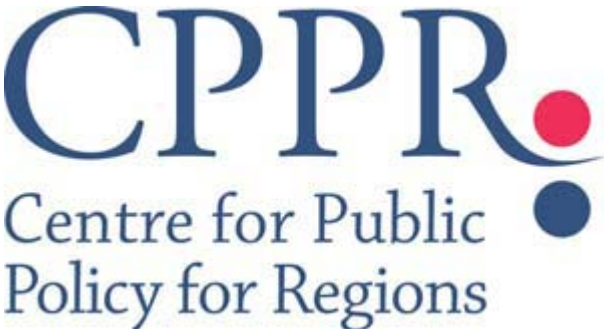

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Beyond Clusters: The Implications of Life Science Commodity Chains for Less-favoured Regions

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ABSTRACT

As manufacturing employment has shifted from economically developed countries to the developing world because of lower labour costs in the latter, developed countries have had to find new ways to compete within the global economy. In part they have done so through the promotion of the so-called 'knowledge economy' constituted by new innovations and new markets produced by high-tech sectors like the life sciences. However, for less-favoured regions (LFRs) in these countries, already suffering from the effects of deindustrialisation and consequent unemployment, this shift to the knowledge economy raises a number of issues. First, the existing uneven development of such high-tech sectors means that LFRs often lack the basic infrastructure required to attract and embed these new types of knowledge economy employment, compounding their already disadvantaged position. Second, the success of a few 'growth regions' such as Silicon Valley or the City of London reinforces continuing uneven development through the international connections and linkages that tie these growth regions into wider, global knowledge networks and further excludes LFRs. Finally, regional actors in growth regions are often more powerful than those in LFRs, which helps to reproduce the uneven position of these different regions in the commodity chain.

KEYWORDS: life sciences, global commodity chains, less-favoured regions, clusters

1 INTRODUCTION

Knowledge is all around us it would seem. Societies and economies are increasingly described as 'knowledge-based', 'knowledge-driven' or some similar epithet, espousing the truism that all human activity involves the processing and application of knowledge and learning (e.g. OECD, 1996; EC, 2000). More specifically, the loss of comparative advantage within new international divisions of labour has meant that developed economies have increasingly sought to promote the idea of 'competitiveness' through the expansion of knowledge-based industries - such as the life sciences - in which innovation drives production and capital expansion. Mainstream debates have centred on several issues with regards to this emerging *knowledge-based economy* (KBE), including the growing importance of science as a source of innovation and new commodities; the growth in knowledge intensity as knowledge replaces other factors of production; the need for organisational change to facilitate learning and the capture of knowledge in new commodity forms; and, the central place of universities and education in economic development (Kitagawa, 2004; Powell and Snellman, 2004; Warhurst and Thompson, 2006).

The KBE agenda has come to dominate social and economic policy in several developed economies, especially in the European Union (EU) where the Commission's *Lisbon Agenda* has explicitly linked 'innovation-friendly' markets with global competitiveness (e.g. EC, 2006b). More critically, several scholars have queried whether the reshaping brought about by this new political-economic project will actually benefit all places equally, or whether it is more likely to valorise continuing processes of capital accumulation and certain types of knowledge over others (see Jessop, 2006; Birch and Mykhnenko, 2009; Hudson, 2009). In light of this new policy vision and strategy, therefore, it is pertinent to ask what this means for less-favoured regions (LFRs), such as Scotland, in developed economies. First, can the vision and pursuit of a KBE alleviate uneven development between regions, even though LFRs may lack the social and economic infrastructure needed to attract and embed new forms of employment? Second, does the success of a few 'growth regions' that epitomise the benefits of the KBE reinforce continuing uneven development, in that the strength of these regions' extra-

local linkages tie them into global knowledge networks to the exclusion of LFRs? Finally, how do the power differentials between social actors within growth and less-favoured regions produce an uneven influence on the arrangements and flows of value between regions in which activities along the commodity chain are organised? All these issues are centrally implicated in the need to look again at the processes that underpin regional development, especially territorial innovation processes, in knowledge-based sectors like the life sciences.

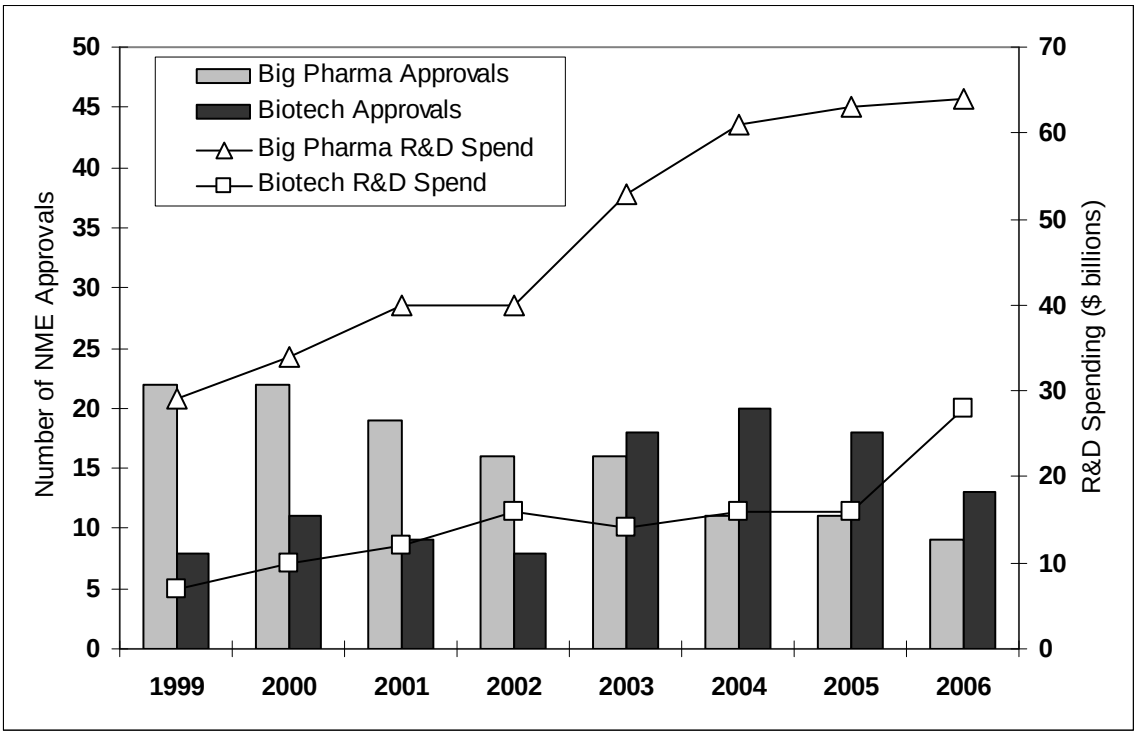
In thinking about these issues, it is necessary to re-evaluate a number of the underlying assumptions of regional public policy in the last few years, especially in countries like the UK which has been dominated by an emphasis on the importance of endogenous capacity as well as - what is more than evident now - a misguided emphasis on market de-regulation and competition (e.g. DTI, 1998, 2001; Brown, 2005). It is the emphasis, though, on what Phelps (2004) calls 'locally-bounded' processes that is of most interest to us here. In light of the concerns about the position of LFRs in the KBE raised above, it is important to re-consider 'regions' as sites and centres of innovation dependent upon specific social, institutional and knowledge assets that are embedded in particular places. The life sciences and biotechnology have been particularly associated with this conceptualisation of regional innovation processes, as is evident in the ever expanding literature on the topic (see Birch, 2007a for a review). In order to explore these issues we first consider the global significance of the life sciences (Section 2) before outlining our analytical approach, which draws on global commodity chains and production network approaches as well as institutional political economy (Section 3). After this, we briefly outline the methodology (Section 4) we have taken before presenting the empirical findings. In the empirical sections we consider three major issues: the geographies of life science commodity chains (Section 5); power and governance in these commodity chains (Section 6); and the institutional geographies of a less-favoured region, Scotland (Section 7). We then finish by looking at the implications of these findings for less-favoured regions in the conclusion (Section 8).

2 THE GLOBAL LIFE SCIENCES: A SOLUTION TO ALL OUR PROBLEMS?

The life sciences cannot be conceived as a single sector, type of activity or organisational form. Instead the life sciences consist of diverse sectors that incorporate biological processes and knowledge in their activities and can therefore range from large multinational pharmaceutical companies to small dedicated biotechnology firms (DBFs). Furthermore, the life sciences are not limited to therapeutic products – such as new drugs or medical treatments – but can also include activities ranging from human diagnostics and platform technologies through to new agricultural crops, environmental services and agro-fuels. The Organisation for Economic Cooperation and Development (OECD), for example, has sought define the life sciences as a new "wave of innovations" with the concept of *bioeconomy* in which the potential of the life sciences is harnessed and exploited "to promote high-level social and economic goals" (OECD, 2005, p.1). A similar policy agenda is also evident at the European Commission (EC) where the idea of a *knowledge-based bio-economy* underpins the funding agenda of Framework Programme Seven (FP7) across a number of different research fields and schemes (Birch *et al*., 2008). In both these policy discourses there is an emphasis on the enormous potential that the life sciences have for contributing to economic, social, and increasingly ecologically sustainable development.

