Innovation & Research Caucus

References

Berba, P. (2020). A gentle introduction to HDBSCAN and density-based clustering

<https://pberba.github.io/stats/2020/07/08/intro-hdbscan/>

Campello, R.J.G.B., Moulavi, D., Sander, J. (2013). Density-Based Clustering Based on Hierarchical Density Estimates. In: Pei, J., Tseng, V.S., Cao, L., Motoda, H., Xu, G. (eds) *Advances in Knowledge Discovery and Data Mining. PAKDD 2013. Lecture Notes in Computer Science*, vol 7819. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-37456-2_14

CST (2023). Engineering Biology: opportunities for the UK economy and national goals. Prime Minister's Council for Science and Technology. <https://www.gov.uk/government/publications/advice-on-engineering-biology>

DSIT (2024). Innovation Cluster Map. <https://www.innovationclusters.dsit.gov.uk/> Accessed November 6, 2024.

DSIT (2023). Government publishes £2 billion vision for engineering biology to revolutionise medicine, food and environmental protection. Press release.

<https://www.gov.uk/government/news/government-publishes-2-billion-vision-for-engineering-biology-to-revolutionise-medicine-food-and-environmental-protection> Accessed December 20, 2024.

EBLC (2021). Building back better with Engineering Biology. Engineering Biology Leadership Council. https://iuk.ktn-uk.org/wp-content/uploads/2021/07/EBLC-Building-back-better-withEngineering-Biology_upload.pdf

European Patent Office (2024). *Espacenet: free access to over 150 million patent documents*. Retrieved from <https://worldwide.espacenet.com/patent/>

Jibril, H., Roper, S., Ortega-Argiles, R., Nyanzu, E., and Stanfield, C. (2024). Mapping the Innovation and Commercialisation Infrastructure for Non-Health Applications of Engineering Biology in the UK. Innovation and Research Caucus Report 003. <https://ircaucus.ac.uk/publications/mapping-the-innovation-and-commercialisation-infrastructure-for-non-health-applications-of-engineering-biology-in-the-uk/>

Accessed November 6, 2024.

Ma, H., Ortega-Argiles, R., & Lyons, M. (2024). UK Levelling Up R&D Mission Effects: A Multi-Region InputOutput Approach. (pp. 3-51). Manchester Institute of Innovation Research. <https://pure.manchester.ac.uk/ws/portalfiles/portal/297809545/mioir.wp.2024-03.pdf> Accessed December 20, 2024.

OECD (2009). "OECD patent statistics manual." France: OECD Publishing.

OECD (2024). REGPAT database, January 2024.

Porter, M.E. (1990, 1998). *The Competitive Advantage of Nations*, Free Press, New York.

Shearmur, R., Carrincazeaux, C. and Doloreux, D. (2016). The geographies of innovation: beyond one-size-fits-all, In: Shearmur, R., Carrincazeaux, C. and Doloreux, D. *Handbook of the Geographies of Innovation*, Edward Elgar.

Simpson, H. (2007). *An analysis of industrial clustering in Great Britain*. London: Department for Business, Enterprise and Regulatory Reform. Available at: <https://ifs.org.uk/publications/analysis-industrial-clustering-great-britain> (accessed: 13 December 2024).

UK Government (2024). *Invest 2035: the UK's modern industrial strategy*. [Invest 2035: the UK's modern industrial strategy - GOV.UK](#)

