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NESTA Making Innovation Flourish

Innovation by Adoption

Measuring and mapping absorptive capacity in UK nations and regions

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Foreword

Today's globalised economy has not only made it easier to trade and to travel. With new technologies and the growth of migration, new knowledge and ideas can be spread more quickly than ever before. Technology has also made novelty and innovation increasingly important to economic growth and development.

When government seeks to encourage regional innovation, it typically seeks to stimulate brand new ideas and their development within regional boundaries. Yet the truth is that many places and firms are better at adapting the ideas of others than generating new ideas of their own.

The ability to draw in new ideas from elsewhere and build on them at home is a more powerful stimulus than ever in today's economy. This important new NESTA report shows that the capacity of cities and regions to meet this challenge will have a major impact on their ability to stimulate economic growth. This 'absorptive capacity' will depend on factors such as the presence of universities – with their international academic networks – and multinational firms. Even in the age of technology, personal contact and travel remain important.

So, more attention needs to be paid to how firms and universities acquire new ideas from other places. International firms, migrants and students often have access to new knowledge from their home countries. Greater effort could be paid to tapping that resource and to persuading both domestic and international students to stay in a city after they graduate from its university.

But not every region will excel in all these areas. There is a strong case for each playing to its strengths, with resources being targeted accordingly. Too many regional plans seem like carbon copies of each other: this framework should help promote diversity. Equally, there is a good case for regions working together to benefit from the others' strengths.

I hope that the analysis offered in this report provides policymakers with the tools to think more imaginatively about how to stimulate regional and urban inventiveness and innovation.

As always, we welcome your input and your comments.

Jonathan Kestenbaum
CEO, NESTA

October, 2008

NESTA is the National Endowment for Science, Technology and the Arts.

Our aim is to transform the UK's capacity for innovation. We invest in early-stage companies, inform innovation policy and encourage a culture that helps innovation to flourish.

Executive summary

This report is an attempt to map and measure the ability of UK nations and regions to draw on and absorb the external innovations and knowledge they need for innovation. Most innovations happen outside boundaries, they are not confined to a particular company, university, cluster, or city-region. However, building such 'absorptive capacity' poses significant challenges for most UK regions, as policymakers too often focus on the capacity of places to create their own new knowledge and innovations and their ability to commercialise them.

Innovation across the UK is unevenly distributed and diverse. Few places are sufficiently capable of developing successful collaborations with external partners. Each city or region's different specialisation affects its capacity to develop innovations. Places need to collaborate and be an integral part of cross-border networks if they are to capture external knowledge and new ideas. However, the ability of participants to benefit from external knowledge can vary significantly from one place to another depending on the number and quality of their universities and other knowledge assets. This creates an imbalance between places.

The capacity to absorb external knowledge was identified as early as the 1950s as playing a major role in bridging economic development gaps between places. The new ideas and innovations brought by migration, trade and foreign investment networks cannot be fully captured and exploited if a place lacks the internal ability to absorb external knowledge.

So, the capacity of places to innovate depends on internal and external sources of knowledge, which complement each other. Traditional innovation policy has ignored the importance of external knowledge in developing local innovation capacity. But a place needs both to be able to draw in good ideas from elsewhere – an innovation absorptive capacity (AC) – and to use them to create new products and services – an innovation development capacity (DC). This is what the report describes as the AC/DC model. Absorptive capacity allows a place to identify, value and assimilate new knowledge. The development capacity of a place allows it to exploit that knowledge. The extent to which different places draw on 'AC' or 'DC' to create new value differs across economic sectors.

Five main components are essential to any innovation system. Three of these elements form the 'absorptive capacity' components of the AC/DC model: (1) the capacity to access international networks of knowledge and innovation; (2) the capacity to anchor external knowledge from people, institutions and firms; and (3) the capacity to diffuse new innovation and knowledge in the wider economy. The two components of the 'development capacities' element of the AC/DC model are (1) knowledge creation and (2) knowledge exploitation.

In order to measure and map these five components, we collected data on 26 regional

indicators of absorptive capacity from the nine administrative regions and the three nations of the UK. These range from the knowledge services infrastructure to broadband access. This report assesses their performance, presents composite indices as a benchmarking tool, and evaluates the relationship between the AC and the DC components.

We find a positive association between absorptive capacity and Gross Value Added performance – and between the AC and DC components. In other words, absorptive capacity contributes to economic growth. And places that are good at drawing on external knowledge also tend to be good at exploiting it. Yet, while the different components of the absorptive capacities often strengthen each other, not all UK regions manage to create the necessary links between them. Indeed, the report finds that the UK needs to boost the absorptive capacity of its nations, regions, and cities. Five out of twelve UK nations and regions are poor at spreading knowledge, only four are good at creating knowledge, and only four are good at exploiting it.

The report concludes with the following policy recommendations:

First, it must be made easier for cities, regions and nations to access relevant national and international sources of new knowledge, ideas, and innovation. Prizes, awards and support schemes should be created to support best practice in creating access opportunities.

Second, more should be done to draw on the knowledge of firms and universities that already make good use of knowledge developed predominantly outside the local area. Such players should be identified or created and support should be provided to strengthen their links with other players in the local economy.

Third, there should be greater investment in the development of a broader pool of firms and organisations with the capacity to spread knowledge in the local economy. Incentives and rewards should be created to encourage open forms of knowledge exchange between various types of organisations and across space, sectors, and industries.

Finally, inter-regional innovation strategies should be based around inter-regional strengths and weaknesses. Neighbouring cities and regions should be encouraged and rewarded for seeking inter-regional synergies and their performance evaluation should consider the value added created by inter-regional collaborations.

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Contents

Part 1: Why is absorptive capacity important?

Most innovations happen outside boundaries. They are not confined to a particular company, university, cluster, city-region or country. In fact, at any time, a place can be both an 'innovation leader' and an 'innovation absorber' – a place that draws new ideas from elsewhere. Indeed, firms, universities or individuals typically absorb more innovation than they initiate.[1] Such actors need to learn from innovations developed elsewhere to create new economic value locally. This creates inter-dependency between places with a consequent need for trade and exchange between those in different locations.

The absorption of external innovation is hardly effortless. It poses significant challenges to many regions and nations. In fact, it may well be the single most important factor in their advancement or stagnation.[2] Nonetheless, in policy circles, such absorptive capacity is often overlooked or confused with innovation capacity, which itself is often understood as merely the capacity to create new knowledge and then commercialise it successfully.[3] But a look at any innovation performance index shows that most regions and countries are innovation 'followers' rather than leaders – they exploit the ideas of others rather than creating wholly new ideas themselves.[4] In fact, according to the Organisation for Economic Co-operation and Development (OECD), in 2003, 38 per cent of total OECD Gross Domestic Product (GDP) was generated by only 10 per cent of regions while 57 per cent of all patents were recorded by just 10 per cent of regions. Even regions classified as innovation leaders only lead in specific knowledge domains.[5]

From a policy perspective, therefore, the challenge of 'keeping up' should be more pressing than the challenge of leading the way. Understanding the different elements of a place's 'capacity' to absorb is therefore very important for both innovators and policymakers. In this part of the report, we explain the theoretical underpinnings behind the important role of absorptive capacity and introduce the conceptual analytic framework upon which the rest of the study is based.

1. Massini, S. *et al.* (2005) Innovators and imitators: Organizational reference groups and adoption of organizational routines. 'Research Policy.' 34 (2005), pp.1550–1569.
2. Simmie, J. *et al.* (2008) 'History Matters: Path-Dependency and Innovation Performance in British City-Regions.' London: NESTA.
3. See for example UK Government (former DTI) definition of innovation in the Innovation Report. DTI (2003) 'Competing in the global economy: the innovation challenge.' London: DTI.
4. See for example the European Commission Regional Innovation Scoreboard.

Chapter 1: 'Absorptive Capacity' as an integral component of innovation capacity

1.1 Theoretical underpinnings

Innovation unevenness, diversity, and interdependence

The geography of innovation is diverse and uneven. Each city or region's specialist knowledge depends on its economic and industrial structure; these structures consequently create diversity between places. For example, Bristol and Leeds largely specialise in services, Cambridge and Oxford are high-tech, while Derby is a manufacturing and engineering centre.[6] Unevenness in levels of innovation can also be observed in the variable intensity of innovation activities. Some cities and regions – including Cambridge, Oxford, and Reading – are cutting-edge innovation leaders constantly expanding the knowledge frontier to develop new products and services. Other cities like London, Northampton and Derby are rapid responders, quickly introducing new processes and technologies to accommodate change and remain competitive. But there are also those that adopt innovations slowly – like Swansea. And there are places where innovation is largely under-developed – cities like Middlesbrough.

The inevitable inter-dependence between regions and the role of networks

Since no place has a monopoly of innovation, countries, cities and regions need to form interdependent networks of partnerships, collaborations, and exchanges.[7] For example, in a study of the Boston biotech cluster in the US, it was found that access to new knowledge does not result from local and regional interaction alone but is more often than not acquired through inter-regional and international strategic partnerships.[8] Access to international knowledge becomes even more imperative for places lying at the periphery of major knowledge hubs of specific industries.[9]

Knowledge is exchanged through a variety of mechanisms, some market-based (closed conduits where knowledge is exchanged on a contractual basis) and some transferred as externalities or spillovers, and as a public good (open channels).[10] The former, market-based knowledge transfer creates competition between places for the supply of certain types of knowledge and expertise, while the latter externalities and spillovers incentivise collaboration and cooperation.[11] Such knowledge exchange networks can be observed in global supply chains, trade in goods and services, collaboration in R&D, and in the flows of students and talents. Networks contribute significantly to the innovative capabilities of firms operating in a specific region, not least by exposing them to new ideas, enabling fast access to resources, and enhancing the transfer of knowledge.[12] In fact, firms developing more radical or complex innovations are more likely to have co-operative arrangements for innovation with external partners.[13] Firms establish systematic links with external sources to maintain the flow of important information about market trends and new technologies and to avoid the risk of stagnation.[14]

The dependency is asymmetric

As knowledge is exchanged through formal and informal networks, it does not necessarily benefit all participants equally, as the ability of participants to extract value from 'external knowledge' can vary significantly. As Barthelt *et al.* put it: "knowledge flows through pipelines are not automatic and participation is not free. The processes behind the establishment and maintenance of global pipelines must be pre-designed and planned in advance, and they

5. OECD (2007) 'Regions at a Glance.' Paris: OECD.
6. See Simmie, J. *et al.* (2008) 'State of the English Cities: The Competitive Economic Performance of English Cities.' London: DCLG.
7. Bottazzi, L. and Peri, G. (2003) Innovation and spillovers in regions: evidence from European patent data. 'European Economic Review.' 47, pp.687–710.
8. Owen-Smith, J. and Powell, W.W. (2004) Knowledge networks as channels and conduits: the effects of spillovers in the Boston biotechnology community. 'Organization Science.' 15, pp.5–21.
9. Gilding, M. (2008) The Tyranny of Distance: Biotechnology networks and clusters in the antipodes. 'Research Policy.' 37, pp.1132-1144.
10. Ibid.
11. Tether, B.S. (2002) Who cooperates for innovation and why? An empirical analysis. 'Research Policy.' 31 (6), pp.947–967.
12. Tether, B.S. and Tajar, A. (2008) Beyond industry–university links: Sourcing knowledge for innovation from consultants, private research organisations and the public science-base. 'Research Policy.' 37 (2008), pp.1079–1095.
13. Tether, B.S. (2002) Who cooperates for innovation and why? An empirical analysis. 'Research Policy.' 31 (6), pp.947–967.
14. Maillat, D., Crevoisier, O. and Lecoq, B. (1994) Innovation Networks and Territorial Dynamics: A Tentative Typology. In: Johansson, B., Karlsson, C. and Westin, I. (Eds) 'Patterns of a Network Economy.' Berlin: Springer-Verlag. pp.33-52.

require specific investments".[15] Most gains are made by those who are best linked and best equipped to absorb and utilise knowledge developed by other parties. Such variation in local learning processes creates a highly fragmented economic landscape with different rates of innovation.[16]

Moreover, places differ in the quantity and quality of the networks to which they belong and in their ability to utilise these networks. For example, not all regions benefit in the same way from transnational migrant networks or by hosting foreign companies' branches. The cost of access to relevant and critical networks varies between places too. Those with strong universities or firms ('knowledge assets') and advanced infrastructure and skills (capabilities) have easier access to global networks. They are also at an advantage in exchanging their expertise with others with complementary knowledge. Places with fewer knowledge assets and capabilities have to offer more to gain similar access. Furthermore, places with weaker or emerging knowledge bases, including Northern Ireland and the English North East, will have to invest more too. They will need the infrastructure, organisations, skills and talent to harness these resources. Innovation researchers have called this 'absorptive capacity'.

1.2 Absorptive Capacity (AC)

'Absorptive capacity' and economic development

By the 1950s, the 'absorptive capacity' of regions and countries had been identified as critical to economic development.[17] Due to their limited access to capital, technical training and formal education, and their poor industrial knowledge base, developing countries have to rely on external sources of capital, technology and knowledge. In a recent report, the World Bank states that domestic absorptive capacity both conditions and attracts external flows.[18] The report adds: "the bulk of technological progress in developing countries has been achieved through the absorption and adaptation of pre-existing and new-to-the-market or new-to-the-firm technologies, rather than the invention of entirely new technologies".[19]

According to the World Bank, two main factors affect the absorptive capacity of developing countries: the extent to which a country is exposed to foreign technologies; and its ability to absorb and adapt those technologies. Figure 1 shows the Bank's depiction of the function of absorptive capacity in developing economies and its role in transforming foreign knowledge inputs into domestic knowledge capabilities.

Figure 1 shows that governance, education, finance and pro-development policies are key pillars of the national absorptive capacities of developing countries. While trade, foreign direct investment (FDI) and diaspora networks can introduce new ideas and products, the spillovers, economic returns and social benefits from such inflows can be reaped only through these four key pillars.

'Absorptive capacity' and international business and investment

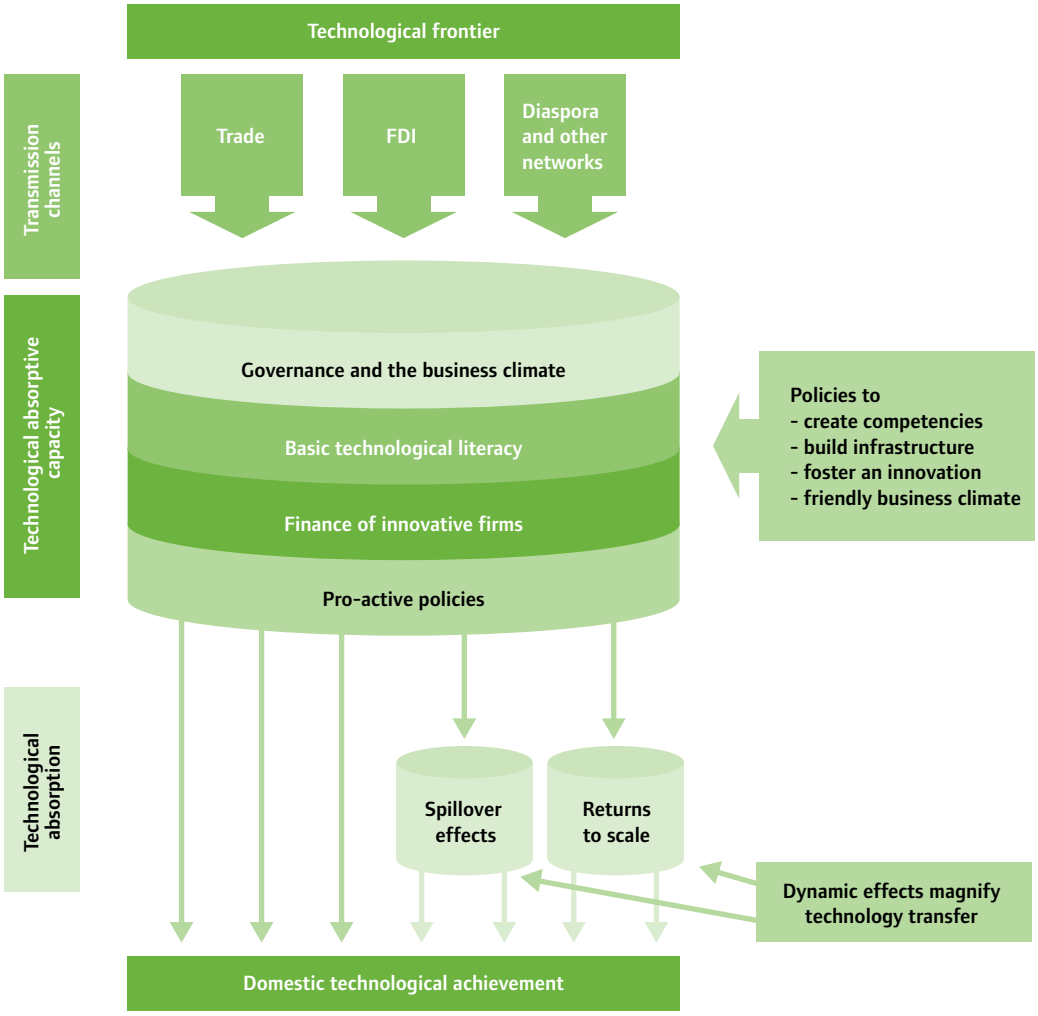
The importance of 'absorptive capacity' in reaping the benefits of foreign investment has gained more significance with the global growth of FDI flows. For example the strength of local absorptive capacity in the Chinese regions ensured that such investment drove knowledge-based development.[20] Likewise, a weaker capacity in Indonesia and Mexico is said to have prevented these countries from taking advantage of growing foreign investment.[21] The strength of absorptive capacity of regions is crucial for the spread of knowledge and ideas through and across multinational enterprises.[22] Indeed, international alliances between firms are the main route for their transfer between countries and territories.[23]

'Absorptive capacity' link firms to their external environment

While firms are not necessarily the sole agents of absorptive capacity, they are the most relevant players in local innovation activities.[24] There are fewer innovating than imitating companies.[25] This is why a great share of absorptive capacity literature has focused on firms. In this context, the concept of 'absorptive capacity' was first coined by Cohen and Levinthal (1990)[26] to refer to a firm's ability to identify, assimilate and exploit knowledge from external sources. Zahra and George (2002)[27] elaborated the concept further, suggesting that absorptive capacity involves the abilities to acquire, assimilate, convert, and exploit knowledge. They highlighted value creation as the dependent variable or outcome of such capacity. Zahra and George went on to suggest that absorptive capacity has two general states: potential and realised; and the gap between these states is dictated by the efficiency with which firms translate knowledge into applications.

15. Bathelt, H., Malmberg, A. and Maskell, P. (2002) 'Clusters and Knowledge: Local Buzz, Global Pipelines and The Process of Knowledge Creation.' DRUID Working Paper No 02-12.
16. Tappeinera, G., Hausera, C. and Waldeb, J. (2008) Regional knowledge spillovers: Fact or artifact? 'Research Policy.' Volume 37, Issue 5, June 2008, pp.861-874.
17. Nurkse, R. (1953) 'Problems of Capital Formation in Underdeveloped Countries.' New York: Oxford University Press. See also: Milikan and Rostow (1957) Foreign Aid: Next Phase. In: 'Foreign Affairs.' 36, 1957/58, pp.418-436. See also: Rosenstein-Rodan, P. (1961) Notes on the Theory of the Big Push. In Ellis, H.S. and Wallich, H.C. (Eds) (1961) 'Economic Development in Latin America.' New York: Macmillan.
18. World Bank (2008) 'Global Economic Prospects 2008: Technology Diffusion in the Developing World.' Washington, DC: World Bank.
19. Ibid.
20. Fu, X. (2008) Foreign direct investment, absorptive capacity and regional innovation capabilities in China. 'Oxford Development Studies.' Vol. 36, No. 1, pp.89-110.
21. World Bank (2008) 'Global Economic Prospects 2008: Technology Diffusion in the Developing World.' Washington, DC: World Bank.
22. Levinson, N.S. and Asahi, M. (1995) Cross-national alliances and interorganizational learning. 'Organizational Dynamics.' Vol. 24, No.2, pp.50-63.
23. Giuliani, E. (2005) Cluster Absorptive Capacity: Why do Some Clusters Forge Ahead and Others Lag Behind? 'European Urban and Regional Studies.' Vol. 12, No. 3, pp.269-288; Dunning, J.H. (2000) 'Regions, Globalization, and the Knowledge-Based Economy.' Oxford: Oxford University Press; see also Doz, Y. and Hamel, G. (1997) The use of alliances in implementing technology strategies. In: Tushman, M.L. and Anderson, P. (Eds) 'Managing Strategic Innovation and Change.' Oxford: Oxford University Press.
24. Simmie, J. *et al.* (2008) 'History Matters: Path-Dependency and Innovation Performance in British City-Regions.' London: NESTA.
25. Massini, S. *et al.* (2005) Innovators and imitators: Organizational reference groups and adoption of organizational routines. 'Research Policy.' 34 (2005), pp.1550–1569.

Figure 1: The function of absorptive capacity in developing economies



Source: World Bank

'Absorptive capacity' in regions and other territories

The 'absorptive capacity' of a firm is mediated by the wider environment in which it competes and operates.[28] A firm that is part of an industrial cluster characterised by a strong absorptive capacity will be better positioned to benefit from high levels of spillovers, learning and growth.[29] The role of the wider innovation environment has triggered a greater interest in the concept of the absorptive capacity of places. This has been implicit in the various bodies of work underlying the learning regions paradigm,[30] such as innovation milieux,[31] innovation networks,[32] and regional productive systems,[33] as well as national and regional innovation systems.[34] The learning region concept stipulates that the coordination and integration of the production and innovation processes requires a reciprocal exchange of information and knowledge along the supply chain. The extent to which this happens drives firms to create and draw on territorial networks that either reinforce ties of proximity or break existing territorial networks to develop extra-territorial links.[35]

1.3 Towards a new innovation system model?

Traditionally, the focus of policy has been on the ability of places to develop and exploit new knowledge locally rather than their ability to access, anchor or diffuse new knowledge acquired from elsewhere. Innovation capacity is often understood as the ability to create new knowledge and then exploit that knowledge to create new value.[36] However, the capacity of places to innovate normally depends on internal and external sources of knowledge,

26. Cohen, W. and Levinthal, L. (1990) Absorptive Capacity: A New Perspective on Learning and Innovation. 'Administrative Science Quarterly.' 35: pp.128–152.
27. Zahra, A. Z. and George, G. (2002) Absorptive Capacity: A Review, Reconceptualization, and Extension. 'Academy of Management Review.' Volume 27, Number 2, pp.185-203.
28. Van den Bosch, F.A.J., Volberda, H.W. and de Boer, M. (1999) Co-evolution of Firm Absorptive Capacity and Knowledge Environment: Organization Forms and Combinative Capabilities. 'Organization Science.' Vol. 10, 5, p.551-568.
29. Giuliani, E. (2005) Cluster Absorptive Capacity: Why do Some Clusters Forge Ahead and Others Lag Behind? 'European Urban and Regional Studies.' Vol. 12, No. 3, pp.269-288.
30. Morgan, K. (1997) The learning region: institutions, innovation and regional renewal. 'Regional Studies.' 31, pp.491–503.
31. Aydalot, P. (Ed.) (1986) 'Milieux innovateurs en Europe – Innovative Environments in Europe.' Paris: GREMI.
32. Camagni, R. (Ed.) (1991) 'Innovation Networks: Spatial Perspectives.' London: Belhaven Press-GREMI.
33. Maillat, D. (1996) Regional Productive Systems and Innovative Milieux. In OECD (1996) 'Networks of Enterprises and Local Develompent, Territorial Development.' Paris: OECD.
34. Morgan, K. (1996) Learning-by-Interacting: Inter-Firm Networks and Enterprise Support. In OECD (1996) 'Networks of Enterprises and Local Development, Territorial Development.' Paris: OECD.
35. Bramanti, A. (1998) 'From Space to Territory: Relational Development and Territorial Competitiveness. The GREMI Approach within the Contemporary Debate.' Paper presented at the conference: SMEs and districts: hybrid governance forms, knowledge creation & technology transfer. Castellanza, 5-7 November 1998.
36. DTI (2003) 'Innovation Report – competing in the global economy: the innovation challenge.' London: DTI.

which complement each other.[37] In any geographic unit, incumbents require both an innovation absorptive capacity (AC) and an innovation development capacity (DC). For illustrative purposes, we call these the AC/DC elements of a place's innovation system. The extent to which different places draw on 'AC' or 'DC' to create new value differs and varies across sectors.

1.4 The AC/DC model

AC/DC is an abbreviation for two different types of electrical currents, where AC stands for 'Alternating Current' and DC stands for 'Direct Current'. In this study, the AC/DC abbreviation, which refers to 'Absorptive Capacity' (AC) and 'Development Capacity' (DC), was chosen deliberately to reflect the role of innovation as a power provider to the economy. But, there is another analogy between electrical and innovation currents: while Direct Current (DC), as its name suggests, always flows in the same direction with an increasing or decreasing order, 'Alternating Current' (AC) flows one way, then the other way, continually reversing direction. Knowledge generation in a territorial innovation system has similar characteristics.

Absorptive capacity, like 'Alternating Current', allows knowledge to flow in different and reverse directions. Accordingly, the innovation capacity of places combines two broad sets of capacities: their absorptive and development capacity. The conceptual and analytic framework presented in Figure 2 combines both the absorptive capacity (AC) of places to identify, value, and assimilate potentially profitable external knowledge and the development capacity (DC) of places to develop and exploit such knowledge.

The traditional focus on domestic innovation capacity has assumed that most of the knowledge needed for local innovation will be found locally. Government has therefore sought to increase knowledge transfer between local players. However, these new insights show the importance of harnessing external knowledge to improve local innovation capacity.

1.4.1 Innovation by adoption

Innovation through adoption is thus an important channel of innovation. External knowledge that flows into a region translates into one or more outputs: (1) the creation of new innovation; (2) the creation of new knowledge; or (3) new economic and social value. Thus new value can be a direct or indirect outcome. Figure 3 illustrates the process of innovation through the adoption of external knowledge.

The ability to ensure that external knowledge adds economic value depends on a region's absorptive capacity channels. In such a process, external knowledge flows into a city or a region through one or more of the following three channels: (1) business, academic, and social networks; (2) established (anchored) firms and organisations in the region; and (3) through active and passive learning and take-up (diffusion). Of itself, absorptive capacity does not add value; knowledge needs to be

37. Cassiman, B. and Veugelers, R. (2002) 'Complementarity in the Innovation Strategy: Internal R&D, External Technology Acquisition and Cooperation.' CEPR Discussion Paper 3284. London: CEPR.

Figure 2: AC/DC innovation model

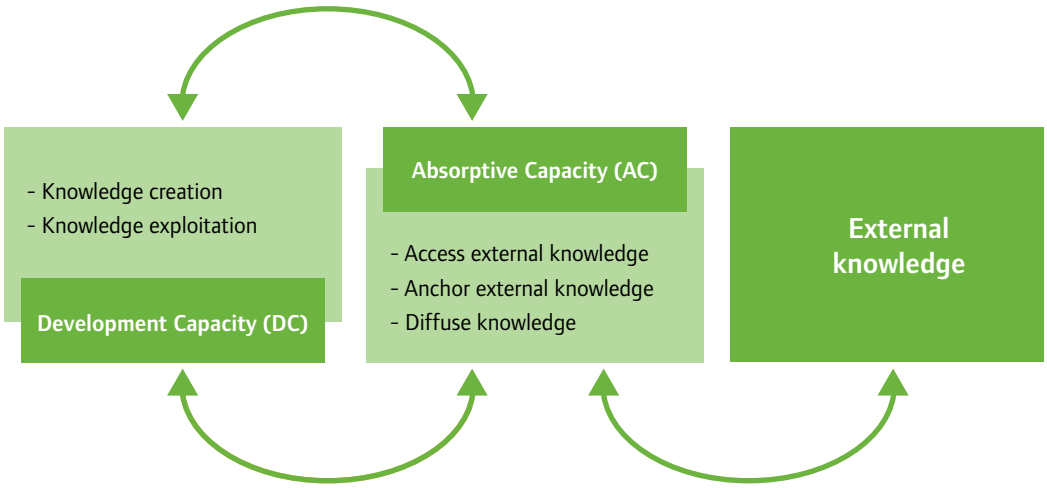
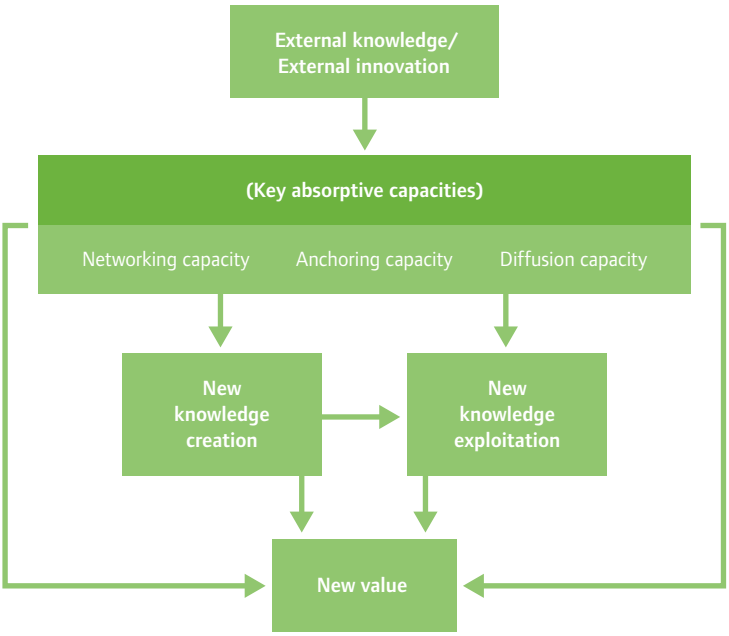


Figure 3: Innovation through adoption model



exploited first.[38] Thus, some capacity to create new knowledge and to exploit it remains essential if a region is to innovate through adoption (see Chapters 3 and 4).

1.4.2 The 'Absorptive Capacity' components of 'innovation through adoption' processes
The five components in Figure 3 are the essential elements of a 'knowledge adoption' innovation system. We now define the various components that form the AC/DC model. Our definitions are derived from the existing literature and from our reading and understanding of that literature. The definitions also benefited from a series of expert workshops organised to help define the components of the 'innovation through adoption' process.

1. **The 'access capacity'** is the ability to connect and link to international networks of knowledge and innovation. This capacity, dealt with in Chapter 5, represents the ability of firms, universities or individuals to secure benefits through network access or membership.[39] The benefits include privileged access to knowledge and information, preferential opportunities and influence.[40] This capacity requires agents, resources and culture. It requires agents who can identify sources of knowledge elsewhere; they can be individuals or teams of practitioners, working at a university or in a firm where they engage with relevant global players. They will require a combination of intellectual, organisational and financial resources to make contacts and diffuse new ideas. A culture of openness and learning is particularly important. Indifference to innovation and isolation from competition is unlikely to lead to the development of external partnerships.

2. **The 'anchor capacity'** is about the ability to identify and domesticate external knowledge from people, institutions and firms. While external knowledge flows contribute to local learning, it is the ability to 'anchor' these external flows that matters most.[41] Anchoring is the capacity to attract international people, investment and firms to set up in a region. It is also defined as a process of identifying, attracting and articulating the context between externally mobile knowledge and immobile local context needs.[42] The quality of anchoring will decide the wealth, diversity, intensity and duration of the relationships between external knowledge and local learning.[43] Knowledge anchoring and domestication are enhanced by 'anchoring' agents, organisations (such as firms and universities) that attract new ideas, technologies or processes from elsewhere and adapt them in the local economy.[44] Anchoring activities are often reflected in business or science parks, and other industrial clusters. Chapter 6 deals at length with this capacity as it shows how

38. Tether, B.S. and Tajar, A. (2008) Beyond industry–university links: Sourcing knowledge for innovation from consultants, private research organisations and the public science-base. 'Research Policy.' 37 (2008), pp.1079–1095.
39. Ibid.
40. Inkpen, A.C. and Tsang, E. (2005) Social capital, networks and knowledge transfer. 'Academy of Management Review.' 30 (1), pp.146–165.
41. Crevoisier, O. and Hugues, J. (2008) 'The Territorial Knowledge Dynamics: from the proximity paradigm to multi-location milieus.' Working Paper 2008/1. Available at: http://www2.unine.ch/webdav/site/socio/shared/documents/publications/workingpapers/wp_2008_01_e.pdf.
42. Ibid.
43. Ibid.
44. Agrawal, A. and Cockburn, I. (2003) The anchor tenant hypothesis: exploring the role of large, local, R&D-intensive firms in regional innovation systems. 'International Journal of Industrial Organization.' 21 (2003), pp.1227–1253.

different UK regions and nations perform in this regard.

3. **The capacity to 'diffuse knowledge'** is the collective ability of a place to adapt and assimilate new innovations, practices and technologies and spread them in the economy. Diffusion can happen through either 'active' or 'passive' emulation. The former takes place through activities such as purchases and imports of new patents, technologies or systems.[45] The latter happens through applied learning, reverse engineering or efforts to catch up with the competition.[46] In 1968, an OECD report *Gaps in Technology*[47] stated that: "the performance of a country in technological innovation has been defined as the rate at which new and better products and production processes have been introduced and diffused throughout its economy". Diffusion is a critical capacity for innovation performance. Accordingly, the OECD proposed measuring two aspects of innovation performance: being first to commercialise new products and processes (performance in originating innovations); and the level and rate of increase in the use of new products and processes (performance in diffusing innovations). We deal with the diffusion capacity at greater length in Chapter 7.

1.4.3 The 'Development Capacity' components of the 'innovation through adoption' processes

Knowledge creation and exploitation are often understood as start and finish points for innovation, with knowledge being created in a university or company research department and then applied by a different department or firm. Policymakers often assume they must take place within a specific geographic political context to be successful.

However, knowledge creation and knowledge exploitation often happen in different places, particularly where regions and smaller countries are concerned.[48] In this report, we show how 'absorptive capacity' is an important channel of 'knowledge creation' and 'knowledge exploitation', the two components of the 'development capacities' which we now define:

4. **The capacity to 'create knowledge'** is the ability of a place to generate new ideas, discoveries, designs and inventions. This capacity is often expressed in the production of scientific papers, patents, registered designs and graduates. This capacity can extend horizontally across a broad range of fields and sectors and vertically through specialisation and concentration in specific knowledge domains. A horizontally broad knowledge creation capacity facilitates knowledge absorption from wider fields of knowledge, while a vertically specialised knowledge development capacity gives a region a stronger absorptive capacity in complex domains of knowledge. This capacity, though classified as a 'development capacity', is nevertheless critical to a place's absorptive capacity. This is elaborated further in Chapter 3. A place's absorptive capacity is not merely subordinated to its capacity to attract external knowledge, but also depends on its capacity to promote local knowledge development and to activate a territorial dynamic of innovation.[49]

5. **The ability to 'exploit' knowledge** is the general capacity to utilise knowledge for commercial use and to extract value from it. This capacity is about the application of knowledge for practical use. In innovation policy literature, this ability is sometimes referred as the 'innovation capacity'. In this report, we consider it only as an innovation output; it is not used to represent all innovation activity. While 'exploitation' activities involve the ability to generate new knowledge too, their main aim is 'knowledge exploitation' rather than 'knowledge creation'. Knowledge exploitation requires agents and resources – as well as an entrepreneurial culture – committed to the generation of new social and commercial value from new knowledge. These tend to be largely formed of large and small firms, though some places have many public sector organisations involved. Increasingly, third-sector organisations are involved too. However, a culture that supports entrepreneurship and risk-taking is often required for a knowledge exploitation capacity to flourish. The exploitation capacity is explain and explored in Chapter 4.

45. Cole, D.T. and Helpman, E. (1995) International R&D Spillovers. 'European Economic Review.' 39: pp.859-887.
46. Nishimura, K., Nakajima, T. and Kiyota, K. (2005) 'Productivity Convergence at the Firm Level.' (March 12, 2005). Available at: http://www.ssrn.com/abstract=721423.
47. OECD (1968) 'Gaps in Technology: General Report.' Paris: OECD. p.14.
48. Martin, R. and Sunley, P. (1999) Slow convergence? The new endogenous growth theory and regional development. 'Economic Geography.' 74 (3), pp.201–228.
49. Bramanti, A. (1998) 'From Space to Territory: Relational Development and Territorial Competitiveness. The GREMI Approach within the Contemporary Debate.' Paper presented at the conference: SMEs and districts: hybrid governance forms, knowledge creation & technology transfer. Castellanza, 5-7 November 1998.

Chapter 2: Mapping and measuring the different AC/DC components

2.1 Indicator selection

Built on existing evidence relating to regional innovation systems and more specifically work relating to absorptive capacity, we constructed the analytical framework for mapping and measuring regional innovation – the AC/DC innovation model. Further evidence was gathered to build the conceptual models for each of the five elements of the AC/DC framework – 'creation', 'exploitation', 'access', 'anchor' and 'diffusion'. Within each of the five elements we explored available data, considering their relevance and robustness in the compilation of long indicator lists.

We then organised three workshops to find the most relevant indicators for each of the five dimensions. These workshops involved the project team, the NESTA Policy and Research Unit, and external stakeholders from academia and policy. The selection of the final indicators was based on relevance, data quality and reliability, and comparability. The lists were refined to a total of 26 indicators across the five dimensions. Whilst not exhaustive, we believe that this provides a rounded picture of regional innovation capacity.

Data were collected for the 26 indicators for each of the UK administrative regions and nations. The indicators are assigned to the five dimensions of the AD/DC framework. Table 2.1 in Appendix 1 lists the 26 indicators within the five dimensions, detailing the numerators and denominators used to construct each of the indicators together with a summary of the significance of the indicator.

2.2 Availability of statistical data and geographic analysis

It is difficult to capture the wider 'hidden' innovation in cities and regions using statistical data. Many of the traditional input indicators of innovation such as R&D and patents are relatively narrow, sector specific and can be skewed by head office location. Measuring wider and newer forms of innovation and investment in intangible assets, such as brand equity, workforce training and organisational capital that can lead to innovation, is more difficult. Another particular challenge is measuring knowledge spillovers due to the invisibility of knowledge flows and limited social network and interaction data. In addition to the more traditional indicators, we have utilised a number of proxy indicators of innovation capacity under each of the five components in order to capture more fully the extent of regional capacities. We have also taken account of the various limitations and considerations to each of the indicators in our analysis.

The innovation capacity of places is best understood within functional economic areas. The majority of sub-national data on innovation, however, exists only at the regional level according to the administrative boundaries for the 12 Government Office Regions and devolved administrations. These administrative boundaries often do not reflect regional economic geographies. Given the limited availability of data at alternative spatial levels we have utilised this regional data in order to capture innovation capacities at the sub-national level. There is also value in analysing data at the regional level as these boundaries provide the frameworks for government policies and strategies. Where

possible we have also included data at a city level. This data is presented for the 13 largest UK cities – London, Manchester, Leeds, Sheffield, Nottingham, Bristol, Liverpool, Newcastle, Birmingham, Cardiff, Edinburgh, Glasgow, and Belfast. In order to better reflect the functional urban areas data is aggregated to Travel-to-Work Area.[50] In all cases we have used the most recent data available, but due to the paucity of data at the regional and local level there is inevitably a significant lag for some variables.

2.3 Construction of composite indicators

Composite indices are provided for each of the five components. Whilst we recognise the limitations of using composites and urge caution when interpreting the figures, it does provide a useful benchmark for the regions and allows for correlation with the other components of the innovation model and with economic outputs.

The composite indices are based on a mean average of the normalised values to remove the effects of unequal variables and ensure that data is comparable to facilitate the combination of data. The mean and standard deviation is calculated for each metric (s), then for each metric (s) the mean (m) is subtracted and divided by the standard deviation (sd): C = (s-m)/sd. An average is then taken for each of the metrics to create the overall composite score (C). Correlations were then run between each of the region 'Capacity' composites and tested for significance.

Sensitivity analysis was also used to determine how 'sensitive' these scores are to changes in the scores for the individual metrics constituting these composites (see Appendix 2). In general, as the composite indices are based on the standardised scores for each metric (where the standard deviation for each metric has been recalculated to equal 1), the composite indices are relatively equal in sensitivity to changes in individual metrics. The overall improvement or decline in the composite score for any particular region, based on a change in individual scores, will clearly depend on how far a particular region is situated away from the mean score of 0. In order to look further at the issue of sensitivity a number of scenarios were highlighted to assess how the composite score index for regions would change if the underlying metrics were to change. These scenarios are presented in Appendix 2.

2.4 Correlations

We ran a number of correlations to test the relationship between the various AC/DC indices. Given the strong performance of London across all indicators, we also tested the significance of these relationships excluding London from the analysis. The results are listed within the specific chapters – we state whether a particular correlation would be weaker, stronger, or the same, if London were excluded.

In the following chapters, we discuss the rationale and theoretical underpinnings of each of the five components – 'Knowledge Access', 'Knowledge Anchoring', 'Knowledge Diffusion', 'Knowledge Creation' and 'Knowledge Exploitation' – providing more detailed explanations of the significance of each of the individual indicators. The analysis of each of the indicators and summary composites that follow takes into account the limitations and considerations that apply.

50. Travel-to-Work Areas as used in DCLG (2006) 'State of the Cities.' London: DCLG.

Part 2: How well do UK nations and regions fare in creating and exploiting knowledge?

The capacity of cities, regions, and nations to create new knowledge has been the core of the science-push innovation agenda that has dominated much of policymaking thinking over the last two centuries. There was then the recognition that the creation of new knowledge alone is not sufficient unless it is coupled with an equally strong capacity to exploit knowledge. In innovation policy thinking, this exploitation often took the form of new technology and has therefore been translated into various streams of technology-push innovation strategies. The two capacities are often understood as start and finish points, with knowledge being created in a university or company research department and then applied by a different department or firm. Policymakers often assume that knowledge creation and exploitation must take place within a specific geographic political context to be successful. Consequently, a large number of knowledge transfer tools and instruments were created at the local level to help complement local creation capacities with local exploitation capacities.

In the next two chapters we take a detailed look at the performance of UK nations, regions, and, where appropriate, cities in terms of their capacities to create new knowledge and to exploit it.

Chapter 3: Knowledge creation capacity in UK nations and regions

Main findings

Over the last 30 years, knowledge has become a central element in the generation of economic growth. The ability to create new knowledge has become critical to the competitiveness of the UK economy.

A city or region's knowledge creation capacity reflects its readiness and ability to generate new ideas, discoveries and innovations. The sources of knowledge creation are varied but can include universities and go-ahead firms; together they are said to constitute the 'knowledge infrastructure' which operates across the economy. However, knowledge creation is just one element of the innovation system.

To measure knowledge creation within cities and regions we use six main indicators grouped under three main themes. The first theme is the human capital base, which is measured by university degrees and other higher education qualifications obtained by region of institution as a proportion of total population. London is ranked first, followed by the North East. The fewest degrees per head were awarded in the East of England. A separate measure of degree quality shows that the most first and upper class degrees are awarded in Northern Ireland, and the fewest in Wales. The greatest number of PhDs is awarded in London. Of the core cities, Nottingham headed the table for HE qualifications by head, while Birmingham came last.