It is obviously difficult, if not impossible, to identify and measure the life sciences as a single sector, although some have tried (e.g. Zika *et al*., 2005). Consequently, it is easier to use the 'biotechnology' industry – itself not a simple category – as a proxy for the life sciences, bearing in mind that such a proxy underestimates the size of whole sector. However, it is still helpful to use the global biotechnology industry in order to consider its importance, its geography and its uneven spread around the world. Before considering biotechnology in more detail, it is important to emphasise that as a sector it has never been profitable, yet it still receives considerable investment. For example, global net losses have hovered around $5 billion over the last eight years, but R&D spending has almost doubled (see Figure 1).

Figure 1 The Pharmaceutical 'Productivity Crisis'



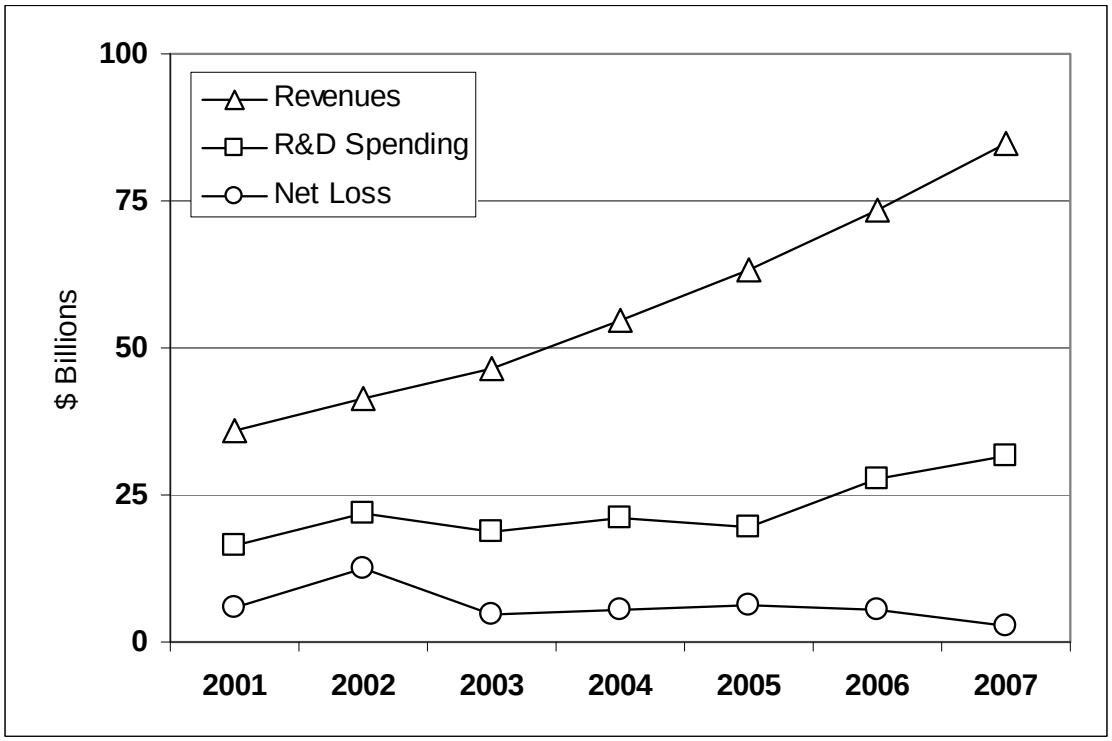
Source: Lawrence (2007)

During the same period revenues have more than doubled, perhaps explaining the growth of investment despite continuing losses. However, looking more closely at the current situation reveals a number of significant issues relevant to the discussion here: first, it was only in 2007 that publicly-listed biotech firms – a small minority in themselves – actually became profitable after 32-years of investment in modern biotechnology (Lawrence and Lähteenmäki, 2008); second, around 80% of global biotech sales go to only ten biotech firms, usually as the consequence of biopharmaceutical sales (Bate, 2005); and third, there is a perceived 'productivity crisis' in the pharmaceutical industry as R&D spending increases whilst new drug approvals decline (see Figure 2).

Whether there actually is a 'productivity crisis' is open to debate since the profits of pharmaceutical firms has continued to increase, as have the number of 'blockbuster' drugs (i.e. those with sales over $1 billion per year). Among other perspectives, the crisis can be seen as the consequence of neoliberal imperatives to put profit above other considerations (see Birch, 2006) and a result of an innovation regime wedded to the

blockbuster model (see Hopkins *et al*., 2007). Whichever perspective is accurate, biotechnology is widely touted as the solution to this particular crisis, offering the promise of replenishing diminishing product pipelines with new products and innovative technologies. Just as it is touted as the solution to this one problem – that is, declining pharmaceutical productivity – biotechnology and the life sciences are presented as (usually) safe, sustainable and technoscientific solutions to numerous other social, economic, political and ecological problems.

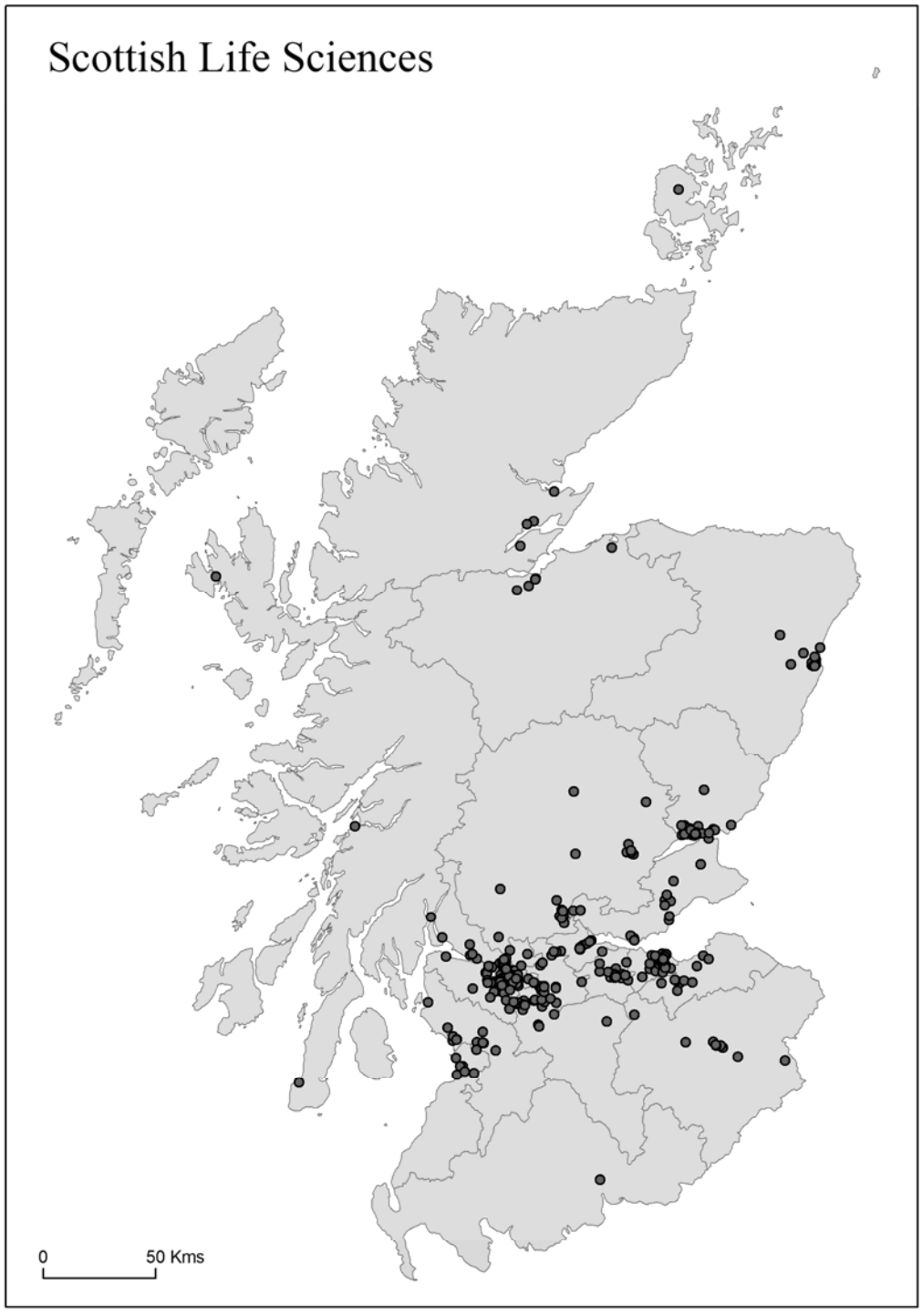
Figure 2 The Global Biotechnology Industry



Source: Ernst and Young (2003), Lawrence (2007, 2008).