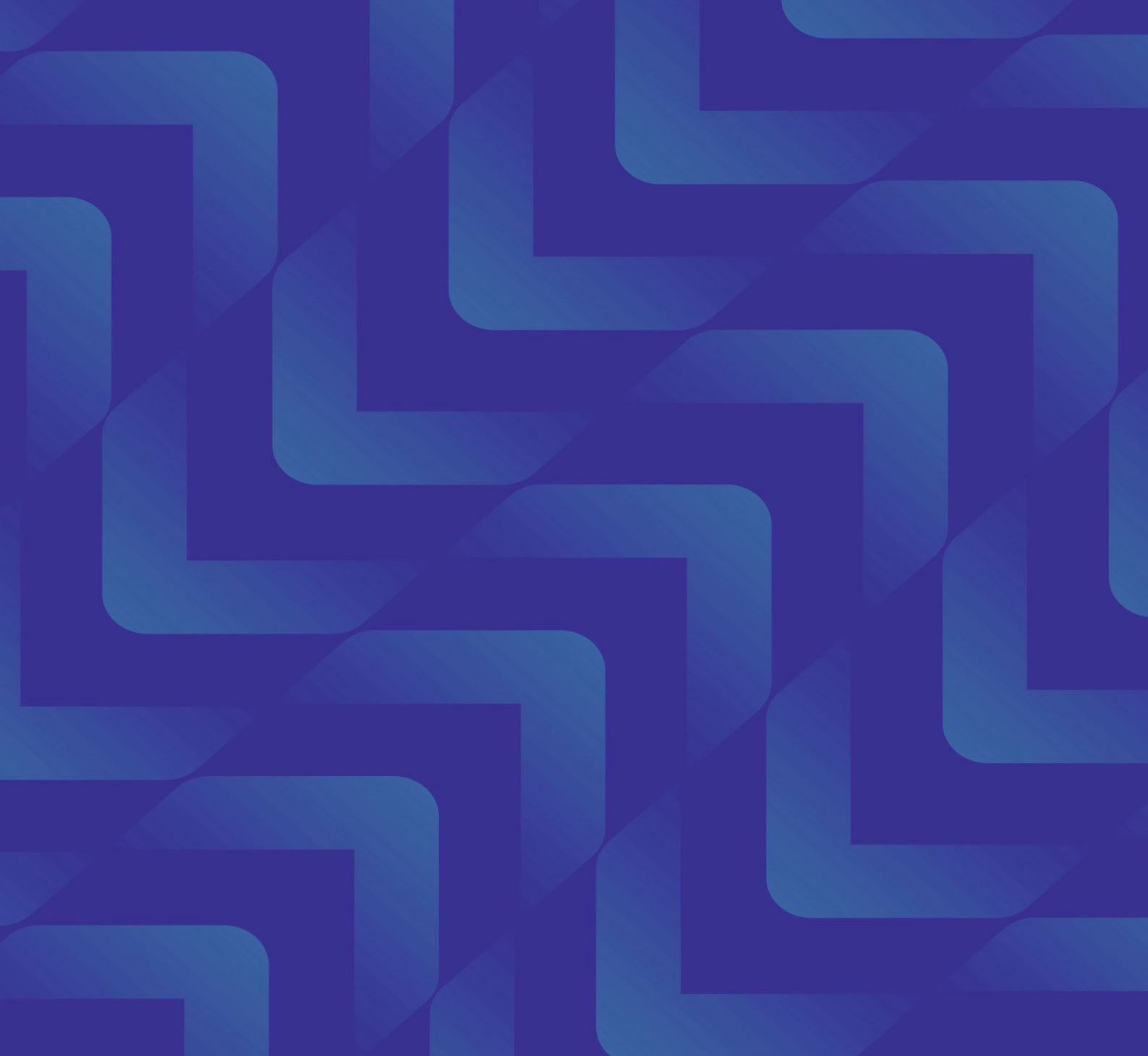
UKRI (2024a). *Innovate UK-funded projects since 2004*. Retrieved from <https://www.ukri.org/publications/innovate-uk-funded-projects-since-2004/>

UKRI (2024b). *Gateway to Research (GtR)*. Retrieved from <https://gtr.ukri.org/>

Appendix A. Keywords for identifying Engineering Biology Activities

Core key words for Engineering Biology	Non-health applications				Health & Life Sciences applications
	Chemicals	Materials	Environment	Agriculture & Food	
"engineer"*	"fine chemical"* + core keywords	"dye"* + core keywords	"biofuel" + core keywords	"biotech" AND "seed" + core keywords	"comput"* AND "drug" AND ("development"* OR "discover"* or "design"*)
"biolog"*	"vitamin"* + core keywords	"paint"* + core keywords	"biodiesel" + core keywords	"transgenic" AND "seed" + core keywords	"Integrated drug discovery"
"synthetic biolog"*	"polymer"* + core keywords	"cosmetic"* + core keywords	"bioenergy" + core keywords	NEAR("modif"* "seed" "geno"*, 5) + core keywords	"bacteria" AND ("drug dev"* OR "drug product"*)
"synthetic gene network"	"natural product"* + core keywords	"aroma"* + core keywords	"bio refining" = core keywords	("agricultural" AND "synthetic biology"	("small" AND molecule"*) + keywords
"biobrick"	"high value chem"* + core keywords	"biobased" + core keywords	"biofuel" AND "synthesis" + core keywords	("gene" OR "genome"*) AND "edit"* + core keywords	"diagnostic" + keywords
"protein design"	monooxyg enases	"biodegrad eable" + core keywords	NEAR("gas"* "biomass", 5) + core keywords	NEAR("synthetic" "DNA", 5) AND ("plant"* OR "crop"*)	"ferment"*
"genetic circuit"	"cytochrom e P450"	"fashion" + core keywords	"biogas"* + core keywords	NEAR("synthetic" "promoter"*, 5) AND ("plant"* OR "crop"*)	"T-cell" + core keywords
"gene regulatory network"			NEAR("natura l" "gas", 3) + core keywords	NEAR("transcrip"* "factor"*, 5) AND ("plant"* OR "crop"*)	("immune cell" AND "therap"*) + core keywords
"cell-free protein synthesis"			NEAR("gas" "liquid" "platform", 3) + core keywords	"CRISPR" AND ("plant"* OR "crop"*)	"monoclonal" OR "Mab" + core keywords
"metabolic"			("butaneidol" OR "BDO") + core keywords	("synthetic" AND "metabol"*) AND NEAR("plant" "carbon" "efficien"*, 5)	"vaccine" + core keywords

Core key words for Engineering Biology	Non-health applications				Health & Life Sciences applications
	<i>Chemicals</i>	<i>Materials</i>	<i>Environment</i>	<i>Agriculture and Food</i>	
"protein"			("syngas" AND "biomass") + core keywords	"synthetic fertili"* + core keywords	"gen"* AND "therap"*
"peptide"			"ABE" + core keywords	("nutrition"* AND ("plant"* OR "crop"*)) + core keywords	NEAR ("drug" "target", 5) + core keywords
					"personalised" + keywords
					"personalized" + keywords
					"probiotic"* + keywords
					("live biotherapeutics" OR "LBP") + keywords
					"targeted" + core keywords



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