The second element is the public and private investment in new knowledge, which can be measured by Research and Development (R&D) intensity. Scotland performs best in higher education R&D, followed by London. But the South West and East of England spend most on R&D (relative to regional GVA). The East of England also tops the table for business investment in R&D – reflecting the presence of Cambridge – spending three times the national average. London's expenditure on R&D is comparatively low, reflecting an industrial structure skewed towards services.

The third element is the new knowledge creation outputs, which can be calculated by looking at the number of patents produced and the 2001 Research Assessment Exercise rating. Over half of all UK patents are granted in the greater South East, and research quality is highest among universities in the East of England. Of the core cities, Edinburgh scores highest and Birmingham lowest in terms of university research quality outputs.

The composite score for knowledge creation reveals that the Greater South East has the greatest capacity to generate knowledge within the UK, while the West Midlands is weakest. Overall, it appears that there is a correlation between a region's knowledge creation capacity and its GVA.

3.1 What is 'knowledge creation'?

'Knowledge creation' can be understood as new ideas, concepts, skills and competencies, or technical and organisational advances. As such, it is defined in this chapter as the capacity available in a city or region to be a source of new ideas, discoveries and innovations.

The traditional or linear models of innovation often assume a causal link between knowledge creation and knowledge exploitation identified as 'science-push' – whereby research leads to applied research and innovations that are then transformed into further innovations which in turn lead to greater growth. In the 1950s and 1960s, OECD countries built up their university systems and dedicated research institutes on the basis of this traditional view.[51] This approach ignores the role of knowledge adoption and diffusion by market forces and knowledge networks in generating innovations.

Nor is the reverse linear relationship – the 'demand-pull' theory that the market stimulates a search for knowledge to increase profits by solving problems – always true. This demand-based model also implies a one-way flow within the innovation system and is now seen as an exception rather than the norm. Knowledge creation itself does not necessarily lead to commercially exploitable innovations, nor does the market always generate sufficient demand for knowledge to generate innovation.

Knowledge on its own is a resource that may or may not be employed and it can be used in many different ways. The central process of knowledge creation is not the design but the redesign of scientific knowledge, building innovatively on existing knowledge and insights.[52]

This means that whilst knowledge creation is a crucial element in the innovation process, it is only one of many. Other factors are important too – learning processes in production, new market demands, applying existing knowledge in new areas. In this interactive process, knowledge creation is both an important input for innovation and an output of innovation activities. As emphasised throughout this report, innovation is a recursive process with a complicated series of feedback loops and interactions, hence our focus on different ways of assessing cities' and regions' capacity to absorb knowledge and create innovation.

51. Arnold, E. and Bell, M. (2001) 'Some New Ideas about Research and Development.' Report to Hernes Commission, Ministry of Foreign Affairs, Denmark, 2001.
52. Freeman, C. (2001) The 'National System of Innovation' in historical perspective. In Archibugi, D. and Lundvall, B. A. (Eds) 'The Globalising Learning Economy.' Oxford: Oxford University Press.

3.2 How do the different parts of the UK fare in their efforts to create new knowledge?

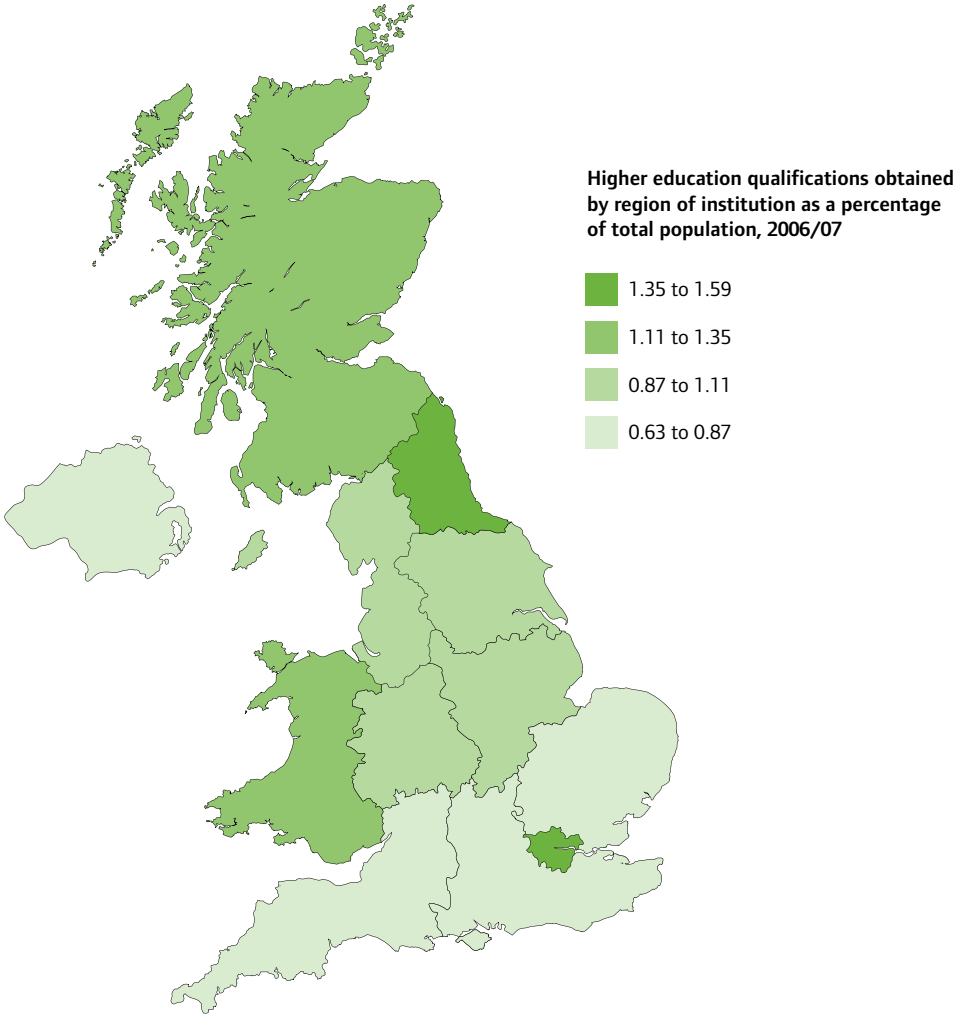
The most common measures of 'knowledge creation' or 'knowledge capital' are R&D expenditure and patent counts. Building on the discussion above and taking into account broader definitions of innovation, our proposed measurements are presented through three main themes:

- The human capital base.
- Public and private investment in new knowledge.
- New knowledge creation outputs.

To measure these we use the following indicators:

- University degrees and other higher education qualifications obtained by region of institution as a proportion of total population – an indication of human capital development and flow of human capital into the labour market.
- R&D performed with Higher Education Institutions (£ million) as a percentage of regional GVA – an indication of knowledge creation taking place through the higher education sector.
- R&D performed with Government Establishments (£ million) as a percentage of regional GVA – an indication of knowledge generating activity taking place within government.
- R&D performed with businesses (£ million) as a percentage of regional GVA – an indication of the amount of resources being channelled into increasing the knowledge base within businesses.
- Number of patent applications granted by region – an output measure of knowledge created in regions and indication of the increase in knowledge stock in the economy.
- 2001 Research Assessment Exercise Rating weighted by category A* and A research staff (FTE) weighted by number of research staff – an output measure of quality of knowledge creation though the higher education sector.

Figure 4: Higher education qualifications obtained by region of institution as a percentage of total population, 2006/07



	Total HE qualifications obtained as a percentage of total population, 2006/07	First degree qualifications as a percentage of total HE qualifications, 2006/07	Percentage of first degrees that are first or upper second class, 2006/07	Number of doctorates awarded, 2006/07
London	1.6	40.2	53.6	3,205
North East	1.4	45.8	57.8	735
Wales	1.1	51.7	53.4	665
Scotland	1.1	53.0	39.2	1,855
Yorkshire and the Humber	1.1	55.7	59.0	1,580
East Midlands	1.0	55.3	58.6	1,280
North West	1.0	51.3	54.5	1,600
West Midlands	1.0	48.7	55.7	1,050
Northern Ireland	0.8	57.2	62.6	420
South East	0.8	52.7	60.4	2,355
South West	0.8	55.5	62.5	980
East of England	0.6	46.3	57.3	1,695

Source: Higher Education Statistics Agency

3.3 Human capital base

A proxy measure of human capital development – the acquisition of knowledge, understanding, skills, competencies through education and training – is the proportion of degrees and other qualifications obtained within universities and colleges providing courses at Level 4 and above, by the city or region where the institution is based. This measure also gives an indication of the flow of human capital into the labour market. This measure includes the proportion of first degree qualifications and the proportion of these that are first or upper second class degrees. The number of doctoral degree completions provides an indication of the vitality of the city or region's institutions in educating new researchers and individuals with Level 5 skills who can have significant returns to organisations and the wider economy.[53] The geography of attainment of HE qualifications is mapped in Figure 4.

3.3.1 What do the data tell us?

As a proportion of total regional population, London produces the highest number of graduates and post graduates
Taking the total HE qualifications gained by region of institution as a proportion of the total regional population, London produces the highest number of graduates and postgraduates – a reflection of the number of universities and colleges in the capital. The North East also produces a large number of graduates for its population size. The lowest proportion of degrees is obtained in the East of England.

An indication of quality, the most first and upper second class degrees are awarded in Northern Ireland. The most PhDs are awarded in London
The class of degree awarded provides an indication of the quality of first degrees obtained with the regions.[54] The highest proportion of first and upper second class degrees was awarded in Northern Ireland. Disregarding the figure for Scotland due to misreporting, the lowest proportion was awarded in Wales. The number of doctorates (or PhDs) awarded was by far the highest in London and the South East, again a reflection of the number of institutions in the Greater South East.

Human capital base in the core cities
Figure 5 shows that Nottingham awards more degrees per head than any other major city, with Leeds running a close second. Conversely, Birmingham awards the fewest. The highest proportion first and upper second class degrees are awarded in Nottingham and Belfast. By far the highest number of doctorates are awarded in London, with Manchester in the lead outside the capital.

3.4 Public and private investment in new knowledge

Both the private and public sectors invest in knowledge creation through Research & Development (R&D). R&D activity is considered to be one of the most significant factors in innovation activity and consequently a key driver of economic growth.[55] A large amount of empirical evidence shows that technological innovation is driven by knowledge stock and R&D intensity. Studies have also shown a positive relationship between economic productivity and R&D.[56]

R&D both advances and uses knowledge, as its generation within a firm also increases a firm's capacity to absorb external knowledge: "firms invest in R&D not only to pursue directly new process and product innovation but also to develop and maintain their broader capabilities to assimilate and exploit externally available information".[57] A firm's R&D investments are seen as a strong indicator of its technological ability.

3.5 R&D in higher education

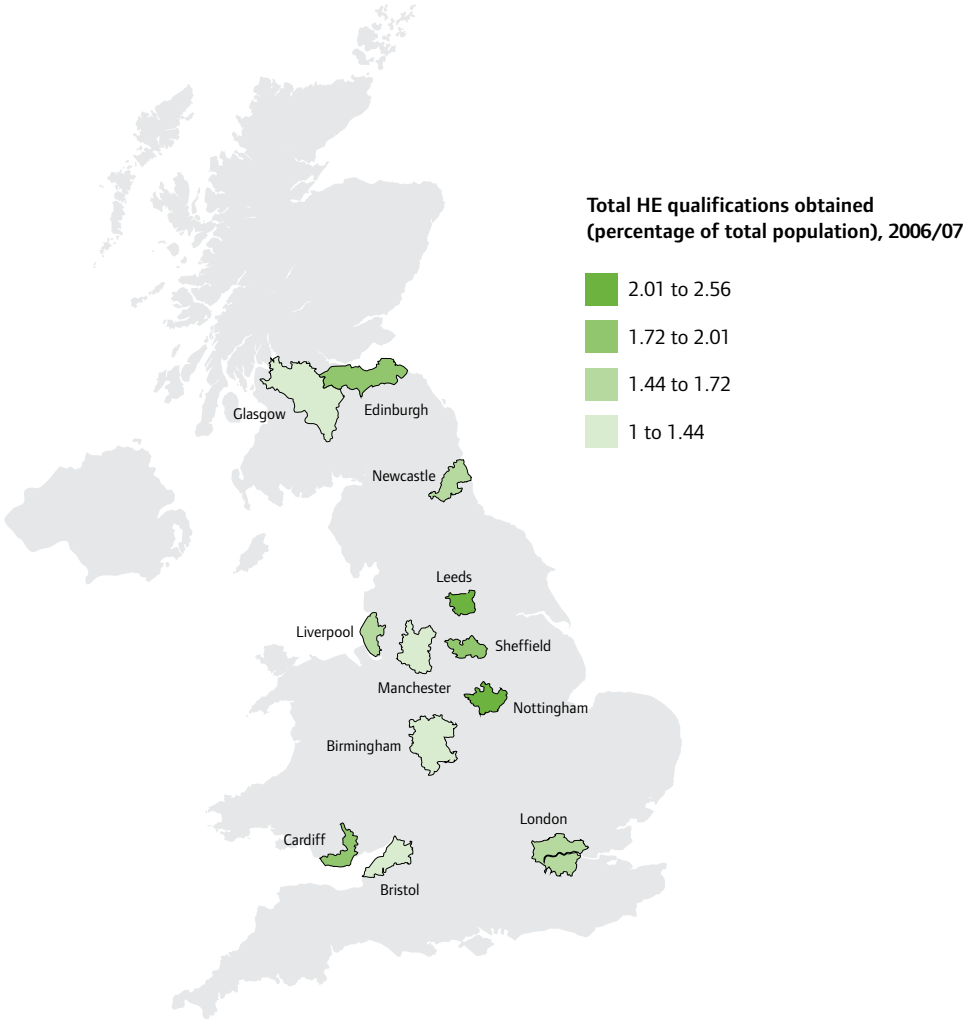
Universities are key centres of research and knowledge creation, and as a result are seen as the basis of innovation. They are a fundamental part of the knowledge infrastructure in cities and regions – viewed as a route to developing indigenous R&D capabilities.

Universities have traditionally focused on producing basic research or less targeted knowledge. This has typically been conducted without much consideration of potential commercial exploitation. The role of universities has, however, increasingly broadened, as the sector is under pressure to contribute more directly to economic development. Academic research is increasingly mission-orientated and contract-based (see chapter on 'Knowledge Diffusion').

The spillovers from higher education R&D improve the innovation capacity of cities

53. Leitch Review of Skills (2006) 'Prosperity for all in the global economy – world class skills: Final Report.' London: HM Treasury.
54. Medical and general degrees are not subject to classification award and are included in the unclassified category. Figures for Scotland will be distorted as the University of Aberdeen misreported 1,285 honours degrees as ordinary degrees, showing in the tables as unclassified awards.
55. Rodriguez-Pose, A. and Crescenzi, R. (2008) Research and Development, Spillovers, Innovation Systems and the Genesis of Regional Growth in Europe. 'Regional Studies.' 41 (1), pp.51-67; Aghion, P. and Howitt, P. (1998) 'Endogenous Growth Theory.' Cambridge, MA: MIT Press.
56. Aghion, P. and Howitt, P. (1998) 'Endogenous growth theory.' Cambridge, MA: MIT Press; Dinopoulos, E. and Thompson, P. (1999) Reassessing the Empirical Validity of the Human-Capital Augmented Neoclassical Growth Model. 'Journal of Evolutionary Economics.' 9, pp.135-154.
57. Cohen, W. M. and Levinthal, D. A. (1989) Innovation and Learning: The Two Faces of R&D. 'The Economic Journal.' Vol. 99, No. 397, pp.569-596.

Figure 5: Higher education qualifications obtained in UK core cities as a percentage of total population, 2006/07



	Total HE qualifications obtained as a percentage of total population, 2006/07	First degree qualifications as a percentage of total HE qualifications, 2006/07	Percentage of first degrees that are first or upper second class, 2006/07	Number of doctorates awarded, 2006/07
Nottingham	2.6	51.0	63.9	655
Leeds	2.4	60.3	60.2	475
Edinburgh	2.0	55.8	47.2	690
Sheffield	2.0	60.5	62.1	560
Cardiff	2.0	54.1	57.9	320
Liverpool	1.7	54.5	51.0	400
Belfast	1.7	57.2	62.6	420
Newcastle	1.6	51.1	55.9	425
London	1.6	40.2	53.6	3,205
Bristol	1.4	58.0	61.9	470
Manchester	1.4	56.5	57.2	920
Glasgow	1.0	54.6	46.5	615
Birmingham	1.0	49.5	52.6	615

Source: Higher Education Statistics Agency

and regions. Businesses' contribution to innovation capacity partly depends on access to knowledge generated through university R&D, and the ability of firms to exploit that knowledge. Corporate patenting activity in the US is associated with increases in the level of expenditure on research undertaken by universities. A number of studies have found evidence of localised knowledge spillovers from university R&D to commercial innovation by private firms. Despite the difficulties in measuring its economic impact, the European Competitiveness Report states that: "expenditure on R&D in the higher education sector significantly stimulates growth of gross domestic product" and the effect of university research is greater than the income share it now receives – an indication of spillover effects".[58]

3.5.1 What do the data tell us?

Higher education R&D intensity is highest in Scotland

Figure 6 shows that expenditure on R&D performed in higher education as a proportion of Gross Value Added (GVA) – often referred to as R&D intensity – is highest in London and Scotland. Scotland ranks first in terms of higher education R&D when compared to regional GVA. Scotland also performs well on an international level and is ranked just below Sweden and Canada amongst OECD countries.[59] For example, as a result of the high intensity of research in its universities, Scotland's biotechnology industry is growing 30 per cent faster than the rest of Europe.[60] London has the highest concentration of universities – expenditure on higher education R&D in the capital accounts for 24 per cent of the UK total[61] – enhancing the region's absorptive capacity and innovation performance actively through the generation of knowledge and the associated spillover effects. The West Midlands has the lowest expenditure on higher education R&D as a proportion of GVA and accounts for just below 8 per cent of total UK expenditure.

In an effort to exploit the knowledge generated by higher education, the government has introduced measures to promote the commercialisation of university research which have started to change its nature. Whilst there are opportunities to lever the sector's direct contribution to innovation, it is also important to recognise the more indirect and distinctive contribution the sector makes through basic research. This, of course, is linked to the difficulties in measuring the more indirect contribution being made by the sector.

3.6 R&D in government

The government funds research performed in the private sector and provides incentives to business though initiatives such as R&D tax credits. Here we concentrate on the R&D performed within government establishments.

As with R&D performed in universities, economic returns are not the primary purpose of government-based R&D. Government R&D is intended to have larger benefits to society as a whole than an individual or enterprise can appropriate. It has mission-specific goals including national security, public health and exploration of space[62] and often produces public goods: health-related research improves average length and quality of life but this is not taken into account in GDP or GVA. The more indirect economic impacts of government research are positive but it is unclear whether their impact is similar to that of R&D carried out in other sectors, due in part to the associated time lags. Government-owned research laboratories have also changed considerably. With cuts in funding, they are under increasing pressure to generate commercial income and technology transfer.

3.6.1 What do the data tell us?

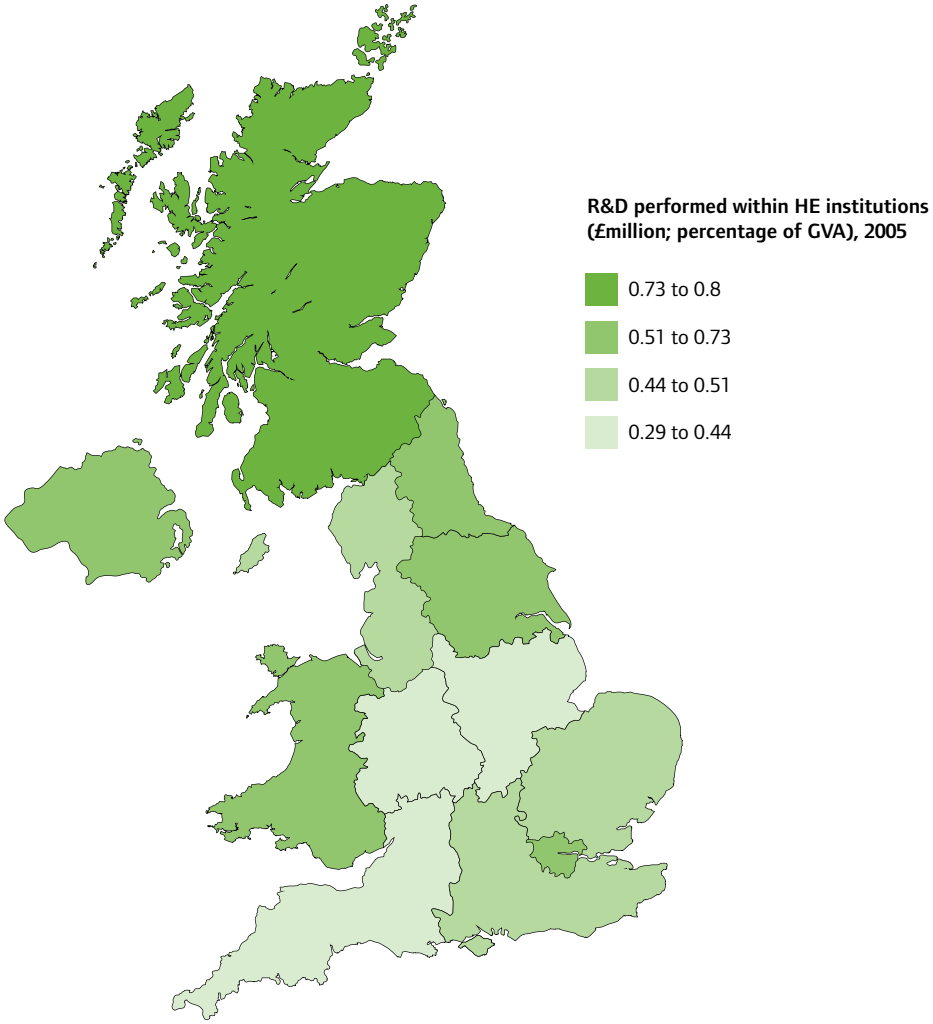
Relative to regional GVA, expenditure on R&D performed with government establishments is highest in the South West and East of England

Figure 7 shows that expenditure on R&D performed with government establishments as a proportion of regional GVA is highest in the South West and East of England. The South West accounts for 16 per cent of total expenditure on such research, 0.4 per cent of regional GVA, and twice the UK average level of government expenditure on R&D,[63] due to the presence of several large government research establishments. A large proportion is in the defence sector, as the region is home to the Ministry of Defence (MoD) Headquarters. MoD expenditure on R&D is significant; currently accounting for around 40 per cent of net government expenditure on R&D.[64] The UK Government Communications Headquarters (GCHQ) is also located in the region.

The East of England accounts for 17 per cent of this R&D expenditure, or just under 0.4 per cent of regional GVA. Much of the UK government's R&D in health is carried out in the region, with several Medical Research Council establishments located near Cambridge. Expenditure as a proportion of regional GVA is lowest in the North East,

58. EUROPA (2004) 'European Competitiveness Report 2004.' Brussels: European Commission.
59. The Scottish Government (2008) 'Business Enterprise Research and Development Scotland 2006.' Available at: http://www.scotland.gov.uk/Publications/2008/01/BERD06
60. The Scottish Government (2008) 'Education, Universities and Research.' Available at: http://www.scotland.org/about/innovation-and-creativity/education-universities-and-research/index.html
61. London also accounts for around 17 per cent of the UK's GVA.
62. EUROPA (2004) 'European Competitiveness Report 2004.' Brussels: European Commission.
63. UK Invest (2008) 'South West England.' Available at: http://www.ukinvest.gov.uk/South-West-England/10516/en-GB.pdf
64. Ministry of Defence (2008) 'UK Defence Statistics.' Available at: http://dasa.mod.uk/natstats/ukds/2007/c1/table108.html

Figure 6: R&D performed within Higher Education Institutions (£million) as a percentage of regional GVA



	R&D performed within Higher Education Institutions (£ million) as a percentage of regional GVA, 2005
Scotland	0.8
London	0.7
Wales	0.5
Northern Ireland	0.5
Yorkshire and the Humber	0.5
North East	0.5
East of England	0.5
South East	0.5
North West	0.4
East Midlands	0.4
West Midlands	0.3
South West	0.3

Source: ONS

with just 3 per cent of R&D in government establishments.

3.7 R&D in business

Much of the R&D performed within business is concentrated on development, unlike the public sector. This indicator – expenditure on R&D performed within UK businesses as a proportion of regional GVA – provides an indication of the resources being channelled into increasing their knowledge base. The objectives and impacts of this R&D are two-fold: "firms invest in R&D not only to pursue directly new process and product innovation but also to develop and maintain their broader capabilities to assimilate and exploit externally available information".[65]

Performance and expenditure on R&D in the private sector are very sector-specific: the largest expenditures were in the pharmaceutical (25 per cent), aerospace (16 per cent) and computer and related activities (8 per cent) sectors. Differences in R&D intensities across cities and regions are consequently likely to reflect differences in industrial structure rather than innovative behaviours and performance.

3.7.1 What do the data tell us?

Within the East of England, three times the national average is spent on business R&D
Figure 8 shows that research intensity in the private sector – or business R&D as a proportion of regional GVA – is by far the highest in the East of England. The region spends three times the national average. The concentration of business R&D in the East of England – it accounts for a quarter of the UK total – reflects regional industrial specialisation. The region is home to 185 biotechnology companies and Norwich has the largest concentration of plant, food and microbial scientists in Europe. The region also has the UK's largest concentration of R&D engineers.

There is a complementary relationship between university and corporate research activities
The region also provides an example of how university and corporate research activities complement each other. Cambridge University has attracted a large amount of inward investment in R&D into the area because of its outstanding global reputation. The university has acted as a research base for a number of companies in software and IT, advanced electronics, engineering materials and instrumentation.[66] Global companies – Hitachi, Toshiba and Microsoft – have located their R&D activity in the region.[67] The impact of university R&D is likely to be higher if businesses are conducting R&D in the same area as it is linked to firms' absorptive capacity.

London's expenditure on R&D is low, reflecting its industrial structure
London's expenditure on R&D performed within business is low – again, a reflection of its industrial structure. As a world financial centre, R&D-intensive sectors are supported by London's equity markets. Research intensity in business R&D is also relatively low in Scotland, Yorkshire and the Humber, and Wales. The government is keen to harness the positive external benefits of the university sector, particularly in these regions where business R&D is weak. Scotland, for example, has tackled shortfalls in corporate R&D by leveraging research at its world-class universities.

3.8 New knowledge creation

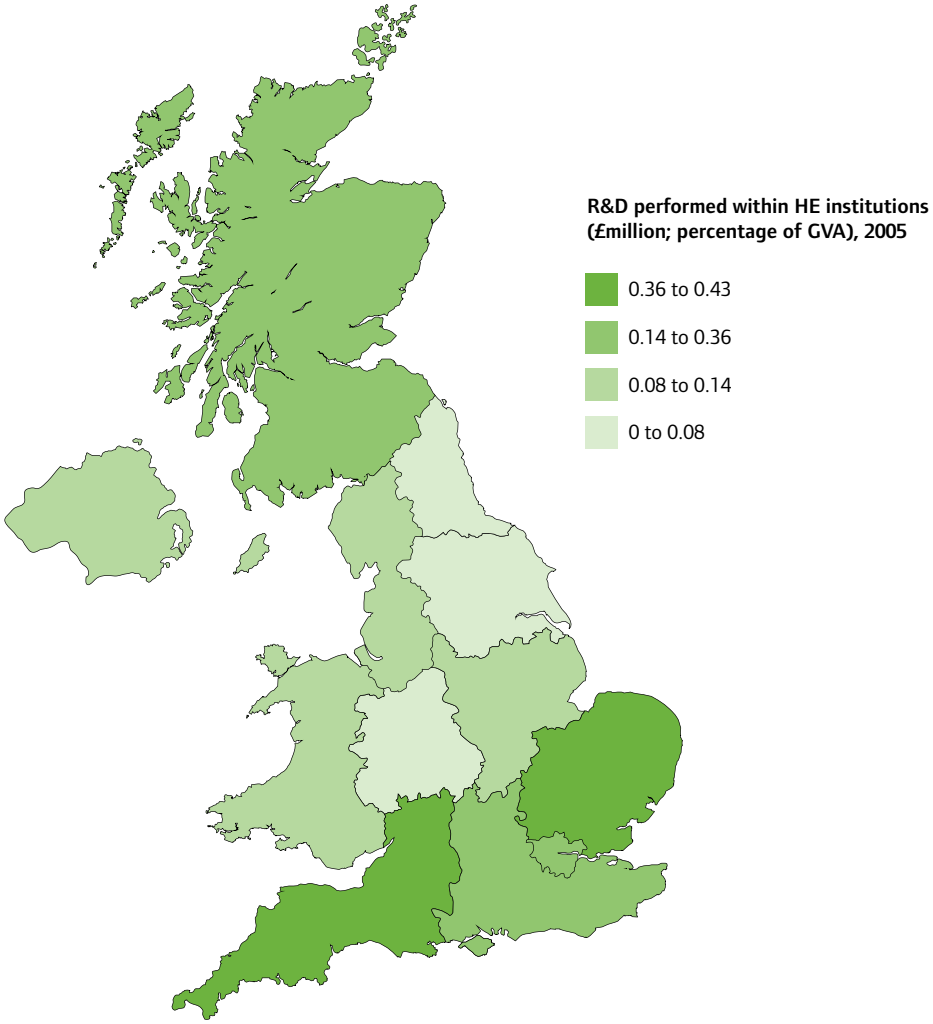
3.8.1 Patents

Patents provide an output measure of the knowledge created within regions. The number of patent applications granted can indicate the success of innovative activities and indicates an economy's increased stock of knowledge. Given the administration process involved in patenting, the indicator is accurate and reliable. There is also a relatively short time lag between R&D activity and patent application. Nationally, the relationship between R&D and patents is very strong, as in the US, Japan and Germany. The relationship is also strong between R&D and patents within individual industries, particularly in computers, instruments, and pharmaceuticals.

Governments have supported the creation and commercialisation of intellectual property (IP) by encouraging patenting by universities and national laboratories – institutions that traditionally did not seek patent protection. As such, there has been a rapid increase in university patenting, licensing and start-up activity. From 2001-2 to 2005-6, the number of patents granted rose by 130 per cent and the number of licence agreements by 271 per cent. Income from licences rose 215 per cent to £187 million. Among the 41 universities that patented in 2002, the average patent rate per university was 8.5 per cent.[68]

65. Cohen, W. M. and Levinthal, D. A. (1989) Innovation and Learning: The Two Faces of R&D. 'The Economic Journal.' Vol. 99, No. 397, pp.569-596.
66. Garnsey, E. and Lawton-Smith, H. (1998) Proximity and Complexity in the Emergence of High Technology Industry: The Oxbridge Comparison. In 'Geoforum.' Vol. 29, No.4.
67. UK Trade and Investment (2008) 'The East of England. Available at: http://www.ukinvest.gov.uk/East-of-England/en-GB-list.html
68. Siegel, D. and Wright, M. (2007) Intellectual property: the assessment. 'Oxford Review of Economic Policy.' 23 (4), pp.529-540.

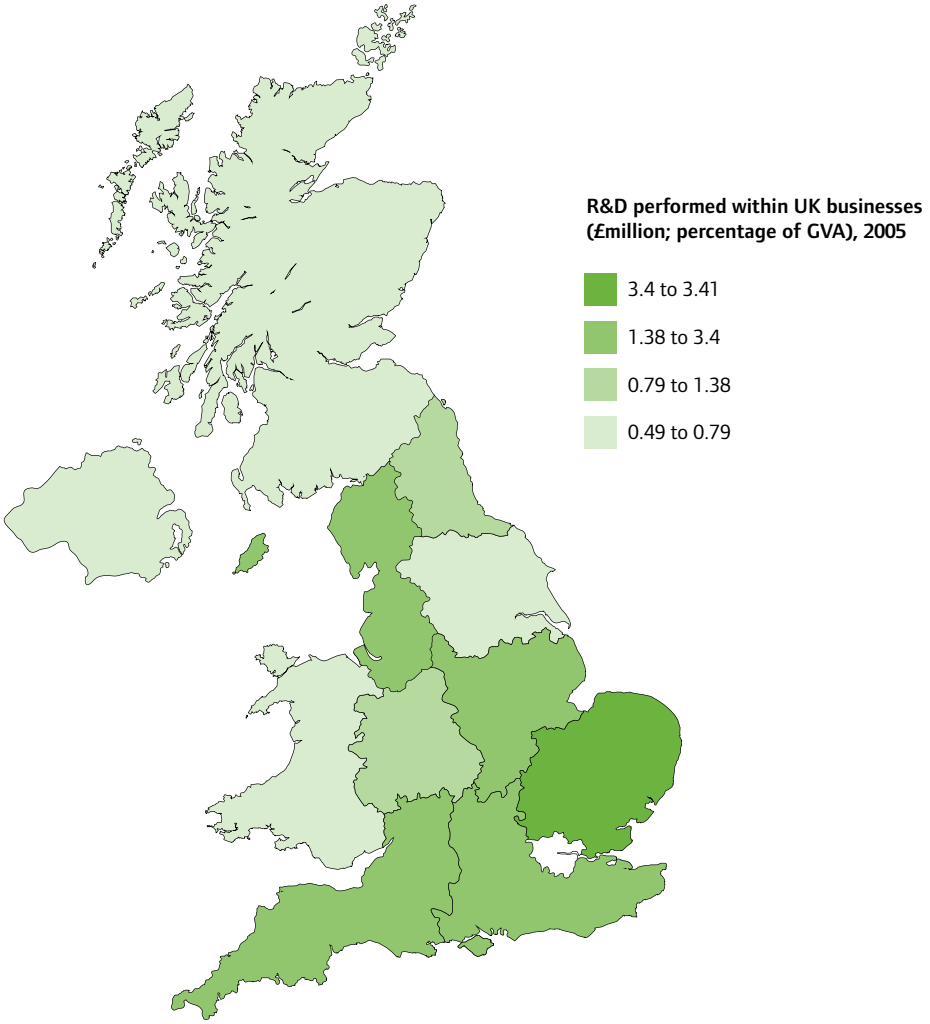
Figure 7: R&D performed within Government Establishments (£million) as a percentage of regional GVA



	R&D performed within Government Establishments (£million) as a percentage of regional GVA, 2005
South West	0.4
East of England	0.4
Scotland	0.4
South East	0.3
London	0.2
Wales	0.1
East Midlands	0.1
Northern Ireland	0.1
North West	0.1
Yorkshire and the Humber	0.1
West Midlands	0.1
North East	0.0

Source: ONS

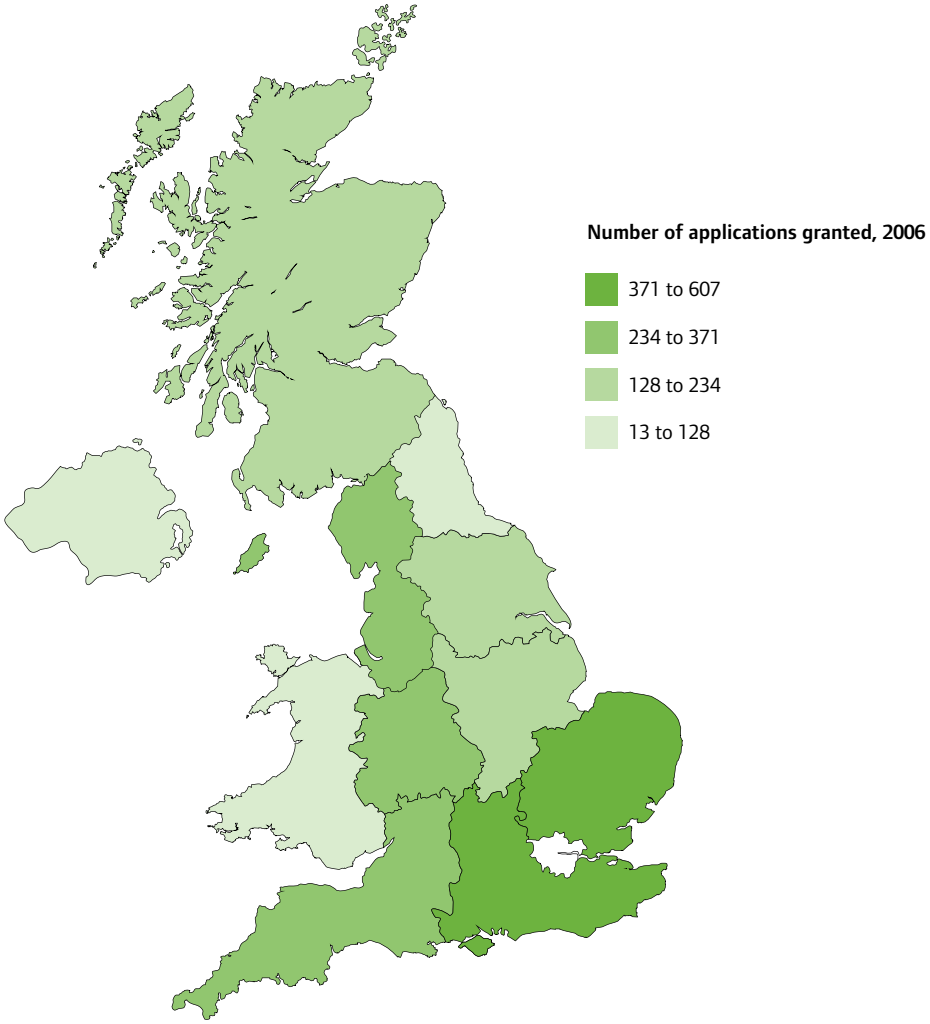
Figure 8: R&D performed within UK businesses by Government Office region as a percentage of regional GVA



	R&D performed within UK businesses by Government Office region as a percentage of regional GVA
East of England	3.4
South East	1.9
South West	1.6
North West	1.5
East Midlands	1.4
West Midlands	1.1
North East	0.8
Scotland	0.7
Northern Ireland	0.6
Wales	0.5
London	0.5
Yorkshire and the Humber	0.5

Source: ONS

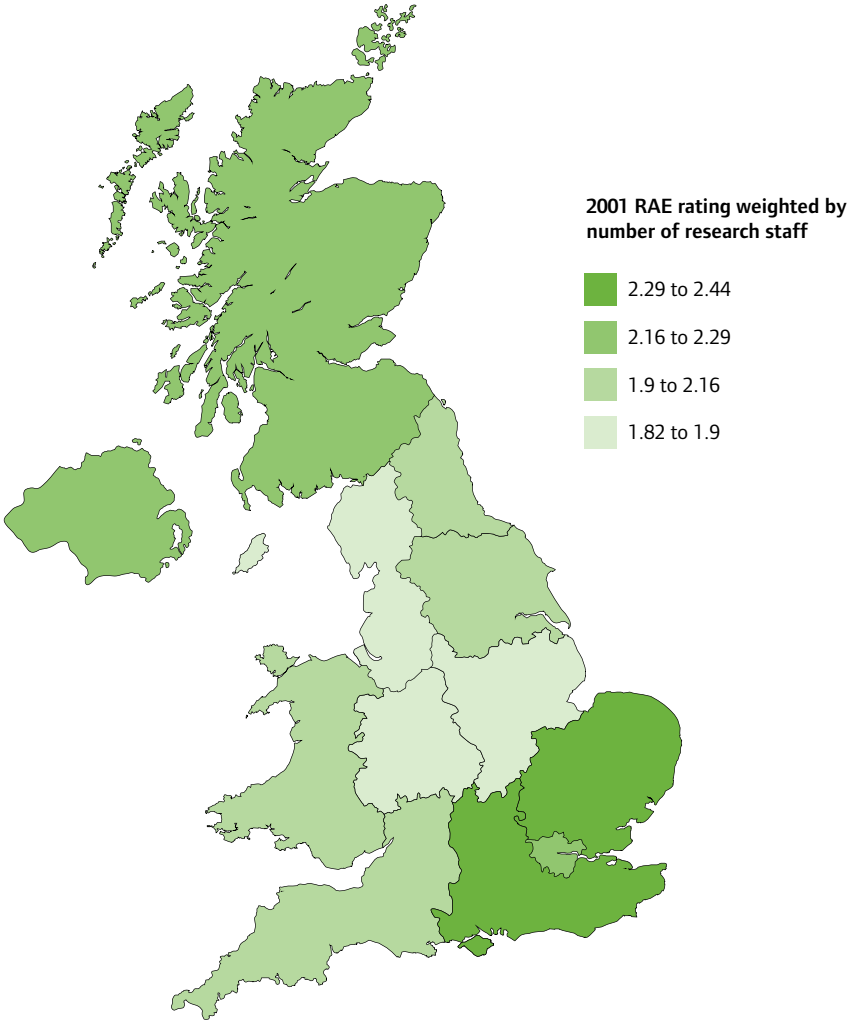
Figure 9: Patent applications granted, 2007



	Patent applications granted, 2007
South East	607.00
London	524.00
East of England	371.00
South West	344.00
North West	254.00
West Midlands	234.00
Yorkshire and the Humber	150.00
Scotland	138.00
East Midlands	128.00
Wales	88.00
North East	82.00
Northern Ireland	13.00

Source: The Patent Office

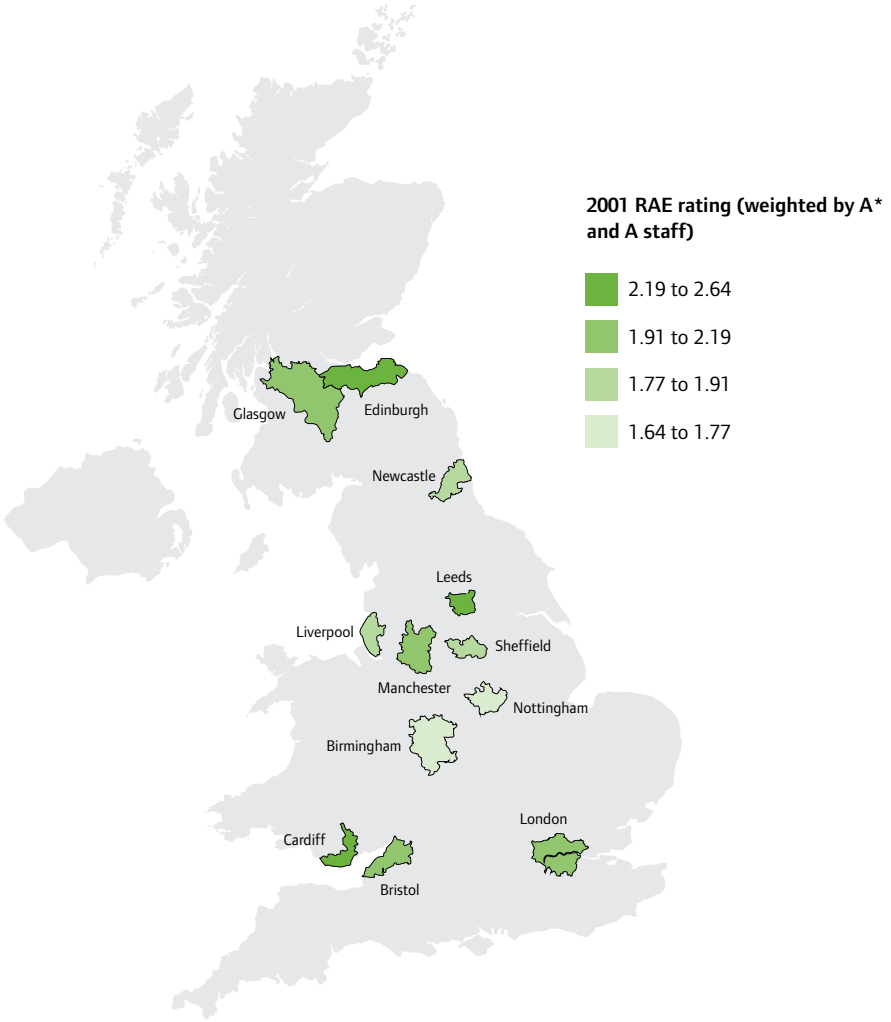
Figure 10: 2001 RAE rating (Linear Score) weighted by category A* and A research staff (FTE); weighted by number of research staff



	2001 RAE rating (Linear Score) weighted by category A* and A research staff (FTE); weighted by number of research staff
East of England	2.44
South East	2.44
Scotland	2.29
Northern Ireland	2.27
London	2.19
Wales	2.16
Yorkshire and the Humber	2.15
North East	1.97
South West	1.90
East Midlands	1.86
North West	1.84
West Midlands	1.83

Source: 2001 Research Assessment Exercise, Higher Education Statistics Agency

Figure 11: 2001 RAE rating (Linear Score) weighted by category A* and A research staff (FTE); weighted by number of research staff



	2001 RAE rating (Linear Score) weighted by category A* and A research staff (FTE); weighted by number of research staff
Edinburgh	2.6
Belfast	2.3
Leeds	2.2
Cardiff	2.2
London	2.2
Glasgow	2.1
Bristol	2.1
Manchester	2.1
Sheffield	1.9
Liverpool	1.9
Newcastle	1.8
Nottingham	1.8
Birmingham	1.6

Source: 2001 Research Assessment Exercise, Higher Education Statistics Agency

The propensity to patent varies across economic sectors and the relationship in individual industries between R&D and patents is influenced by this variation. It is likely then that the geography of patents will be influenced by the UK's regional industrial structure. It is also important to note that patents are often registered at the headquarters of a business, producing regional distortions – this is taken into account in the analysis. We should also recognise that not all new ideas and inventions are patented; and not all patents are exploited – some companies may patent an innovation as a signal to competitors even if they do not plan to exploit it. Figure 9 shows the distribution of patent applications across the UK.