The main issue with viewing new, high-tech industries, such as the life sciences, as the solution to socio-economic problems is that they are unevenly spread around the world, not simply between but also within countries and regions: for example, in Scotland the life sciences are concentrated in the Central Belt (see Figure 3). For example, there are major concentrations in 'growth' regions – e.g. California and South-east England – around the world (Cooke, 2007). Even though the UK biotechnology industry is

Figure 3 The Scottish Life Sciences



considered by many as second only to the USA, the life sciences are still highly concentrated in specific regions including the East and South-east of England, London, and Central Scotland (see Birch, 2009). Consequently, this uneven development of the life sciences may prove problematic for less-favoured regions (LFRs) since these regions could, once again, lose out on the opportunity to develop new industrial sectors compounding their already disadvantaged position. However, as stated above, Scotland represents both an LFR and a site of a growing life science sector, which means that it represents a useful empirical case for understanding broader issues around the (re-)positioning of LFRs in emerging knowledge-based sectors and the opportunities (and threats) that the KBE political-economic agenda poses for such regions.

3 BEYOND CLUSTERS: MULTI-SCALAR INNOVATION

3.1 Knowledge, Space and the Life Sciences

A considerable literature has been built up over the last 20 years or so on the relationship between knowledge, space and the life sciences (see Birch, 2007a). It can be split, rather crudely, between research that has focused on knowledge processes and that which has focused on spatial processes. The former interest in knowledge processes arose from work in economic sociology, strategic management and innovation studies in the early 1990s and was concerned mainly with the importance of alliances, collaborations and networks to new biotech firms (e.g. Chakrabarti and Weisenfeld, 1991; Deeds and Hill, 1996). The particular stress laid on complementary linkages between organisations was underscored by the analysis of innovation systems that sought to explain the apparent competitive advantage of the USA over Europe in national institutional terms (e.g. Senker, 1998, 2005; Acharya, 1999). This has encouraged a critical rethinking of the role played by institutions and changing political-economic priorities and agendas for biotechnology, particularly in relation to the problematic promotion of global competitiveness and the extension of property rights in the life sciences (e.g. Loeppky, 2004; Birch, 2006; Tyfield, 2008).

Despite the insights from this research, however, the latter spatial and geographical literature initially placed a greater emphasis on the idea of 'clustering' in the life sciences drawing on the work of Michael Porter. In particular, Porter's (1990, 2000) *cluster* concept has proven especially popular in policy-making circles where it has influenced a number of analyses (e.g. DTI, 1999a, 1999b). As we mention later, it has been influential in Scotland in particular, where it has directly informed policy decisions regarding the life sciences (see Rosiello, 2004). In part, this popularity is the consequence of Porter's (2000, p.15) definition of clusters as:

> "[G]eographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g. universities, standards agencies, trade associations) in a particular field that compete but also cooperate".

The cluster concept, therefore, closely maps onto recent policy concerns, especially in the UK, with both competitiveness and endogenous capacity in the characterisation of competitive performance as an effect of 'home base' conditions (e.g. labour markets, knowledge spillovers and supporting organisations) and the embedding of firms in a series of localised inter-firm and intra-firm relationships. Whilst a growing body of work in economic geography has criticised both the concept of competitiveness (e.g. Bristow, 2005) and clusters (e.g. Asheim *et al*., 2006), the idea of *clustering* – i.e. concentrations of economic activity – has still dominated much of the previous research agenda on the life sciences whether or not it adheres strictly to Porter's ideas (see Birch, 2007a, 2008). For example, there has been a growing interest in the idea of regional institutional and innovation systems (e.g. Cooke, 2004), which provides greater nuance to the theory of clustering, but still emphasises the importance of local interaction.

More recently there has been greater recognition of the role played by (and importance of) extra-local linkages, particularly global linkages that tie regional systems into broader global networks (e.g. Bathelt *et al.*, 2004; Moodysson, 2008). In the life sciences, this research has, however, still placed an emphasis on the concentration of 'whole value chains' in certain places (Coenen *et al*., 2004; Cooke, 2007), which does not

address the multi-scalar patterns and processes of life science innovation as opposed to the linking of 'local nodes' with 'global networks' (e.g. Gertler and Levitte, 2005; Gertler and Vinodrai, 2009). It is crucial to consider the multi-scalar dimensions because of the different factors that influence the life sciences from regional knowledge capacities and infrastructure through national regulatory systems to global trade rules. Consequently, a focus on localised interaction and relationships misses the concentration *and* dispersal of innovation processes across multiple scales (Malmberg and Power, 2005). In this sense, innovation is multi-scalar involving "linkages and interrelationships *between* and *across* these various spatial levels or scales" (Bunnell and Coe 2001: 577; also Coe and Bunnell, 2003), which means that any approach that places too much emphasis on the 'locally-boundedness' of such processes fails to address the role played by a diverse array of relationships (Phelps, 2004).

3.2 Global Commodity Chains and Production Networks

In order to understand this multi-scalar innovation process it is necessary to adopt alternative approaches to study the life sciences, ones that do not emphasise localised interaction and learning above other scalar relationships. Currently such multi-scalar analyses are limited (Birch, 2008; Haakonsson, 2009), drawing on concepts such as global commodity chains (GCC) and global production networks (GPN). The main conceptual benefit these approaches provide is that they avoid both a firm-centric and region-centric focus and thereby enable an examination of the multi-scalar linkages and relationships that make up life sciences innovation and production.

The GCC approach has its origins in world-systems theory (Hopkins and Wallerstein, 1986), but is most identified with the work of Gary Gereffi (1994, 1996). Whilst Gereffi later moved towards a global value chain (GVC) approach (see Gereffi *et al*., 2005), this latter conceptualisation focuses more explicitly on the relationship between two actors within a chain and, therefore, it provides a limited purchase on the institutional context in which such actors operate (Bair, 2005; Haakonsson, 2009). It is thus more useful to adopt a modified GCC that incorporates the geographical concerns of the GPN approach (see Coe *et al*., 2004; Coe *et al*., 2008). Such an approach provides a

number of benefits (see Gereffi, 1994, 1996; Bair, 2005; Birch, 2008). First, it enables an analysis of the interplay between different institutional systems; second, it enables an analysis of multi-scalar linkages; third, it enables an analysis of power and governance relationships between actors; and, fourth, it enables analysis to focus on industrial sectors, rather than particular locations or firms. The GPN approach enables the 'spatialisation' of such concerns because it acknowledges that there are diverse innovation processes across different sectoral, institutional and organisational networks that are all embedded within concentrations of economic activity and their relational dispersal around the world.

Originally, the GCC approach was explicitly concerned with developing economies and especially the benefits that the linkages with developed economies provide in terms of technology upgrading and knowledge transfer. Consequently the GCC approach focuses on issues with governance along the commodity chain, highlighting two particular models: *producer-driven* and *consumer-driven* (Gereffi, 2001). Each model is characterised by specific features which help to explain the internationalisation – i.e. dispersal – and globalisation – i.e. integration – of industrial sectors. This emphasis on governance is a useful entry point when trying to understand the multi-scalar dimensions of innovation and production processes because it provides a way to conceptualise the relationships and linkages within and between different types of organisations along with the embedding of those organisations within specific institutional environments and arrangements, and thus the political economic underpinnings of the re-positioning of different places in production.

3.3 Alliance-driven Governance Model

The incorporation of spatial and institutional concerns into the GCC approach enables to development of a theoretical framework that can address issues of adaptation and change as different places are positioned and re-positioned in relation to the changing needs of production. Previously, Birch (2008) has conceptualised this as an *alliance-driven governance* (ADG) form of global commodity chain, which contrasts with the earlier models developed in the literature; for example, *producer-driver* and *consumer-driven* (Gereffi 2001). These earlier models specifically concentrate on developing

countries and the possibility of upgrading through technology and knowledge transfer from developed countries; the ADG model, however, is more concerned with the networks of knowledge and production processes in high-technology sectors like the life sciences and can be applied to the issue of upgrading in LFRs. Consequently it is concerned as much with the embedding of these processes in space and time, as with the inter-linkages across different scales. In this sense it accounts for two important analytical points that are currently under-theorised in the GCC literature. First, the relative 'stickiness' of knowledge in different places (Markusen, 1996), which can provide the locational assets necessary to withstand or ameliorate the worst impacts of industrial restructuring. Second, the idea of regional development and restructuring as more than the local capabilities of organisations and institutions; it also consists of the interaction between local and extra-local actors and new priorities and agendas that arise across scales.