3.8.2 What do the data tell us?

Over half of all UK patents are granted in the Greater South East
Figure 9 shows that there is a concentration of new patents in the Greater South East (London, South East and East of England) – over half of all UK patents are granted in the regions around London. By far the fewest patent applications are granted in Northern Ireland (just 13) followed by Wales. This may partly reflect head office location. If the head offices[69] in each of the regions are taken into account a very different picture is produced. The number of patents granted per head office is highest in the South West – 87 per head office unit, whereas it is lowest in Scotland – 22 applications granted per head office unit.

69. SIC 24 (Management activities of holding companies) is used as a proxy for head offices
70. The University of Edinburgh (2008) 'Research Quality.' Available at: http://www.ed.ac.uk/studying/postgraduate/research-degrees/research-quality

3.9 Research outputs from universities

The 2001 Research Assessment Exercise rating provides a second output measure for knowledge creation. Although slightly dated now, it is the most reliable indicator relating to the quality of research carried out in universities and other HE institutions. It also provides a broader indication of knowledge creation as it assesses the quality of research across all disciplines. 'Research' is regarded by the RAE as original investigation undertaken in order to gain knowledge and understanding. Figure 10 above shows the distribution of active researchers with high quality outputs across UK nations and regions.

3.9.1 What do the data tell us?

Research quality is highest amongst universities in the East of England
Figure 10 shows that the East of England, home of the University of Cambridge, the UK's top research university, scores highest for research quality when measured against the number of research staff in the region. Scotland, with a number of highly rated research universities, also performs well. Regions that perform less well are Northern Ireland, the North East and the South West.

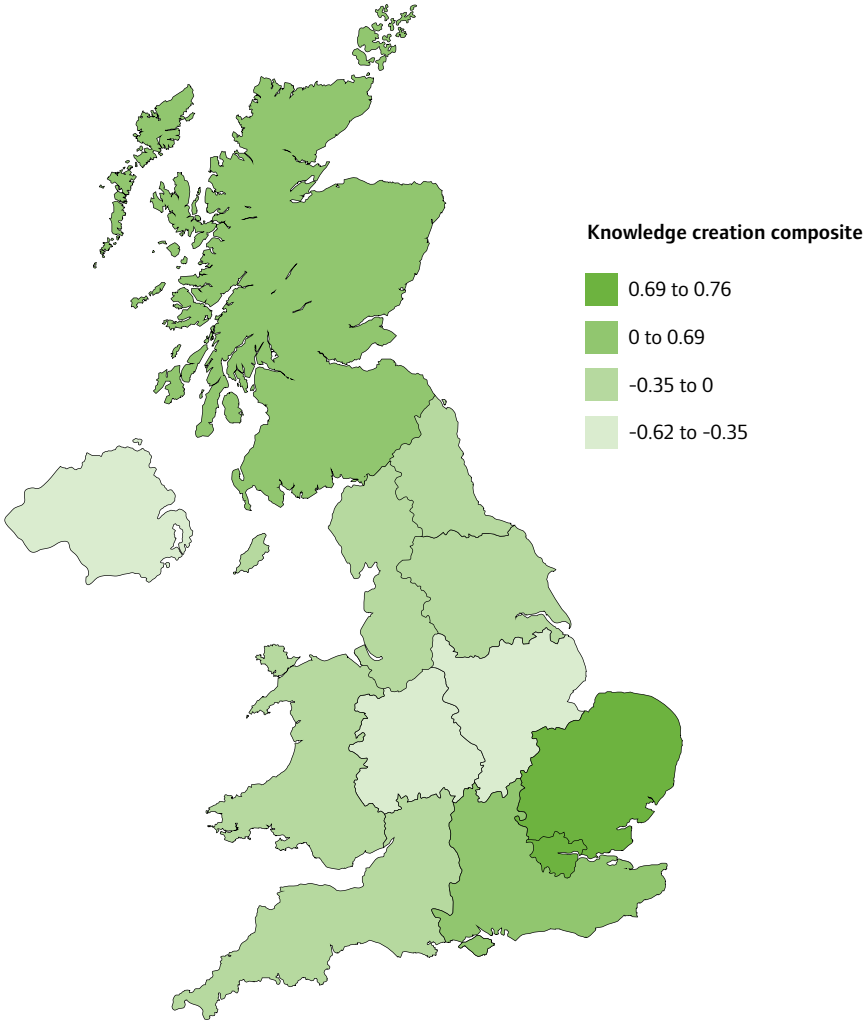
Research Outputs from HE in the core cities
Figure 11 shows that of the core cities, Edinburgh scores highest for the quality of research outputs from the higher education sector, taking account of the number of research staff in the region. The University of Edinburgh scores particularly highly on the RAE ratings – 75 per cent of staff work in 5 or 5* departments.[70] Cambridge and Oxford, with smaller populations, are not deemed core cities, although the two cities would also score well against this indicator and impact on their respective region's score. Birmingham has a significantly lower score for research outputs against the Research Assessment Exercise ratings.

3.10 Conclusions

We have provided a quantitative analysis of 'knowledge creation' across the UK regions (and where possible for the core cities) using six indicators themed under 'human capital base', 'public and private investment in new knowledge' and 'new knowledge creation'. In this concluding section, these indicators have been combined to create a composite score which we then compare to regional economic productivity.

Figure 12 shows a composite score for 'knowledge creation' across the UK. London has the highest score of the 12 regions, largely due to the institutional density in the capital and concentration of head offices. The large number of higher education institutions in the capital means that London produces the highest number of graduates and postgraduates. These institutions are also research-intensive – London scores highly for the higher education R&D when compared to regional GVA. A large number of patents are also granted in London, a reflection of the concentration of head offices.

Figure 12: 'Knowledge creation' composite indicator[71]



71. Methodology: the mean and standard deviation is calculated for each metric, then for each score (s) the mean (m) is subtracted and divided by the standard deviation (sd), i.e. new s = (s-m)/sd. An average is then taken for each of the metric to create the overall composite score. See DTI (2006) 'Innovation in the UK: Indicators and Insights.' DTI Occasional Paper No. 6, London: DTI.

	Knowledge creation' composite indicator
London	0.76
East of England	0.72
South East	0.69
Scotland	0.53
South West	-0.11
Wales	-0.18
Yorkshire and the Humber	-0.27
North East	-0.28
North West	-0.35
Northern Ireland	-0.42
East Midlands	-0.47
West Midlands	-0.62

Source: 2001 Research Assessment Exercise, Higher Education Statistics Agency

3.10.1 Regional knowledge creation capacity and GVA

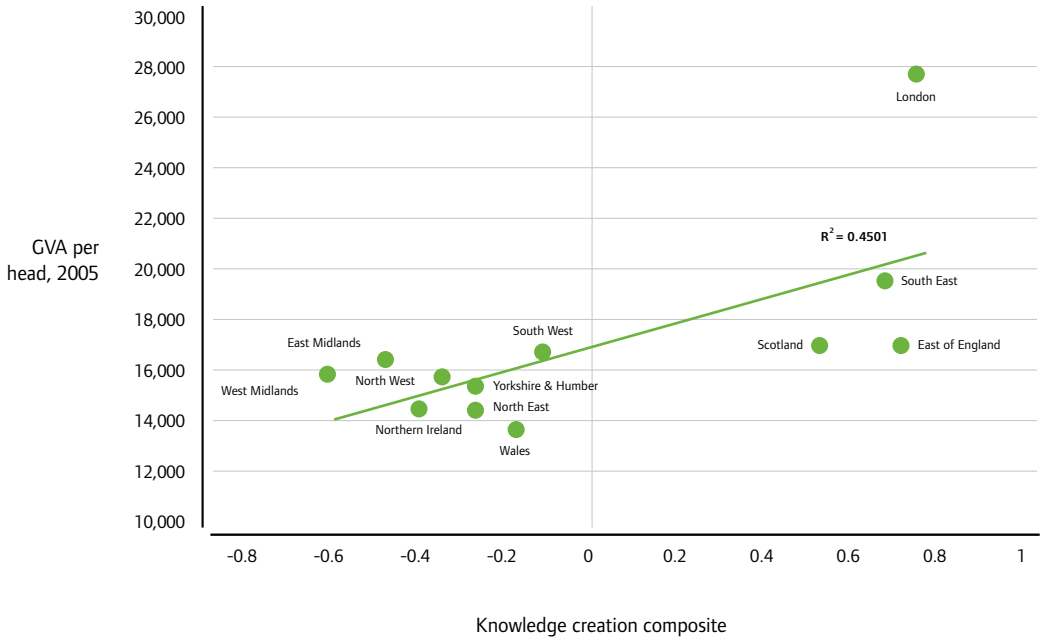
Correlating the composite 'knowledge creation' figure with GVA per head (Figure 13), there is an apparent association between the capacity to generate new knowledge and economic growth.

The East of England and the South East also score highly for the expenditure on R&D performed within businesses and government establishments, the quality of research outputs and patent applications. Taken together, these measures indicate that the 'Greater South East' has the greatest capacity to generate knowledge within their region. In the East of England, three times the national average is spent on business R&D, a reflection of the industrial specialisation in biotechnology. The University of Cambridge contributes to the region's high score for the quality of research outputs, ranked highest amongst the UK's universities, and has attracted a large amount of inward investment into the area. As a result of the research-intensive activity in the East of England, a high number of patents are awarded in the region. Research intensity is also high in the South East due to the concentration of knowledge-intensive high-technology companies. The South East also scores highly for the quality of research outputs from its universities – a score increased by the University of Oxford.

At the other end of the spectrum, the West Midlands has the lowest score for 'knowledge creation', scoring poorly for public sector R&D, the quality of university research outputs and the number of patents. For cities and regions with little indigenous knowledge creation, the challenge is to support the local players who can identify and assimilate knowledge created elsewhere.

Correlating the composite 'knowledge creation' figure with GVA per head, there is an apparent association between the capacity to generate new knowledge and economic productivity across the UK regions (see Figure 13). Generally, regions with higher 'knowledge creation' scores are also more economically productive. Within the composite the patent data has the strongest correlation with GVA per head. London stands out as having the most productive economy and the highest score on the composite. There is no clear relationship, however, between the composite score and regions with lower economic productivity. Wales for example, has the lowest GVA per head but a relatively high score on the composite, whereas the West Midlands has the lowest composite score and the seventh highest GVA per head. Excluding London from the regional correlation, there remains an association between 'knowledge creation' capacity and GVA per head (R-squared=0.45 and significant at the 0.05 level (2-tailed)).

Figure 13: Relationship between 'knowledge creation' and GVA



Whilst we have created a composite score for 'knowledge creation' capacity to give an overview of regional performance, it is important to consider regional performance against each of the separate indicators as knowledge is created through different channels and through different processes. For example, whilst much of the knowledge creation in the East of England is driven by private sector R&D, in Scotland and Wales it is the higher education sector that supports much of the regions' 'knowledge creation' activities.

As discussed above, there is a mutually reinforcing relationship between knowledge creation and absorptive capacity. The generation of knowledge within a city or region not only increases its stock of indigenous knowledge but also increases its ability to acquire external knowledge. This will be explored further in the 'absorptive capacity' chapters of this report.

The danger is that regional disparities increase through virtuous circles of development: in other words, those that start with research-intensive universities and firms are mostly likely to create and use knowledge in an innovative way, which in turn can lead to the acquisition of more knowledge. The lack of capacity to search for and generate new economic knowledge in some cities and regions appears to limit the capabilities of their firms and institutions – creating more disparities at the local, regional, national and international level.

In this chapter we have attempted to quantify the capacity of UK nations, regions and (where available) cities to generate new knowledge. A particular challenge is capturing wider and newer forms of knowledge creation and investment in intangible assets that increase individuals', firms' and regions' capacity to innovate. Many of the traditional input indicators of innovation such as R&D and patents are relatively narrow and sector-specific. It is important not to abandon these indicators but to build on them so that we may gain a fuller picture of the geography of innovation across the UK.

Chapter 4: Knowledge exploitation capacity in UK nations and regions

Main findings

The capacity to exploit knowledge refers to the capabilities existing within a city or a region to commercialise new knowledge and extract value from it. Knowledge exploitation can be seen as the reward for absorbing knowledge through the anchoring, access, and diffusion channels.

The capacity to exploit knowledge can be measured with five main indicators.

The first is the number of innovation active enterprises. The South East of England is the most innovation active region. West Midlands, Eastern England and Northern Ireland have the lowest proportion of innovation active enterprises. Across the UK, the most innovation active sectors are manufacturing, especially engineering-based manufacturing and knowledge-intensive services.

Second, process innovation new to industry indicates the exploitation of knowledge to create novel innovation. The North East leads in process innovation and Eastern England on invention.

The third indicator measures the share of product innovations that are new to the market. Scotland and Eastern England perform best here, while Wales and the West Midlands come last. There also is an association across UK regions between the share of innovations new to the market and the number of businesses operating in knowledge-based sectors as a percentage of all businesses in the region.

Early-stage private investment is also a useful tool to measure the knowledge exploitation capacity of a region. London is at the heart of the venture capital activity in the UK, followed by the South East and Eastern England. In the remaining regions and nations, the public sector is the biggest early-stage investor.

Finally, exports of knowledge services constitute a solid indicator of knowledge exploitation. The three South Eastern England regions dominate the knowledge export market. Focusing on supporting the growth of knowledge-based services exports, appears to be a rewarding wealth generation strategy.

When these measures are aggregated to measure overall knowledge exploitation capacity, London comes first, followed by South East England and South West England. The West Midlands, North West England and Wales perform poorly. The relationship between regional knowledge exploitation capacity and GVA is not always strong, but there is a strong positive relationship between the capacity to exploit knowledge and the capacity to anchor, and diffuse it.

4.1 What is 'knowledge exploitation' capacity?

Knowledge exploitation is the process of transforming, combining and reshaping knowledge in the form of research, science and technology into a tradable commodity. It is the general capacity to use knowledge commercially and extract value from it. This is often the most visible form of innovation, particularly at a policy level, and is a more direct form of value extraction often linked to the process of knowledge creation. As knowledge-based competition becomes globalised, firms cannot afford to remain stationary with their existing products and processes; they must acquire knowledge, create new ideas and translate them into commercial products. Although knowledge production and learning is undertaken by many organisations, such as universities, the onus to exploit this knowledge still largely falls on the business sector. Therefore, it is critical that regions understand the capacity of their business communities to exploit knowledge.

4.2 How do the different parts of the UK fare in the efforts to exploit knowledge?

As a means of effectively capturing and measuring the most important aspects related to regional knowledge exploitation, we draw together a range of metrics concerning the levels of innovation occurring within businesses across the regions, as well as the scope for financially supporting these activities and the extent to which value is created through the exportable sale of knowledge-based services. The indicators we use to measure knowledge exploitation capacity are as follows:

- **Innovation active enterprises** – this indicates the potential propensity of businesses to exploit their knowledge.
- **Process innovations new to industry** – this indicates the exploitation of knowledge to create novel innovation.
- **Product innovations new to market** – this indicates the exploitation of knowledge to commercialise new or improved products.
- **Early-stage private equity investment** – this indicates a demand for finance to exploit and commercialise knowledge.
- **Exports of knowledge services** – this indicates the output of the commercialisation of knowledge.

4.3 Innovation active enterprises

Business innovation through the exploitation of knowledge is important to regional competitiveness. Business innovation activity not only includes the introduction of new products and processes, but also major changes in management practices, business structure, organisation or marketing strategies, and investments in the implementation or development of future products or processes.[72] Figure 14 shows the regional distribution of firms undertaking one or more of these forms of innovation ('innovation active firms') during the period 2002-2004. In this case business innovation activity covers: the introduction of a new or significantly improved product (good or service) or process for making or supplying them; innovation projects not yet complete, or abandoned; expenditure in areas such as internal research and development, training, acquisition of external knowledge or machinery and equipment linked to innovation activities.[73]

4.3.1 What do the data tell us?

West Midlands, Eastern England, and Northern Ireland have the lowest proportion of innovation active enterprises
As shown by Figure 14, South East England is the most innovation active region, followed by North West England, and Yorkshire and the Humber. The least innovation active regions are the West Midlands, Eastern England, Northern Ireland, and Scotland. The majority of innovation active firms across all UK regions generally claim to be investing in the development of future products and processes.

Manufacturing and KIBS are the most innovation active sectors
Across the UK, the most innovation active sectors are manufacturing, especially engineering-based manufacturing (including the manufacture of chemicals, minerals, electrical and optical equipment, as well as transport equipment), followed by knowledge intensive services (including telecommunications, financial intermediation, computer and related activities, and research and testing services). In general, there is little variation across UK regions in the proportion of firms claiming to be innovation active on some

72. Not specified in document.
73. DTI (2006) 'Innovation in the UK: Indicators and Insights.' DTI Occasional Paper No. 6, London: DTI.

level, which suggests we should examine the nature of their innovation more closely.

4.4 Process innovations new to industry

The intensity of regional innovation can be furthered measured by the proportion of firms introducing process innovation new to the industry within which they operate. Process innovations consist of significant changes in the way that goods or services are produced or provided.[74] New to industry innovation represents completely novel innovations as opposed to those that are new only to the innovating firm. Processes of extracting and combining knowledge for exploitation often require particularly intensive interactions among a firm's employees. Transferring and combining knowledge within a firm is not a costless and spontaneous process, and firms need to devise and manage the process of knowledge transfer and combination effectively if they are to make the best use of their knowledge. Even in markets where steep learning curves and economies of scale help incumbents to fend off competition, new entrants with novel processes and products may surpass them as market leaders.[75] Figure 15 shows the share of process innovations that are new to the industry in which firms operate across the UK's regions.

4.4.1 What do the data tell us?

The North East leads in process innovation
The North East leads in process innovation, followed by London and Yorkshire and the Humber. While it may be surprising to see the North East at the head of the rankings it is not totally unexpected (Figure 15). Complementary innovation indicators suggest there has been significant improvement in the innovation capacity within the region in recent years. For example, data from the Patent Office finds that on a per capita basis the North East tops the regional rankings for design applications made to the Patent Office, and is second behind only London for trademark applications.[76] At the bottom of the regional rankings is Eastern England, followed by the East Midlands, North West England and Wales.

Eastern England – big on invention
Again, it is perhaps not surprising to see Eastern England propping up the rankings, since the region is acknowledged as possessing one of Europe's leading high-technology clusters in the form of Cambridge. This may be because the sectors in which the region excels, especially IT and biotechnology, focus more on radical innovation in the form of new product development than on process innovation. In general, knowledge-intensive services and engineering-based manufacturing are the industries with the highest propensity for new to industry process innovation.

4.5 Product innovations new to market

Figure 16 shows the regional distribution of the share of product innovations that are new to the market, with product innovation referring to bringing new and improved products or services either to the market or business use. Across the UK, those sectors introducing the most new products are retail and distribution, knowledge-intensive services, and the primary sector (including mining, quarrying, electricity, gas and water supply).

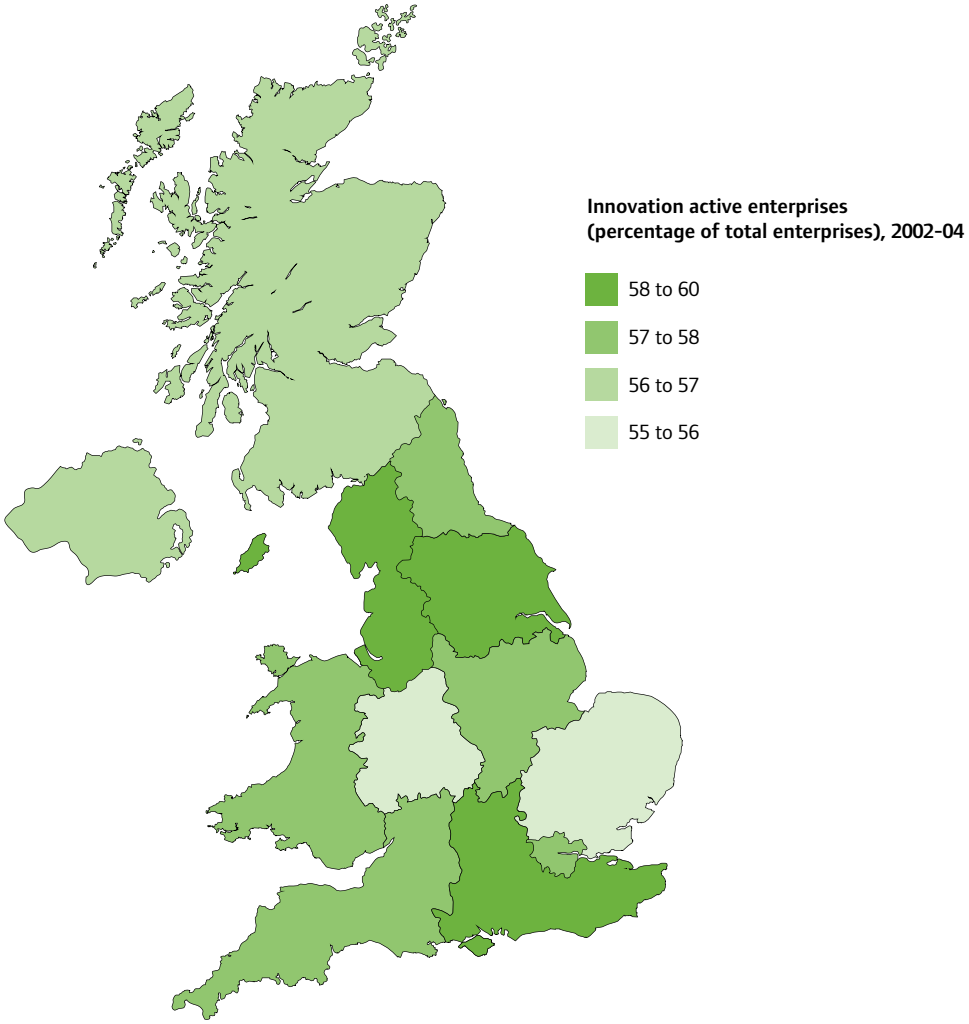
4.5.1 What do the data tell us?

Scotland and Eastern England lead in new products innovation
Scotland and Eastern England lead on product innovation, followed by London and South West England. At the bottom of the rankings are North West England, Yorkshire and the Humber, Wales and the West Midlands. Regional rates of new product development appear to be related to the prevailing industrial structure and sector composition within each region.

New knowledge drives product innovation
There is an association across UK regions between the share of innovations new to market and the number of businesses operating in knowledge-based sectors as a percentage of all businesses in the region.[77] This suggests a need for regional policymakers to focus on catalysing and developing those firms in sectors with the greatest capacity and capability to exploit knowledge through innovation. In recent years, regional policies such as cluster development have sought to address this issue, particularly through a focus on high-technology and knowledge-based sectors. Policies aimed at making connections across these sectors, as well as with other knowledge creating institutions, such as universities, have also become more apparent through a regional innovation systems approach.

74. Ibid.
75. Huggins, R. and Izushi, H. (2007) 'Competing for Knowledge: Creating, Connecting, and Growing.' London: Routledge.
76. Patent Office (2006) 'The Patent Office Annual Review.' Newport: The Patent Office.
77. The OECD definition of knowledge-based businesses is used, covering the following sectors: pharmaceuticals; office machinery and computers; aerospace; precision instruments; electrical/electronic engineering; telecommunications; financial intermediation (except insurance and pension funding); insurance and pension funding (except compulsory social security); activities auxiliary to financial intermediation; computer and related activities; R&D; other business activities; motion picture and video activities; and radio and television activities.

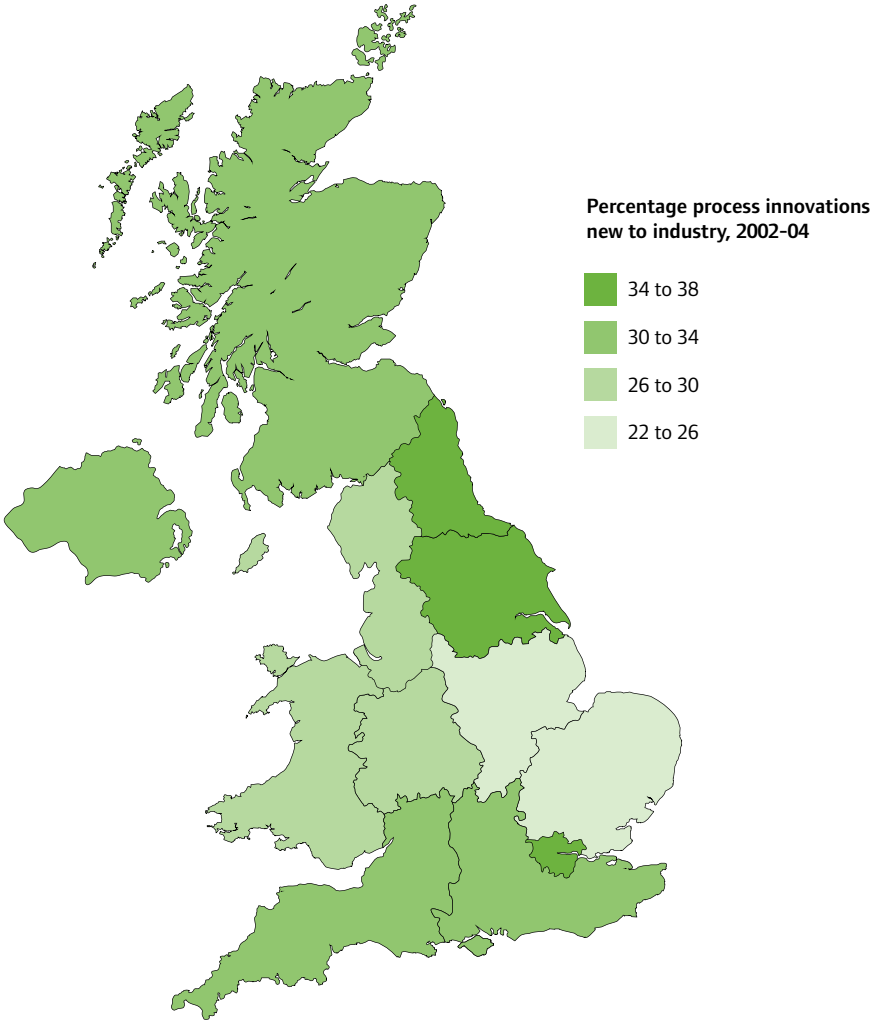
Figure 14: Innovation active enterprises (percentage of total enterprises) 2002-2004



Rank	Region	Innovation active enterprises (percentage of total enterprises) 2002-2004
1	South East	60
2	North West	58
2	Yorkshire and the Humber	58
4	London	57
4	South West	57
4	East Midlands	57
4	Wales	57
4	North East	57
9	Scotland	56
9	Northern Ireland	56
11	Eastern	55
11	West Midlands	55

Source: Community Innovation Survey 4

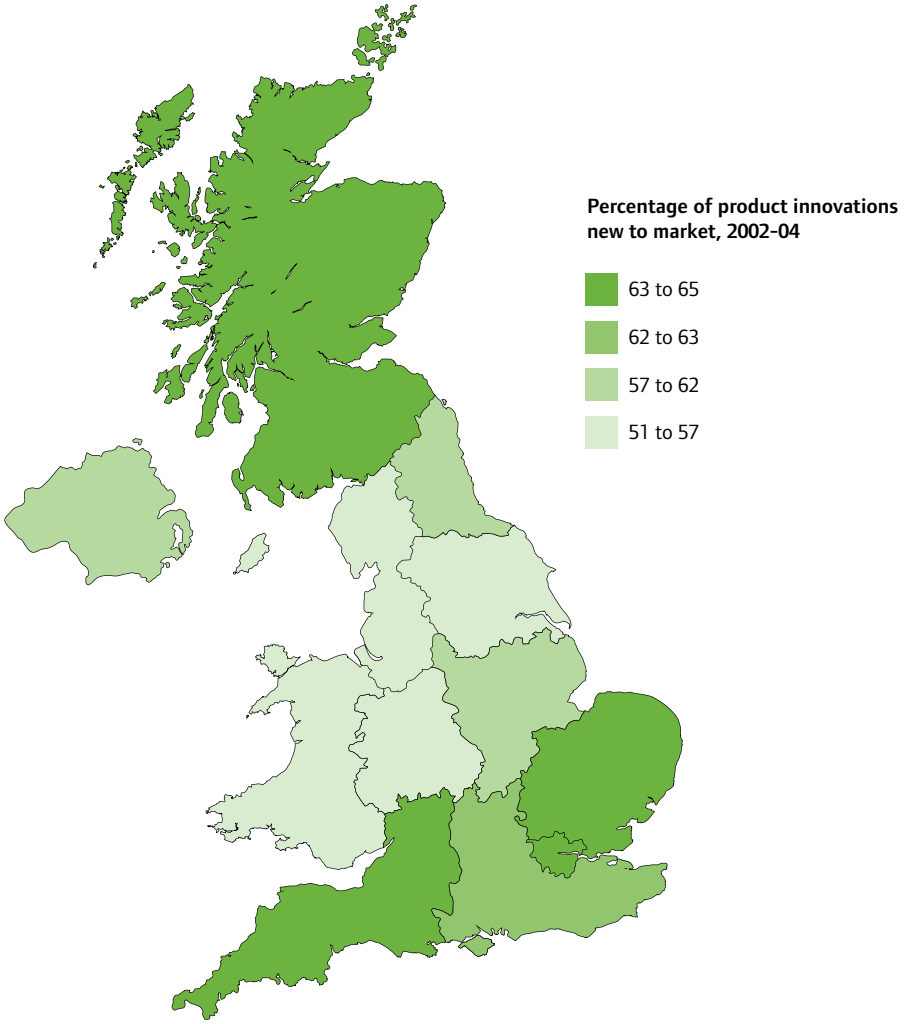
Figure 15: Percentage of process innovations new to industry 2002-2004



Rank	Region	Percentage of product and process innovations new to industry 2002-2004
1	North East	38
2	London	35
3	Yorkshire and the Humber	35
4	South West	33
5	Northern Ireland	32
6	South East	30
6	Scotland	30
8	West Midlands	29
9	Wales	28
10	North West	26
11	East Midlands	24
12	Eastern	22

Source: Community Innovation Survey 4

Figure 16: Percentage of product innovations new to market 2002-2004



Rank	Region	Percentage of product and process innovations new to market 2002-2004
1	Scotland	65
1	Eastern	65
3	London	63
3	South West	63
5	South East	62
6	North East	57
6	Northern Ireland	57
6	East Midlands	57
9	West Midlands	56
9	Wales	56
11	Yorkshire and the Humber	54
12	North West	51

Source: Community Innovation Survey 4

4.6 Early-stage private equity investment

Access to finance is an important factor determining whether new knowledge is successfully commercialised and exploited. Such finance is often provided by venture capitalists through private equity capital investments, and what is termed seed or early-stage capital. Early-stage or seed funding is required when a project has demonstrated its ability, within a research setting, to meet a well-defined challenge. At this point, the project requires funding to demonstrate its commercial viability. Early-stage financing is a step on the funding ladder designed to bridge a gap between pure research and product development. It provides investigators and entrepreneurs with sufficient resources to develop their ideas to a stage where they can approach venture capitalists or other finance institutions for further funding. Therefore, it is a key stage in the R&D cycle. Figure 17 ranks the UK's regions on the basis of the early-stage venture capital investment received on a per capita basis in 2006.

4.6.1 What do the data tell us?

London – the heart of venture capital activity

London tops the table with total early-stage venture capital amounting to £278 million, equating to £37 per resident, followed by the East Midlands and Yorkshire and the Humber. Early stage investment is low in Northern Ireland, North East England and the West Midlands. With the exception of Scotland, all regions have achieved a significant increase in early-stage investment since 1997, which suggests that increased flows of financial investment for innovation and the exploitation and commercialisation of knowledge are being made available.

Increased supply of public sector venture capital

Over recent years, national and regional public policy in the UK has sought to stimulate increased flows of venture capital through the establishment of regional venture capital funds targeted at the business community and seed funds usually geared towards exploiting opportunities emerging from universities. While in the Greater South East, the private sector dominates funding, in other regions public sector-backed funds are more important. In North East and North West England, and the East Midlands, publicly-backed funds actually account for a greater proportion of investments than those emanating from the private sector.[78] However, improved private sector early-stage investment suggests that public sector intervention is playing a positive role in stimulating and facilitating greater private sector injections of finance for commercialisation.

4.7 Exports of knowledge services

As a means of securing competitiveness, the regional exploitation of knowledge requires outputs and commodities to be tradable in external markets. In a knowledge-based economic environment, it is fair to say that trade in knowledge-based activities is a primary measure of a region's capacity successfully to commercialise and market its knowledge and innovation. Within a relatively de-industrialised advanced economy such as the UK, services have become increasingly important in securing a healthy balance of payments.[79] Service firms in the UK spend on average 4 per cent of their turnover on innovation-related acquisitions and R&D, while manufacturing firms spend 3.2 percent.[80] The purchase of productivity-enhancing machinery and equipment by the service sector also shows how manufacturing can further contribute to productivity growth. Increased investment in innovation efforts by services industries, particularly the information sector, in turn gives rise to growth in the sales of manufactured goods to service industries.[81] Figure 18 shows the regional distribution of the value of exports of knowledge services per VAT registered company within each UK region.[82]

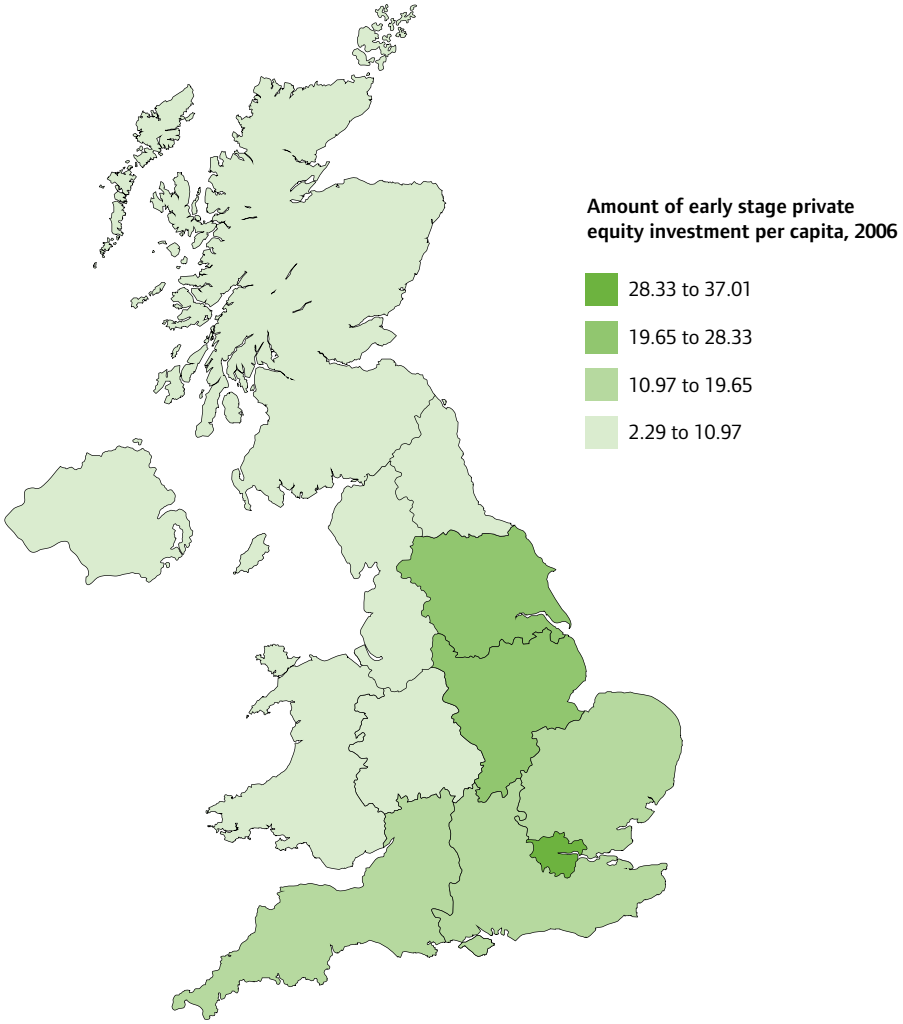
4.7.1 What do the data tell us?

The Greater South East dominates the knowledge export market

As shown by Figure 18, London leads these rankings with £35,000 in knowledge services per VAT registered company in 2004, followed by South East England and Eastern England. At the bottom of the rankings are Yorkshire and the Humber, West Midlands and East Midlands (although this is somewhat misleading due to a lack of disaggregated data for the devolved regions of Northern Ireland, Scotland and Wales). This confirms independent studies of knowledge services in UK regions – covering advertising, market research, graphic design, product design, and management consultancy – which find that service providers in London and the South East region are characterised by higher productivity and greater export penetration, as well as faster growth and wider

78. Almeida Capital (2005) 'A Mapping Study of Venture Capital Provision to SMEs in England.' Sheffield: Small Business Service.
79. Rowthorn, R. and Coutts, K. (2004) De-industrialisation and the balance of payments in advanced economies. 'Cambridge Journal of Economics.' Vol. 28, No. 5, pp.767-790.
80. OECD (2001) 'Science, Technology and Industry Scoreboard: Towards a Knowledge-Based Economy.' Paris: OECD.
81. Huggins, R. and Izushi, H. (2007) 'Competing for Knowledge: Creating, Connecting, and Growing.' London: Routledge.
82. In this case knowledge services are defined as covering: computer and information; royalties and license fees; legal, accounting and management consulting; advertising and market research; and research and development. Only aggregated data for Northern Ireland, Scotland and Wales are available.

Figure 17: Amount of early-stage private equity investment per capita (£) 2006 (Map); early-stage private equity investment 1997-2006 (Table)



Rank	Region	Amount of early-stage private equity investment (£m) 2006	Amount of early-stage private equity investment (£m) 1997	Amount of early-stage private equity investment per capita (£) 2006
1	London	278	30	37.01
2	East Midlands	105	6	24.06
3	Yorkshire and the Humber	113	13	21.97
4	South West	90	10	17.56
5	Eastern	97	16	17.30
6	South East	142	37	17.24
7	North West	56	13	8.17
8	Wales	16	4	5.39
9	Scotland	20	22	3.91
10	West Midlands	18	5	3.35
11	North East	7	1	2.74
12	Northern Ireland	4	2	2.30
	United Kingdom	**946**	**159**	**15.61**

Source: British Private Equity and Venture Capital Association

Figure 18: Value of exports of knowledge services per VAT registered company 2004 (£) (Map); value of exports of knowledge services 2001-2004 (table)

Rank	Region	Value of exports of knowledge services 2004 (£m)	Value of exports of knowledge services 2001 (£m)	Value of exports of knowledge services per vat registered company 2004 (£)	Value of exports of knowledge services per vat registered company 2001 (£)
1	London	10,015	7,205	34,913	25,541
2	South East	7,290	4,495	25,509	16,251
3	East	1,820	1,305	9,951	7,343
4	North West	1,645	680	9,560	4,052
5	South West	1,155	525	6,832	3,185
6	Northern Ireland, Scotland, and Wales	1,220	570	4,634	2,188
7	North East	195	100	4,295	2,250
8	East Midlands	500	500	4,034	4,190
9	West Midlands	550	370	3,629	2,506
10	Yorkshire and the Humber	400	240	3,085	1,897
	UK	**24,790**	**15,990**	**13,693**	**9,047**

Source: Derived from a DTI analysis of the ONS International Trade in Services (ITIS) Inquiry, adjusted to Pink Book Totals

markets, than their counterparts in peripheral regions. Further scrutiny of the data however shows that there has been significant growth in the value of knowledge service exports across all regions with the exception of the East Midlands.

4.8 Conclusions: UK regional knowledge exploitation capacity

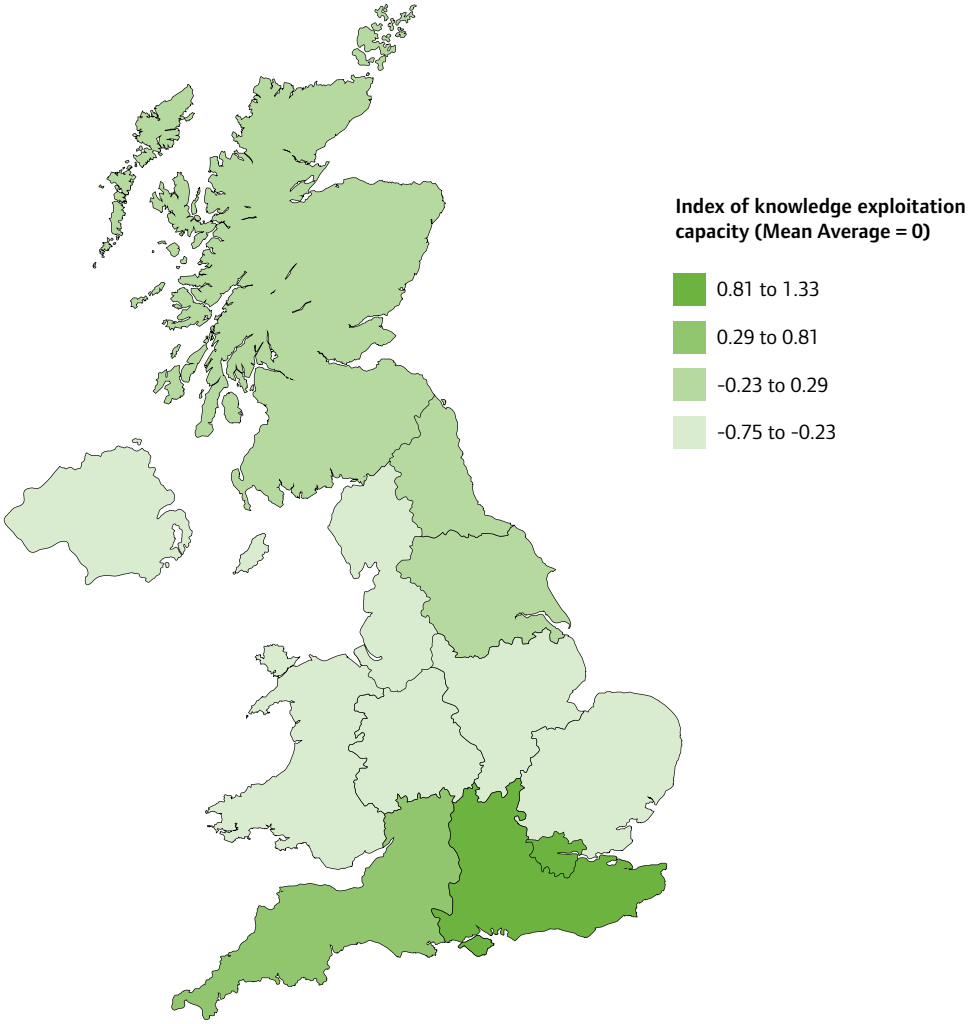
Figure 19 presents a composite index of regional knowledge exploitation capacity across UK regions, based on the mean average of the standardised values of the indicators presented, with a score of zero equating to the average for all regions. A positive score indicates that a region is performing above the regional average and a negative score below. London tops the index overall, followed by South East England and South West England, as regions showing the best performance for the commercialisation of knowledge and innovation. Yorkshire and the Humber also performs above average, reflecting improved levels of innovation and better access to capital to finance such innovation. In recent years, policymakers in Yorkshire and the Humber have placed an onus on developing regional innovation capabilities. This index suggests that these developments are being converted into positive returns. At the opposite end of the index are the West Midlands, North West England and Wales, which show a significantly weaker knowledge exploitation capacity. However, it should be borne in mind that such a determination is based on a relatively limited number of indicators and does not give us a detailed understanding of the quality of exploitation and innovation undertaken in the respective regions.

4.9 Regional exploitation capacity and GVA levels

Productivity levels represent a useful guide to the quality of innovation, and Figure 20 illustrates a strong relationship between regional knowledge exploitation capacity and Gross Value Added per capita (as a proxy of regional productivity). However, the relationship is far from totally linear. East England, for example, has below average knowledge exploitation capacity and above average GVA per capita. This suggests that wealth generation and productivity in the region may be reliant on factors beyond those measured here, while knowledge exploitation capacity is limited to one part of the region. Such a concentration implies either potential intra-regional disparities or a significant proportion of the region's knowledge being exploited beyond its boundaries. Conversely, Yorkshire and the Humber scores above average for knowledge exploitation, but below average GVA per capita, suggesting that exploitation capacities have yet fully to transfer into improved productivity; or that other weaknesses in the regional economy – such as absorptive capacity and ability to induce knowledge spillovers – are dampening the impact of these capacities.

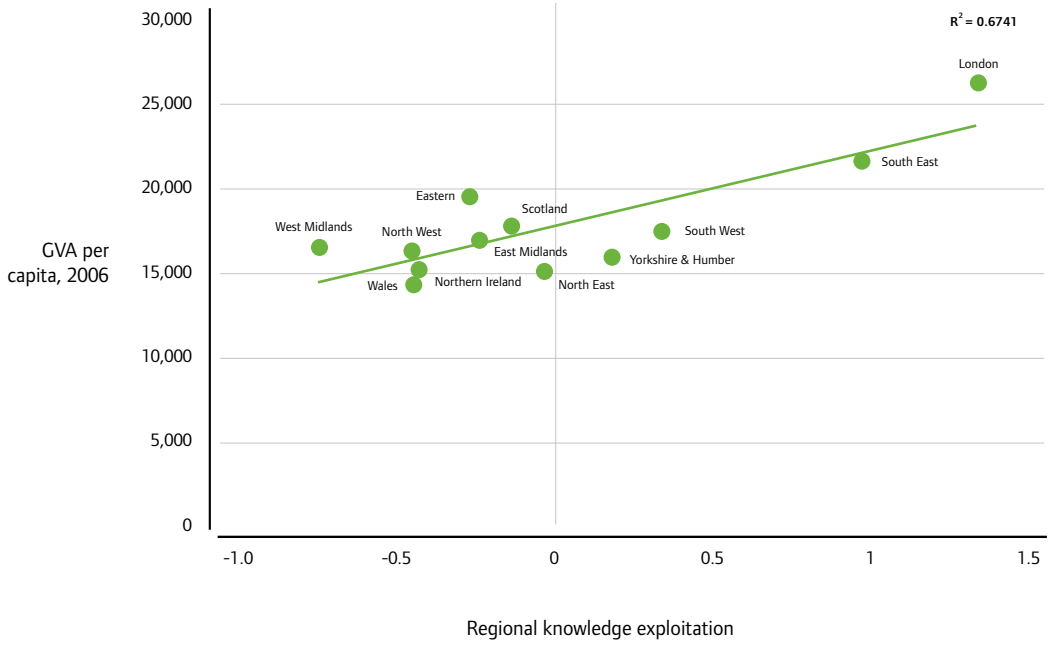
The effective exploitation of knowledge is central to a region's value creation. Those regions able effectively to exploit knowledge enjoy higher levels of competitiveness. However, the exploitation of knowledge is heavily reliant on a strong functioning system of innovation and absorptive capacity, allowing knowledge to be accessed, anchored and diffused across a region. Such systems facilitate the highest possible propensity for subsequent exploitation and commercialisation to occur. Exploitation capacity is also related to economic structure, and those regions with a more mature base of knowledge-based businesses necessarily have greater exploitative capacity. However, this relationship is neither fixed nor pre-determined. As we have seen, both Yorkshire and the Humber and North East England are showing real signs of innovation catch-up with the UK's core regions. In time, this should reap benefits for each region in terms of the wealth they generate.

Figure 19: Index of regional knowledge exploitation capacity (Map); index of regional knowledge exploitation capacity (Mean Average = 0) (Table)



Rank	Region	Index of knowledge exploitation
1	London	1.33
2	South East	0.96
3	South West	0.33
4	Yorkshire and the Humber	0.18
5	North East	-0.04
6	Scotland	-0.14
7	East Midlands	-0.24
8	Eastern	-0.28
9	Northern Ireland	-0.44
10	Wales	-0.45
11	North West	-0.46
12	West Midlands	-0.75

Figure 20: Relationship between regional knowledge exploitation capacity and GVA per capita



Part 3: How well do UK nations and regions fare in absorbing knowledge?

In the last two chapters we have mapped and measured the creation and exploitation capacities of the different parts of the UK. We have seen how the Greater South East has the greatest capacity to generate knowledge within the UK, while the West Midlands is weakest. This is important as overall it appears that there is a correlation between a region's knowledge creation capacity and its GVA. Of course correlations do not tell you the direction of causality between the two and it might well be that richer jurisdictions (with higher GVA) can afford to invest more in knowledge creation and hence the latter is dependent on the former.

London has the greatest overall regional knowledge exploitation capacity, followed by South East England and South West England. The West Midlands, North West England and Wales perform poorly. Here too there appears to be a strong relationship between regional knowledge exploitation capacity and GVA, though it is not the case in all UK regions and nations. This implies that possessing a strong exploitation capacity is not enough to guarantee a strong economic performance.

In Part 3 we take a detailed look at the performance of UK nations and regions across three other capacities which we believe to be often neglected in the measurement of innovation capacity and/or economic performance. These are the absorptive capacity components of an innovation system of a locality, which as we will see in this part of the report tend to often correlate positively with the economic and innovation performance of places. The next three chapters will thus look at the UK nations and regions' capacity to access knowledge, anchor knowledge, and diffuse knowledge.

Chapter 5: Knowledge access capacity in UK nations and regions

Main findings

Knowledge is the main driver of social and economic development. It knows no boundaries and flows across local, regional, and national borders. It is crucial for regions to secure access to these global flows of knowledge to gain access to new ideas, become part of knowledge networks, and benefit from the spillover effects that accompany them.

The ability to access knowledge sources is the capacity to link and connect to international networks of knowledge and innovation. This capacity can be measured by using four main indicators.

The first indicator is the Advanced Producer Service (APS) Network Connectivity, which allows regional metropolitan network connectivity to be measured and shows where the UK core cities are linked through business services across the world. Analysis of the data reveals that London is five times more connected than the average UK city, and that its connections are particularly strong with East Asia, Europe, and the US. Most other Core Cities have their strongest links with 'Old Commonwealth' Australasia and Canada.

The second indicator is the co-authorship between UK regions and non-UK partner organisations that indicates access to inward flows of knowledge through research networks. Taken together, London and South East researchers lead in collaborative global networking. Links with the US, Europe, and 'Old Commonwealth' are the strongest, and links with China are intensifying quickly. Universities forming the Russell Group are playing a central role in the UK's access to global research networks, and make the most effective contribution to knowledge transfer between academia and businesses.

Knowledge access via infrastructure networks can also be used to measure knowledge access capacity. Flights from international regional airports constitute the third indicator. Analysis of the data reveals perhaps unsurprisingly that London airports dominate all other UK airports and connect the whole of the South East.

Finally, coverage by broadband cable and fixed wireless access (FWA) technologies reveals the international flow capacity of UK regions through broadband infrastructure. London comes first in terms of FWA, but is overtaken by the West Midlands in Cable. Northern Ireland, Scotland, Wales and the North East's coverage in FWA is minimal and the speed and broadband speed for the first three of these regions is nearly half that of London's.

Overall, places' ability to access global flows of knowledge is likely to be linked with high densities of specialised, knowledge-intensive firms, and research universities supported by high volume flow infrastructures. There also appears to be a positive relationship between knowledge access and a proxy for regional productivity – Gross Value Added per capita. Access capacity, while very important for local economic development and innovation performance, is by no means a sufficient condition to drive local economic growth alone.

5.1 What is 'knowledge access' capacity?

The ability to 'access knowledge' sources is the capacity to link and connect to international networks of knowledge and innovation. With increased globalisation, information increasingly flows through organisational networks such as firms with multiple offices around the world. The ability to make global connections in the knowledge economy requires agents, resources and culture. Agents are active actors in universities or firms who can identify and value relevant sources of knowledge and developments elsewhere and use them to acquire, produce and distribute new knowledge. These can be individuals or teams of practitioners, working at a university or in a small or large firm who collaborate with relevant players across the world. The importance of network agents in knowledge production, transmission and transfer is well-established.[83] In the knowledge-based economy, "firms search for linkages to promote inter-firm interactive learning and for outside partners and networks to provide complementary assets", but institutional capabilities to transfer knowledge through network forms of organisation occur both in business and academic sectors.[84]

Resources are needed for such linkages to be created and for subsequent knowledge transfer to take place within and between sectors. Such resources can be intellectual, organisational or financial. Culture matters too, particularly a culture of openness and learning.[85] Openness and integration in global knowledge networks are conducive to global knowledge flows; indifference to external competition does not drive resources and agents to embrace the economic vibrancy associated with global associations. As explained in Chapter 1, in 'less cutting edge' UK places, innovation may occur predominantly outside local territorial and jursidictional areas. Without global network connections and flows of information, the capacity for innovation of UK cities and regions – crucial for social and economic vibrancy – would be seriously compromised.[86]

5.2 How can it be measured?

Quantifying territorial stocks of knowledge capital is not possible because knowledge flows are dynamic. The complexity of the contemporary geography of knowledge flows means that their measurement is also far from simple. Proxies are needed especially to estimate tacit knowledge transfer.[87] The indicators we use to measure knowledge access capacity are as follows:

- **Advanced Producer Service (APS) network connectivity** – this indicates access to inward flows of knowledge through firms' global networks in the advanced service economy.

- **Co-authorships between UK regions and non-UK partner organisations** – this indicates access to inward flows of knowledge through research networks.

- **Communications and international transport networks:**
  1. Flights from regional international airports – this indicates the international knowledge flow capacity of UK regions through airline infrastructure.
  2. Coverage by Broadband Cable and Fixed Wireless Access (FWA) technologies – this indicates the international flow capacity of UK regions through broadband infrastructure.

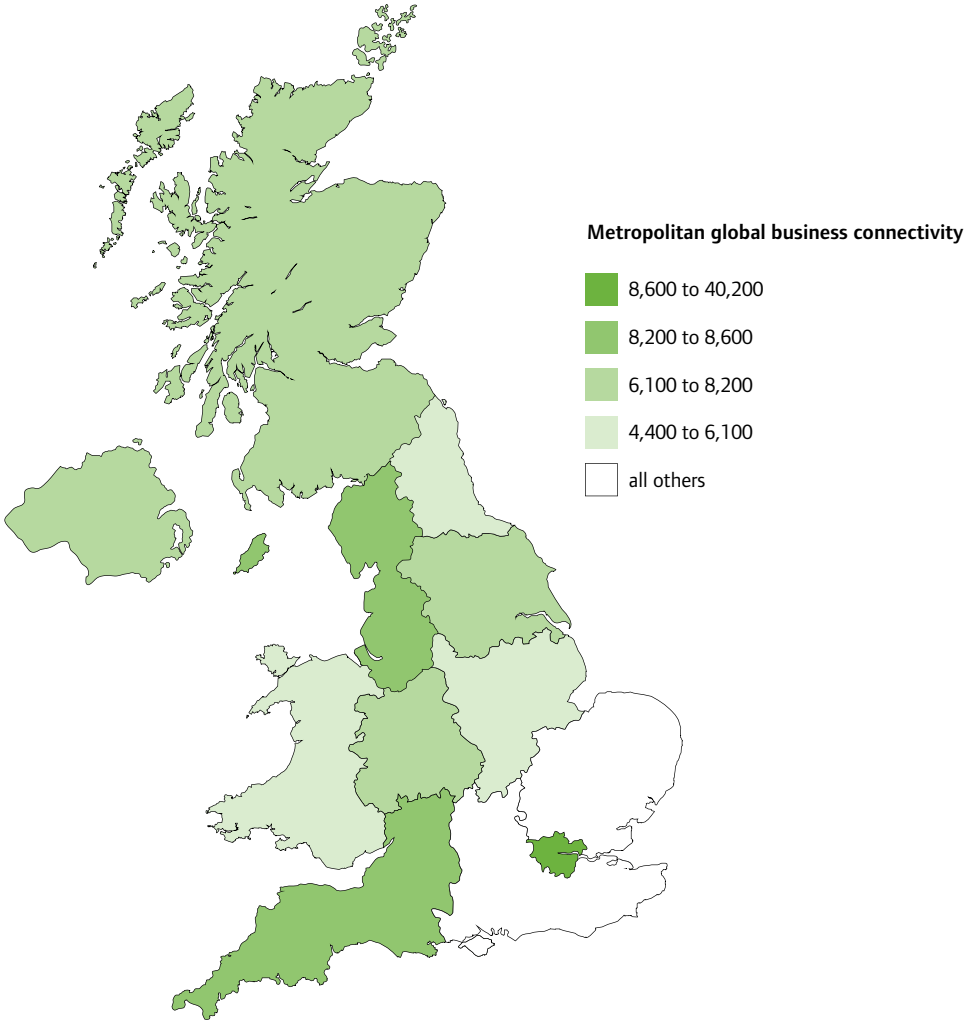
Advanced Producer Service (APS) network connectivity – this indicates access to inward flows of knowledge through firms' global networks in the advanced service economy

Recent research has shown the importance of knowledge-intensive business services (known as 'KIBS') in regional knowledge diffusion and transfer due to their ability to link many economic sectors and actors.[88] For example, innovation-related interactions between KIBS and small firms have been found to help generate and diffuse knowledge within national and regional innovation systems.[89] We therefore look at the global KIBS networks in major UK city-regions.

Within KIBS, Advanced Producer Services (APS), including finance, banking, law and accountancy, provide services specifically to other businesses rather than retail customers and this makes them a very strong indicator for knowledge-intensive flows and transfer between agents and places. They are recognised in the literature for their distinctive role in the development of well connected and innovative city economies[90] and have a particularly important interactional role in the most knowledge-intensive parts of the new world service economy.

83. Knoke, D. and Kuklinski, J. H. (1982) 'Network Analysis. Quantitative Applications in the Social Sciences.' Newbury Park, CA: Sage.
84. OECD (1996) 'The Knowledge-Based Economy.' Paris: OECD. p.15 and p.41.
85. See for example Grossman, G.M. and Helpman, E. (1994) Endogenous Innovation in the Theory of Growth. 'Journal of Economic Perspectives.' 8 (1), pp.23-44.
86. Taylor, P.J., Evans, D.M., Hoyler, M., Derudder, B. and Pain, K. (2007) 'The UK Space Economy as Practised by Advanced Producer Service Firms.' GaWC Research Bulletin 227. Available at: http://www.lboro.ac.uk/gawc/rb/rb227.html
87. Pain, K. and Hall, P. (2008) Informational Quantity versus Informational Quality: The perils of navigating the space of flows. 'Regional Studies.' 42(4).
88. Strambach (2001) Innovation Processes and the Role of Knowledge-intensive Business Services. In Koschatzky, K., Kulicke, M. and Zenker, M. (2001) 'Innovation Networks – Concepts and Challenges in the European Perspective. Heidelberg: Physica. pp.53-68; Tödtling, F., Lehner, P. and Trippl, M. (2006) Innovation in knowledge intensive industries. The nature and geography of knowledge links. 'European Planning Studies.' 14 (8), pp.1035-1058.
89. Muller and Zenka (2001) 'Business as Actors of Knowledge Transformation and Diffusion: Some empirical findings on the role of KIBS in regional and national innovation systems.' Working Papers, Firm and Region, R2/2001. Karlsruhe: ISI. p.5 and pp.18-19.
90. Sassen, S. (2002) (Ed.) 'Global Networks, Linked Cities.' New York: Routledge.

Figure 21: Global business network connectivities



Global business network connectivities of UK metropolitan regions

UK cities	World	East Asia	East Europe	West Europe	South East Asia	USA	Latin America	Canada	Aus.	Middle East/ N. Africa	South Asia	Sub-Saharan Africa
London	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
N. West/Manchester	0.21	0.15	0.18	0.18	0.18	0.19	0.22	0.24	0.25	0.27	0.28	0.30
S. West/Bristol	0.21	0.15	0.18	0.18	0.19	0.20	0.19	0.27	0.26	0.25	0.26	0.27
W. Midlands/Birm.	0.20	0.16	0.15	0.17	0.18	0.20	0.19	0.27	0.25	0.21	0.27	0.24
Scotland/Edinburgh	0.20	0.14	0.18	0.17	0.16	0.18	0.20	0.22	0.24	0.23	0.23	0.24
N. Ireland/Belfast	0.16	0.11	0.15	0.13	0.12	0.13	0.18	0.18	0.19	0.24	0.19	0.26
Yorks & Hum./Leeds	0.15	0.11	0.13	0.12	0.13	0.14	0.16	0.19	0.17	0.19	0.22	0.22
N. East/Newcastle	0.13	0.09	0.13	0.11	0.11	0.12	0.13	0.17	0.14	0.19	0.16	0.21
Wales/Cardiff	0.12	0.09	0.11	0.10	0.11	0.10	0.12	0.15	0.14	0.17	0.19	0.19
E. Midlands/Nott.	0.11	0.08	0.10	0.09	0.10	0.08	0.12	0.12	0.13	0.15	0.16	0.16
S. East/Southampton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eastern/Norwich	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: all figures are given as proportions of the highest recorded connectivity (i.e. London's).

Source: GaWC Loughborough University, 2008.

91. Taylor, P.J. (2001a) Specification of the World City Network. 'Geographical Analysis.' 33, pp.181-94; Taylor, P. J., Catalano, G. and Walker, D. (2002) Exploratory Analysis of the World City Network. 'Urban Studies.' 39, pp.2377-2394.
92. Pain, K. (2007) Integrating the European Space – Flows and places in North West European city-region networks. In Cattan, N. (Ed.) 'Cities and Networks in Europe.' Montrouge: John Libbey Eurotext. pp.161-171; Pain, K. and Hall, P. (2006) Flows and relationships: Internal and External Linkages. In Hall, P. and Pain, K. (Eds) (2006) 'The Polycentric Metropolis: Learning from Mega-City Regions in Europe.' London: Earthscan. pp.104-112.
93. Wagner, S. and Leydesdorff, L. (2006) 'Measuring the Globalization of Knowledge Networks.' Paper presented at 'Blue Sky II' 2006: What Indicators for Science, Technology and Innovation Policies in the 21st Century? Paris: OECD. Available at: http://www.oecd.org/dataoecd/9/62/37450761.pdf.
94. Hewitt-Dundas, N. (2008) 'Knowledge Generation, Innovation and Space – Exploring the relationship between UK Universities and Business Innovation.' Paper prepared for NESTA.

Measures of APS global business network connectivity[91] have become an established indicator of the intensity of global advanced business knowledge flows for cities and regions.[92] We analyse 2004 data for the UK metropolitan regions (see the methodology in Appendix 3). Supplementary analyses show the UK core cities' APS business links to the major world globalisation regions. We also consider three additional interrelated indicators of knowledge access capacity, vital to knowledge economy flows.

5.2.1 What do the data tell us?

London is five times more connected than the average UK city

Detailed results are presented in Figure 21. The data show the dominance of London which is nearly five times more connected than any other region. This is no surprise but the subsequent ordering is instructive. Below London, leading UK regions fall into three groups: North West/Manchester to Scotland/Edinburgh; Northern Ireland/Belfast to East Midlands/Nottingham. There is no connectivity for the South East and Eastern regions in this analysis because both lack a major metropolitan area. Figure 21 illustrates the connectivity gradient below London with the North West and South West taking the lead and the two regions closest to London showing no global connectivity at all. Supplementary data showing where the regional core cities are strongly and weakly linked through their business services across the world are presented in Table 1. (Note, there are no core cities located in the South East and Eastern regions.)

Co-authorships between UK regions and non-UK partner organisations – this indicates access to inward flows of knowledge through research networks

Universities reach out to distant knowledge centres, whilst promoting innovation and economic growth through their business engagement and knowledge transfer activity locally. They have extensive intellectual networks that transcend different world regions.[93] They can also promote innovation and economic growth through other forms of direct domestic business engagement and knowledge transfer activity, for example through collaborative R&D activity.[94]

We measure the contribution of university inputs to UK knowledge access using bibliometric data provided by *Evidence Ltd*. This offers an indicator of the international

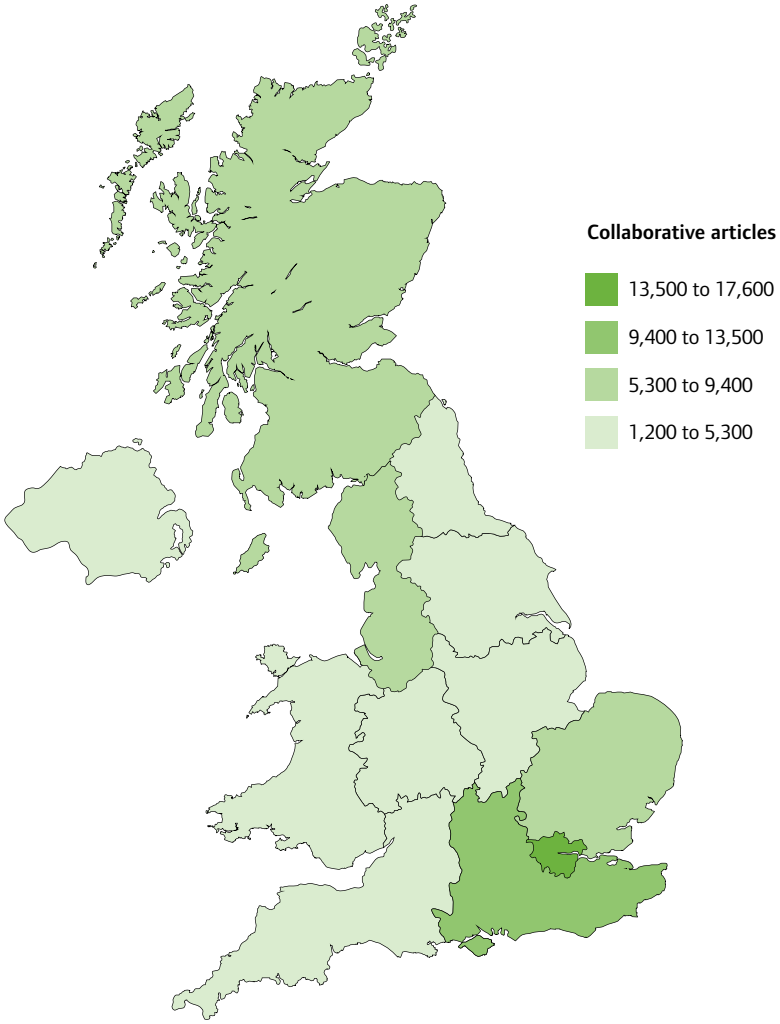
Table 1: Business hinterworld scores for UK core cities

UK cities	East Asia	East Europe	West Europe	South East Asia	USA	Latin America	Canada	Aus.	Middle East/ N. Africa	South Asia	Sub-Saharan Africa
London	0.850	0.419	0.315	0.224	0.177	-0.176	-0.672	-0.738	-0.860	-0.996	-1.155
Manchester	-0.087	-0.033	-0.043	-0.069	-0.006	0.041	0.069	0.011	0.079	0.089	0.113
Bristol	-0.087	-0.007	-0.001	-0.056	0.030	-0.073	0.098	0.131	0.003	0.025	0.006
Birmingham	-0.021	-0.029	-0.018	-0.186	0.065	-0.036	0.094	0.184	-0.076	0.093	-0.058
Edinburgh	-0.087	0.016	-0.054	0.008	0.014	0.010	0.082	0.009	-0.008	-0.021	-0.017
Belfast	-0.099	-0.042	-0.084	0.045	-0.079	0.097	0.048	-0.007	0.207	0.016	0.241
Glasgow	-0.110	-0.050	-0.069	0.012	0.041	0.015	0.107	0.096	0.026	0.074	0.076
Leeds	-0.060	-0.071	-0.027	-0.019	0.004	0.045	0.018	0.079	0.077	0.144	0.130
Liverpool	-0.089	-0.063	-0.032	0.044	-0.072	0.046	0.077	0.036	0.175	0.145	0.179
Newcastle	-0.099	-0.042	-0.045	0.035	0.014	-0.001	-0.004	0.071	0.129	0.025	0.159
Cardiff	-0.059	-0.041	0.007	0.002	-0.059	0.000	0.041	0.059	0.097	0.163	0.135
Nottingham	-0.048	-0.018	0.005	-0.010	-0.073	0.040	0.044	0.003	0.078	0.120	0.080
Sheffield	-0.004	-0.038	0.046	-0.031	-0.056	-0.008	-0.002	0.067	0.072	0.125	0.112

Note: 1. Positive scores indicate over-linkage; negative scores indicate under-linkage. 2. Regions are ordered by London's over-linkage.

Source: GaWC Loughborough University, 2008.

Figure 22: Internationally co-authored articles



UK regions	Collaborative articles (annual average 2002-2006)	Population (annual average 2002-2006)	Collaborative articles per thousand population 2002-2006
London	17,519	7,416,660	2.36
South East	13,098	8,136,300	1.61
Scotland	8,795	5,080,460	1.73
Eastern England	7,764	5,517,580	1.41
North West	7,275	6,818,240	1.07
Yorks & Humber	4,574	5,068,640	0.90
South West	4,122	5,046,180	0.82
West Midlands	3,825	5,330,180	0.72
East Midlands	3,067	4,291,780	0.71
North East	2,315	2,546,000	0.91
Wales	2,193	2,943,360	0.75
Northern Ireland	1,237	1,715,020	0.72
UK Total*	**75,783**	**59,910,400**	**1.26**

Note: *Articles counted once for each region.

Source: *Evidence Ltd*, 2008 based on data from Thomas Reuters.

links of UK academics and researchers which may contribute to the knowledge of local actors and to local business innovation. Data on co-authorships between UK regions and non-UK partner organisations between 2002 and 2006 are sourced by *Evidence Ltd* from Thomson Reuters Philadelphia-based Scientific Business Unit[95] which maintains the most complete international data on research journal publications and their citations. The *Evidence Ltd* analysis uses the 'UK National Citation Report' to identify papers published over the most recent ten years (up to the end of 2006) that have at least one non-UK address.

95. See http://www.thomsonreuters.com/business_units/scientific/
96. National Statistics Online (2005) 'Population density: by country and government office region, UK, 2004.' Based on data from the Office for National Statistics; General Register Office for Scotland; Northern Ireland Statistics and Research Agency. Available at: http://www.statistics.gov.uk

5.2.2 What do the data tell us?

London and South East researchers lead in collaborative global networking

The data on regional internationally co-authored articles (Figure 22) show that London has the highest annual average number of co-authorships for 2002-2006. Apart from the South East, London has almost twice as many as the next highest scoring region, Scotland, whereas Wales and Northern Ireland have the lowest scores, ranking 11th and 12th respectively. Taken together, co-authorships for London and the South East represent between a third and a half the UK total – 30,617 out of a total of 75,783. This partly reflects the UK regional distribution of population.[96] But it also shows a higher average number of articles, per thousand population produced for these regions – London 2.36 (ranked first) and South East 1.61 (ranked third). Scotland not only scores higher than any other UK region apart from London and the South East, for its annual average number of collaborative articles, but it also ranks second after London for average number of articles per thousand. The Eastern region ranks fourth, reflecting the world status of Cambridge University, and the North West ranks fifth. Detailed supplementary data on the geographical distribution of different types of university across the UK regions are provided in Table 2.

Communications and international transport networks – international flights and broadband internet

Active knowledge flows through business and university networks require conduits. They need both virtual and material means of transferring knowledge and ideas when agents work at a distance or face-to-face. Paradoxically, the high volume of contemporary virtual interactions associated with ICT exacerbates

Table 2: Regional profile of higher education institutions in the UK

GOR		Russell Group n	%	Post 1992 n	%	1994 Group n	%	Other n	%	Total HEI n	GOR Pop (000's)	Pop per HEI
London		4	10.3	10	25.6	4	10.3	21	53.8	39	7517.7	192.8
Scotland		2	10.5	6	31.6	1	5.3	10	52.6	19	5094.8	268.1
South East		2	11.8	7	41.2	4	23.5	4	23.5	17	8164.2	480.2
North West		2	14.3	8	57.1	1	7.1	3	21.4	14	6846.3	489.0
West Midlands		2	16.7	5	41.7	0	0.0	5	41.7	12	5365.4	447.1
Yorks & Humber		2	20.0	4	40.0	1	10.0	3	30.0	10	5063.9	506.4
South West		1	7.7	4	30.8	2	15.4	6	46.2	13	5067.8	389.8
Wales		1	9.1	2	18.2	0	0.0	8	72.7	11	2958.6	269.0
East Midlands		1	11.1	5	55.6	2	22.2	1	11.1	9	4306.3	478.5
Eastern England		1	11.1	3	33.3	2	22.2	3	33.3	9	5541.6	615.7
North East		1	20.0	3	60.0	1	20.0	0	0.0	5	2558.3	511.7
Northern Ireland		1	50.0	1	50.0	0	0.0	0	0.0	2	1724.4	862.2

Note: GOR Population Values based on Mid-2005 Population Estimates.

Source: Hewitt-Dundas, 2008, op. cit. based on ONS (2005) Key Population and Vital Statistics, Local and Health Authority Areas, VS No. 32, PPI No. 28, Table 1, p.10 ISSN 1469-2732.

the need for face-to-face contact.[97] This is because the quality of informational exchanges is crucially important and high-value exchanges require relationship building and trust which can only be established and maintained through face-to-face encounters.[98]

We measure two major international infrastructure network capacity indicators: high capacity broadband by UK region; and international flights at regional airports. Data on the regional distribution of broadband technologies are sourced from the Ovum UK Broadband Status Report, 2006, and data on flights from regional international airports are from the Civil Aviation Authority database, 2008.

International flights

If the need for face-to-face communication in key knowledge domains remains vital, proximity and distance are complementary logics of the new knowledge economy.[99] Figure 23 shows the number of flights for scheduled passengers at the international airports for each region. In the case of London, data for the Gatwick, Luton and Stansted airports are included with those for Heathrow and City airport because, as designated London hubs,[100] in practice they have a strategic national role serving London and the UK as a whole,[101] as much as their regions (South East and Eastern regions).

5.2.3 What do the data tell us?

London airport dominates and connects the entire South East

Figure 23 shows the very high international flight connectivity of the London region through its five airports. London airports dominate all others with nine times the traffic of the next regional hub, North West/ Manchester. As illustrated in Figure 23, the volume of flows for the North West, Scotland and the West Midlands replicates their high ranking for APS business connectivity – one-fifth of London's – compared to other UK regions (Figure 21).

Figure 23 shows that the South West has less international flight connectivity than through its business networks. The region's traffic volume is similar to Northern Ireland, the East Midlands and North East. This suggests business people travel from the South West to superior London terminals for many overseas business journeys (Figure 23). The limited flights from the South East and Eastern regions are deceptive because in practice they share connectivity by international flights with London having access to the major international air terminals around London in spite of lacking a major UK metropolitan area within their regional boundaries. While accurate quantitative measurement of access to the five London airports is not possible, the South East and Eastern regions are likely to enjoy a similar level of international flight connectivity to London.[102]

It is important to be aware that the regional rank order here will be distorted by two analytical issues. Firstly, the data on flights do not distinguish between business (mainly metropolitan) and retail traffic; and secondly, as demonstrated by the case of London and its neighbouring regions, actual airport usage cross cuts the statutory administrative boundaries used for regional comparisons. However, the position of Wales may be of specific concern because its topography to the north of Cardiff/South Wales limits ease of access to airports in adjacent regions. In spite of the problems of applying this indicator in regional analysis, overall, the data on international flights shows that regional connectivity is focused on major UK metropolitan areas, resulting in a particularly high capacity for London and the densely populated 'Greater South East'.[103]

Broadband Internet

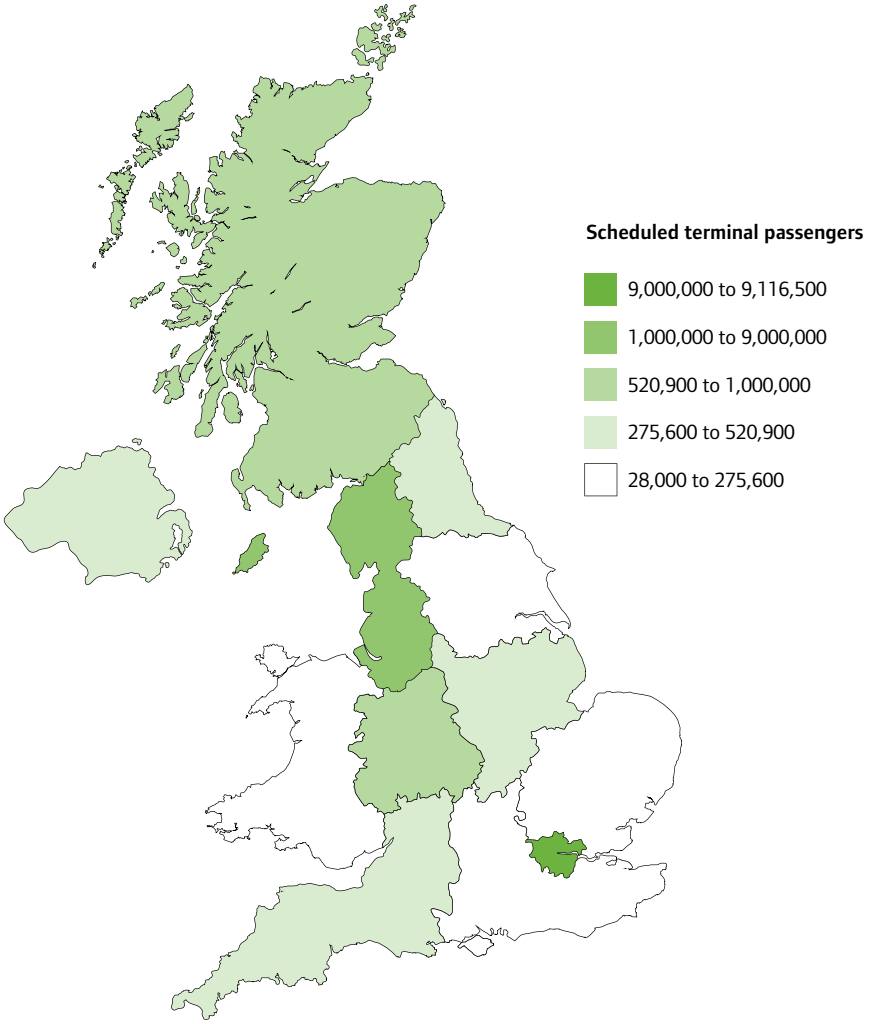
Data availabilixty on UK broadband access is incomplete due to the large number of market suppliers. The most recent position report prepared for the Department of Trade and Industry in 2006[104] shows that while DSL (Digital Subscriber Line) broadband, principally designed originally for the residential market, is generally strong throughout the UK, the same cannot be said of high capacity broadband provision. At the end of 2005, 99.8 per cent of UK households could choose to access broadband technology (see Figure 24) but this figure distorts the picture because wide variations exist in the availability of higher-bandwidth services. For this reason, the distribution of high capacity cable and FWA (fixed wireless access) provision is important.

5.2.4 What do the data tell us?

Figure 24 illustrates the dominance of cable and FWA coverage in London and the West and East Midlands. Coverage across a central belt of England contrasts with lowest provision in Scotland, Northern Ireland and Wales and zero or very low FWA coverage in these three regions (Figure 24). A recent survey of 138,000 'thinkbroadband.com' registered broadband users reveals a wide ongoing UK

97. Pain, K. and Hall, P. (2008) Informational Quantity versus Informational Quality: The perils of navigating the space of flows. 'Regional Studies.' 42(4).
98. See for example Gertler, M.S. (2003) Tacit knowledge and the economic geography of context, or the undefinable tacitness of being (there). 'Journal of Economic Geography.' 3, pp.75-99.
99. Pain, K. (2007) Global Cities, Gateways and Corridors: Hierarchies, roles and functions. In Gillen, D., Prentice, B. and Parsons, G. (Eds) 'Sustainable Transportation Policy for Gateways and Corridors, Canada's Asia-Pacific Gateway and Corridor Initiative.' Available at: http://www.gateway-corridor.com/roundconfpapers/papers.htm
100. Aerodromes Designation (Facilities for Consultation) Order 1996 (SI 1996/1392) as amended (SI 2002/2421), Civil Aviation Act 1982, section 35. Available at: http://www.ukaccs.info/statutory.htm
101. The Future of Aviation White Paper and Civil Aviation Bill, December 2003, Department for Transport.
102. Department for Transport estimates suggest that in 2003, 120 million out of a national total of 200 million journeys passed through the London airports and that 80 per cent of passengers using the main London airports are travelling to or from somewhere in the South East of the country. See http://www.dft.gov.uk/about/strategy/whitepapers/air/chapter11thesoutheast .
103. The Greater South East includes the South East, East and London regions. See http://www.seeda.co.uk/publications/Strategy/docs/GreaterSouthEast.pdf
104. Ovum Broadband Status Summary, Report for the Department of Trade and Industry March 2006, www.ovum.com

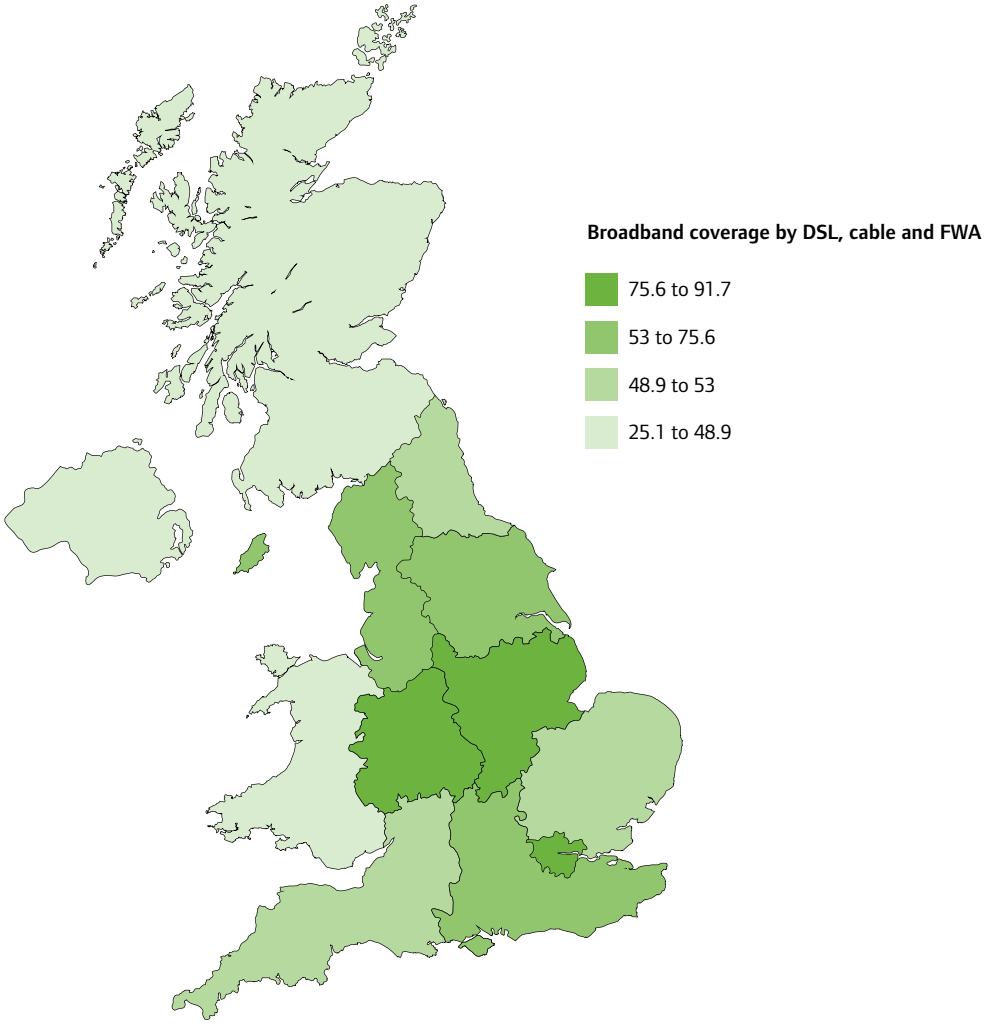
Figure 23: Flights from UK regional airports



	Scheduled terminal passengers in 2008
London/Heathrow	9,116,452
North West/Manchester International	1,000,529
Scotland/Edinburgh International	620,786
West Midlands/Birmingham International	520,919
South West/Bristol International	368,809
Northern Ireland/Belfast International	333,220
East Midlands/ Nottingham	315,523
North East/Newcastle International	275,644
Yorkshire and the Humber/Leeds International	167,793
South East/Southampton	134,880
Wales/Cardiff International	77,591
Eastern/Norwich	28,040

Source: Civil Aviation Authority, 2008

Figure 24: Terrestrial broadband coverage by DSL, cable and FWA



	DSL	Cable	FWA	Total
London	99.9%	55.1%	36.6%	100%
East Midlands	99.9%	54.8%	20.8%	99.9%
East of England	100%	49.4%	0.3%	99.9%
North East	99.9%	48.9%	0%	99.9%
North West	99.9%	54.7%	3.4%	99.9%
Yorkshire and the Humber	99.4%	42.6%	13.8%	99.9%
West Midlands	99.5%	63.0%	22.2%	99.7%
South East	99.6%	45.6%	7.4%	99.7%
South West	99.5%	40.2%	12.1%	99.7%
Scotland	99.3%	42.0%	0%	99.5%
Northern Ireland	99.7%	32.5%	0%	99.5%
Wales	99.9%	25.1%	0%[2]	99.3%
	99.7%	**48.2%**	**11.2%**	**99.8%**

Notes: 1. Proportion of households covered by broadband technologies by geographical region. 2. While there is no definite figure available for FWA coverage in Wales, Broad Band Wales Observatory (BBWO) recognises that a limited number of niche providers do offer services within Wales and, as such, BBWO does not concur with this figure.
Source: Ovum UK Broadband Status Report, Q4 2005, March 2006

Table 3: Broadband speed by UK region, 01 January – 12 May 2008

UK region	Download speed (kbps)	Upload speed (kbps)	Unique postcodes
London	4,460	507	600
North East	3,594	426	192
North West	3,393	418	689
East Midlands	3,275	407	346
South East	3,253	404	1,229
Yorkshire and the Humber	3,204	391	405
West Midlands	3,193	382	457
East	3,090	394	639
Scotland	2,876	385	608
South West	2,869	370	667
Wales	2,587	360	295
Northern Ireland	2,258	343	133

Source: http://www.thinkbroadband.com

regional disparity in high speed access with an estimated 1-2 per cent of the UK population still unable to access broadband.[105] Users in London can enjoy a download speed of 4,460 kbps, which contrasts with that of 2,258 kbps for Northern Ireland (see Table 3).