As previously theorised by Birch (2008), the ADG model consists of a number of characteristics particular to new high-technology sectors like the life sciences (see Table 1). Specifically, these include the need for core competencies in collaborating with and acquiring and absorbing knowledge from diverse organisations (Senker, 2005), as well the capability to operate across different and distinctive institutional and regulatory regimes in order to access multiple markets (Ossenbrügge and Zeller, 2002). All this entails an inherent uncertainty and the coordination of diverse incentives, which both necessitate a reliance on certain forms of capital investment that is neither short-term nor risk-averse; for example, public and venture capital (Casper and Kettler, 2001). Such uncertainty is the consequence of the high asset specificity of new scientific and technological discoveries and innovations whose value can be both initially unclear and intangible (e.g. intellectual property), necessitating new forms of (intellectual) property protection to encourage investment (Arora and Merges, 2004). Consequently, it is evident that such a model is built around the idea of a multi-scalar innovation process in which firms and other organisations engage in numerous relationships with a variety of different actors ranging from publicly-funded universities through multi-national corporations to government regulatory agencies. All such relationships are, therefore, relationally embedded in different institutional environments and arrangements.

Table 1 Alliance-Driven Governance (ADG) Model

MODEL	CHARACTERISTICS	THEORETICAL UNDERPINNINGS
GCC Drivers	'Patient capital'	High asset specificity of new science and technology leads to risk and uncertainty and therefore discourages short-term, low-risk investment necessitating public funding and venture capital.
Core competencies	Collaborating, regulations	Specialisation and complexity preclude integration so organisations rely on collaborations that cross national regulatory regimes necessitating an understanding of different regulatory standards.
Entry barriers	Economies of complexity	High-cost, analytical knowledge (i.e. science) infrastructure and diverse national regulatory policies inhibit entry.
Sectors	High-technology, intangibles	Sectors dependent upon intellectual property protection to ensure value capture.
Network linkages	Alliance based	Requirements of collaborating and regulatory adherence mean that organisations rely on the coordination of diverse incentives.
Network structure	Matrix	The collective nature of innovation and high asset specificity mean that networks consist of dynamic, multi-organisational and multi-scalar interaction.

Source: Adapted from Birch (2008).

4 METHODOLOGY

Our research design was based on a multi-method approach incorporating a number of different stages that we carried out in 2008. Firstly, we collated information on Scottish life science firms from the Scottish Enterprise database,[i] using these data to map out the location of around 600 different organisations (see Figure 3). Second, we surveyed all the 'core' life science firms from this database where 'core' is defined as those firms using biological techniques and applications to develop products or intellectual property (IP). The survey was sent to around 190 firms and achieved a 39% response rate (n = 74) after telephone follow-ups. Third, we then interviewed 19 people from these firms to explore the governance and coordination of activity along the commodity chain, focusing in particular on how power played out between different actors and the impacts that this had on regional economic development. Finally, we interviewed 13 'institutional' actors drawn from various Scottish organisations connected to the life sciences focusing explicitly on the impact that different institutional arrangements have on the life sciences and what this means for economic development. All the empirical fieldwork was positioned within the theoretical framework outlined above using the new ADG model to conceptualise the relationships between different actors across the commodity chain.

5 GEOGRAPHIES OF LIFE SCIENCE COMMODITY CHAINS IN A LESS-FAVOURED REGION

Over half the life science firms we surveyed were involved in research and development (R&D) supporting previous research that positions these small, innovative firms as feeding new knowledge into early-stage product development before commercialisation by larger companies (see Gray and Parker, 1998). However, unusually, and an important finding given the severe deindustrialisation in other sectors in Scotland, a significant proportion (nearly 50%) of firms were also engaged in manufacturing. These two categories could overlap with each other as well as with basic science research (15% of firms), product testing (11%) and product marketing (10%). It is

evident that Scottish life science firms are predominantly positioned at certain points of the commodity chain, namely R&D and manufacturing. Another interesting finding, in light of the emphasis on the role of universities in the KBE, was that only 25% of the firms were spin-offs from universities and public research organisations (PROs). This finding contradicts the importance placed on universities as major initiators of regional development in the KBE – a view which has been criticised by Power and Malmberg (2008) – and would suggest that a more nuanced view of universities is needed acknowledging their contribution to regional development without ignoring the importance of other organisational drivers (e.g. firms, government) and inter-organisational linkages. A final feature of the firms worth noting is that most of the firms were very young with 40% established in the 2000s and another third in the 1990s: this provides some encouragement for Scotland in terms of new firm start-ups, which has been an area in which Scotland has performed poorly in the past.

When considering the positioning of life science commodity chains, we were concerned with four main patterns. First, the relationships that life science firms have with other organisations along the commodity chain; second, the location of these other organisations; third, the importance of the public sector along the commodity chain; and fourth, the type of relationship that life science firms have with these other organisations and the direction of knowledge transfer through these relationships.

First, in looking at the total number of organisational relationships (n = 898, mean = 12), it is evident that certain external linkages were more common than others (see Figure 4). For example, around a third (n = 291) of these relationships were with Suppliers & Service Providers, illustrating that most life science firms are too small to internalise these capabilities and supporting the argument that such 'intermediaries' are vital for such firms (Cooke 2007). However, the patterns of these organisational relationships reveals very little about their geographies.

Second then, the findings on these external organisations' location illustrate the evolving and multi-scalar geographies of life science commodity chains. In particular, these results show that there is a need to take a more nuanced view than one that is 'locally-bounded' (Phelps 2004), especially with regards to innovation processes, since life science firms had a range of relationships across three broad scales: Scotland, Rest of

the UK, and Rest of the World (see Figure 5). Overall the proportion of 'regional' relationships declines as firms move along the commodity chain towards the market; at the same time, the proportion of international relationships increases. Two other notable findings are worth mentioning: first, most of the science-related relationships (i.e. Science Funding, Basic Science Research, and R&D) are multi-scalar with only a slightly higher regional proportion. This implies that whereas certain activities can be locally based, others necessitate extra-local linkages that tie firms into wider organisational networks; this latter point seems especially evident in terms of tying firms into global knowledge networks. Second, only 4% of the firms had an R&D relationship with another Scottish life science firm suggesting that local interaction and learning between cognate firms is limited, at least in the initial development stages of the firm's life cycle supporting Moodysson *et al.*'s (2008) arguments. In contrast, the most common regional relationships were with Suppliers & Service Providers and Early-stage Investors.