105. See http://www.thinkbroadband.com/news/3569-broadband-speeds-across-the-uk.html.

5.3 Analysis

This chapter has considered four indicators for international network connectivity vital to UK knowledge access in globalisation: (1) business (APS) networks; (2) academic networks (co-authorships) and infrastructure networks; (3) international flights, and (4) internet broadband. In spite of the limitations inherent in the application of these indicators to statutory regional statistical areas, they do provide useful snapshots of some wide variations in the 'access capacity' of different parts of the UK. The relative importance of each indicator to the regions' capacity to innovate requires careful consideration and scrutiny with reference to the caveats discussed, however on the basis of the current results we are able to provide the following analyses:

1. The overall picture for access capacity across the UK.
2. The relationship between 'access capacity' and 'knowledge creation capacity'.
3. The relationship between 'access capacity' and 'knowledge exploitation capacity'.
4. 'Access capacity' and 'Gross Value Added'.

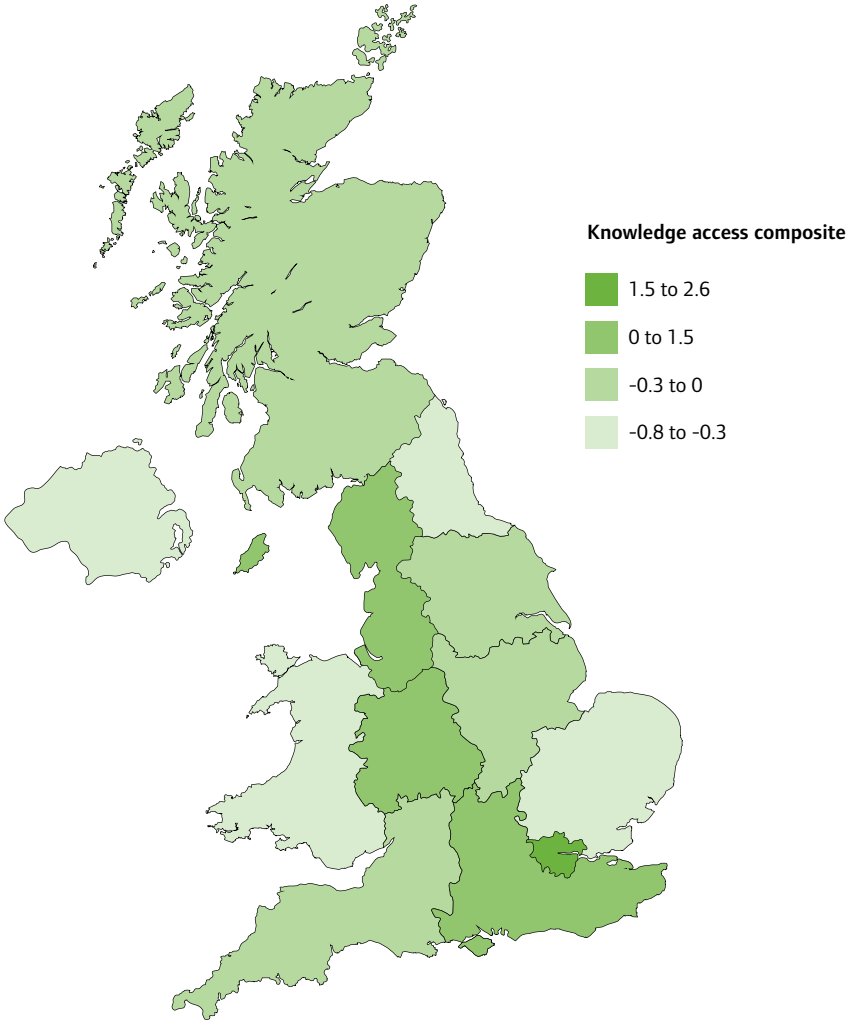
5.4 Access capacity across the UK

The 'knowledge access' index in Figure 25 shows an arc of high international connectivity sweeping from the North West to the South East of England with London constituting an intense centre of connectivity that straddles the South East and Eastern region boundaries. Wales, Northern Ireland, the North East and Eastern England appear relatively isolated in comparison, however regional access capacity differs across the four indicators as shown by Figures 21-24 and regional boundaries sometimes distort the reality of connectivity.

Analysis of the four indicators produces some mixed results. All data sets clearly establish the strong international connectivity of London through knowledge-intensive business and research networks, and physical and virtual network infrastructures.

After London, the ordering of regional connectivity shows some patterns, the

Figure 25: Knowledge access composite index



City/Region	Metropolitan APS business connectivity	Collaborative articles	Scheduled terminal passengers	Cable + FWA broadband coverage	Index from 4 dimensions
London	3.047	2.287	3.158	1.814	2.576
W. Midlands/Birmingham	-0.018	-0.508	-0.220	1.477	0.183
N. West/Manchester	0.014	0.196	-0.031	0.111	0.073
S. East/Southampton	-0.804	1.384	-0.371	-0.146	0.016
E. Midlands/Nottingham	-0.375	-0.663	-0.300	0.993	-0.086
Scotland/Edinburgh	-0.047	0.506	-0.180	-0.701	-0.105
South West/Bristol	0.018	-0.448	-0.279	-0.181	-0.223
Yorks and the Humber/Leeds	-0.216	-0.355	-0.358	0.025	-0.226
Eastern/Norwich	-0.804	0.296	-0.413	-0.313	-0.309
North East/Newcastle	-0.291	-0.816	-0.316	-0.353	-0.444
N Ireland/Belfast	-0.200	-1.036	-0.293	-1.179	-0.677
Wales/Cardiff	-0.325	-0.841	-0.394	-1.552	-0.778

geography of UK knowledge access appears diverse. Most notably, the South East and Eastern regions change their rank position, moving up the scale dramatically when their research networks are considered. But they appear to lack business network connectivity with no major city within their administrative boundaries. However in practice, the London functional region extends far beyond its administrative boundaries into the South East and East, hence the latter regions are more connected to global business networks than is apparent from the present analysis.[106]

The location of the Russell Group universities, globally acclaimed for research quality, in the South East and Eastern regions is likely to play an active part in the higher research network scores for these regions. The relatively strong access of the South East to high capacity broadband infrastructures also leads to its overall ranking across all four indicators in fourth place.

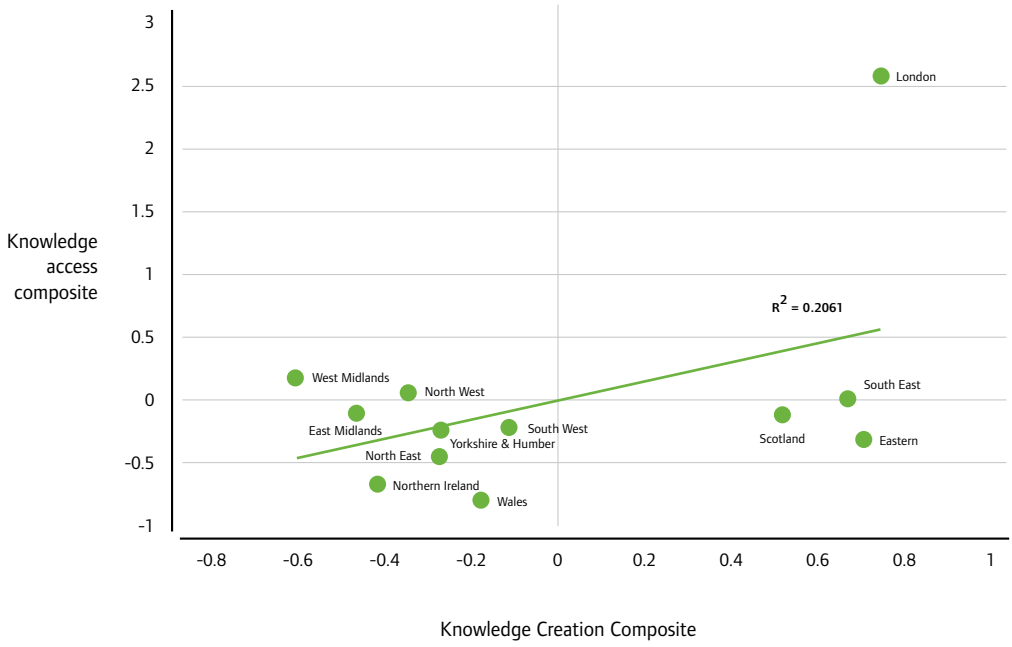
Other interesting patterns revealed are that Scotland's relatively strong access in three indicators is pulled down by its poor high capacity broadband coverage (largely as a result of low connectivity in the rural areas). By contrast, the East Midlands generally appears in the lower regional rankings with the exception of high capacity broadband where it scores exceptionally well. Wales has a consistent pattern of poor access, and the North West of strong access, across all four indicators. Northern Ireland's overall low ranking (eleventh) reflects its poor research and high capacity broadband connectivity whereas the West Midlands, which scores strongly with respect to three indicators, ranks second to London overall in spite of its poor connectivity to research networks. The South West, Yorkshire and the Humber and North East have different patterns of connectivity across the indicators. Research networks play a significant part in low access for all three, with the North East also lacking business connectivity and Yorkshire and the Humber low in international flight capacity though the latter result may reflect functional ground travel patterns that cut across statutory regional boundaries.

106. Pain, K. (2008) Examining Core-Periphery Relationships in a Global Mega-City Region – The case of London and South East England. 'Regional Studies. 42(4).

5.5 Access capacity and 'knowledge creation'

We test the relationship between 'knowledge creation' and 'knowledge access' (Figure 26). There is no relationship between 'knowledge creation' and 'knowledge access' outside London, probably reflecting the administrative and statistical boundaries of the regions and the limitations associated with quantitatively measuring knowledge flows and intangible

Figure 26: Relationship between 'knowledge creation' and 'knowledge access'



assets. This is illustrated by the case of the South East and the East regions which, considering the inter-regional access capacity provided by Gatwick, Stansted, Luton and other London airports, should show a positive relationship between access and creation.

5.6 Access capacity and 'knowledge exploitation'

There is a strong relationship between knowledge exploitation and access capabilities (Figure 27). This is perhaps to be expected as we move to a more integrated global knowledge economy, where access to international markets drives local economic growth. It is noticeable that both the West Midlands and the North West have above average access scores, which is unsurprising given the key cities situated within their regional boundaries. However, it is surprising that their exploitation levels are below the regional average, suggesting that above average knowledge access in these regions may be restricted to major urban and metropolitan localities, resulting in significant intra-regional access disparities. As in the case of knowledge creation, the relationship between access and exploitation is likely to be stronger than depicted here for the South East and the East regions.

5.7 Access capacity and 'Gross Value Added'

The capacity to access international business, knowledge, and markets, as we have argued, is an essential instrument of regional economic development. While it is difficult to establish the link between international accessibility and productivity, many economists agree that there is a relationship between openness and economic growth.[107] Figure 28 shows that there is a positive relationship between 'knowledge access' and a proxy for regional productivity – Gross Value Added per capita (GVA).

The strong GVA performance of the South East compared to the North West with its above average overall 'knowledge access' capacity (Figure 28) but below average GVA, suggests that access capacity is not being translated effectively into productivity in the latter region. Some of the reasons become clearer in the following chapters where the North West appears also to be performing below par in its 'knowledge anchoring' and 'knowledge exploitation'. The improved performance of the Eastern region with respect to GVA in comparison with 'knowledge access' may also reflect the significance of proximity to London. Thus, access capacity, while very important for local economic development and innovation performance, is not a sufficient condition to drive local economic growth alone. Other capacity is needed and its components are introduced in the next chapters.

107. Sachs, J. and Warner, A. (1995) Economic reform and the progress of global integration. In 'Brooking Papers on Economic Activity.' 1, pp.1-118.

Figure 27: Relationship between regional knowledge exploitation capacity and regional knowledge access capacity

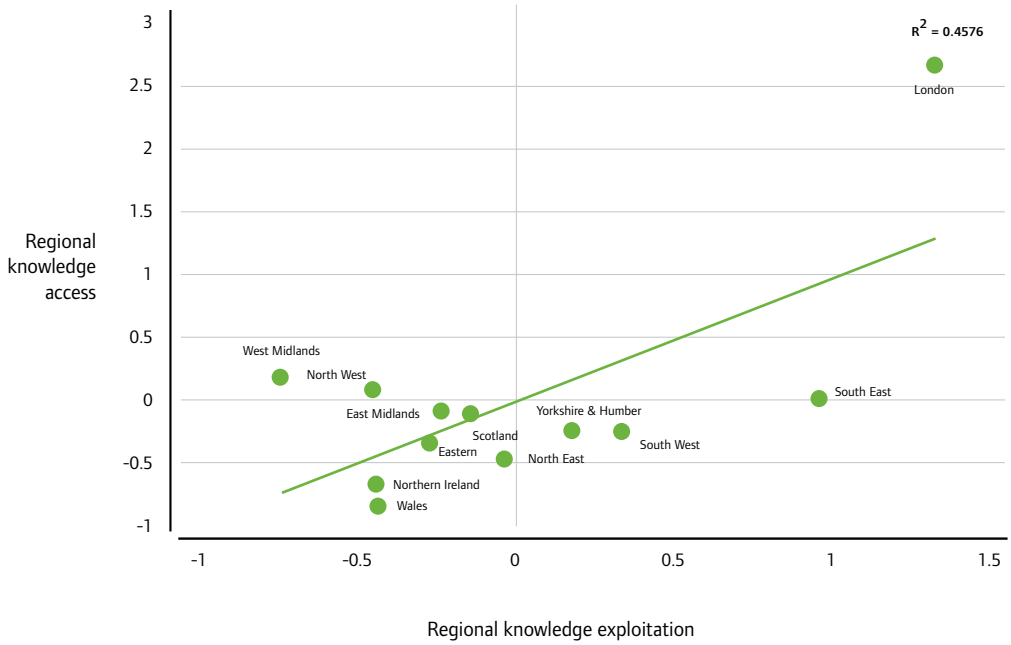
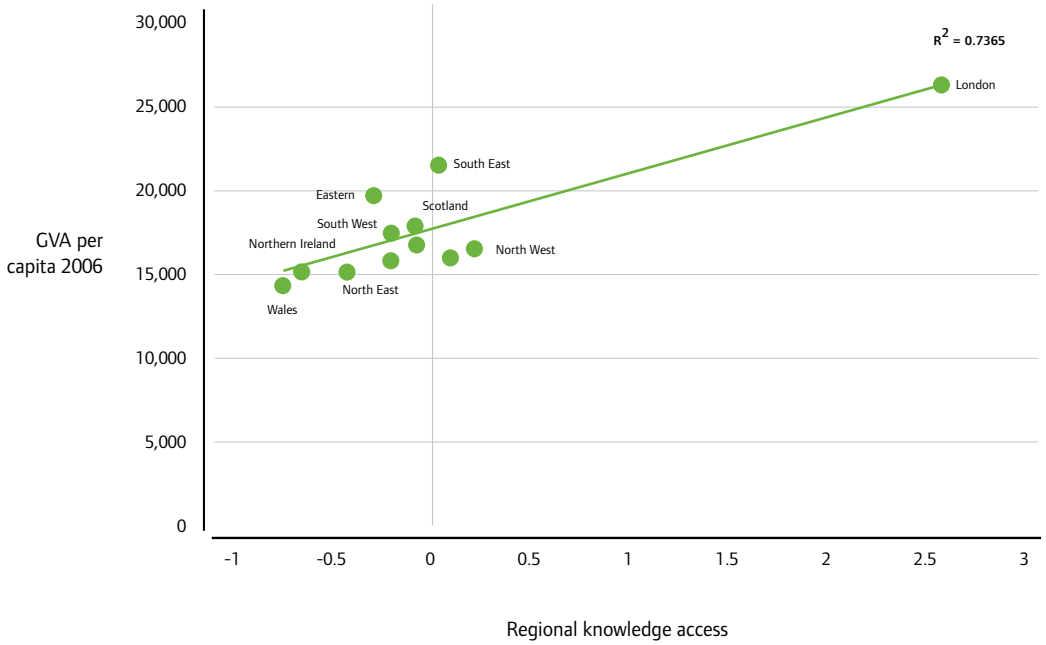


Figure 28: Relationship between regional knowledge access capacity and GVA per capita



5.8 Conclusions

External knowledge is now a key determinant of the ability to innovate locally. The capacity to access external knowledge is therefore of vital importance to promote UK-wide development in the knowledge-based global economy.

Overall, the findings suggest that the ability to participate actively in global networks is more likely to be associated with high densities of specialised knowledge-intensive firms and research universities supported by high volume flow infrastructures. Bearing in mind the arbitrary positioning of the statutory regional boundaries, density – of population, advanced business services, research universities and infrastructures – associated with metropolitan agglomeration, would seem to be a key determinant of regional 'knowledge access' capacity.

Chapter 6: Knowledge anchoring capacity in UK nations and regions

Main findings

Regions compete with each other to attract and retain the highest possible number of businesses, students and talent, all of them important channels for the transfer of new skills, science and management techniques. Consequently, what matters most for the competitiveness of places is their ability to persuade external sources of knowledge, such as overseas people, investments and firms to establish and embed themselves in a region.

This process is known as 'anchoring'. Five indicators have been chosen to measure the UK regions' knowledge anchoring capacities.

The first is the density of international firms. This indicates the stock of international investment and knowledge. Eastern England, London, and South East England between them account for more than half of all foreign firms located in the UK. Foreign investment is relatively low in Northern Ireland, Wales, and the East Midlands.

The rate of FDI investment project successes is an indicator that reveals new inward flows of international investment and knowledge. London appears most successful here, followed by the North East and Wales, with the East Midlands, the South West and the North West of England having least success, though interestingly, the most affluent and competitive regions do not always attract the most FDI projects. London and the South East are the main anchor regions for services FDI.

The third indicator is service sector investment by foreign-owned companies, which indicates the depth of foreign investment anchoring in a region. Such investment is greatest in the South East of England followed by London, the North East, and Eastern England.

The fourth indicator is the net within-UK migration of people in higher managerial and professional occupations. Analysis reveals a stark North-South divide with the four southern regions of England attracting far more high-skilled individuals than leave the South, while the other regions experience a net outflow. This regional brain drain acts to the detriment of the Northern regions.

Finally, the retention of graduates is the indicator used to measure the knowledge anchoring capacity of UK regions. Northern Ireland and Scotland experience the highest retention rates followed by London and North West England. This is probably due to the fact that many students attend home universities and are therefore reluctant to move because they are highly connected in their country/region. Regions close to London have the lowest retention rates, probably because many graduates from these regions seek work in London.

Overall, the analysis of UK regional anchoring capacity reveals that London – followed by South East England and Eastern England – shows the greatest capacity to anchor knowledge within its regional boundaries. North East England and Scotland also perform well. Finally, there is a significant relationship between the knowledge anchoring capacity of UK regions and their GVA per capita.

6.1 What is 'knowledge anchoring' capacity

Knowledge anchoring in this report refers to the capacity to attract overseas people, investments and firms to establish and embed themselves in a region. It requires an ability to nurture and attract skills and talent that will improve and sustain competitiveness. In effect, highly skilled workers are crucial to regional innovation systems, since without them innovation cannot take place.[108] As knowledge circulates, it is continuously mobilised and combined within interacting firms and regions, with development and growth dependent on the capacity to anchor knowledge within regional production systems.[109]

6.2 How can it be measured?

As a means of measuring knowledge anchoring capacity it is important to focus on two units of analysis, in this case, the anchoring of businesses and people. Therefore, we have sought indicators that capture the flow of business investment across regions, as well as the attraction and retention of skilled people. The indicators we use to measure knowledge anchoring capacity are relatively UK specific[110] and are as follows:

- **Density of international firms** – this indicates the stock of international investment and knowledge.
- **Foreign direct investment project successes** – this indicates new inward flows of international investment and knowledge.
- **Service sector investment by foreign-owned companies** – this indicates the depth of anchoring of foreign investment.
- **Net within-UK migration of people in higher managerial and professional occupations** – this indicates the attraction of new talent and skills.
- **Retention of graduates** – this indicates the anchoring of new talent and skills.

6.3 Density of international firms

As the knowledge economy prioritises the nurturing of skills and talent, it is also changing how regions attract the type of overseas investment that creates high value-added output. Global competition for such investment is increasing, requiring shifts in policy and strategy. While all UK regions host some international firms, some regions have a far greater density of such firms than others. Figure 29 presents a regional ranking of the stock of international firms in the UK, ranked in terms of international firms as a proportion of the total stock of VAT-registered firms in each region.

6.3.1 What do the data tell us?

Eastern England, London and South East lead the way

As illustrated by Figure 29, although Eastern England has fewer international firms than London or South East England, it heads the rankings because of their density, with London in second and South East England in third position. Overall, these three core regions account for more than half (52 per cent) of all foreign firms located in the UK. It is, therefore, no surprise that these regions are also the most competitive regions.[111]

Northern Ireland, Wales and the East Midlands hover at the bottom

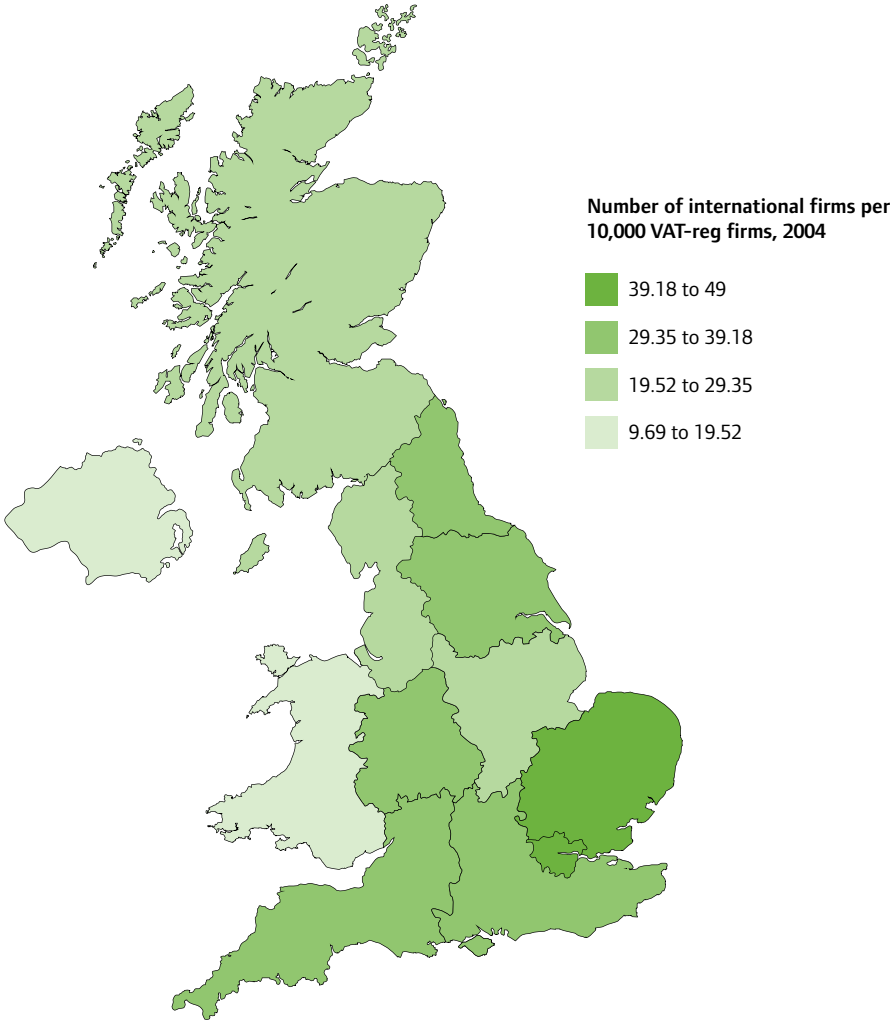
Conversely, at the bottom of the rankings we find Northern Ireland, followed by Wales and East Midlands, which in both absolute and relative density terms are hugely detached from the leading regions. Of course, these differences are rooted in economic and industrial history which continues to exert a significant influence on regional innovation and wider economic development patterns. International businesses have naturally sought to locate themselves near the sources of innovation and development, restricting their propensity to invest in more peripheral regions. The ability of a region to act as an anchor for a significant stock of overseas investment increases its likelihood of creating wealth.

6.4 Foreign direct investment project successes

In general, FDI policies have increasingly focused upon the importance of embedding firms within their host environment.[112] For instance, many policymakers have taken considerable steps to encourage workforce development activities so that local suppliers match investor needs.[113] Without this, poor trading conditions would force certain investors to leave the host region, repatriating

108. Cooke, P., Heidenreich, M. and Braczyk, H. (Eds) (2004) 'Regional innovation systems: the role of governance in a globalized world.' London: Routledge.
109. Crevoisier, O. and Jeannerat, H. (2008) 'The Territorial Knowledge Dynamics: From the proximity paradigm to multi-location milieus.' Working Paper 1/2008-E. Neuchâtel: Groupe de recherche en économie territoriale (GRET), Université de Neuchâtel.
110. For example, our inclusion of service sector investments given the importance of this sector in the UK economy.
111. Huggins, R. and Day, J. (2006) 'UK Competitiveness Index 2006.' London: The Work Foundation.
112. Huggins, R. (2001) Embedding inward investment through workforce development: experiences in Wales. Environment and Planning C. 'Government and Policy.' Vol. 19, No. 6, pp.833-848.
113. UNCTAD (2001) 'World Investment Report 2001: Promoting Linkages.' New York and Geneva: United Nations Conference on Trade and Development.

Figure 29: Number of international firms per 10,000 VAT-registered firms



Rank	Region	Number of International Firms	Number of international firms per 10,000 VAT-registered firms
1	Eastern	897	49.0
2	London	1,377	48.0
3	South East	1,048	36.7
4	West Midlands	538	35.5
5	Yorkshire and the Humber	451	34.8
6	South West	583	34.5
7	North East	139	30.6
8	North West	500	29.1
9	Scotland	331	26.1
10	East Midlands	296	23.9
11	Wales	132	16.7
12	Northern Ireland	56	9.7

Source: Filippaios and Kottaridi (2007) (Derived from LexisNexis Corporate Affiliations Database)

investment to their country of origin to bolster local employment and income. Traditionally FDI required capital and land; now less tangible inputs such as education, networks and innovation infrastructure have become as important.[114] This requires new thinking from those who wish to remain or become major global knowledge investment and attraction players.

Moreover, the general size of initial FDI investments in developed economies has fallen in recent years, as smaller and growing knowledge-intensive businesses predominate while large-scale manufacturing operations relocate to Eastern Europe and Asia.[115] As well as the stock of foreign investment, therefore, it is also important to gauge more recent flows into the UK's regions as a means of further understanding new patterns of investment attraction. Figure 30 ranks the UK's regions on their success in attracting FDI projects on a per capita basis over a four-year period.

6.4.1 What do the data tell us?

The most affluent and competitive regions do not always attract the most FDI projects
Figure 30 shows that London has been most successful at attracting foreign investment, followed by the North East and Wales. Those regions attracting the fewest FDI projects (although these rankings do not take account of the size of the investment) are the East Midlands, South West and North West England. Although London tops the list, the rankings do not all reflect affluence, with two relatively peripheral regions ranked second and third. Over a number of years, the availability of grant aid and lower labour costs have contributed to their success, especially with manufacturing FDI.

The peripheral regions continue to lag behind
In general, peripheral and competitively lagging regions have been less successful in attracting high value added service sector FDI projects than economically strong regions. Less competitive regions tend to have a lower density of high-value service sector employment and are therefore less likely to have the service-based clusters that act as magnets for investors. Moreover, service sector FDI may be less reliant on the type of grant aid for new plants that is often attractive to large-scale manufacturing investors.

London and the South East are the main UK anchor regions for Services FDI
As Figure 30 shows, London and South East England are the preferred locations for a large proportion of service sector projects. This reflects their infrastructure, accessibility and regional markets. If this bias is to be overcome, regional policy must continue to move its focus from creating the conditions for attracting manufacturers to one that fully encompasses globally mobile service sector operations.

6.5 Service sector investment by foreign-owned companies

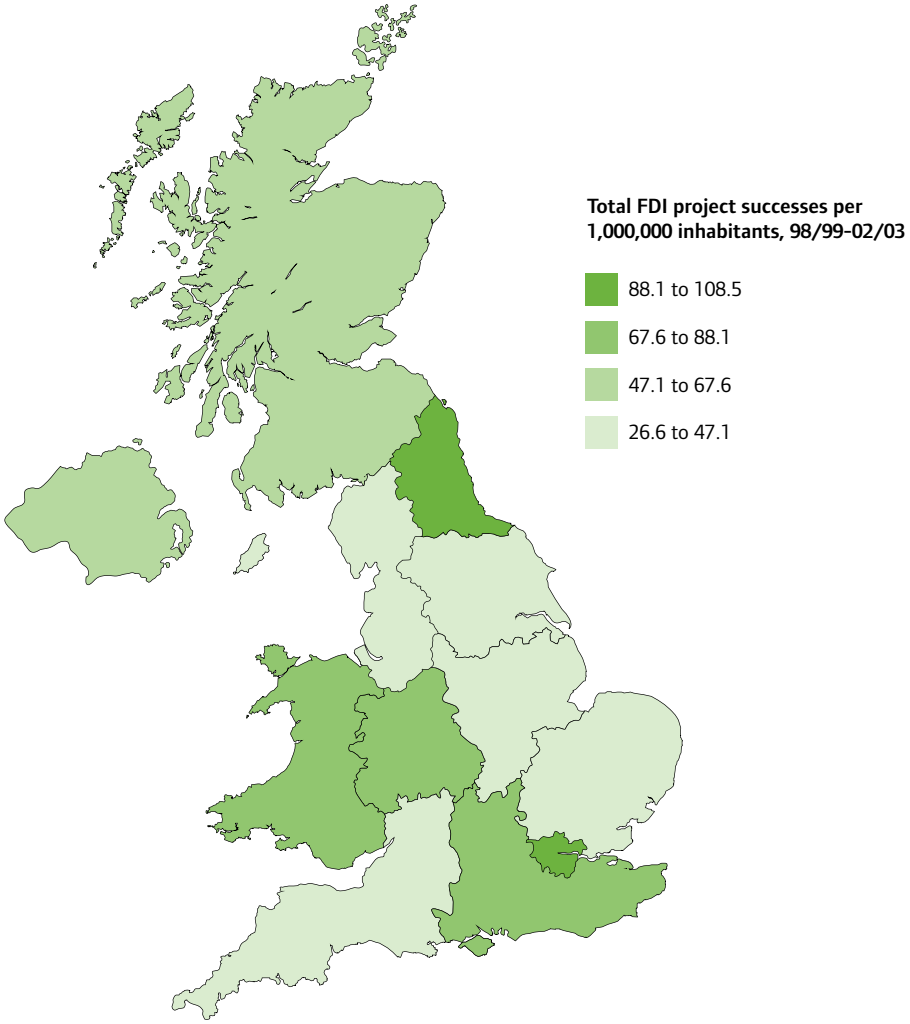
A useful indicator of regional anchoring is the ongoing investment by foreign-owned firms in the regions where they are located. Figure 31 shows investment levels by foreign-owned firms operating in the service sector across UK regions, based on an annual average over a six-year period (with the rankings presented on an investment per capita basis). Our focus on service sector investment is based on our understanding that as the UK continues to de-industrialise and mass employment manufacturing investment continues to shift to China, Eastern Europe and elsewhere, the regional battle in the UK and other advanced nations to attract and embed foreign investment with knowledge-based capabilities is shifting towards high-value services.

6.5.1 What do the data tell us?

Large regional disparities in overseas service sector investment
South East England has the most overseas service sector investment, followed by London, North East and Eastern England. The North East is the most notable base for overseas service sector investment outside southern England (Figure 31). In Chapter 4, we see that for a number of indicators, the North East has a relatively high innovation performance. Therefore, it is possible to hypothesise a regional link between knowledge exploitation and anchoring tendencies. The most telling feature of this indicator is the wide regional variation in both absolute and per capita investment. This highlights the significant challenges faced by lower ranked regions in seeking to attract new high value added investment.

114. Huggins, R., Demirbag, M. and Ratcheva, V. (2007) 'Glbal Knowledge and R&D Foreign Direct Investment Flows: Recent Patterns in Asia Pacific, Europe, and North America. 'International Review of Applied Economics.' 21:3, pp.437–451.
115. Huggins, R. and Izushi, H. (2007) 'Competing for Knowledge: Creating, Connecting, and Growing.' London: Routledge.

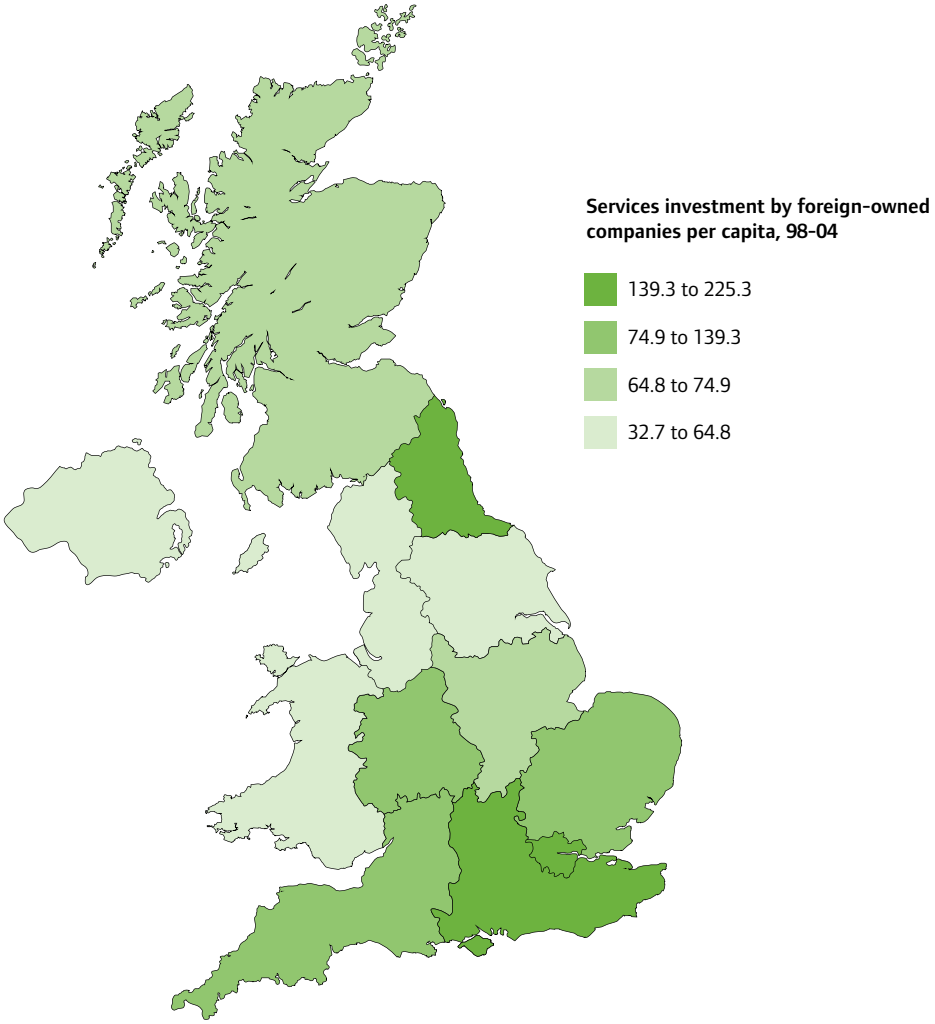
Figure 30: Foreign direct investment project successes per 1 million inhabitants 1998/99-2002/03



Rank	Region	Manufac. projects	Non-manufac. projects	Total projects	Total projects per 1,000,000 inhabitants
1	London	49	766	815	108.5
2	North East	133	102	235	92.0
3	Wales	182	73	255	86.0
4	West Midlands	199	224	423	78.8
5	South East	116	503	619	75.1
6	Scotland	143	167	310	60.6
7	Northern Ireland	58	40	98	56.3
8	Yorkshire and the Humber	164	74	238	46.3
9	East	50	180	230	41.0
10	North West	122	156	278	40.6
11	South West	65	117	182	35.5
12	East Midlands	60	56	116	26.6
	United Kingdom	**1,344**	**2,462**	**3,806**	**62.8**

Source: Office for National Statistics

Figure 31: Services investment by foreign-owned companies per capita (annual average 1998-2004) (£)



Rank	Region	Number of international firms	Number of international firms per 10,000 VAT-registered firms
1	South East	1,856	225.30
2	London	1,302	173.31
3	North East	356	139.30
4	Eastern	728	129.85
5	West Midlands	448	83.48
6	South West	384	74.94
7	East Midlands	310	71.03
8	Scotland	354	69.18
9	North West	444	64.79
10	Yorkshire and the Humber	297	57.76
11	Wales	114	38.44
12	Northern Ireland	57	32.73

Source: Annual Business Inquiry, Office for National Statistics

6.6 Migration of talented people

Across the UK, immigrants possess many skills, especially related to science and technology-driven innovation.[116] Many skilled workers operate as globetrotters driven by push or supply-side factors relating to their willingness to emigrate, as well as pull or demand-side factors relating to the requirement for such skilled workers in locations around the world.[117] As Joel Kotkin argues: "if people, companies or industries can truly live anywhere, or at least choose from a multiplicity of places, the question of where to locate becomes increasingly contingent on the peculiar attributes of any given location".[118] Figure 32 shows the distribution of high-skilled internal migrants (those employed in higher managerial and professional occupations) across the UK's regions.

6.6.1 What do the data tell us?

A stark North-South divide in internal migration patterns

Figure 32 illustrates a stark North-South divide, with the four southern regions of England a net recipient of highly-skilled individuals, while the other regions show a net deficit, confirming evidence of a regional brain drain.[119] Highly skilled workers with the propensity for migration within the UK clearly seek to move from less competitive regional environments, taking their knowledge and talent with them. Increasingly, this is leading to the emergence of regional 'talent wars' involving regional development stakeholders as well as public and private sector employers. For example, universities in the UK are engaging in talent attraction strategies not unlike those for highly valued footballers.[120] The result seems to be the creation of virtuous and vicious circles of regional competitiveness, whereby the most competitive attract talent and further improve their competitiveness, and the least competitive see depletions in their talent base resulting in further decline.

All regions of UK have seen an increase in immigrants

Across the UK as a whole, the foreign workforce is generally more skilled than its domestic counterpart (approximately two percentage points higher), although recent influxes may have diluted this gap.[121] Data from the Annual Population Survey indicate that all regions of the UK have seen an increase in immigrants. For instance, the number of employed immigrants in Yorkshire and the Humber increased by 74 per cent between 2004 and 2006 (57 per cent in the East Midlands and 48 per cent in North West England). The increased circulation and mobility of human capital is clearly changing the skills-base, and necessarily the knowledge-base, of regions.

Alongside international migration, internal migration patterns across the UK regions are a useful measure of the redistribution of knowledge and talent, since they are a much larger group from which potentially to attract people and may also provide relatively good information on the differences between regions of the UK.[122]

6.7 Retention of graduates

If less competitive regions are to improve their position, they must be able to retain new talent and knowledge within their region. One way to do this is through the retention of graduates from a region's universities, something largely overlooked until recently in regional policy circles.[123] The production and retention of these recent graduates has been referred to as 'growing your own', whereby regions take a responsibility for establishing opportunities for local students to study in their respective region, as well as establishing relevant employment opportunities upon graduation.[124] Figure 33 presents regional retention rates for those obtaining first or postgraduate degrees, defined as students entering employment within the region of study.