Figure 4 Life Science Commodity Chain Relationships

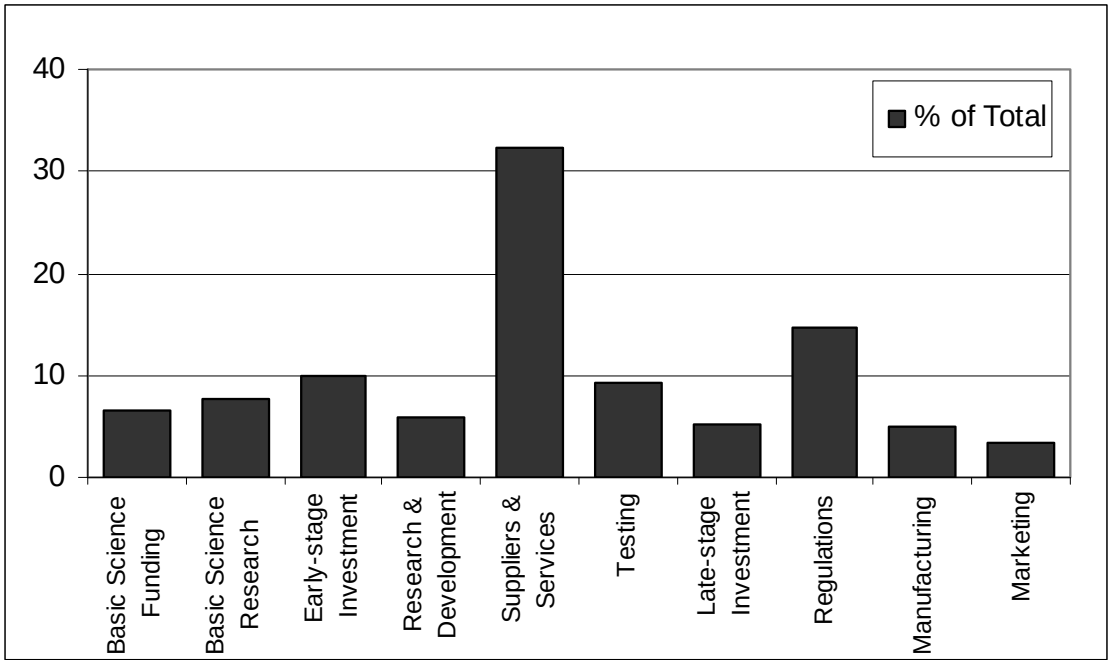
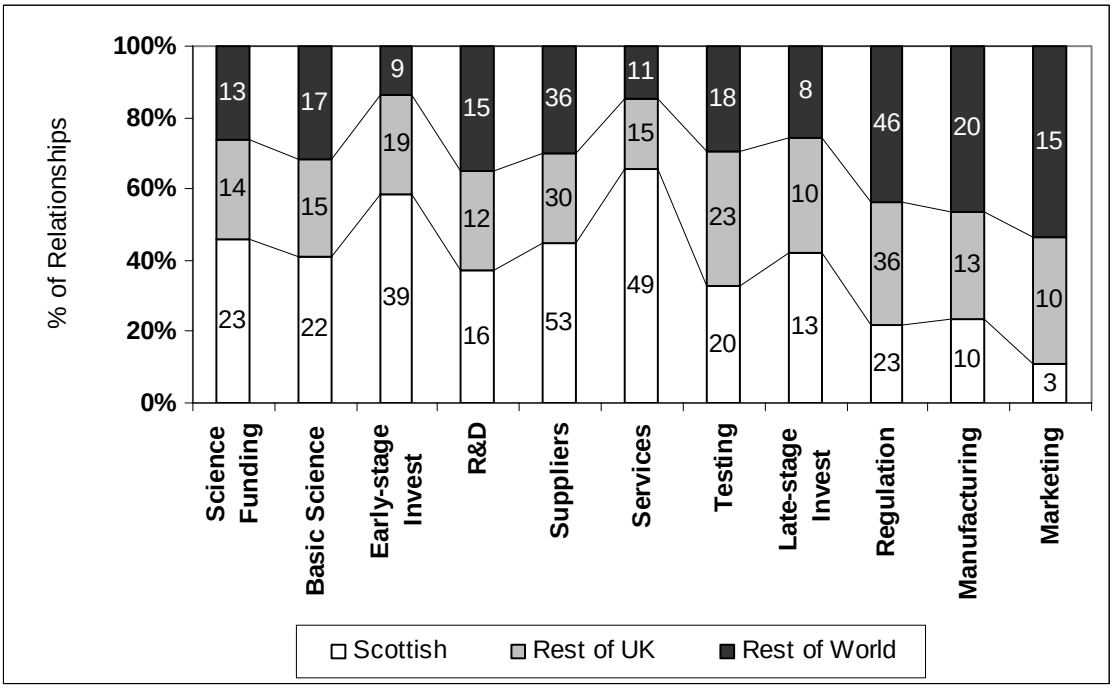


Figure 5 Organisational Relationships along the Commodity Chain



Third and related to the last point above, the geographies of these relationships is connected to the type of organisation that life science firms are linked to; a point which was reinforced in the in-depth interviews discussed later. We split organisations between 'public' and 'private' sector to explore their geographies, which revealed an obvious geographical basis to these relationships (see Figures 6 and 7). First, relationships with public organisations are predominantly limited to the early stages of the commodity chain, whilst those with private organisations are more dominant later in the chain. Second, the public sector relationships are predominantly regional, whereas private sector relationships are multi-scalar and increasingly global nearer the market (e.g. Manufacturing and Marketing stages). What this helps to illustrate is the extent to which the public sector – especially agencies like Scottish Enterprise – has played an important anchoring role in Scotland providing financial support for both firms and universities. Such early-stage support is vital because it enables small firms to initiate new research and product development, which would otherwise encounter financing problems as more traditional investment sources in the life sciences (e.g. venture capital) are limited in Scotland.

Figure 6 Public Sector Organisations along the Commodity Chain

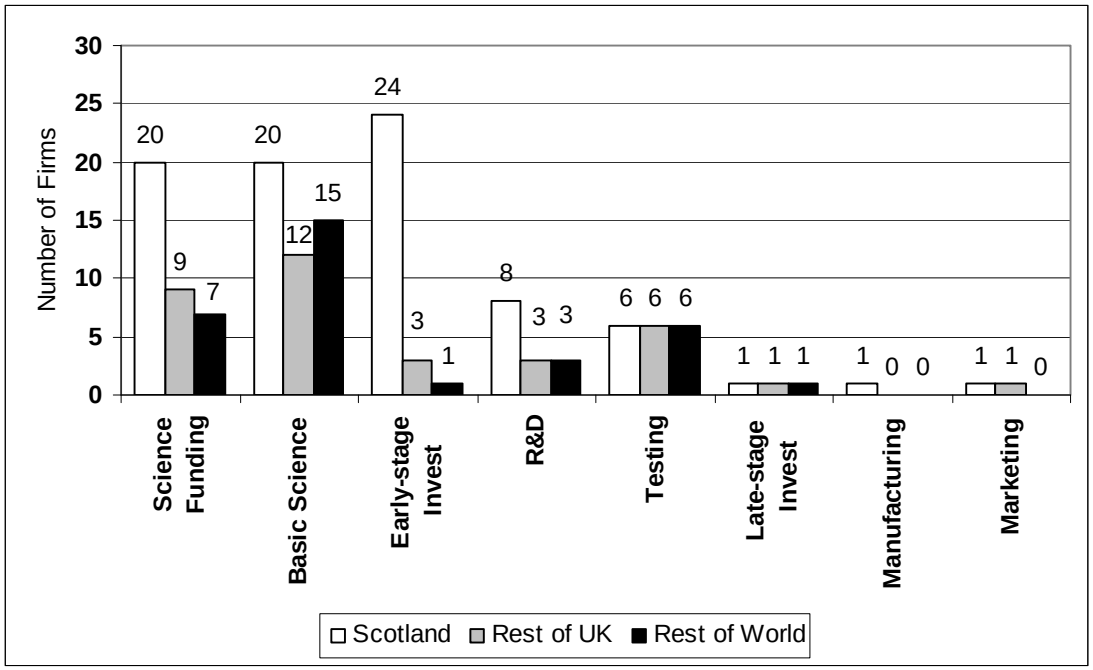
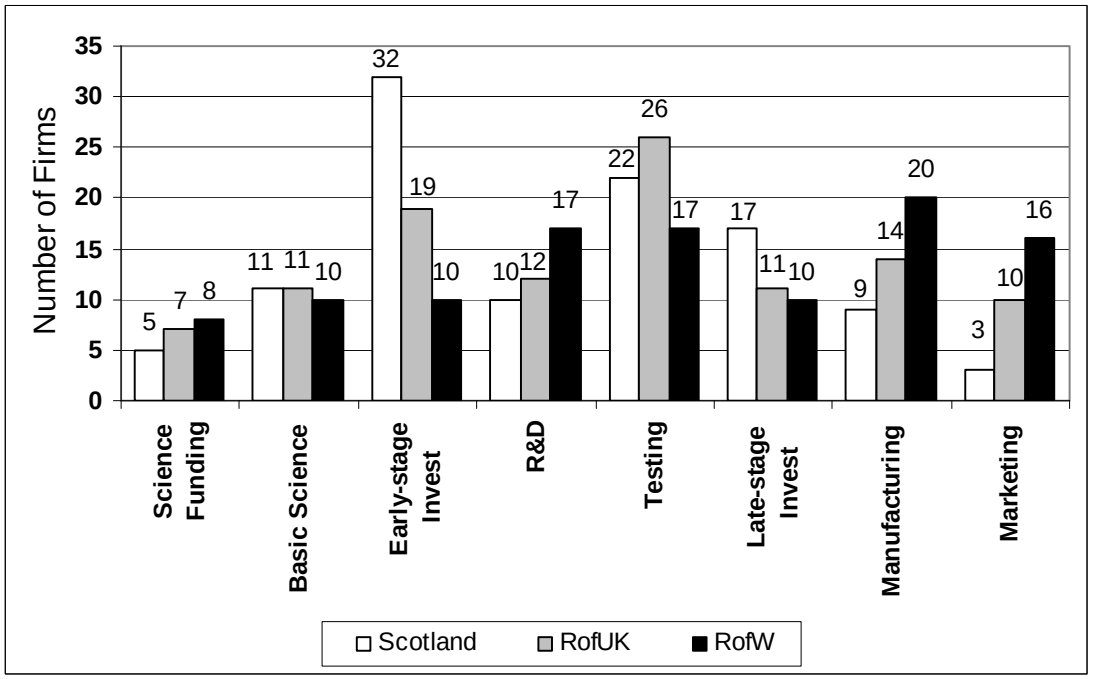
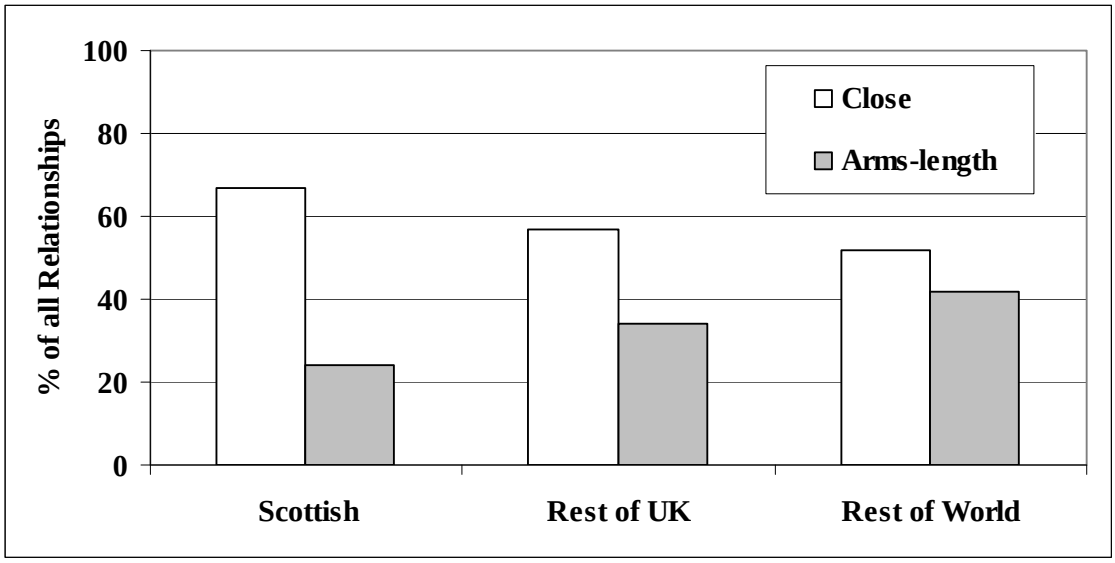


Figure 7 Private Sector Organisations along the Commodity Chain



The fourth pattern we are interested in is the types of relationship that firms have with other organisations and how geography might affect these types of relationship: for example, we might expect these relationships to change from close, local ties to more contractual, global linkages along the commodity chain. There was evidence that even international linkages consist, more often than not, of 'close' and 'collaborative' than 'arms-length' relationships; however, this is to a lesser extent than regional or national linkages (see Figure 8).

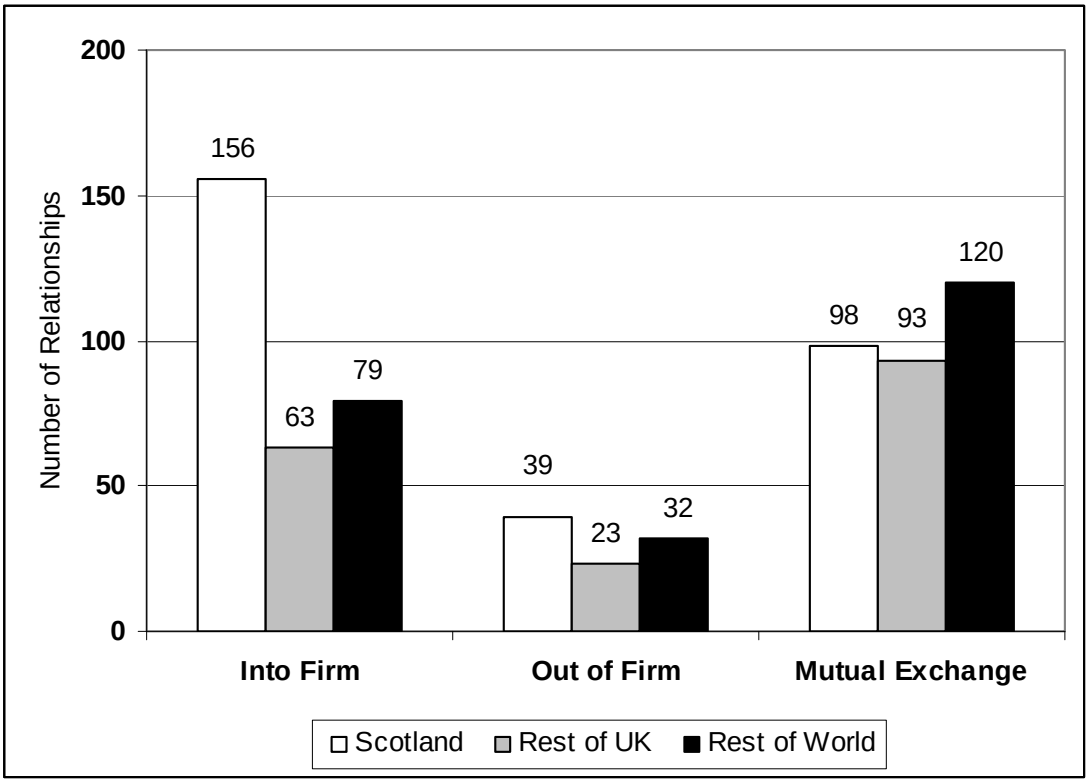
Figure 8 Relationship Type along the Commodity Chain



This suggests that spatial proximity may encourage, but only slightly, closer linkages between organisations, although there is little support for the view that local and global relationships are distinct types of linkage (e.g. Bathelt *et al.*, 2004). What may partly explain the slight difference between these types of relationship is the change in direction of knowledge transfer along the commodity chain. Whereas early-stage relationships are characterised by knowledge transferring 'into' the life science firms, this shifts to a greater propensity for 'mutual exchange' between firms and other organisations at later stages (see Figure 9). What this implies is that firms are reliant upon regional knowledge resources and infrastructure at the start of the commodity chain – perhaps unsurprisingly – but that later on the same firms help to constitute the global

knowledge networks and do not simply draw on these networks to acquire extra-local knowledge.

Figure 9 Knowledge Exchange along the Commodity Chain



Overall these four patterns show how the geographies of commodity chain relationships help to tie Scottish life science firms into wider global knowledge networks that depend on an alliance-driven form of governance in which knowledge collaboration and mutual exchange become increasingly important *across* multiple scales (Birch, 2008), contrasting with the idea of 'local buzz' and 'global pipelines' (Bathelt *et al*., 2004). What we turn to next is a more in-depth analysis of this form of governance and particularly how power plays out along the commodity chain, before considering what institutional geographies underpin this governance, and the implications this all has for less-favoured regions (LFRs).

6 GOVERNANCE AND POWER IN LIFE SCIENCE COMMODITY CHAINS

6.1 Governance, Coordination and Power

The complexity of the life sciences as a new technoscientific regime (Coriat *et al*., 2003) is evident in the intricacy and variety of relationships along the commodity chain we have highlighted above. As argued in the theoretical section, this entails a new form of governance driven by alliance-making and collaborative competencies in which the coordination of specialised and interdisciplinary capabilities and incentives across different organisations is paramount (Birch, 2008). As the same time, such competencies and capabilities necessitate a *multi-scalar* view of governance and coordination. In the life sciences, this coordination process is underpinned by two main factors. First, as mentioned, the complexity of new technoscientific discoveries and innovations means that no single organisation - whether multi-sited, multi-national or not - is capable of integrating or incorporating all the necessary competencies in their own organisational arrangements. As a Life Science Alliance official put it:

> LSA: …Wyeth [and the Transnational Medical Research Consortium] shows that even the biggest companies in the world need to collaborate, they can't do it all on their own. They used to be able to do it all on their own, but they can't now because the technology is too broad, too many different lines of expertise required, so it really is, you can't do it on your own anymore.

So, as this interviewee and others point out, it is not simply that complexity necessitates collaboration and precludes organisational integration, it is also the concomitant breadth of technoscience and 'different lines of expertise' that drives alliance-making and collaboration across different places and scales. So, second, there is an evident shift in the form of knowledge production entailing interdisciplinary, transdisciplinary and multidisciplinary working, which has been described as 'Mode 2' knowledge by Gibbons *et al*. (1994). A Universities Scotland representative summed this up nicely with reference to the Scottish Enlightenment:

US: Interdisciplinarity has something that comes back into this again, and that is something we've got to figure, we've got to figure comparatively quickly. You could argue, I sometimes do, that interdisciplinarity is not something that we have to develop, it's something we ought to re-discover, because that's exactly how the Scottish Enlightenment happened with a bunch of houses in Edinburgh, no kitchens, and I was amazed when I read it, it sounds like some kind of fantasy, genuinely every night Adam Smith, Robert Ferguson, a guy Black, [who] developed modern medicine, yeah came up with the idea of empirical medicine. Adams [sic], the guy, the Architect [i.e. Robert Adam], the guy who did modern geology [i.e. Smith's friend, James Hutton], these people had dinner together every night, because they all lived in Edinburgh and there was no kitchens so they had to dine in clubs, and when read it through it's fascinating the extent to which the development of the steam engine and the development of modern medicine come from almost exactly the same room.