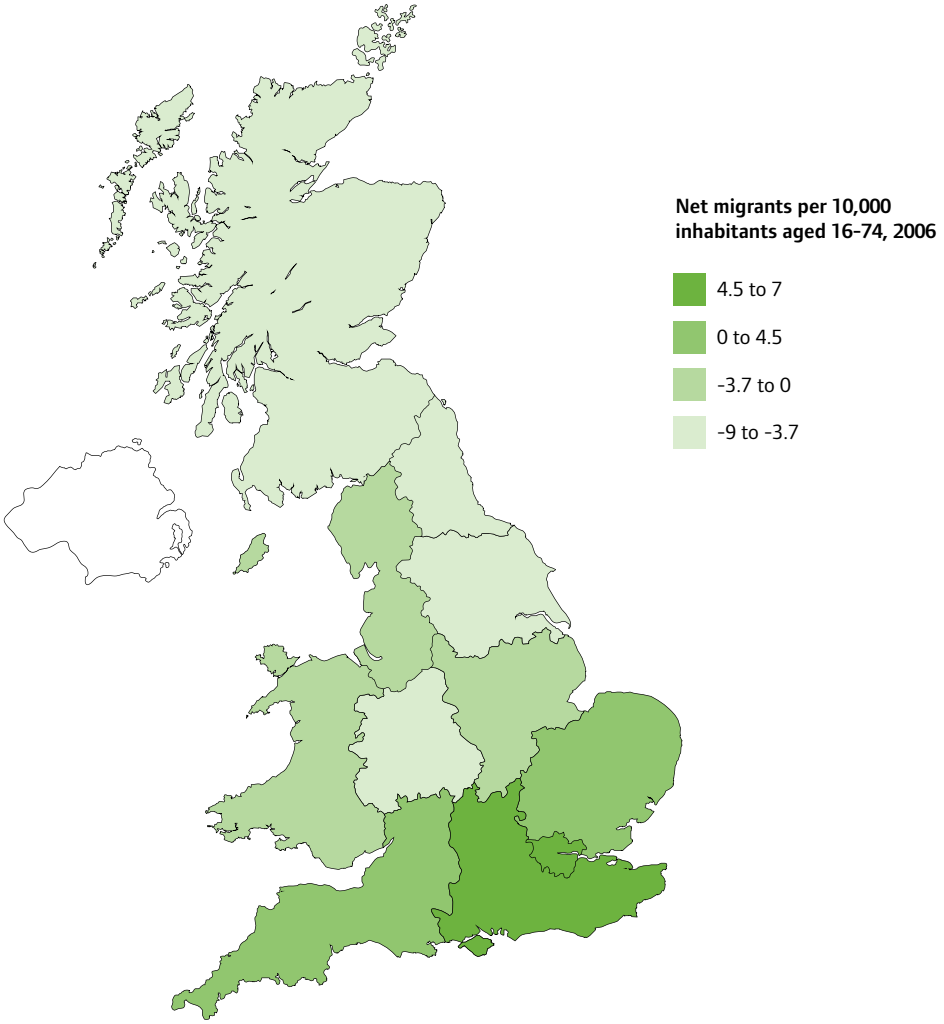
6.7.1 What do the data tell us?

Devolved nations are experiencing the highest levels of student retention

As Figure 33 shows, the devolved nations of Northern Ireland and Scotland experience the highest retention rates followed among English regions by London and North West England. With Wales ranked in fifth position, it appears that graduate retention is at least partly a cultural phenomenon, as well as one linked to employment opportunities. The cultural distinction of the three devolved nations appears to increase the propensity of new graduates to seek employment within their region of study, rather than relocate elsewhere. Such trends can be associated with the higher proportion of students indigenous to these regions who are already highly socially connected.

116. Leadbeater, C. (2008) 'The Difference Dividend: Why immigration is vital to innovation.' NESTA Provocation 06. London: NESTA.
117. Mahroum, S. (2000) Highly skilled globetrotters: mapping the international migration of human capital. 'R&D Management.' Volume 30, Issue 1, pp.23-32.
118. Kotkin, J. (2000) 'The New Geography: How the Digital Revolution is Reshaping the American Landscape.' New York: Random House.
119. Experian (2006) 'Attracting Talent.' London: Experian.
120. Universities UK (2007) 'Talent wars: the international market for academic staff.' Policy Briefing. London: Universities UK.
121. Salt, J. and Millar, J. (2006) 'Foreign labour in the United Kingdom: current patterns and trends.' London: Office for National Statistics. October, pp.335-355.
122. Experian (2006) 'Attracting Talent.' London: Experian.
123. Boucher, G., Conway, C. and van der Meer, E. (2003) Tiers of engagement by universities in their region's development. 'Regional Studies.' Vol. 37, No. 9, pp.887-897; Charles, D. (2003) Universities and Territorial Development: Reshaping the Regional Role of UK Universities. 'Local Economy.' Volume 18, Number 1, pp.7-20.
124. Pollard, E., Williams, M. and Hill, D. (2004) 'Graduate Employment Choices in the East Midlands. Report to the East Midlands Development Agency.' Brighton: Institute for Employment Studies.

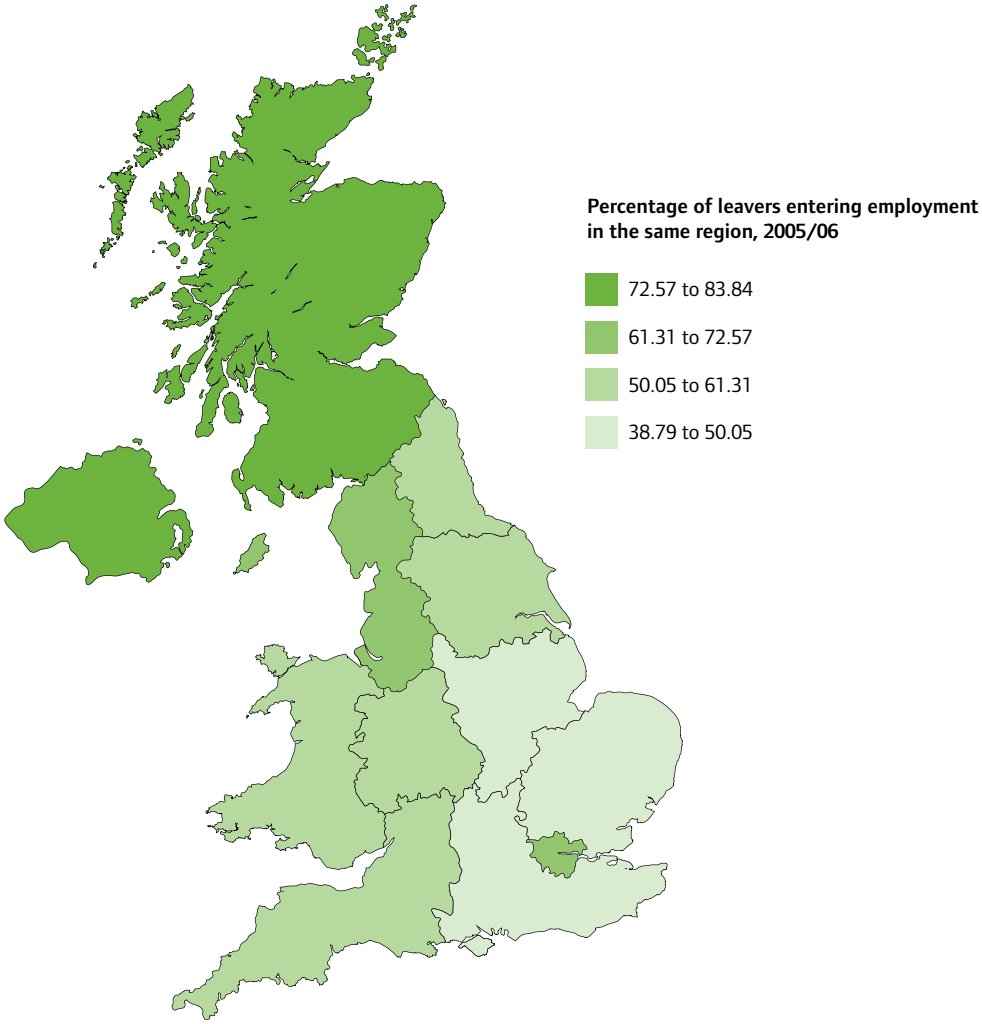
Figure 32: Net within-UK migration of people in higher managerial and professional occupations 2001 (per 10,000 inhabitants aged 16-74)



Rank	Region	Net migrants per 10,000 inhabitants aged 16-74
1	London	7.00
2	South East	4.50
3	South West	4.00
4	East	4.00
5	East Midlands	-2.50
6	Wales	-3.00
7	North West	-3.50
8	West Midlands	-3.75
9	Scotland	-4.00
10	Yorkshire and the Humber	-5.00
11	North East	-9.00
12	Northern Ireland	n/a

Source: Community Innovation Survey 4

Figure 33: Retention of graduates (first and postgraduate) studying in the region – percentage of leavers entering employment in the same region, 2005/06



Rank	Region	Total leavers entering employment 2005/06	Total leavers entering employment in same region 2005/06	Percentage of leavers entering employment in the same region 2005/06
1	Northern Ireland	6,452	5,409	83.8
2	Scotland	21,741	17,708	81.4
3	London	37,432	24,359	65.1
4	North West	24,907	16,141	64.8
5	Wales	11,562	6,746	58.3
6	North East	10,806	6,253	57.9
7	West Midlands	16,357	9,120	55.8
8	Yorkshire and the Humber	20,803	10,581	50.9
9	South West	17,247	8,746	50.7
10	Eastern	10,042	4,825	48.0
11	South East	31,166	13,297	42.7
12	East Midlands	18,029	6,995	38.8

Source: Higher Education Statistics Agency

Regions close to London lose out on student retention
Those regions with the lowest retention rates are the East Midlands, South East England, and Eastern England. Graduates in these regions probably seek employment in London; in the East Midlands, both London and Birmingham (West Midlands) may act as magnets for new graduates. In many respects, Scotland and Northern Ireland have established strong and self-sufficient skills economy systems, since they have the highest school educational attainment levels (based on GCSE results) across all UK regions or nations, and efficient methods for further developing and retaining their skills base.

6.8 Analysis

In this chapter we considered 5 indicators of regional anchoring capacity.

We now turn into our four strands of analysis:

1. We provide an overall picture for anchoring capacity across the UK.

2. The relationship between 'anchoring capacity' and 'knowledge creation capacity'.

3. The relationship between 'anchoring capacity' and 'knowledge exploitation capacity'.

4. 'Anchoring capacity' and 'Gross Value Added'.

6.9 Anchoring capacity across the UK

Figure 34 presents a composite index of regional knowledge anchoring capacity across UK regions, based on the mean average of the standardised values of the indicators presented, with a score of zero equating to the average for all regions. A positive score indicates that a region is performing above the regional average and a negative score below.

As might be anticipated, London shows the greatest capacity to anchor knowledge within its regional boundaries, followed by South East England and Eastern England. These regions are the leading UK bases for mobile international investment, as well as the home for some of the UK's leading universities.

Outside the big three regions, North East England and Scotland also perform well, indicating their capacity to attract and retain knowledge capital. The lowest ranked regions are the East Midlands, Northern Ireland, and Yorkshire and the Humber. A number of indicators suggest that these regions have been less successful in attracting and retaining knowledge, although such a calculation is based on a relatively limited number of indicators, which give us little detail of the type or quality of anchored and unanchored knowledge.

6.10 'Regional anchoring capacity' and 'knowledge creation capacity'

We test the relationship between 'knowledge creation' and 'knowledge anchoring' (Figure 35) and find there to be a relatively strong association between the two composite indicators (although this is somewhat weakened if London were to be excluded). London, the South East and East England all score highly on both composites. Conversely, Northern Ireland and East Midlands score poorly for both. The West Midlands is an anomaly – despite having an average score for anchoring knowledge, it has the lowest score for knowledge creation.

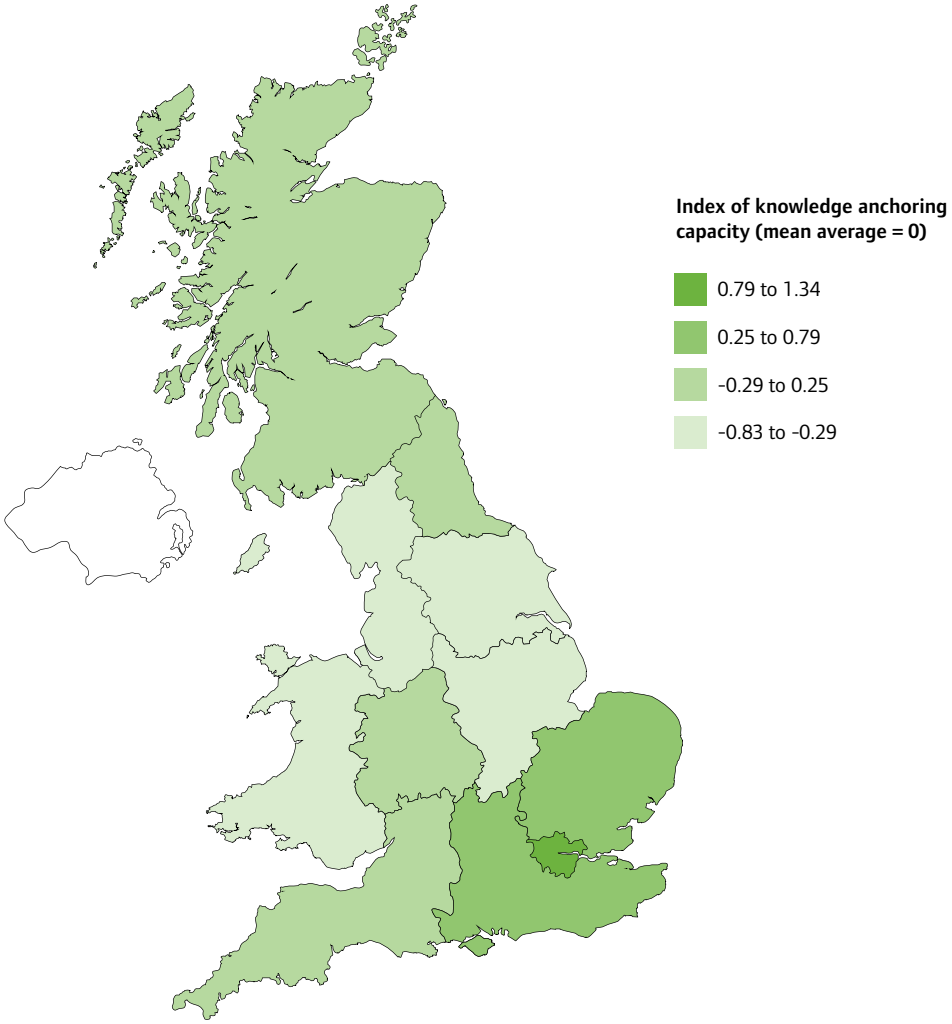
6.11 'Regional anchoring capacity' and 'knowledge exploitation capacity'

There is a strong positive relationship between exploitation and anchoring capacities (Figure 36), indicating that those regions most adept at rooting both internally and externally generated knowledge tend to enjoy better rates of knowledge exploitation and commercialisation. But when London is removed from the index, the relationship remains positive but becomes flatter.

6.12 'Regional anchoring capacity' and 'Gross Value Added'

Figure 37 illustrates a significant relationship between the knowledge anchoring capacity of UK regions and their GVA per capita (which remains significant even if London were excluded). This underlines the importance of attracting and retaining knowledge – human capital and business investment – to regional

Figure 34: Index of regional knowledge anchoring capacity



Rank	Region	Index of knowledge anchoring
1	London	1.34
2	South East	0.63
3	Eastern	0.31
4	North East	0.05
5	Scotland	0.02
6	West Midlands	0.02
7	South West	-0.13
8	North West	-0.32
9	Wales	-0.35
10	Yorkshire and the Humber	-0.46
11	Northern Ireland	-0.59
12	East Midlands	-0.83

Source: Community Innovation Survey 4

Figure 35: Relationship between 'knowledge creation' and 'knowledge anchoring'

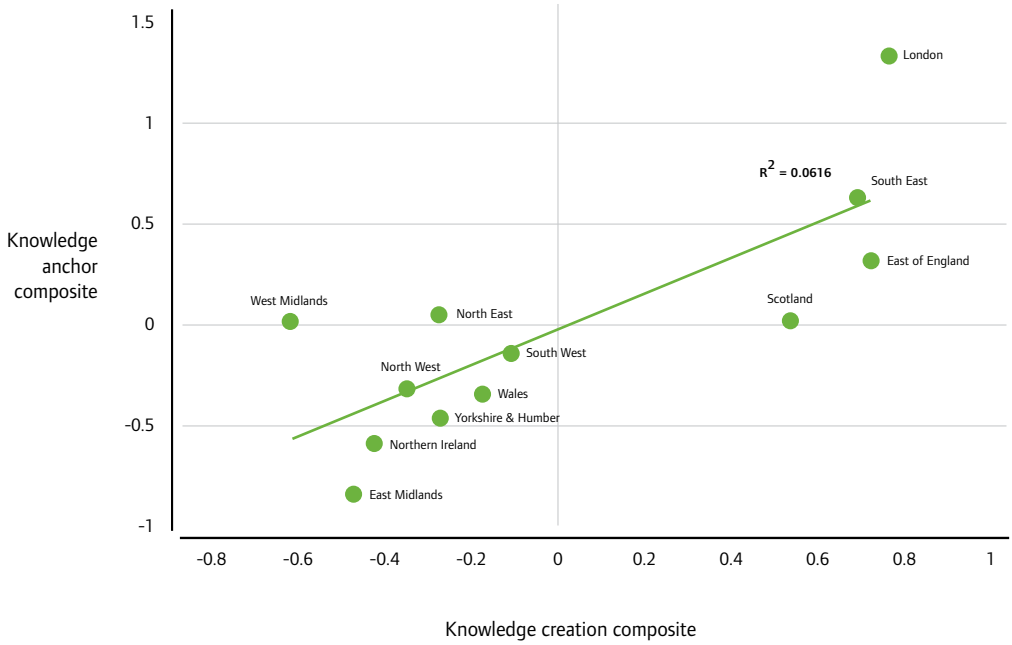


Figure 36: Relationship between regional knowledge exploitation capacity and regional knowledge anchoring capacity

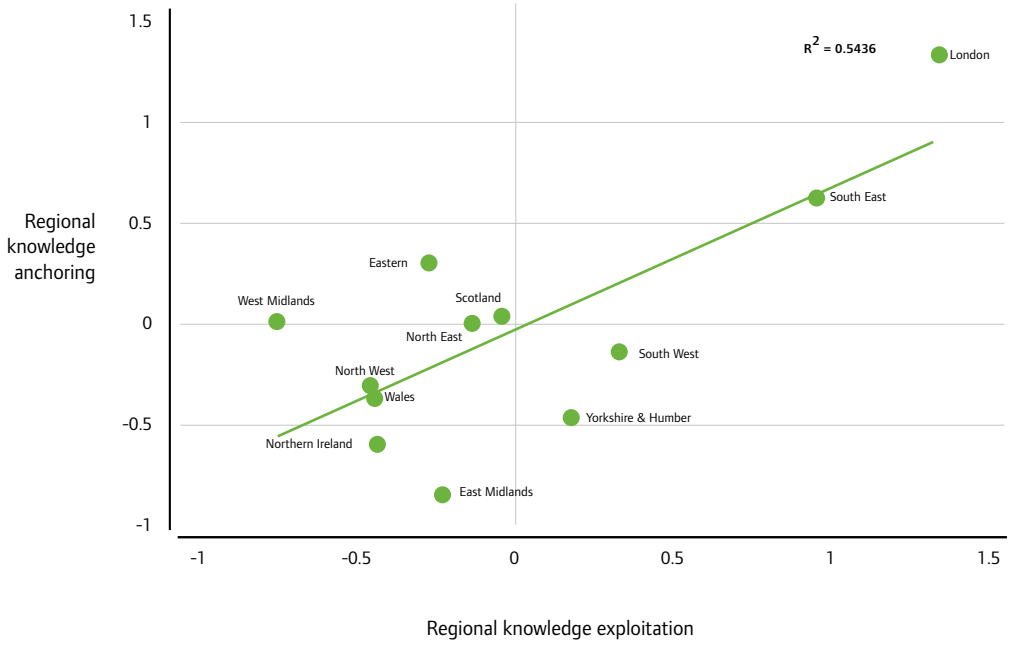
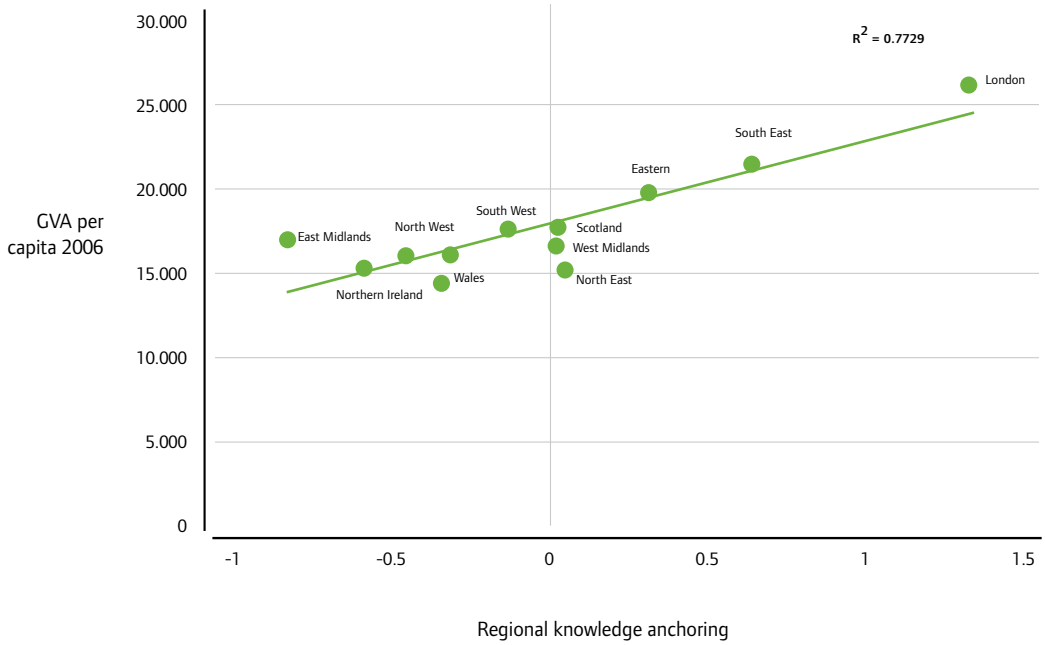


Figure 37: Relationship between regional knowledge anchoring capacity and GVA per capita



economic performance, since without these capabilities the absorptive capacity of regions is likely to diminish.

6.13 Conclusions

Knowledge anchoring agents provide a platform for the development of external knowledge networks in a region. This is critical because regional innovation systems cannot function in isolation and depend on interaction with global, national and other regional systems of innovation.[125] The attraction of talent and investment from outside a region must be adapted to a new set of requirements that go beyond simple job creation or filling university vacancies. It is important that such anchoring agents are well picked to fit within the needs of the local economy and its innovation system. Attracting knowledge-based investments should be based on the ability of these to interact with the rest of the local economy and to provide an access to much wider sets of global networks.

125. Cooke, P. (2004) Regional innovation systems – an evolutionary approach. In Cooke, P., Heidenreich, M. and Braczyk, H. (Eds) (2004) 'Regional innovation systems: the role of governance in a globalized world.' London: Routledge.

Chapter 7: Knowledge diffusion capacity in UK nations and regions

Main findings

Places need to make the maximum use of new knowledge to ensure that these gains are embedded in the local economy as a whole. This requires that new knowledge is eventually diffused or shared so that it is more widely used within a region, a process known as diffusion.

The capacity to diffuse knowledge is the collective ability of a place to adapt and assimilate new innovations, practices, and technologies and spread them in the economy. The characteristics of individual cities and regions play an important role in knowledge diffusion. Location matters because it supports the diffusion of 'tacit knowledge' – knowledge that is known to individuals and is less easy to communicate without their presence. Indeed, proximity allows the formation of social networks, greater mobility of highly-skilled workers, and guarantees businesses' easier access to input at any stage of the innovation process.

There are four main elements that help determine a city or region's ability to spread and absorb knowledge more widely.

The first is the population's learning capacity which can be examined by measuring the skills profile of the population within cities and regions. The analysis reveals that South East has the strongest skills profile. London appears to have a high proportion of graduates but its skills profile is more polarised with nearly a third qualified below GCSE level. Regarding the nations, Scotland also ranks third across the UK, whereas NI has the weakest skills profile of the UK regions. An analysis of the core cities reveals that Edinburgh has the strongest skills profile with the highest proportion of graduates, and Bristol is also in the top.

The second is the proportion of those in employment with NVQ Level 4 and above. London has the largest pool of highly skilled labour when its resident and commuter workforce is combined. Its 'knowledge workforce' stretches well into the South East region.

The third element is the knowledge sharing capacity, which can be measured through knowledge business density and business cooperation for innovation. The data reveal that London and the South East have the highest knowledge-intensive business density; of the core cities, Newcastle has the lowest business density, while London has the highest. If we look at the number of innovating businesses cooperating with other organisations, regional variations appear to be low, with the exception of Northern Ireland which is less likely to have cooperation agreements. Interaction between businesses and universities is also an indicator of knowledge sharing capacity. It reveals that funding for business-university interaction is highest in the North East and lowest in Northern Ireland. Newcastle receives more funding for business-university interaction activities than any other core city.

The last element that helps to reveal the capacity of a place to diffuse knowledge is the knowledge diffused in firms – the knowledge and innovation spread through existing products, processes, and services. The North West scores highest here.

Using a composite score for the 'knowledge diffusion' indicators, London has the highest score of the 12 UK regions, followed by the South East. Northern Ireland performs poorly. There is an association between the composite indicator for 'knowledge diffusion' and the regional GVA per head. London has the highest GVA per head.

7.1 What is 'knowledge diffusion'?

'Knowledge diffusion' is identified as one of the three core measures of urban and regional absorptive capacity. It is defined as the movement of ideas, information and knowledge between people, firms and institutions, and the capacity of a city or region to absorb this knowledge, which may be embodied in new innovations, practices or technologies. The capacity to diffuse in the local economy knowledge absorbed from external sources is vital for the "creative imitation and the exploitation of existing stocks of knowledge [which] account for most innovation and economic development".[126]

Knowledge diffusion provides increasing returns to innovation through imitation and further innovation "involving improvements and 'innovating around' the first innovator's design, rather than simple copying".[127] As a result, "diffusion is essential to maximise potential national economic returns".[128] Knowledge diffusion is particularly important to firms and places with little or no significant research and development activities.

7.2 How can it be measured?

A useful way to understand knowledge diffusion in places and how to measure it is by defining it as consisting of four elements, building on our previous analysis:

1. Populations learning capacity.
2. Workforce learning capacity.
3. Knowledge sharing capacity.
4. Knowledge diffused in firms.

These indicators can't capture every element of knowledge diffusion; rather they aim to reflect, insofar as the data allows, urban and regional capacity to absorb diffused knowledge. The next sections go on to explore the variations and disparities between the UK's cities and regions under each of these four sub headings.

The indicators we use to measure knowledge diffusion capacity are as follows:

- **Human capital index (a weighted average of National Vocational Qualifications – NVQs)** – an indication of the capacity of the resident population to diffuse and absorb knowledge effectively.
- **Proportion employed in the region with NVQ Level 4 and above (workplace-based data)** – an indication of regional firms' access to skilled labour.
- **Number of knowledge-intensive enterprises per thousand population** – an indication of the opportunities for the exchange of knowledge between firms.
- **Proportion of businesses with cooperation agreements** – an indication of the potential for knowledge diffusion between firms.
- **Total funding for business-university research and consultancy (per academic staff)** – an indication of the transfer of knowledge taking place between universities and businesses.
- **Innovation new to firms (innovation active firms only)** – an indication of the take-up of existing innovations by individual firms.

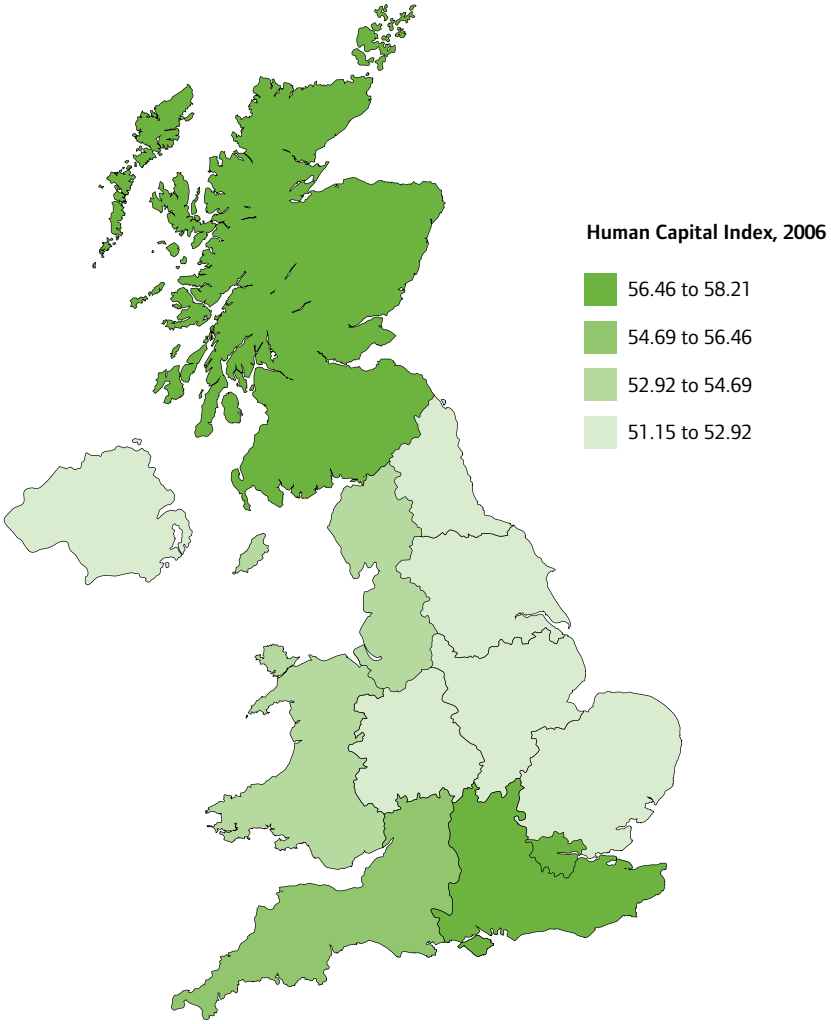
7.3 Population learning capacity

The human capital – skills, knowledge and competencies – embodied in a city or region's population is essential to both the diffusion of knowledge and the capacity to absorb knowledge. A highly skilled population also aids the transmission of skills and ideas. Proximity to individuals with greater skills or knowledge facilitates the acquisition of skills and the exchange of knowledge.[129] The ability to evaluate and use outside knowledge is largely dependent on prior knowledge.[130]

It is important to note that human capital plays a key role at every stage of the innovation process: "the ability to produce, diffuse and use knowledge effectively relies heavily on its capacity to produce highly educated people for its firms to be engaged in a continuing process of innovation".[131] Figure 38 uses this measure to examine human capital within UK nations and regions by looking at their skills profile. We take a weighted average of the NVQs held amongst their resident populations.

126. Arnold, E. and Bell, M. (2001) 'Some New Ideas about Research and Development.' Report to Hernes Commission, Ministry of Foreign Affairs, Denmark, 2001.
127. Ibid.
128. Arnold, E. and Thuriaux, B. (1997) 'Developing Firms' Technological Capabilities.' Report to OECD. Brighton: Technoplis.
129. Jovanovic, B. and Nyarko, Y. (1995) The Transfer of Human Capital. 'Journal of Economic Dynamics and Control.' Vol. 19, No. 5-7, pp. 1033-1064; Glaeser, E. L. (1999) Learning in Cities. 'Journal of Urban Economics.' Vol. 46, pp.254-277.
130. Cohen, W. M. and Levinthal, D. A. (1989) Innovation and Learning: The Two Faces of R&D. 'The Economic Journal.' Vol. 99, No. 397, pp.569-596.
131. Peters, M. A. (2006) Higher Education, Development and the Learning Economy. 'Policy Futures in Education.' Vol. 4, No. 3.

Figure 38: Human Capital Index, 2006



Region	Human Capital Index, 2006
South East	58.2
Scotland	57.8
London	57.5
South West	56.0
North West	53.6
Wales	53.3
East Midlands	52.9
East of England	52.8
North East	52.0
Yorkshire and the Humber	51.4
Northern Ireland	51.2

Source: Annual Population Survey

7.3.1 What do the data tell us?

The South East has the strongest skills profile; Scotland also has a strong skills profile; whilst London has a high proportion of graduates, it also has a more polarised skills profile

Figure 38 maps the Human Capital Index across the UK's regions. The South East has the strongest skills profile with over 30 per cent qualified to graduate level and above, whilst only 9 per cent have no qualifications. Despite over 34 per cent of the population having degrees – the highest percentage of any region – London has a more polarised skills profile with nearly a third qualified below GCSE level. 14 per cent have no qualifications. Scotland has similar proportions of high and low skills, although its skills profile as a whole is less polarised with a higher proportion of residents qualified to at least NVQ level 2.

Northern Ireland has the weakest skills profile of the UK regions

Northern Ireland has the weakest skills profile of the UK regions. It has a low proportion of graduates: just 23 per cent hold a degree level qualification or above, and the region has by far the highest proportion of residents with no qualifications – 23 per cent (compared to a national average of 14 per cent) – both of which will limit productivity and hinder innovative activity within the respective regions. Yorkshire and the Humber also has a low proportion of graduates, 22 per cent, although the proportion of residents without qualifications is far lower at 15 per cent.

7.3.2 Human capital in the core cities

Of the core cities, Edinburgh has the strongest skills profile with the highest proportion of graduates.

At the city level, a slightly different geography presents itself, highlighting the intra-regional disparities in skills (Figure 39). Edinburgh has the strongest skills profile, with a high proportion of graduates, 38 per cent (by far the highest of the 12 comparator cities) and relatively few with no qualifications. Bristol also has a strong skills profile. We take the regional boundary for London at the city level but below this at district level there is huge variation, with Richmond-upon-Thames having a highly skilled resident population (53 per cent with NVQ 4 and above), whilst only 15 per cent of Barking and Dagenham residents are graduates. Among the core cities, Birmingham has the weakest skills profile – just over 21 per cent have degrees whilst almost 40 per cent have low or no qualifications (or below NVQ Level 2).

Edinburgh and Bristol are more likely to benefit from human capital spillovers

Cities with higher concentrations of human capital, such as Edinburgh and Bristol, will benefit from the human capital spillovers, as these dense agglomerations of highly skilled people "provide a faster rate of contact between individuals and each new contact provides an opportunity for learning".[132]

7.4 Workforce learning capacity

The capacity of a firm to acquire and absorb knowledge is dependent on the human capital in its workforce.[133] Workplace-based qualifications measure firms' access to skilled labour beyond that of the resident population and are related to travel to work patterns and the pool of labour to which a region or city has access. In Figure 40, we examine the proportion of those in employment with NVQ Level 4 (degree or equivalent) and above. Workplace qualifications often differ from residence – the London pool of labour extends well into the 'Greater South East' – the South East and East of England – meaning that London benefits from a skilled workforce that cannot be captured in residents' skills alone. Having a large travel-to-work area can significantly increase a city or region's capacity to absorb diffused knowledge.

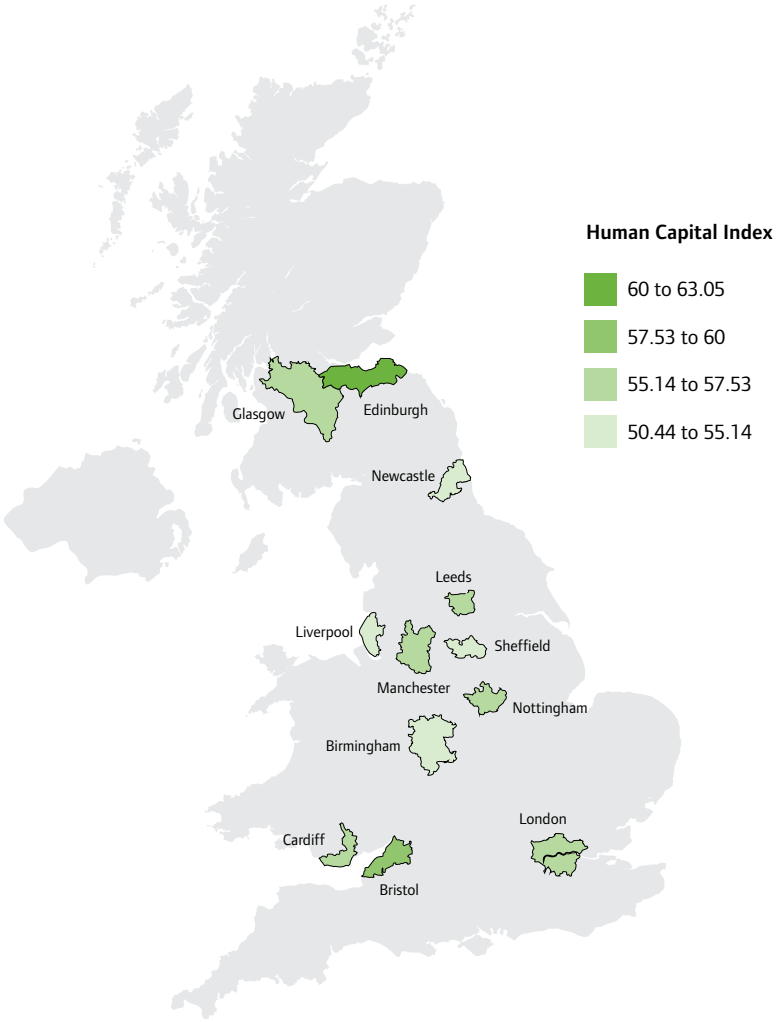
7.4.1 What do the data tell us?

London has the largest pool of highly skilled labour reflecting travel-to-work patterns

The geography of skills by workplace across the UK varies quite substantially from that of the resident population due to commuting patterns. The disparity between the regions becomes more acute, partly due to the geography of highly skilled organisations. London has access to the largest pool of talented, highly skilled labour – 45.5 per cent of its employees hold degrees, a figure that includes both the resident and commuter workforce. The travel-to-work patterns for London 'knowledge workers'[134] stretch well into the Greater South East – a reflection of the high value jobs located in the capital. In Scotland, 38 per cent of the workforce has a degree, indicating a reasonably high level of self-containment in the relatively highly skilled region. Reflecting the indigenous skills profile,

132. Glaeser, E. L. (1999) Learning in Cities. 'Journal of Urban Economics.' Vol. 46, pp.254-277.
133. Cohen, W. M. and Levinthal, D. A. (1989) Innovation and Learning: The Two Faces of R&D. 'The Economic Journal.' Vol. 99, No. 397, pp.569-596.

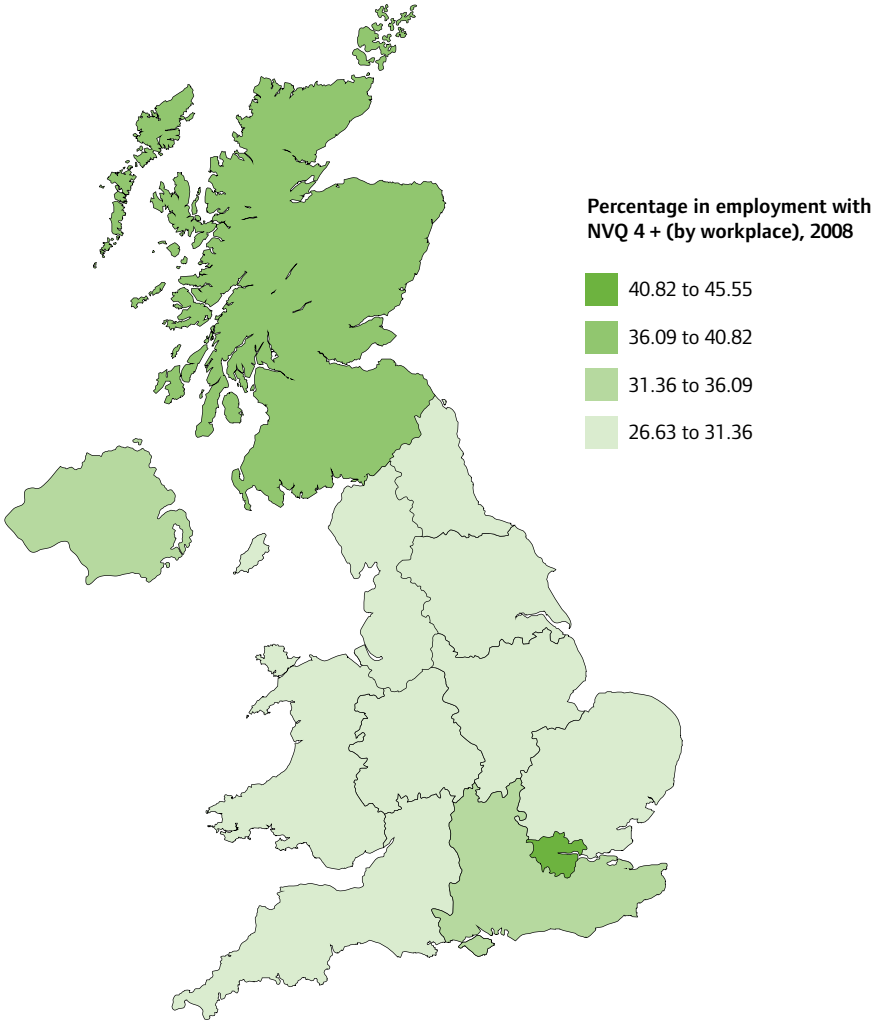
Figure 39: Human Capital Index (regions and core cities), 2006



City/region	Human Capital Index, 2006
Edinburgh	63.0
Bristol	58.4
Glasgow	57.5
London	57.5
Cardiff	56.6
Manchester	56.2
Leeds	55.3
Nottingham	55.1
Newcastle	52.2
Sheffield	51.5
Liverpool	50.9
Birmingham	50.4

Source: Annual Population Survey

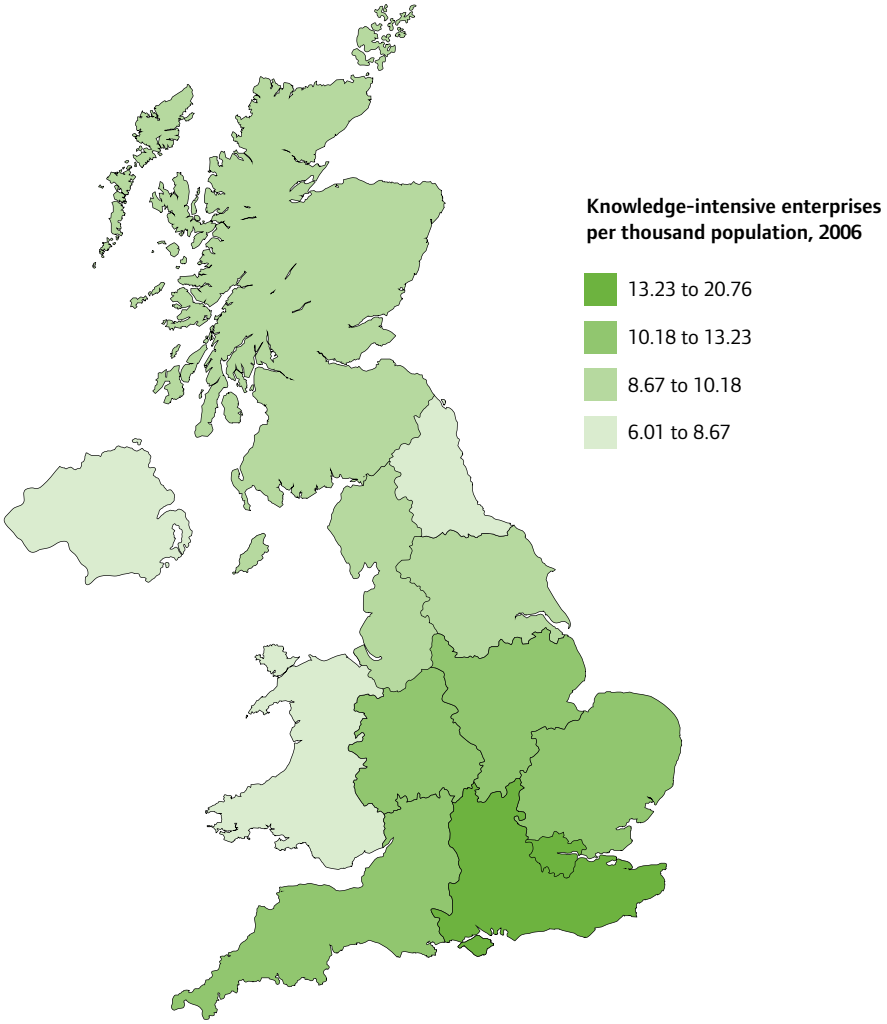
Figure 40: Proportion in employment qualified to NVQ 4 and above, 2008



Region	Proportion in employment qualified to NVQ 4 and above, 2008
London	45.5
Scotland	38.0
South East	33.4
Northern Ireland	33.2
Wales	31.0
North West	30.8
South West	30.8
West Midlands	30.0
Yorkshire and the Humber	29.2
Eastern	28.3
North East	28.2
East Midlands	26.6

Source: Labour Force Survey

Figure 41: Number of knowledge-intensive enterprises per thousand population



Region	Number of knowledge-intensive enterprises per thousand population
London	20.8
South East	16.3
East of England	13.2
South West	12.1
West Midlands	10.4
East Midlands	10.2
North West	9.5
Scotland	8.7
Yorkshire and the Humber	8.7
Wales	7.7
Northern Ireland	7.6
North East	6.0

Source: Inter-Departmental Business Register

East Midlands has the least qualified workforce with only 27 per cent being graduates.