What this means is that there is little chance that all the expertise and knowledge necessary for life science innovation will be (or can be) located in any one organisation, or even one region, since so many different disciplines contribute to life science innovation. Not only will the types and forms of knowledge be different across different organisations and regions, but the processes of learning and commercialisation will also vary at the same time depending on a variety of factors such as the size, type and reach of each organisation. In this sense, commodity chain coordination is intricately bound up with multi-scale governance and power relationships to the extent that firms cannot operate alone or *in situ* nor without reference to national and global regulatory regimes and international market demand. However, this point needs to be more nuanced in order to illustrate the complex relationships that life science firms have with other organisations. First, life science firms engage in numerous extra-local and mulit-scalar relationships along the commodity chain in order to access the requisite knowledge and capabilities necessary to move from 'discovery' to 'market': what we call governance *upscaling* (see below). As one Biotechnology Manager put it when asked if there partners were based in Scotland:

Biotech B: No, they're based, um, in Germany or France, around Europe.

Interviewer: Is there any particular reason for…?

> Biotech B: Well the righ-, I, I , I wasn't making the decisions in terms of where they were, it will be based on the fact that these guys have the right skill, um, they can do it at the right cost, um, they've got the background, the kudos to do it.
>
> Interviewer: And there's been no particular, sort of, issue with them being a global or a, you know, outside of the UK?
>
> Biotech B: No, not at all. I mean I can tell you, I can tell you that um, this may come up later, but I think if you try and run a Scottish life sciences company only using Scottish parts, it would struggle. I've seen that.

This point was reiterated by another Biotechnology Manager who emphasised that such extra-regional relationships do not merely result from the need for international market access, which is centrally implicated in the need for multi-scalar coordination and governance, but that there is also a need to connect into broader knowledge networks:

> Biotech C: Ok, so that's the know-how that it hinges on, but in terms of market, you know, it's a small country, the markets are everywhere else. So, so it's very important to have these connections with the rest of the world. And that's not, not just in, in sort of harsh commercial terms, but in other intellectual terms as well. We have to go out there and make our expertise known globally.

Such networks are necessary because the inherent specialisation of life science firms (and related organisations) means that the localised cross-fertilisation of ideas is limited, except where there are a number of firms working in *exactly* the same field (e.g. reproductive healthcare); otherwise "the amount of interaction is limited" (Biotech B). This goes some way to explaining the finding that only 4% of Scottish life science firms had a relationship with a cognate firm.

However, secondly, firms have to tread a fine line between collaborating with other organisations, especially other firms, and maintaining their own distinct and specialised knowledge and expertise. This opens up problems in the arrangement of external relationships since life science firms are specifically reliant upon developing and protecting in-house expertise and knowledge at the same time that they coordinate external collaborations: this is what we call governance *downscaling* (see below). This is

evident in the comments of another Biotechnology Manager when talking about the importance of international linkages:

> Interviewer: Right, and what do you expect from these, sort of, international events and so on?
>
> Biotech G: More contacts and hopefully interesting collaboration. But I don't think any company will, will, em, explain their technology, I won't get…
>
> Interviewer: No?
>
> Biotech G: …ideas from other people. No, that's what technology's about. If you have something new you keep it yourself.

Here the interviewee points out the need to retain and strongly protect in-house expertise and knowledge, whilst seeking collaboration; a point reiterated by others. It is this in-house capability that is necessary prior to collaboration since, as another interviewee put it: "any good biotech has to have a good enough platform of its own that you can then add to through collaborations" (Biotech D). Overall it is evident that there are contradictory pressures on life science firms that drive the establishment of multi-scalar linkages and the specific form of coordination that these take. On the one hand they need to develop and protect knowledge and expertise in-house, whilst, on the other hand, the same knowledge and expertise enables them to connect into broader knowledge and innovation networks along the commodity chain. The governance of these contrasting pressures entails the formation of different types of relationships and different influences on coordination as we discuss next.

6.2 Governance Upscaling

As we have emphasised a number of times already, life science firms engage in a variety of relationships along the commodity chain. These linkages, however, cannot be considered as the same as one another because they involve a variety of organisations, different institutional settings, different types of relationship, and different geographical dimensions. All these are implicated in the coordination and governance of commodity

chains. In this sense then, these linkages exhibit different modalities in that they involve diverse ways of coordinating relationships that (re)produce certain scalar dimensions and are embedded in specific institutional arrangements. From our research we can distinguish two major modes of governance: governance *upscaling* and governance *downscaling*. We address the former here and the latter in the next sub-section. What we mean by governance upscaling is the scaling of the social processes of coordination of organisational agendas and strategies in the (re)production and performance of certain scales (e.g. national and global) as more important than others (e.g. local and regional).

The construction of scalar hierarchies is evident in the emphasis placed on access to global markets and global knowledge that was repeatedly referred to by interviewees, as well as in the 'upscaling' of technoscientific capabilities across organisational relationships, as a Biotechnology Manager points out:

> Interviewer: So, is this, is this relationship with the Dutch company been fairly important?
>
> Biotech G: It is crucial. Yes. And it is still crucial to maintain the relationship.
>
> Interviewer: So what does it, what does it contribute in terms of the development of the company and the technology?
>
> Biotech G: Because they can, they can upscale the technology, and they can put the technology into, ah, manufacturing. They put the technology together with the engineers and then they manufacture a product that they can sell. So they make the technology practical. And so the relationship is still ongoing.

Here, the ability to 'upscale the technology' is deemed to be outwith the capabilities of the small life science, but not of large manufacturing companies whose size provides economies of scale that make technology 'practical', by which the interviewer means produced at a costs that can be sold for profit. However, it is not simply the size limitations of life science firms – and the associated limitations on certain capabilities that their size implies, as discussed below – that necessitates the shifting of coordination upwards towards large multinational companies (MNCs) whose size, reach, knowledge and reputation are sufficient to capture the value embodied in the commodity (Birch,

n.d.). Governance upscaling also involves more than simply moving operations or activities from the regional to the national or global.

First, the process of upscaling is underwritten by the *objectification* of trust-based relationships, contrasting somewhat with other conceptualisations of trust: for example, 'competence trust' and 'goodwill trust' (see Cumbers *et al.*, 2003; MacKinnon, *et al.*, 2004). Whereas the former is based on the idea that trust is performance-based, the latter emphasises the informal, personal-based nature of certain relationships. That is not to say that these sort of trust-based relationships are absent in the Scottish life science; in contrast they are ever present, as the following Environmental Biotechnology Manager explains:

> Environment Biotech A: And so we have relationships with contractors, and we have preferred suppliers for all that, and we have people we know we can trust, and we have people we have used many times and know that we can use again, and we have ones, by the way, we've used who were a disaster and we'll never use again.

Despite the existence of these forms of trust and the ubiquitous reliance on personal recommendations in the Scottish life sciences, however, there is a strong emphasis on the objectification of firm-level capabilities and activities, which helps to produce a form of *objective trust*. For example, as one Healthcare Manager, referring to their supplier relationships, puts it:

> Healthcare C: Well we have to have careful relationships because we're ISO [International Standards Organisation] 9001, so we have to have approved suppliers, and of course, for our regulatory work we need to have properly approved suppliers as well. So, um, we, every single one of ours has to be listed, have an ISO or be inspected or individually audited by us, *so we have good relationships with our suppliers* [our emphasis].

Here the ISO standards represent the basis for the 'good relationships' that the firm has with its suppliers; notably, it is not the type or form of the relationships themselves that matters.

Second, objective trust is an iterative effect of each firm's need to be ISO compliant that then drives their need to ensure the ISO compliance of their suppliers,

manufacturers etc, especially when it involves 'regulatory work' which is what will ensure product sales in the long-run. Since product development is such a long process, it is perhaps inevitable that firms build these 'objective' standards into their work from an early stage, which has an recurrent, trust-engendering effect as firms seek 'quality assurance' along the commodity chain as illustrated by a Biotechnology Manager's comments:

> Biotech D: For all of these we have done full Q-A [Quality Assurance] audits, um, with our, it's another realm of the company who we use for regulatory advice, they also have a kind of, quality assurance division. Um, so they've helped set up our own quality management systems in house, so as part of that supply selection is absolutely key. Um, and because of how important these CROs [clinical research organisations] and our manufacturers are to what we do, we've audited them all, which was interesting.