7.5 Knowledge sharing capacity

Knowledge business density
Geographic proximity and high business density offer greater opportunities for cooperation, collaboration and the exchange of knowledge through face-to-face contact.[135] There is empirical evidence in favour of dense and stable local communities, with strong ties, for the sake of high collective absorptive capacity.[136] Whilst there is disagreement over diversity and specialisation and their impact on innovation, there is agreement that locational density encourages the flow of ideas.[137]

Focusing on business density as a stimulus for knowledge diffusion, we look specifically at knowledge-intensive businesses. They show a considerable innovation and growth potential and support economic development at regional and national levels. In Figure 41 we take the Eurostat definition of knowledge-intensive industries[138] to examine their number per thousand people.

7.5.1 What do the data tell us?

London and the South East have the highest knowledge-intensive business density
Regionally, there is a higher concentration of knowledge-intensive enterprises based around London and the South East. Business density amongst enterprises in the financial and business services, communications, health and education is also highest in London, where there are around 21 VAT-registered enterprises per thousand of population. This creates greater opportunities for inter-organisational interaction and the diffusion of ideas and knowledge. The South East also has a high density of knowledge-based enterprises, 16 per 1,000. Similarly in the East of England there are 13 VAT-registered knowledge-intensive enterprises per 1,000, but just six per thousand in the North East.

7.5.2 Knowledge businesses in the core cities

Of the core cities, London has the highest business density whilst Newcastle has the lowest
Of the core cities, Bristol, Edinburgh and Manchester have the highest business density outside London, with relatively high concentrations of financial and business service enterprises. But as Figure 42 shows, London has by far the highest business density, with particularly high business densities in the City of London and Westminster, which alone hosts nearly 25,000 knowledge-based enterprises. Following regional trends, Newcastle in the North East has the lowest knowledge-based business density.

7.6 Business cooperation for innovation

The term 'spillover', discussed in the last section, implies the accidental transfer of knowledge. This is often not the case. Some of the mechanisms by which knowledge 'spills' over from one organisation to another include bilateral cooperative agreements, informal networks, spin-off companies and the movement of skilled labour. All these are purposeful and indeed often are intended to share and diffuse knowledge.[139]

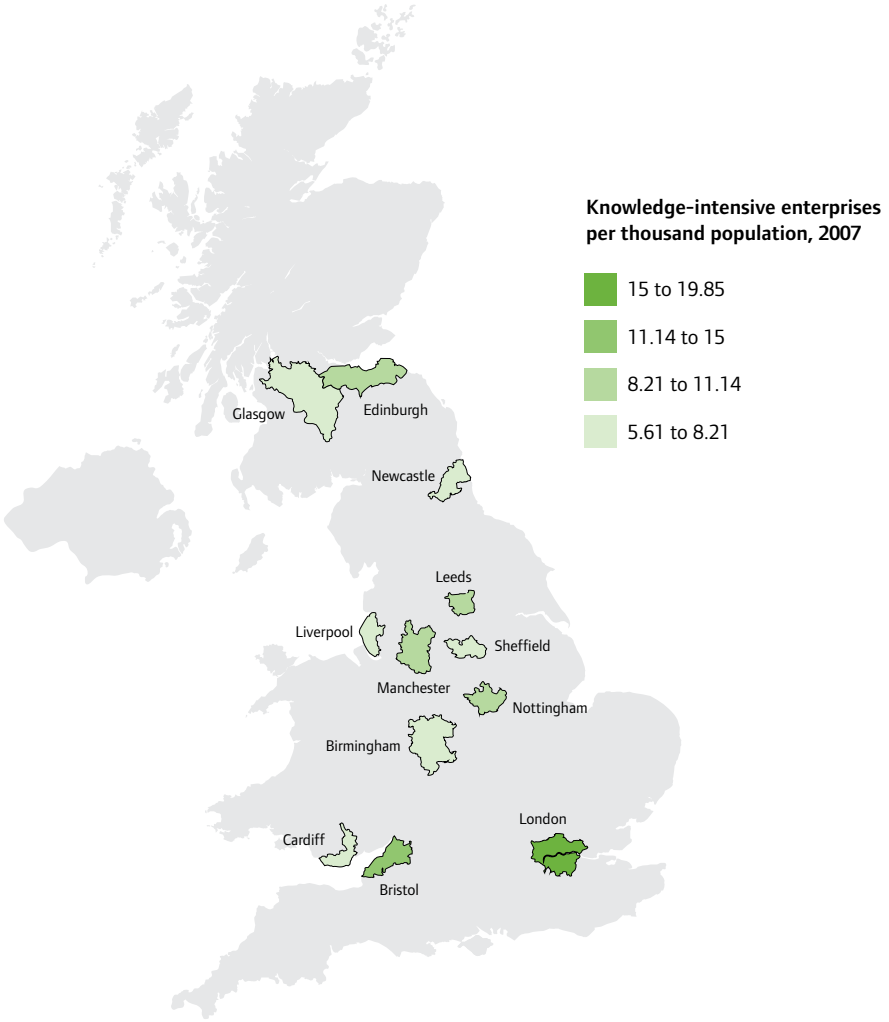
This indicator looks at the number of innovating businesses cooperating with other organisations, both formally and informally. Derived from the UK Innovation Survey 2005, cooperation may have involved other businesses, suppliers, clients or consumers, competitors, consultants, universities, government or public research institutes.[140] Cooperation is not necessarily for commercial benefit; these partnerships can act as sources of knowledge. Accumulated evidence of the benefits of such cooperation has made this a high policy priority.[141] Figure 43 shows the spread of businesses with cooperation agreements with other organisations.

7.6.1 What do the data tell us?

There is limited regional variation, although firms in Northern Ireland are less likely to have cooperative agreements
Unlike business density, business cooperation agreements show no decisive geography and there is limited regional variation. London, the South East, Yorkshire and the Humber, North West and Scotland are all more likely to have cooperative agreements, although not significantly more so than in other regions. Firms in Northern Ireland are least likely to have such agreements.

134. See Jones, A. *et al.* (2006) Ideopolis: Knowledge City Regions. London: The Work Foundation.
135. Baptista, R. (2000) Do innovations diffuse faster with geographical clusters? 'International Journal of Industrial Organisation.' Vol. 18, pp.515-535.
136. Nooteboom, B. (2006) 'Learning and Innovation in Inter-organisational Relationships and Networks.' Discussion Paper 39. Tilburg: Centre for Economic Research.
137. Glaeser, E. D. (1999) Learning in Cities. 'Journal of Urban Economics.' Vol. 46, pp.254-277.
138. Includes the following broad industrial sectors: Transport, Post and Communications, Finance, Property & Business Services, Education, Health and Public Administration.
139. Frenz, M. and Oughton, C. (2005) 'Innovation in the UK regions and devolved administrations: a review of the literature.' Final report for the Department of Trade and Industry and the Office of the Deputy Prime Minister. London: DTI.
140. This excludes routine sub-contracting out of work with no active cooperation.
141. DTI (2006) 'Innovation in the UK: Indicators and Insights.' DTI Occasional Paper No. 6. London: DTI.

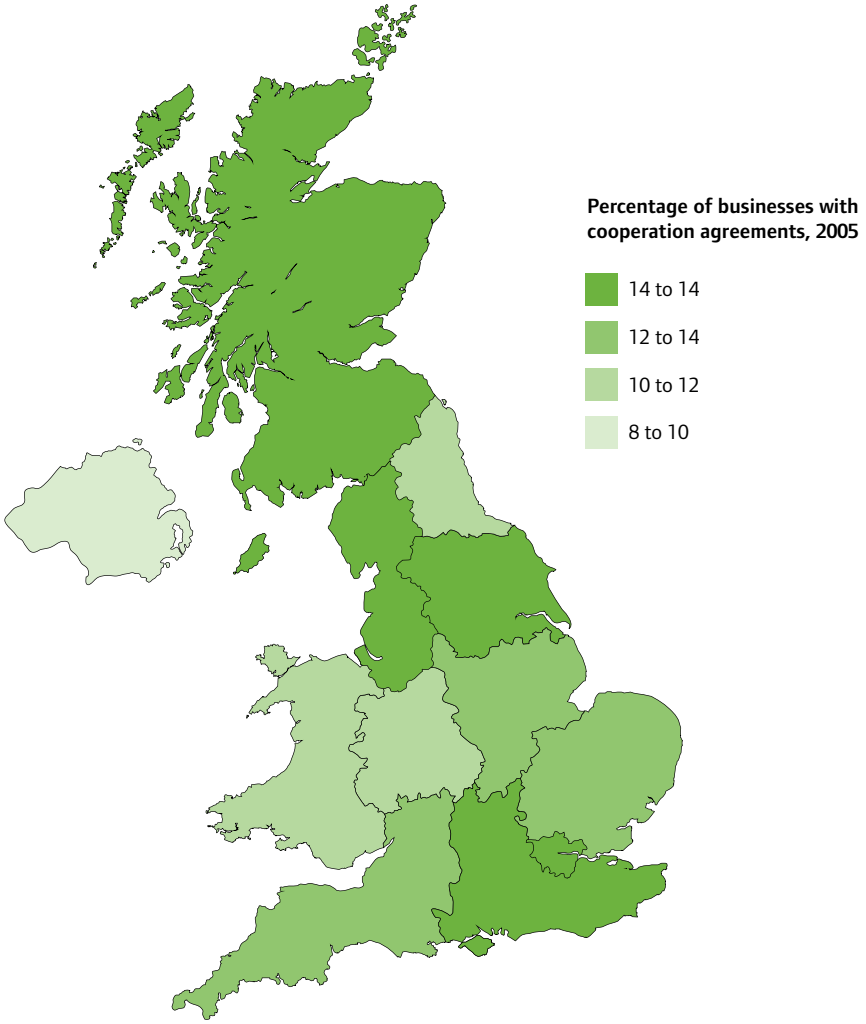
Figure 42: Number of knowledge-intensive enterprises per thousand population



City/region	Number of knowledge-intensive enterprises per thousand population
London	20.8
Bristol	12.8
Manchester	12.0
Edinburgh	11.2
Leeds	10.3
Nottingham	9.1
Birmingham	9.0
Cardiff	8.8
Belfast	8.4
Glasgow	7.6
Sheffield	7.2
Liverpool	7.1
Newcastle	6.2

Source: Inter-Departmental Business Register

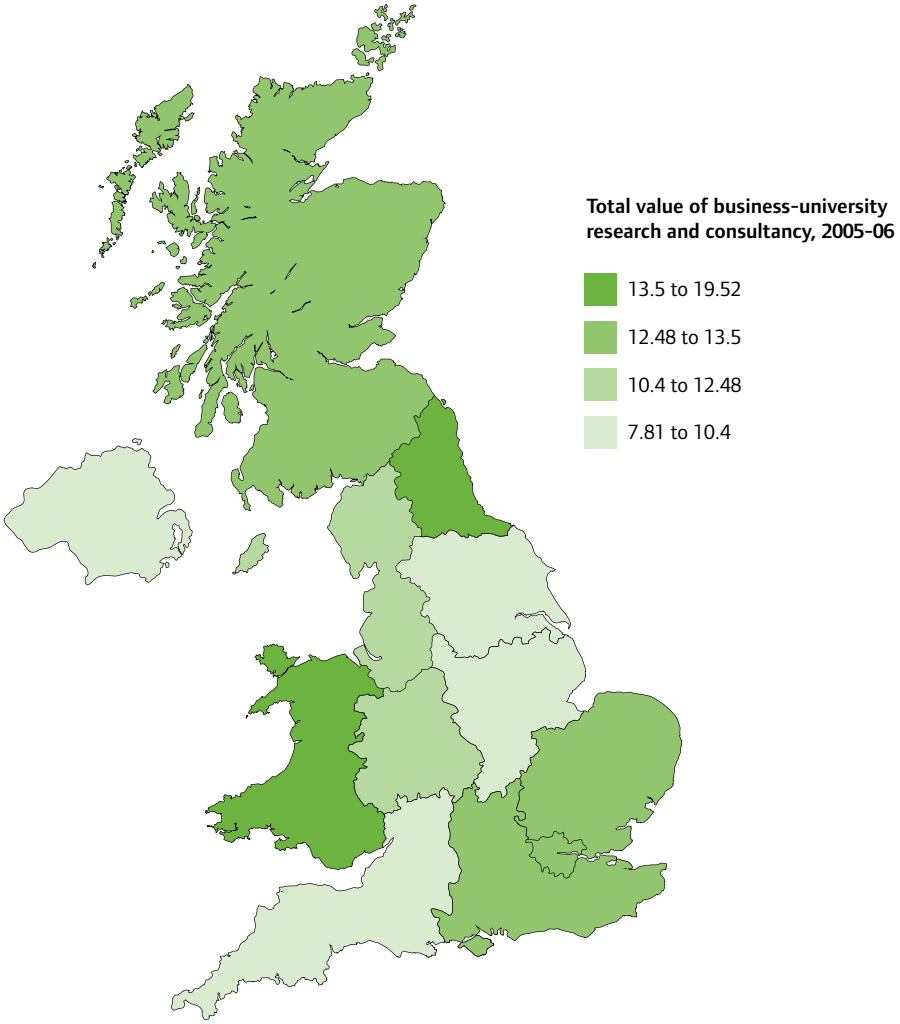
Figure 43: Percentage of businesses with cooperation agreements



Region	Percentage of businesses with cooperation agreements
London	14
North West	14
Scotland	14
South East	14
Yorkshire and the Humber	14
East Midlands	13
East of England	13
South West	13
North East	11
Wales	11
West Midlands	11
Northern Ireland	8

Source: UK Innovation Survey

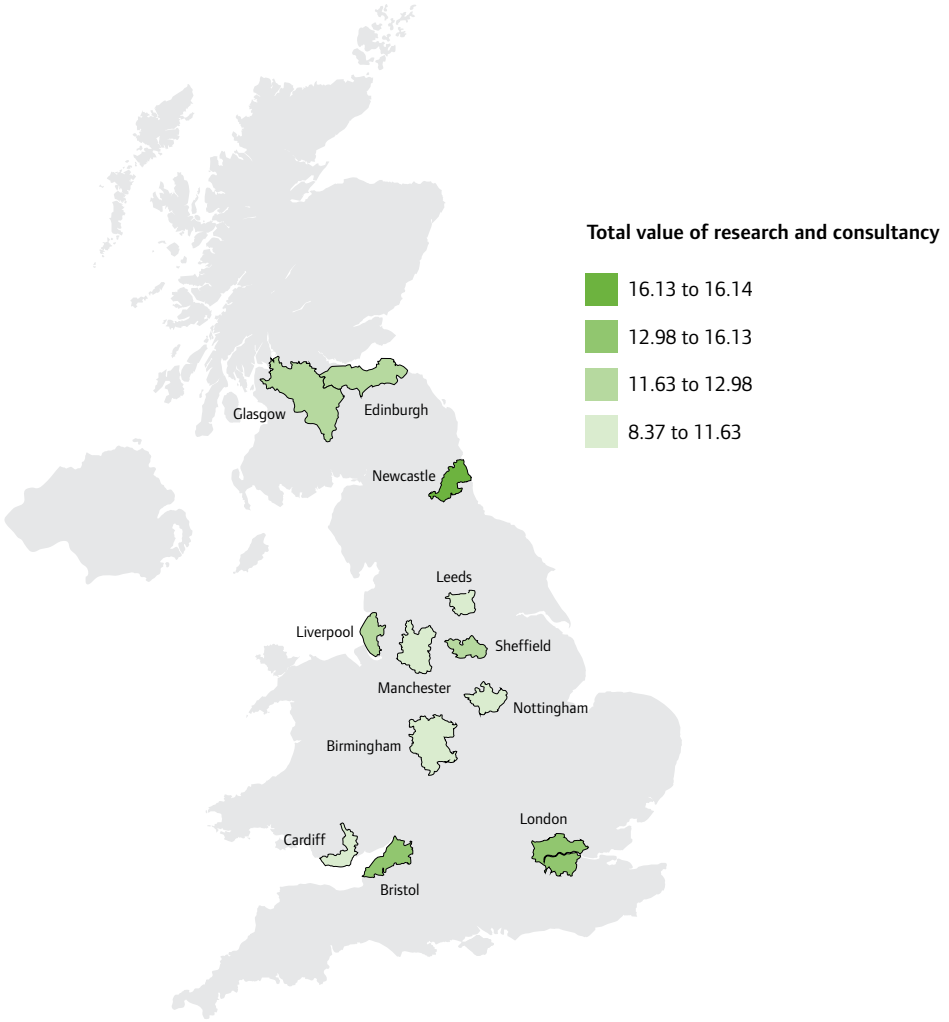
Figure 44: Total funding for business-university research and consultancy (per academic staff)



Region	Total value of business-university research and consultancy, 2005-06
North East	19.5
Wales	18.9
East of England	13.5
London	13.2
South East	12.8
Scotland	12.5
West Midlands	11.5
North West	10.7
Yorkshire and the Humber	10.4
South West	9.8
East Midlands	9.3
Northern Ireland	7.8

Source: HE-BCI

Figure 45: Total funding for business-university research and consultancy (per academic staff)



City/region	Total value of business-university research and consultancy, 2005-06
Newcastle	16.1
London	13.2
Bristol	13.0
Liverpool	13.0
Edinburgh	12.9
Sheffield	12.7
Glasgow	11.7
Cardiff	11.6
Manchester	11.5
Leeds	11.3
Nottingham	8.8
Birmingham	8.4
Belfast	7.8

Source: HE-BCI

7.7 Business-university interaction

The nature of business-university interactions has changed. Traditionally high-tech firms purchased the knowledge created by universities. Increasingly the focus is to stimulate a process of joint creation of more fundamental knowledge, which is less directly applicable to other firms.[142] This unified research allows for the exchange of both codified and tacit knowledge between the firm and university and is more relevant to the needs of the firm. The 'Ivory Tower' is being displaced by strategies of alliances and networking.[143]

This indicator (see Figure 44) focuses on funding for business-university collaborative research, and research and consultancy contracts. Taken from the Higher Education Business and Community Interaction survey, it provides a useful measure of the level of interaction and exchange of both tacit and codified forms of knowledge across sectors between higher education and the wider world.

Although few companies (5 per cent) collaborate directly with local or regional universities,[144] their number is increasing. Income from collaborative research between higher education institutes and the business community has risen in the UK overall. Often referred to as universities' 'Third Stream' work, it is gaining more strategic importance and is being prioritised more heavily by government and the higher education sector itself. Figure 44 shows the intensity of business-university research and consultancy across the UK.

7.7.1 What do the data tell us?

Funding for business-university interaction is highest in the North East and lowest in Northern Ireland

Taking account of the number of academic staff,[145] the value of collaborative, research and consultancy contracts is highest in the North East. Total funding for business-university research and consultancy is highest in London, at over £314 million, although the capital also has the highest number of academics (over 24,000). The North East comparison is £131 million funding to around 5,000 staff: given the size and number of institutions means it brings in the highest revenue of all the regions.

Within this indicator, Wales receives the highest funding from Research Councils, UK government departments, EU government and the private sector, for collaborative research compared to its number of academic staff. London receives the largest amount of funding for research contracts (exclusive of funding for collaboration research). The North East receives the largest income for each of its academic staff for consultancy contracts. These North East contracts appear to include far more small contracts (over 20,000) than other regions. This would appear a deliberate regional strategy to integrate the higher education sector with industry, through initiatives such as the consultancy 'Knowledge House', a collective service from the five regional universities.[146]

7.7.2 University-business interaction in the core cities

Newcastle receives the largest amount of funding for university-business interaction activities

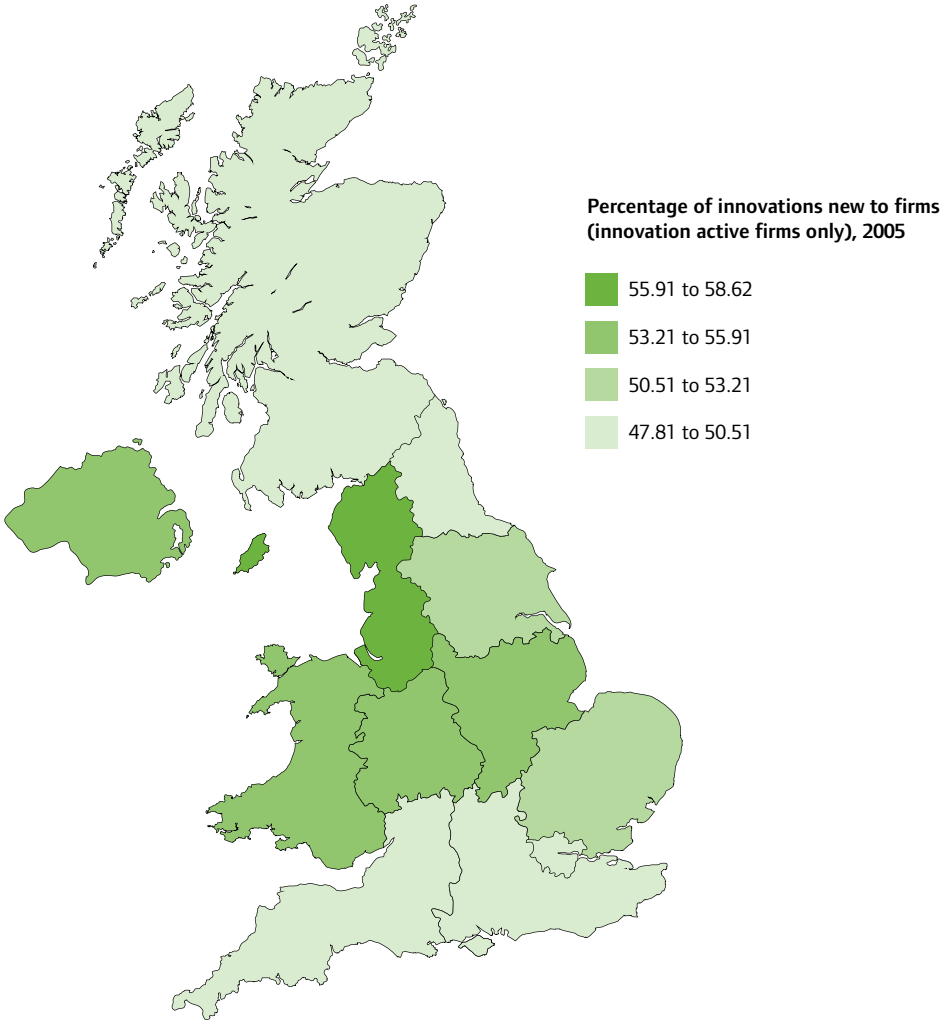
Following regional trends in 'Third Stream' activity, Newcastle, with just two universities, receives the largest amount of funding relative to the number of academic staff in the city's universities, whilst Belfast receives the least when compared to the number of academic staff (Figure 45). As an indication of local business-university interaction, a higher proportion of 'Third Stream' funding (research and consultancy) received by the universities in Belfast, Liverpool and Glasgow comes from within their respective regions.[147]

7.8 Knowledge diffusion in firms

This chapter focuses on the diffusion of knowledge and innovation found in existing products, processes and services. The UK Innovation Survey provides a broad measure of innovation, capturing imitation as well as novel innovation. Innovations new to firms provide an indication of the take-up of existing innovations by individual firms – or of knowledge diffused – as these innovations are not necessarily new to the market. The economic benefits of innovation are influenced by processes of diffusion, which commonly accrue from diffusion throughout the market, rather than the introduction of completely new products or services. To measure the diffusion of existing innovations Figure 46 looks at the proportion of innovations, both process and product innovations, which are new to the firm at the regional level.

142. Schienstock, G. and Hämäläinen, T. (2001) 'Transformation of the Finnish innovation system. A network approach.' Sitra Reports Series 7. Helsinki: Sitra.
143. Peters, M. A. (2006) Higher Education, Development and the Learning Economy. 'Policy Futures in Education.' Vol. 4, No. 3.
144. DTI (2006) 'Innovation in the UK: Indicators and Insights.' DTI Occasional Paper No. 6. London: DTI.
145. Includes teaching and research staff (HESA data).
146. Source: Higher Education Business and Community Interaction Survey, 2007.
147. University-business collaboration is not limited by proximity and much of the collaboration takes place on a national or international level (SURF, 2007). Although, Porter stresses the importance of building linkages between universities and national firms: "without strong linkages, upstream scientific and technical advances may diffuse more quickly to other countries than they can be exploited". Whilst many have stressed the importance of embedding universities at the local and regional level to increase economic development, there are possible conflicts between local and global roles.

Figure 46: Innovations (process and product) new to firms



	Percentage of innovations that are new to firms (innovation active firms only), 2005
North West	58.6
East Midlands	55.3
Wales	55.2
Northern Ireland	54.9
West Midlands	54.8
Yorkshire and the Humber	53.1
Eastern England	52.0
North East	50.4
Scotland	49.7
South East	49.6
South West	48.7
London	47.8

Source: UK Innovation Survey

7.8.1 What do the data tell us?

Imitation of existing products and processes is highest in the North West
The highest level of diffusion within firms – imitation of existing products and processes – takes place in the North West where 59 per cent of innovations are new to firms rather than new to the market. The diffusion of process innovations is particularly high in the region – 74 per cent of process innovations are just new to the firm (innovation active firms only). Such imitation is also relatively high in Wales, the East and West Midlands and Northern Ireland.

7.9 Analysis

The previous sections provided a quantitative analysis of 'regional knowledge diffusion' across the UK (and where possible for the core cities) using six indicators themed under 'population's learning capacity', 'workforce learning capacity', 'knowledge sharing capacity', and 'knowledge diffused'.

Here we examine regional performance across the UK against a composite measure of these indicators. We then test the relationship between the composite indicator for 'knowledge diffusion' and the composites for 'knowledge creation' and 'knowledge exploitation' and regional economic productivity, using GVA per head.

7.10 Knowledge diffusion across the UK

Taking a composite score for the 'knowledge diffusion' indicators[148] (see Figure 47), London leads the 12 UK regions. London scores particularly highly for knowledge-based business density providing greater opportunity for inter-organisation interaction and workers' mobility. These knowledge-based businesses attract highly skilled workers into the capital – promoting the diffusion of ideas and knowledge and increasing firms' capacity to absorb knowledge. Skills amongst the resident workforce, however, are more polarised with around a third of residents with graduate level qualifications and a third with low or no qualifications. The South East also performs well on this composite score, having particularly high levels of human capital and relatively high business density amongst knowledge-based firms.

At the other end of the scale, Northern Ireland performs poorly, with low levels of human capital, low knowledge-based business density and low levels of university-business interaction. North East and Yorkshire and the Humber also score relatively low on the composite score, again having low levels of human capital. Although we are not able to capture all elements of knowledge diffusion, the data available indicate that there is less opportunity for knowledge diffusion in these regions and lower capacity to absorb knowledge that is exchanged.

7.11 Regional 'diffusion capacity' and 'knowledge creation capacity'

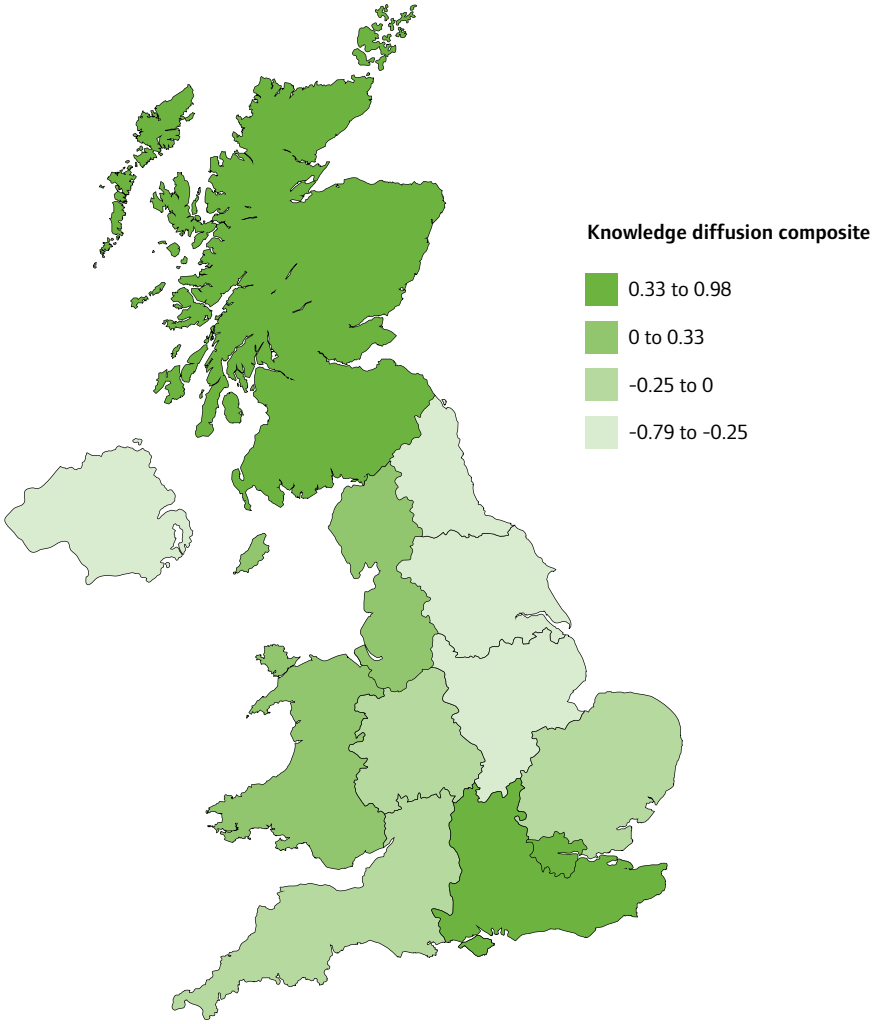
We examine the relationship between 'knowledge creation' and 'knowledge diffusion' by correlating the two composites created to measure these two capacities (Figure 48). There is an association between a region's capacity to diffuse knowledge and its capacity to create knowledge. London, South East and Scotland all score highly for both the 'knowledge diffusion' and 'knowledge creation' composites. These three regions have a large proportion of highly skilled workers, who play a key role at every stage of the innovation process – in the creation of knowledge, the assimilation of knowledge and the exploitation of knowledge. We test the effect of London on the correlation to find that there is still a significant association when the capital is excluded (R-squared = 0.49). Although we distinguish between knowledge creation and diffusion for measurement purposes, the two are joint products. The creation of knowledge is essentially an interactive process and the diffusion of knowledge can often lead to the creation of new knowledge. Therefore, it is difficult in reality to differentiate them as they are inseparable.

7.12 Regional 'diffusion capacity' and regional 'exploitation capacity'

Second, we examine the relationship between regional 'diffusion capacity' and regional 'exploitation capacity' (Figure 49). We find that there is a significant relationship between the two capacities, which is perhaps to be expected given that the ability to exchange and absorb knowledge will be an important determinant of exploitation potential.

148. Methodology for creating composites: the mean and standard deviation is calculated for each metric, then for each score (s) the mean (m) is subtracted and divided by the standard deviation (sd), i.e. new s = (s-m)/sd. An average is then taken for each of the metrics to create the overall composite score.

Figure 47: Knowledge diffusion composite indicator



Region	Knowledge diffusion composite
London	0.98
South East	0.52
Scotland	0.33
North West	0.23
Wales	0.08
East of England	-0.05
South West	-0.14
West Midlands	-0.25
East Midlands	-0.25
Yorkshire and the Humber	-0.30
North East	-0.37
Northern Ireland	-0.79

There are exceptions, however, with Scotland, Wales and North West England scoring significantly higher on the composite score for 'diffusion' than 'exploitation'. Explanations for these differences are necessarily complex and may relate to a range of institutional factors. The most obvious of these is that 'knowledge diffusion' in these regions is bolstered by relatively strong research activities within their higher education systems. This disconnection between this diffusion 'infrastructure' and exploitation 'outputs' indicates the scope for greater knowledge commercialisation, by harnessing this infrastructure.

7.13 Regional 'diffusion capacity' and regional 'Gross Value Added'

There is an association between the composite indicator for 'knowledge diffusion' and regional GVA per head (Figure 50), with an R-squared of 0.6. London outperforms the rest of the country with the highest GVA per head or highest level of economic productivity and the highest score on the composite. The South East follows with the second highest GVA per head. Wales stands out as having an above average score for knowledge diffusion, despite having the lowest GVA per head.

There does appear to be a relationship between a region's capacity to diffuse and absorb knowledge and the 'development' measures of regional innovation capacity – knowledge creation, knowledge exploitation – and economic productivity. This highlights the importance of absorptive capacity in the ability of cities and regions to develop and exploit knowledge.

7.14 Conclusions

This chapter highlights the importance of place in the diffusion of knowledge. Cities in particular create opportunities for learning and interaction through agglomeration, meaning that geography acts as a "mediator for knowledge transmission".[149] In an economy where increasing value is placed on knowledge, place and proximity are increasingly important in the diffusion of knowledge.

Exploration of 'knowledge diffusion' in cities as well as regions in relation to many of the indicators has highlighted the differences between cities within regions as well as between regions. For example, there are considerable differences in the levels of human capital between Manchester and Liverpool located in the North West and in access to skilled labour. This raises interesting questions

149. Baptista, R. (2001) Geographical Clusters and Innovation Diffusion. 'Technological Forecasting and Social Change.' Vol. 66, pp.31-46.

Figure 48: Relationship between regional 'knowledge diffusion' and regional 'knowledge creation'

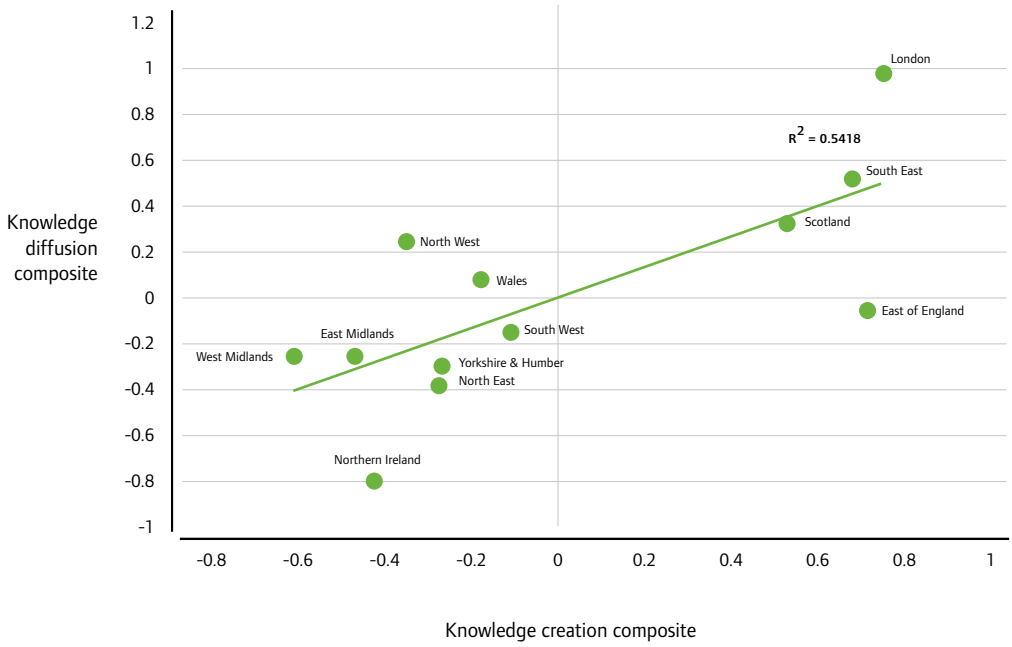
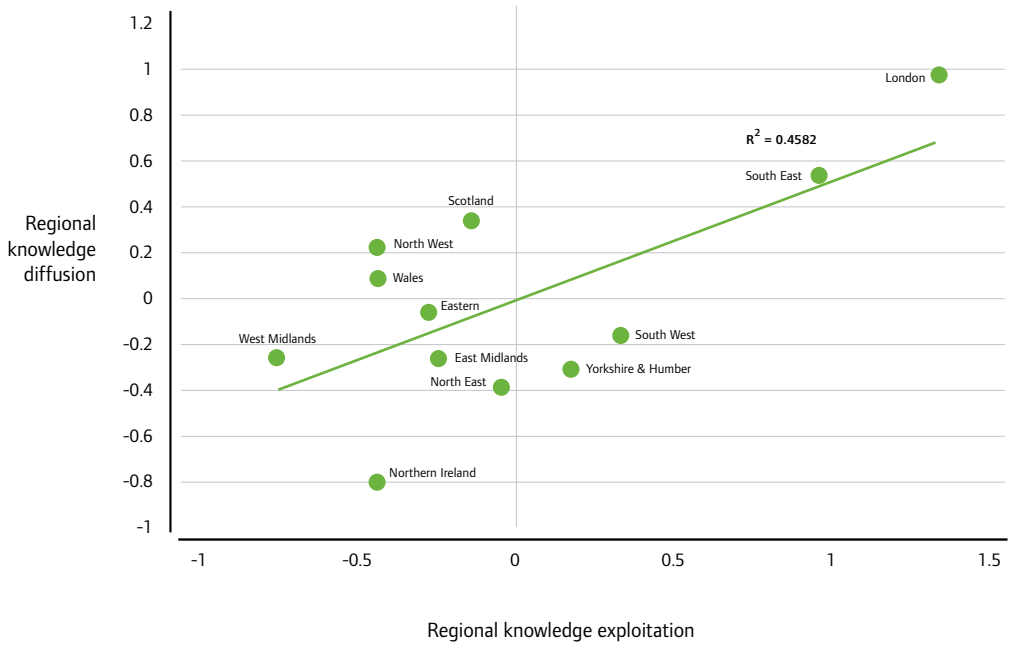


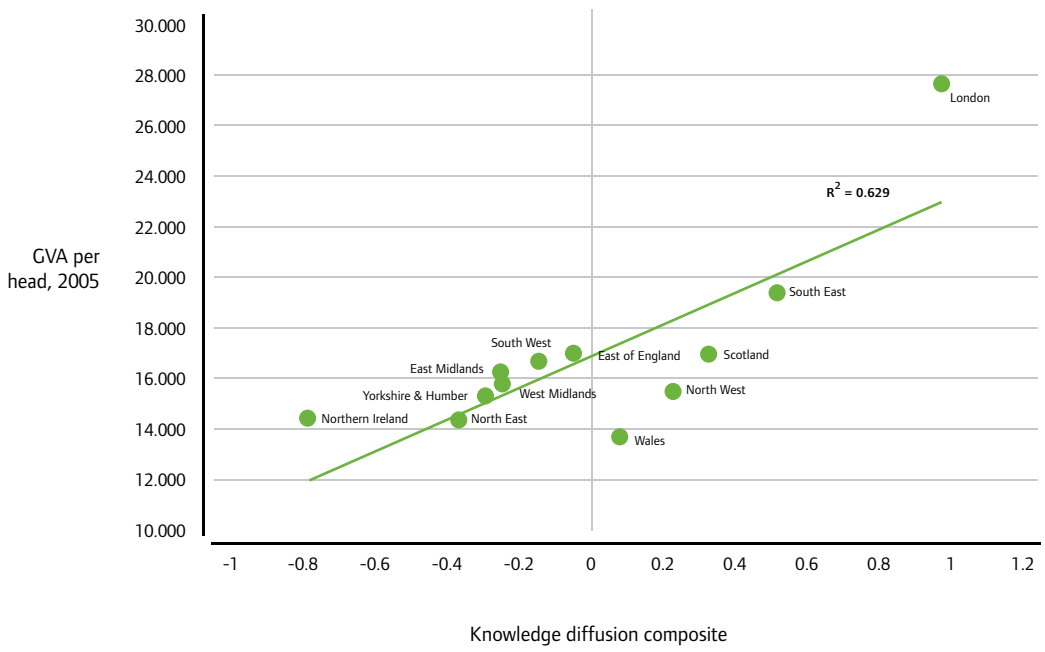
Figure 49: Relationship between regional knowledge exploitation capacity and regional knowledge diffusion capacity



around how places reduce disparities and increase their learning capacity and become more effective at knowledge diffusion.

There remain difficulties in measuring 'knowledge diffusion' given the importance of social capital, the nature of intangible knowledge and the invisibility of knowledge flows. In order to better capture and increase our understanding of 'knowledge diffusion' in cities and regions, it is necessary to measure more accurately the interactions and collaborations between businesses, suppliers and other actors and institutions.

Figure 50: Correlation between 'knowledge diffusion' composite and GVA per head



Part 4: What are the policy implications?

Overall, it appears that the three components of absorptive capacity and the two components of development capacity are positively correlated in the UK. This raises a broad question on what can be done to ensure that the five components are operating as close to an optimal level as possible to maximise knowledge creation, exploitation, and flow.

If absorptive capacity is an important source of new innovations and knowledge creation, should policymakers not design and develop support programmes geared specifically towards improving absorptive capacities? While some programmes might already exist, they tend to exist in silos and are not part of one coherent system driving both innovation capacity and economic development. This perhaps calls for a stronger alignment between public programmes aimed at innovation and those aimed at other socio-economic objectives.

Then there is the question of inter-regional alignment. As we have seen, different parts of the UK have different levels of capacities across all AC/DC dimensions and this begs the question about how much sub-national innovation strategies should be embedded in inter-regional frameworks that are based on coordination between neighbouring regions where different 'capacities' can be shared.

The Greater South East is a case in point, where the regions of London, Eastern England and the South East draw on each other's comparative advantage in AC/DCs. The Northern Way is another example of inter-regional planning aimed at the creation of synergies and 'joined-up' comparative advantage.

Finally, a more practical question follows: if new economic value can be created through various forms of 'knowledge absorption', should policy not be as concerned with 'absorptive capacity' as it is with innovation capacity? Indicators of failure and success of public policy interventions will need then to include the creation of new economic and social value created through accessing, anchoring and/or diffusing external sources of knowledge within the local economy.

Chapter 8: Policy lessons

8.1 Introduction

Innovation is now regarded by policymakers as central to a place's competitiveness, social wellbeing, and prosperity. Policy often focuses on domestic knowledge creation and exploitation to drive innovation. However, most places draw as much on external knowledge sources to develop domestic innovations. Accessing, attracting, and diffusing innovation from elsewhere are often as important to a region's ability to innovate as the creation and exploitation of indigenous new knowledge.

Not all regions draw on the same capacities to innovate, nor do they all require strength in all five AC/DC capacities. Each region has its specific drivers and channels of innovation, thereby making one-size-fits-all policies often inappropriate. Two regions with similar industrial structures might attract new ideas in completely different ways. For example, one might have better universities or a more highly skilled workforce, while the other could enjoy better airports or access to venture capital. These absorptive capacity factors are very important in distinguishing between the abilities of different regions to innovate even when they share similar industrial structures. The AC/DC model offers a useful tool to capture such differences.

8.2 Using the AC/DC model for policymaking

Intelligence gathering
Traditionally, data have been collected to measure innovation performance in regions through an input-output framework; specific areas of under-performance were either hidden or presented as input/output measures. The AC/DC model offers a more distributed form of data collection which should highlight areas in need of improvement to those who can most effect change.

The AC/DC framework also offers policymakers access to more distributed data which can be made relevant to various actors within a region, each with a strategy of their own.[150] For example, the AC/DC framework can help regions draw their plans, set the priorities and allocate resources more strategically. It also makes innovation data relevant to internationalisation data, communications and transport networks, as well as foreign investment, migration and student retention. It thus aims to help different actors within an innovation system understand better the relevance of their areas of responsibility to the overall performance of the system.

Strategy making and priority-setting
The framework can help decision-makers (in regional and central governments) understand the comparative advantage of the region in a complex and fragmented global innovation scene.[151] Regions (in a broader sense) may vary not only in their innovation performance, but also in how they innovate. Consequently, classifying regions in terms of their level of innovation performance might be too broad a criterion to allow targeted interventions. Policymakers should focus on how their region innovates and develops policies according to their region's specific needs.

For example, not all cities and regions have the same need for R&D and academic research, and not all have the need for better airport links. Some cities and regions create economic value primarily on the basis of

technological-knowledge leadership (e.g. Cambridge and Oxford), while others maintain broader economic structures that specialise less in innovation creation than in the strategic diffusion of innovation (e.g. North West). These realities are not always reflected in regional economic and innovation strategies. In fact, many such strategies so resemble each other that one might think every UK region had the same innovation strengths and weaknesses. In Scotland, devolution means that the Scottish Government is in a position to draw up not only regional innovation strategies within Scottish Enterprise and Highlands and Islands Enterprise but also to have them play a frontline role in delivering the Scottish Government's Economic Strategy which gives more strategic innovation objectives.

8.3 Main issues derived from findings

There is a positive association between absorptive capacity and GVA performance
The analysis that has been undertaken in this report points to a positive correlation between the various components of absorptive capacity and regional GVA performance. This is important to know since most UK nations and regions have traditionally focused on the positive relationship between knowledge creation and exploitation and GVA performance. Further research to establish the relationship between absorptive capacities and GVA, however, is required.

There is also a positive association between the AC and DC components
There is a mutually reinforcing relationship between absorptive capacity and knowledge creation and exploitation. The generation of knowledge within a city or region not only increases its stock of indigenous knowledge but also increases its ability to acquire external knowledge. Likewise, the exploitation of knowledge is heavily reliant on a strong functioning absorptive capacity, allowing knowledge to be accessed, anchored, and diffused across a region.

A majority of UK regions have a weak absorptive capacity
Figure 51 shows that the UK has the problem of having a weak absorptive capacity outside London and the Greater South East. Many, if not most, UK nations and regions have weak or mediocre absorptive capacities. This is undermining their ability to benefit from knowledge developed elsewhere and to capitalise on investments in new knowledge and innovation made by external parties.

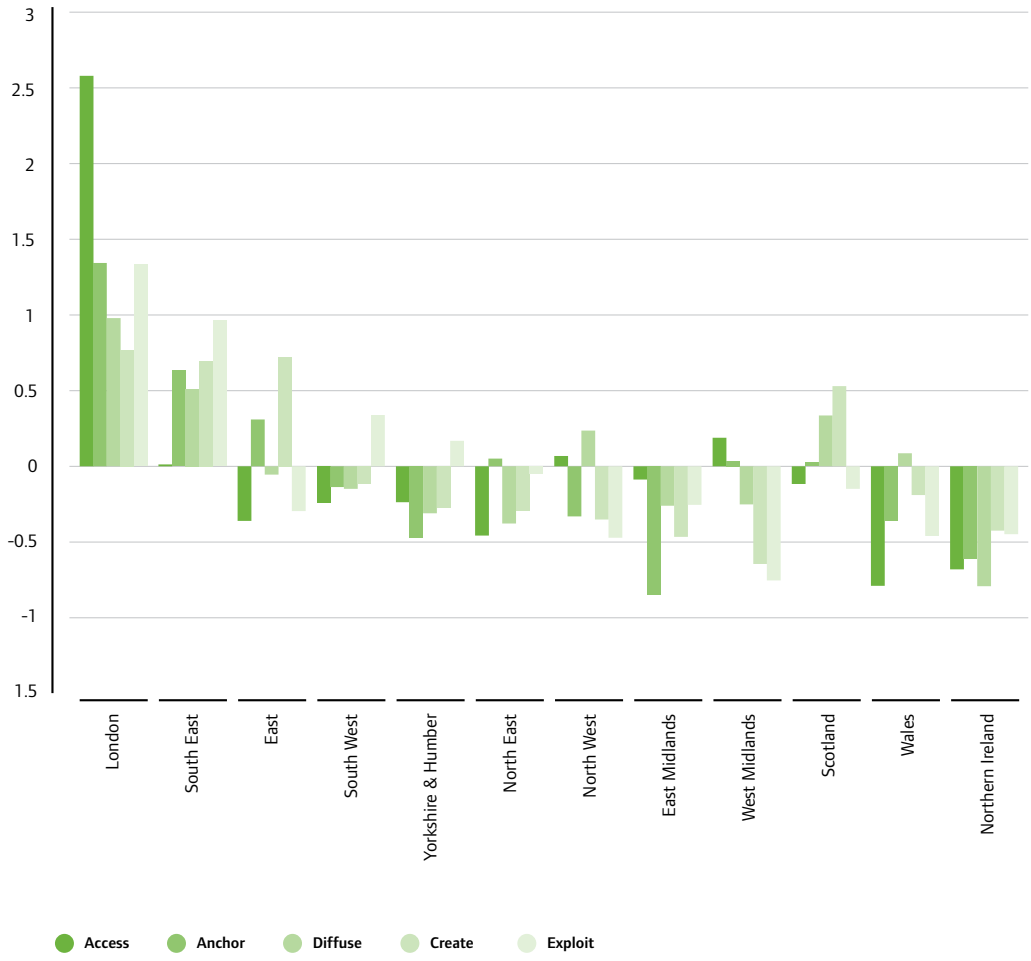
Not all UK regions manage to create the necessary complementarities between them
We have also seen that, with a few exceptions, these capacities tend to correlate with each other. 'anchoring' and 'accessing' capacities are positively correlated for the vast majority of UK regions and nations. This means that anchor agents help provide better access to national and international sources of knowledge and ideas, and an increased access may increase the attractiveness of a place to external players. North East England and Eastern England constitute exceptions because they perform above average in terms of anchoring capacities but below average in terms of access capacities. This poor performance in terms of access capacity may be explained by the rural nature of the two regions, although in the case of Eastern England this is less true because of the region's easy access to London.

There is also a positive relationship between the knowledge 'anchoring' and 'diffusing' capacities. But this is not always the case, with Wales and the North West performing above average in diffusion but below average in anchoring. This might well be due to the high levels of human capital stocks in these two regions compared with their lesser capacity to attract foreign investments.

Finally, there is a strong positive correlation between 'access' and 'diffusing' capacities. The regions that have a higher internal capacity to diffuse knowledge also appear to be better placed to engage in more global networks.

Five out of 12 UK regions are weak in knowledge diffusion capacity
Diffusion is a capacity largely based on the presence of a strong human capital base, and thus the positive relationship between diffusion and all other capacities is another vindication of the importance of human capital for the absorptive capacity of places. In this regard, most UK nations and regions emerge as doing well. But only five out of the 12 nations and regions that make up the UK innovation system have strong diffusion capacity. This is attributed largely to a low density of knowledge-based firms and weaker skills within the workforce in many areas of the UK.

Figure 51: AC/DC profiles in UK nations and regions



Both the capacities to create and exploit knowledge remain a problem for most UK nations and regions
While the UK prides itself on being a world leader in knowledge creation, only three English regions (Greater South East) and Scotland have a strong knowledge creation capacity. This not only shows that UK knowledge creation capacity is geographically concentrated; it also implies that most UK regions and nations lack in this capacity. Similarly only four regions have a strong exploitation capacity, confirming the widely held perception that the UK commercialisation of knowledge remains weak.

8.4 Policy propositions

The main policy recommendation stemming out of this report is that the UK innovation policymakers need to recognise the important role of innovation by adoption in the UK innovation system and to strengthen the UK's capacity in this regard. There are a number of things that can be done to achieve these objectives.

First, develop and improve access channels to relevant national and international sources of new knowledge, ideas, and innovation. A number of important channels may be identified here:

- **Universities:** These can act as important channels for interacting with the global knowledge scene, by attracting foreign

students, engaging in international staff and student exchanges, conducting international collaborations, and becoming formal and informal members of global knowledge networks.

- **Firms with global office networks:** Such firms form in themselves webs of global knowledge exchanges facilitated by a global governance structure that channels learning and disseminates it among actors present in different geographic locations.

- **Export-oriented firms:** Such firms enjoy access to information derived from clients overseas, from the global competition, and from foreign markets needs in general.

- **Local immigrant and expatriate population:** Various research has shown that immigrant and expatriate communities may act as important links to countries of origin. They are often important sources of knowledge and information on their countries and increasingly a source of transnational entrepreneurial activities.

Second, create or help establish anchoring agents who are lead local users of strategic knowledge developed predominantly outside the local area. Anchoring agents are more challenging because they need to be able to embed in the local economy to be effective. Anchoring agents can be created through a variety of channels too, of which we mention the following:

- **'Niche' start-ups:** Start-up companies are typical embracers and transmitters of new ideas. These can be instrumental in the local development of innovations developed elsewhere. They create local communities that are interested in such new developments and in their pursuit to succeed locally they forge national and international ties that help them transfer more know-how into their regions. Different regions might choose to set prioritised areas of focus when providing support for new start-ups rather than creating all purpose start-up funds.

- **Foreign firms/institutes:** These can be attracted to locate in a place on the basis of certain incentives, such as the quality and quantity of the workforce, costs, tax credits, or location. But such foreign players need to be carefully targeted as it is important that they can forge strong links with the local environment if they are to be effective players in the local innovation scene. It is important that such anchoring agents play three roles: improve a region's external access; forge local links; and be magnets for more knowledge inflows to the region. These three criteria should be used by decision-makers when assessing or targeting international investment and relocation opportunities.

- **Foreign talent:** These are many different types such as students, professionals, and immigrants. Each of these groups can act as magnet for more inflows from abroad. But like all anchoring agents their effectiveness depends on their ability to embed in the local environment. For example, government might create matchmaking programmes that bring together local firms and foreign students from countries where local firms aim to develop markets. Or various local players like universities or firms might benefit from a government-set programme to invite distinguished experts from overseas to spend time in the local region. A main objective of attracting anchor agents is to create locally led users of new knowledge developing elsewhere – to create a local community of users that would help domesticate such knowledge.

Third, invest in the development of a broader and more mobile pool of users (exploiters) to enable and speed up knowledge diffusion in the local economy. While anchored agents need to be relevant, they need to improve access to external knowledge sources and create local demand for specific knowledge. Otherwise, their activities risk remaining secluded and shielded from the local economy. A number of channels can be identified in this regard:

- **Education and training:** In many cities and regions there is a growing need for skills upgrade, re-training, and education. This is particularly important in those that are still undergoing the transition from an old labour-intensive economy to the new knowledge-based economy. However, the skills and learning agenda should correspond to the needs of the local business community, particularly those active in areas deemed as critical and strategic to the region. There is a need to forge stronger links between training and businesses, and between research and education. This is to ensure that training is both available and is up to date. Lifelong learning emerges here as a critical instrument in this regard. As it is often sponsored by the employers themselves and it comes as a response to specific needs related to

improving the absorptive capacity of an employer.

- **Workers mobility:** There is the need to improve knowledge transfer links between firms and between firms and external sources of knowledge, such as universities and specialist organisations (e.g. consultancies). While an increasing number of firms cite having collaboration agreements with other firms and/or universities, firms' density appears to be a problem. When there are only a small and limited number of firms in a region active in specific fields of knowledge, this creates a barrier for worker mobility as the employment opportunities for the specialists will be small. Worker mobility is an important channel of knowledge diffusion. When people move jobs they take them a wealth of information, knowledge, and know-how from one place to another. Given that the density of firms is much higher in the South than the rest of the country, when workers move, they tend to go southward. Policymakers might want to explore various sorts of incentives to boost intra-UK workers mobility that flows in all directions.

- **'Open collaboration':** Knowledge can also flow without workers' mobility, particularly through virtual communities of practice or interdisciplinary groups. An increasing percentage of UK enterprises cite external sources such as clients, suppliers, and universities as main sources for new innovations. The UK already has a plethora of schemes and programmes supporting knowledge transfer and cooperation such as the Innovation Advisory Services, Knowledge Transfer Networks, etc. But these tend to be formalised, closed networks of collaborators. What is needed are specific initiatives encouraging more open forms of collaboration in knowledge domains considered as currently lagging behind. For example, the East of England Development Agency (EEDA) is teaming up with large players such as GlaxoSmithKline and Unilever to create open innovation 'spaces' in newly created enterprise science parks. Schemes can be created to reward leveraging and sharing rather than merely creating and exploiting knowledge assets.

Finally, create inter-regional innovation strategies based around regional strengths and weaknesses. Inter-regional strategy alignment is necessary, especially given the small size of a majority of UK nations and regions. A number of things can be done:

- In England, neighbouring Regional Development Agencies could develop inter-regional innovation strategies based on comparative AC/DC stengths and weaknesses. For example in the North, the North West emerges as relatively stronger in diffusion, Yorkshire and the Humber in exploitation, and the North East emerges as relatively stronger in anchoring. These are based on the data and indicators used in this report, but further exploration of these and other elements of comparative strengths and weaknesses could be part of a inter-regional innovation strategy. The Northern Way is a well positioned organisation to play such an integrating role. The Government's plan for new 'Partnerships for Innovation' in regions should perhaps be extended to become inter-regional partnerships for innovation.

- In Scotland, it is important that Scottish Enterprise and Highlands and Islands Enterprise work closely together to acknowledge and take advantage not only of the strengths and differences compared to the UK, but using the regional differences within Scotland, such as biotechnology, financial services or renewable energy technology, in order to create broader innovation strategies.

- Alignment can work at different scales. Cities, for example, might also develop cross city-regional integrative innovation strategies where synergies can be developed on the basis of comparative AC/DC strengths and weaknesses. The Manchester Knowledge Capital is one such initiative, and others like the Leeds City Region are in the making. Cross regional integrative innovation strategies will allow for a more effective and optimal use of otherwise regionally fragmented resources.

- Alignment is not only a regional and territorial issue; it is also a sector issue. There is a greater need to integrate innovation strategy with other local strategies for transport, housing, skills, and planning. These are all policy areas with a strong links to innovation strategy. Transport, for example, can have a huge impact on 'accessibility', housing on quality of life and workers' mobility, and skills on almost everything else related to innovation including anchoring and diffusion.

Appendix 1

	Indicator	Numerator (source)	Denominator (source)	Interpretation
Knowledge Access	1. Co-authorships between UK Regions and Non-UK Partner Organisations	Collaborative articles (annual average 2002-2006) (*Evidence Ltd* from Thomas Reuters, 2008)	Total population (annual average 2002-2006) (Population Estimates, ONS)	Co-authorships indicate access to inward flows of knowledge through research networks. Bibliometric data provide an indication of the international links of UK academics and researchers which may contribute to the knowledge of local actors and to local business innovation.
	2. Flights from Regional International Airports	Scheduled terminal passengers in 2008 (Civil Aviation Authority, 2008)	n/a	International flights provide an indication of global infrastructure network capacity. It also reflects the level of access a place enjoys and the demand for informational exchanges. International travel is also an indicator of extent of face-to-face contact. Airline infrastructure acts therefore as a conduit for knowledge flows on an international scale.
	3. Coverage by Broadband Cable and Fixed Wireless Access (FWA) Technologies	Number of households covered by broadband technologies (Ovum UK Broadband Status Report, 2006)	Total households (Ovum UK Broadband Status Report, 2006)	Broadband infrastructure provides an indication of the demand for remote virtual contact and the capacity of UK regions to meet that demand.
	4. Advanced Producer Service (APS) Network Connectivity*	See Chapter 2 for details on methodology	See Chapter 2 for details on methodology	APS network connectivity indicates access to global flows of knowledge through firms' global networks in the advanced service economy. Advanced producer services criss-cross many economic sectors and actors because they provide services to other businesses rather than retail customers. This makes them a very strong indicator for knowledge-intensive flows between agents and places.
Knowledge Anchoring	5. Density of International Firms	Number of international firms (Filippaios and Kottaridi derived from LexisNexis Corporate Affiliations Database, 2007)	VAT-registered firms (per 10,000) (Inter-departmental Business Register)	The density of international firms indicates the stock of international players that a region managed to attract to locate within it. The definition of an international firm is synonymous with a multinational corporation.
	6. Foreign Direct Investment (FDI) Project Successes	Total FDI project successes (1998/99-2002-03) (Office for National Statistics)	Total population (per 1,000,000) (Population Estimates, ONS)	FDI project successes indicates new inward flows of international investment, bringing new knowledge into the region, and the success in embedding firms within their host environment.
	7. Service Sector Investment by Foreign-Owned Companies	Service investment by foreign-owned companies (£) (annual average 1998-2004) (Annual Business Inquiry)	Total population (annual average 1998-2004) (Population Estimates, ONS)	An indicator of the on-going investment by foreign-owned firms in the regions where they are located. Foreign-owned firms have the capacity to act as 'anchor tenants' within their host regions, enhancing innovation systems and stimulating local R&D and innovation activity.
	8. Net within-UK Migration of People in higher Managerial and Professional Occupations	Net within-UK migration of people in higher managerial and professional occupations (Attracting Talent, Experian, 2006)	Total population between 16 and 74 years (Office for National Statistics)	It's a measure of people moving from one region of the UK to another. Net migration indicates the attraction of new talents and skills.
	9. Retention of Graduates	Total leavers entering employment in the same region (Higher Education Statistics Agency, 2005/06)	Total leavers entering employment (Higher Education Statistics Agency, 2005/06)	The retention of new talent and knowledge is an important indicator of a region's ability to domesticate some of the talent it produces. The proportion of graduates (first degree and post graduate) entering employment within the region of study provides an indication of regional retention of new talent and skills.

	Indicator	Numerator (source)	Denominator (source)	Interpretation
Knowledge Diffusion	10. Human Capital Index (NVQ weighted average)	Number qualified below NVQ 2, qualified to NVQ 2 only, qualified to NVQ 3 only, qualified above NVQ 4 (Annual Population Survey, 2006)	Total working age population (Annual Population Survey, 2006)	Qualifications provide an indication of the general capacity of the resident population to diffuse and absorb knowledge.
	11. Proportion employed with NVQ Level 4	Employed workforce qualified NVQ Level 4 and above (Labour Force Survey)	Total employed (Labour Force Survey)	The capacity of a firm to acquire and absorb knowledge is dependent on the human capital in its workforce. This workplace-based indicator provides an indication of regional firms' access to skilled labour.
	12. Number of knowledge-intensive enterprises per thousand population	Number of knowledge-intensive businesses (Inter-departmental business register, 2006)	Total population (per thousand) (Population Estimates, ONS, 2006)	Knowledge-intensive business density provides an indication of the opportunities for the exchange of knowledge between firms in a region. Geographic proximity and high business density offer greater opportunities for cooperation, collaboration and the exchange of knowledge through face-to-face interaction.
	13. Proportion of businesses with cooperation agreements	Number of businesses with cooperation agreements (UK Innovation Survey, 2005)	Total businesses (UK Innovation Survey, 2005)	Cooperation agreements provide an indication of the potential knowledge diffusion between firms.
	14. Total funding for business-university research and consultancy (per academic staff)	Total value of collaborative research, research contracts and consultancy contracts (Higher Education-Business Community Interaction Survey, 2006/07)	Total academic staff (Higher Education Statistics Agency, 2006)	Funding for university-business collaborative research and research and consultancy contracts between universities and businesses provides an indication of diffusion taking place through the interaction and exchange of knowledge between the higher education sector and the private sector.
	15. Innovation new to firms	Innovation new to firms (UK Innovation Survey, 2005)	Total innovation active firms (UK Innovation Survey, 2005)	Innovations new to firms provide an indication of diffusion by measuring the take-up of existing innovations by individual firms in a region.
Knowledge Creation	16. Higher education qualifications	All higher education qualifications obtained (Higher Education Statistics Agency, 2006/07)	Total population (Population Estimates, ONS)	Higher education qualifications obtained provide an indication of knowledge creation embodied in human capital.
	17. R&D performed within Higher Education Institutions	R&D performed within Higher Education Institutions (£million) (Office for National Statistics, 2005)	Regional GVA (£million) (Office for National Statistics)	R&D performed in HE institutions provides an indication of the knowledge creation activity taking place through the higher education sector.
	18. R&D performed with government establishments	R&D performed within government establishments (£million) (Office for National Statistics, 2005)	Regional GVA (£million) (Office for National Statistics)	R&D performed within government Institutions provides an indication of the knowledge creation activity taking place within government. R&D performed within government has mission-specific goals including national security and public health and often produces public goods.
	19. R&D performed within businesses	R&D performed within businesses (£million) (Office for National Statistics, 2006)	Regional GVA (£million) (Office for National Statistics, 2006)	R&D performed within businesses provides an indication of the resources being channelled into increasing the knowledge creation within businesses.

	Indicator	Numerator (source)	Denominator (source)	Interpretation
	20. Number of patent applications granted per region	Number of patent applications granted (The Patent Office, 2007)	n/a	Patents provide an output measure of the knowledge created within regions. The number of patent applications granted can indicate the success of innovative activities and indicates an economy's increased stock of knowledge.
	21. 2001 Research Assessment Exercise (RAE) rating weighted by category A* and A research staff (FTE) weighted by number of research staff	2001 RAE rating (Linear Score) weighted by category A* and A research staff (RAE, 2001)	Total research staff (Higher Education Statistics Agency, 2001)	The 2001 RAE rating provides an output measure for knowledge creation and relates to the quality of research carried out in universities and other HE institutions. It provides a broader indication of knowledge creation as it assesses the quality of research across all disciplines.
Knowledge Exploitation	22. Innovation Active Enterprises	Innovation active enterprises (Community Innovation Survey 4, 2002-2004)	Total enterprises (Community Innovation Survey 4, 2002-2004)	Innovation active enterprises give an indication of the propensity of businesses to exploit their knowledge. Business innovation activity not only includes the introduction of new products and process but also major changes in management practices, organisational structure and marketing strategies.
	23. Process Innovations New to Industry	Process innovations new to industry (Community Innovation Survey 4)	All process innovations (Community Innovation Survey 4)	Process innovations new to industry indicate the exploitation of knowledge to create novel innovation. Process innovations consist of significant changes in the way that goods and services are produced or provided.
	24. Product Innovations New to Market	Product innovations new to market (Community Innovation Survey 4)	All product innovations (Community Innovation Survey 4)	Product innovations new to market indicate the exploitation of knowledge to commercialise new or improved products.
	25. Early-Stage Private Equity Investment	Early-stage private equity investment (£million) (British Private Equity and Venture Capital Association)	Total population (Population Estimates, ONS)	Access to finance is an important factor in determining whether new knowledge is successfully commercialised and exploited. Private equity investment indicates a demand for finance to exploit and commercialise knowledge.
	26. Exports of Knowledge Services	Value of exports of knowledge services (£million) (DTI analysis of the ONS International Trade in Services Inquiry)	VAT-registered firms (per 10,000) (Inter-departmental Business Register, 2006)	Exports of knowledge services indicate the output of the commercialisation of knowledge. It provides a primary measure of a region's capacity to successfully commercialise and market its knowledge and innovation.

Appendix 2: Sensitivity of composite indices

When comparing the composite indices it is important to understand how sensitive these scores are to changes in the scores for the individual metrics constituting these composites. In general, as the composite indices are based on the standardised scores for each metric (i.e. where the standard deviation for each metric has been recalculated to equal 1), the composite indices are relatively equal in sensitivity to changes in individual metrics. In other words, the composite indices provide an equitable weighting and balance for each of the individual metrics underlying their construction.

As means of expressing the impact of changes in the scores for individual variables on the composite index scores, we can take the example of the North West, which is ranked in 8th position on the Knowledge Anchoring Index with a score of -0.32. A hypothesised increase of 20 per cent in the North West's scores for each of the metrics constituting the Index improves the North West's score to -0.22, i.e. an increase of 31 per cent. Similarly, the North West is ranked in 11th position for the Knowledge Exploitation Index with a score of -0.46. An increase of 20 per cent in the North West's scores for each of the metrics constituting the Index improves the North West's score to -0.30, i.e. an increase of 35 per cent. However, the overall improvement or decline in the composite score for any particular region, based on a change in individual metric scores, will be dependent on how far a particular region is situated away from the mean score of 0.

In order to look further at the issue of sensitivity it is useful to highlight a number of scenarios to assess how the composite score index for regions would change if the underlying metrics were to change.

Figure 52 highlights the change in the Knowledge Anchoring Index score for the East Midlands (the bottom ranked region on the index) if in each case the score for a constituent metric changed to the UK average. The region's current score is -0.83. However, if it were to achieve the UK average score for either 'Foreign Direct Investment Project Successes' or 'Graduates Taking up Employment in the Region' it would improve its score to -0.55. An improvement in the 'Net Migrants' to the UK average would have the least overall impact on the composite score.

Figure 53 highlights the change in the Knowledge Anchoring Index score for London (the top ranked region on the index) if in each case the score for a constituent metric changed to the UK average. The region's current score is 1.34. However, if it were to fall to the UK average score for 'Foreign Direct Investment Project Successes' its composite score would fall to 0.98, and to 1.02 if the 'Net Migrants' were to fall to the UK average. In London's case, the composite index is least sensitive to changes in the proportion of 'Graduates Taking Up Employment in the Region', whereby a decline to UK average would result in only a fall of 0.10 to 1.24.

Figure 54 highlights the change in the Knowledge Exploitation Index score for the West Midlands (the bottom ranked region on the index) if in each case the score for a constituent metric changed to the UK average. The region's current score is -0.75. However, if it were to achieve the UK average score for the proportion of 'Innovation Active Enterprises' its score would improve to -0.48,

Figure 52: Knowledge Anchoring Index for the West Midlands based on a change to the UK average score for individual metric scores

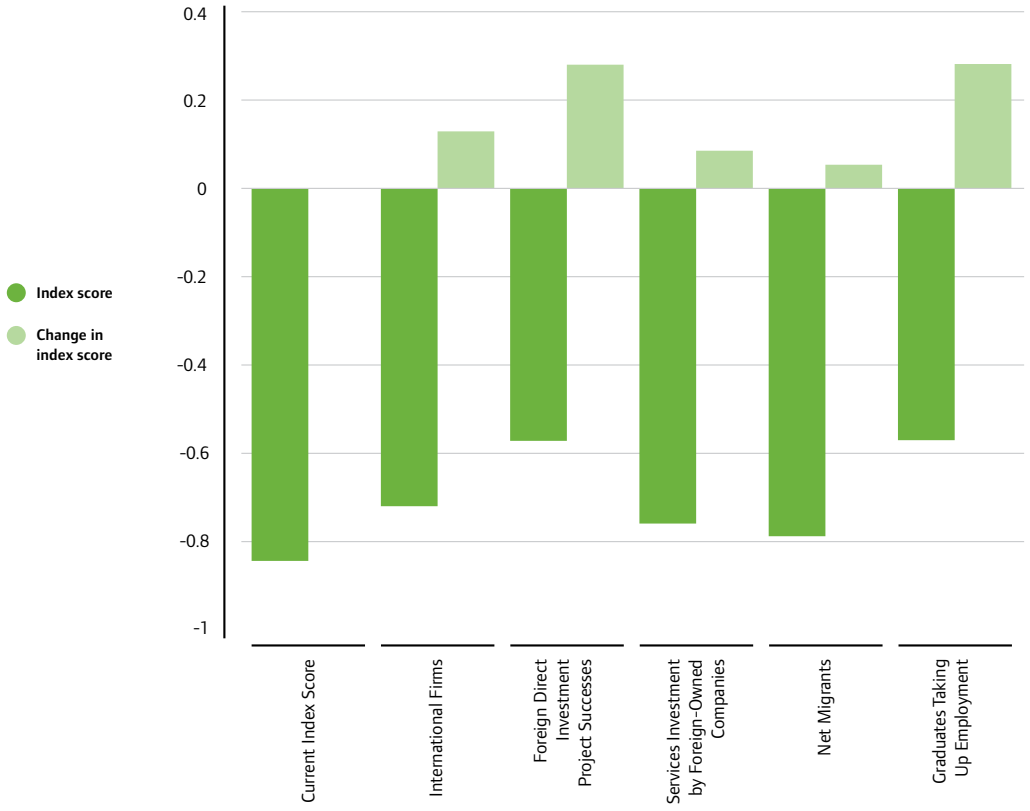


Figure 53: Knowledge Anchoring Index for London-based on a change to the UK average score for individual metric scores

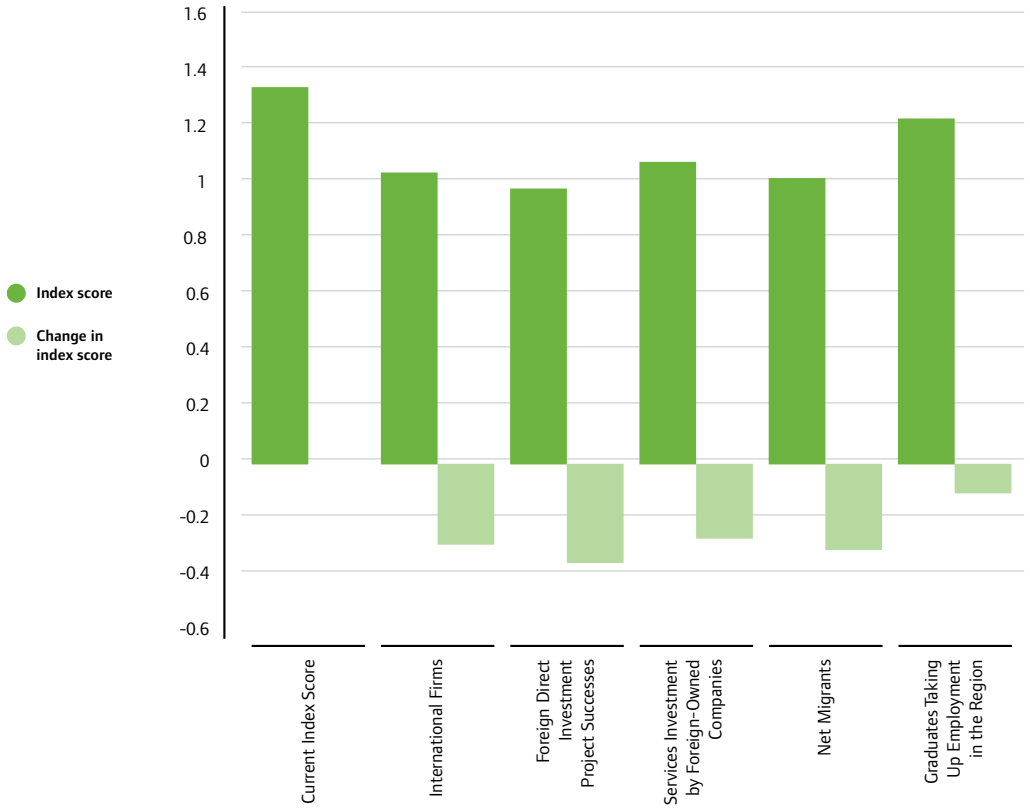


Figure 54: Knowledge Exploitation Index for the West Midlands based on a change to the UK average score for individual metric scores

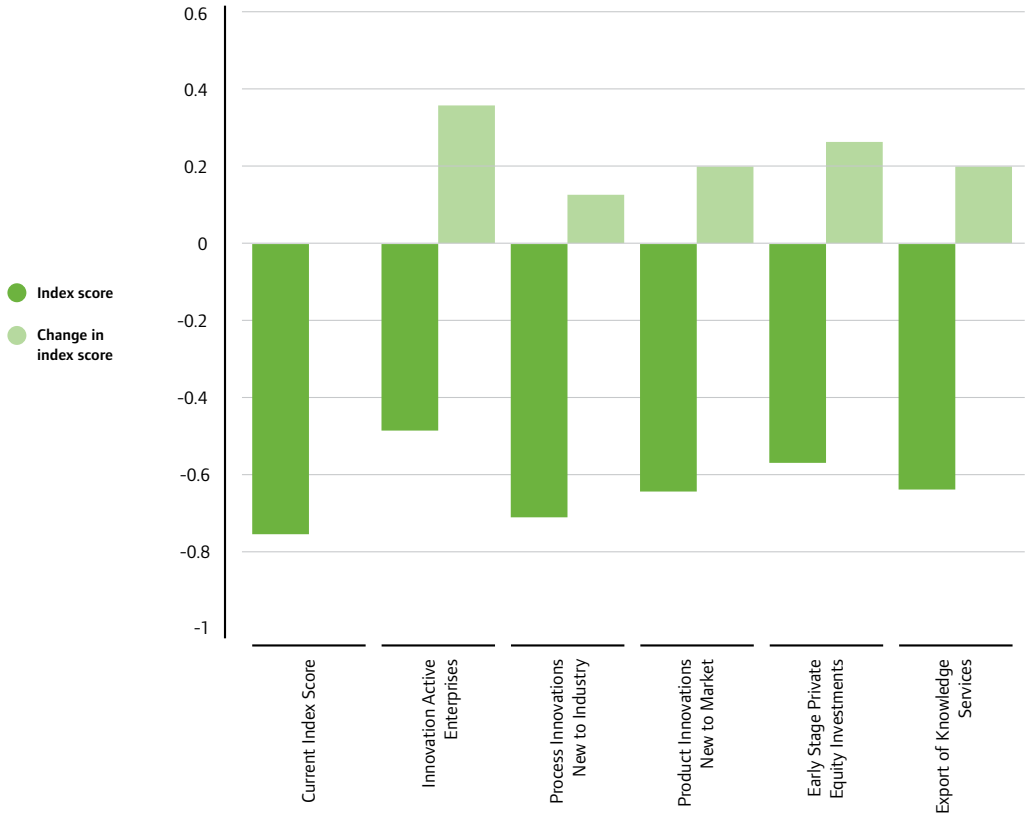
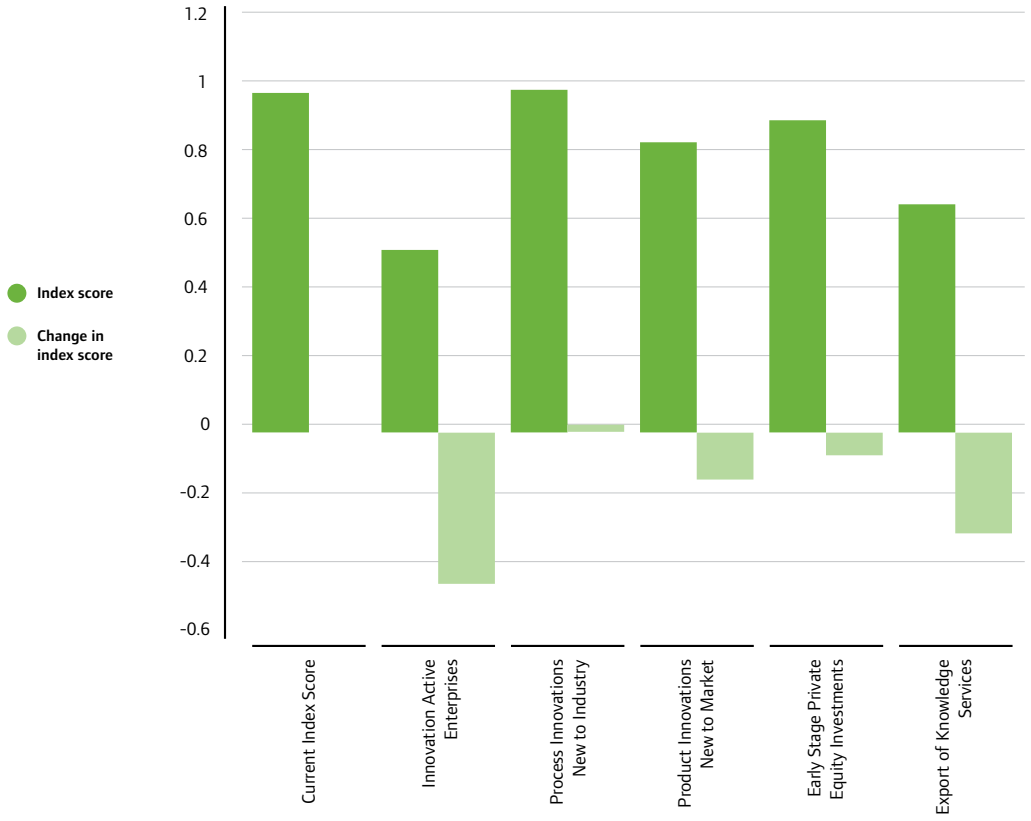


Figure 55: Knowledge Exploitation Index for the South East based on a change to the UK average score for individual metric scores



and if it were to achieve the UK average for 'Early Stage Investment' its score would rise to –0.57. However, an improvement in 'Process Innovations New to Industry' to the UK average would only improve the composite score by 0.12 to 0.71.

Finally, Figure 55 highlights the change in the Knowledge Exploitation Index score for the South East (the second ranked region on the index) if in each case the score for a constituent metric changed to the UK average. The region's current score is 0.96. However, if it were to fall to the UK average score for 'Innovation Active Enterprises' its composite score would fall to 0.52, and to 0.65 if the 'Exports of Knowledge Services' were to fall to the UK average. Interestingly, a change to the UK average for 'Process Innovations New to Industry' would actually increase the composite score very slightly from 0.96 to 0.97.

These scenarios make clear that each region's composite index score is uniquely sensitive to changes in the individual metrics underlying the composite measure. This further indicates that each region's innovation fortune is uniquely defined and must be attuned to a rigorous understanding of which scenarios represent the preferred developmental options. Nevertheless, the methodology (as outlined in Chapter 2) does provide a consistent means of objectively comparing regions across a complex range of datasets.

Appendix 3: Interlocking network analysis

Interlocking networks are unusual because they have three layers. Most network analysis deals with two layers – the 'net' and 'nodes' that create the net (e.g. a gang as a net with gang members as nodes). In world city networks the net is the worldwide set of inter-city relations, the nodes are the cities, and there is an additional sub-nodal level of the firms. The latter are not just additional, they are crucial as the agents, the network makers. Thus in this model it is not the nodes – cities – that make the network, and therefore cities are not reified as actors in their own right. As the agents, it is firms that are the subjects of research, with UK metropolitan regions and core cities as the object, the outcome of the process being modelled.

The model is formally specified as follows. A universe of m advanced producer service firms located in n world cities is defined. The importance of the office of firm j in city i, which is called the service value of a firm in a city, is vij. Service values for all firms in all cities define a service value matrix. The conjecture behind using these values is that the more important the office the more connections it will generate with other offices in a firm's network.

The equation:

$$S_i = \Sigma\, v_{ij} \qquad (1)$$

defines the total quantity of services provided by a city. This is a simple attribute measure but a relational measure can be generated from a second equation:

$$r_{ab,j} = v_{aj} \,.\, v_{bj} \qquad (2)$$

which defines the relation between cities a and b in terms of firm j. This is an elemental interlock link between the two cities for one firm. The aggregate city interlock link between the cities for all firms is then given by:

$$r_{ab} = \Sigma\, r_{ab,j} \qquad (3)$$

For each city there are n-1 such links, that is one to every other city. These links can be used to measure the overall status of a city within the network:

$$R_a = \Sigma\, r_{ai} \qquad (4)$$

This is the gross interlock connectivity, which defines the integration of a city in the network. To make such results more easily interpretable, they are converted to proportions of the largest connectivity recorded in the given universe. If the largest connectivity is designated L, the city network connectivity is given as:

$$C_a = R_a \,/\, L \qquad (5)$$

C_a will have a range from 0 to 1: cities with no offices of firms in the universe of the study will score zero and the city with the highest interlock connectivity will score one. This is the basic output of an interlocking network analysis: it assesses each city's overall position within the network, their relative levels of integration into the network.

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