Regulatory standards and expectations represent the key influence underpinning governance upscaling as evident in the above comment. Since there are a number of different national and supranational regulatory regimes, firms have to incorporate these national and increasingly international standards into their operating procedures at an early stage. This, in turn, engenders trust in their operations, which covers not only tangible product development but also knowledge production as the same interviewee explains:

> Biotech D: When it's in house, um, there are certain ISO requirements for things like data recording. Um, that's one, also how we generate the date. In house we do it to a standard called CLSI, which is the Clinical Laboratory Standards Institute. Um, it's not something that you do have to stick to, but it is internationally recognized, and it's something that will provide a lot of comfort, if you saw data coming across your desk that was done to a particular CLSI method, you should be able to repeat that and get the same data, pretty much under the same conditions. So that's something that we adhere to.

The incorporation of these standards into a firm's practices means that other firms can trust the work that the firm is doing. Consequently it is a different kind of trust than competence or goodwill trust, both of which are not necessarily based on the

objectification of the relationships between organisations. Again, the previous interviewee points this out:

> Interviewer: And that, that, that encourages, um, trust in what you're doing in other companies.
>
> Biotech D: Absolutely. And then, I guess, moving up from there we have a requirement as a company who now sponsors, um, CROs who are obviously doing work to GLP [Good Laboratory Practice], GCP [Good Clinical Practice], and GMP [Good Manufacturing Practice], so good clinical and lab manufacturing, um, standards, that we have to, provide work to them that they know that the background to what they're doing has been derived out of work, um, that has been done to almost the same quality.

Such regulatory compliance is probably the most obvious example of governance upscaling in that it illustrates how coordination between organisations is structurally produced, reproduced and performed at particular scales (i.e. national and international) along the commodity chain. The social processes that constitute this scalar coordination are built around the idea of objective trust, which both objectifies certain forms of relationship as trust-worthy – i.e. they are treated as a property of an object rather than social relations – and iteratively inform the practices of the firm itself as trust in their own activities necessitates the incorporation of standard procedures that are accepted across national and international scales.

6.3 Governance Downscaling

Whereas governance upscaling involves the (iterative) incorporation of specific standards into firm-level practices, governance downscaling involves both the embedding of distinct, specialised and differentiated knowledge in firm-level expertise and capabilities, and the protection of this knowledge in-house and when collaborating with external partners. Without the protection of in-house expertise there would be no incentive for other organisations to collaborate with a firm since the knowledge would be freely available. Whilst this may sound like it is detrimental to large transnational corporations (TNCs), the production and protection of knowledge by small life science

firms actually has a beneficial effect in that it helps to shift risk back down the commodity chain. This is because product development in high-technology sectors like biotechnology and the life sciences is extremely uncertain and therefore risky for large firms to invest in when they have existing pressures, especially from shareholders concerned with short-term share prices values; for example, one Biotech Manager from a publicly-listed firm pointed out:

> Biotech B: That's not the model we have, we've licensed and acquired. And, you know, that's what everybody's doing. The amount of organic in-house drug discovery that is generated in your pipeline these days is pretty small, that's why people are buying, spending so much money buying and acquiring.

So governance downscaling, again, involves the scaling of social processes of coordination of organisational agendas and strategies in the (re)production and performance of certain scales (e.g. local and regional) as more important than others (e.g. national and global).

Generally however, the emphasis on in-house expertise is characterised by the development of certain types of business model in which a firm is not left dependent upon a single idea or product: one popular hybrid model was to combine product discovery with the provision of services (e.g. screening, laboratory testing etc). As several Managers pointed out, a strategy based on a single idea or product leaves no room for failure, an all-too-common phenomena in the life sciences. Consequently, most small, unlisted firms sought to diversify their capabilities in order to alleviate the risks of failure, although, at the same time and in what might appear a slightly contradictory position, the same firms had largely built up or based their strategy on niche or speciality expertise (see Moodysson, 2008). For most firms, especially those working in analytical or science-based fields such as modern biotechnology (Moodysson *et al*., 2008), an inherent feature of this business model was a strategy of out-licensing or partnering since small firms expected to license their expertise and, largely, intangible assets to larger firms which would then 'upscale' the technology into products. This is evident in the empirical findings from the survey above, but is also clearly emphasised in the interviews with several Managers:

> Biotech A: We want to out-licence as well. I mean we have business model that revolves around early, mid, and long term licensing opportunities.
>
> Biotech C: So, we take molecules from discovery, from isolation, develop them through into clinical trials, basically as far as we can get them, probably to Phase 2a, at which stage we license them to pharmaceutical companies.
>
> Medical Devices C: We are at the point, we are looking, we are looking also for a, um, probably corporate partner, this would be someone who would have the, sort, of, world-wide reach in terms of marketing and product support that we'll never have, we're too small to do that.
>
> Medical Devices E: So, it is basically, it's a research and development skill set, um, to develop products which are then licensed, so actually it is quite a long-term outlook.

Whilst the creation of licensing revenues – the lifeblood of these firms – is thus dependent on governance upscaling, in which commodity chain coordination is driven by larger firms as we discussed above, there is a parallel process in which larger firms – especially in the bio-pharmaceutical sector – are increasingly dependent upon the very specialised knowledge outputs and often niche expertise of these small firms. Licensing and partnering arrangements tie these small and large firms together in collaborative and alliance-based relationships which shifts some aspects of coordination down the commodity chain and 'down-scales' governance accordingly.

First, the downscaling of governance is based, to a greater extent than governance upscaling, on inter-subjective forms of trust such as 'competence trust' and 'goodwill trust' (see Cumbers *et al.*, 2003; MacKinnon, *et al.*, 2004). For example, life science firms commonly relied upon the personal networks of their chairperson or boards to recruit personnel or access finance. Although less common, firms would also benefit from other 'non-personal' relationships as a Biotech Manager pointed out:

> Biotech D: Bizarrely we have even been recommended other CROs [Clinical Research Organisations] from their competitors sometimes, if you have a good relationship with them and there's something that they genuinely cannot do, there seems to be a kind of constant circulation of, of people within the industry, and if people have friends that they know can do a good job in

> another organization, they will actually say, well we can't do this, but I know someone at XYZ who can.

Due to the particular out-licensing business model pursued by most life science firms, the relationship between small firms and larger ones was characterised by the coordination of specific incentives which serve to engender trust through the aligning of different interests. One such example is the use of royalties, rather than outright sale, as part of licenses and partnerships, as one Biotech Manager explains:

> Biotech D: And I think it shows a potential partner that, um, yeah if you've got the confidence that you're prepared to focus more on the royalties and the backend of it.

Thus, in the light of the uncertain commercial viability of most firms' knowledge assets, the licensing model depends on the *performance* of confidence in one's own knowledge and expertise by accepting specific forms of remuneration; e.g. royalties instead of direct payments. Such coordination of incentives – money and legitimacy for small firms versus new products and expertise for larger firms – illustrates the complex relationships that underpin governance downscaling. There is a secondary aspect of this coordination that is particularly beneficial for smaller firms: partnerships, collaborations and licensing provide protection from takeovers for small firms since agreements restrict access to their knowledge and capabilities, at the same time that such agreements can build in "sufficient poison pills" as one interviewee (Biotech F) put it. However, conversely, the withdrawal of a large firm from an agreement can leave the small firm exposed to takeover.

Second, governance downscaling is intrinsically tied up with the protection of intellectual and intangible assets; that is, a firm's knowledge and capabilities. Without such protection there would be few opportunities for small firms to collaborate with larger firms and move along the commodity chain. What is striking about this process is the extent to which intellectual property (IP) protection – usually in the form of patents, but also covering internal proprietary *know-how* – represents a "defensive" strategy as one Biotech Manager explained:

> Biotech H: Um, and the patenting strategy is you tend to file base, very broad based patents, and then you begin to file on top of them more specific and exclusive patents, and that's really been our patenting strategy. And, and five of them that we've filed.
>
> Interviewer: Five broad ones or five…?
>
> Biotech H: Ah five in total, so one broad one and then filing on top of that.
>
> Interviewer: Where did you get that, sort of, the idea for that strategy, or is that just kind of…?
>
> Biotech H: It's common within the industry. Yep. You're just basically building a wall around what you do so that there's no gaps.

In this sense, inter-subjective trust is sanctioned by a more formal and contractual arrangement that enables small life science firms to trust in the first place. Another Biotech Manager explained that their firm's R&D strategy was explicitly designed to stop their larger manufacturing partner from finding a loop-hole in their existing IP:

> Biotech G: Very much the R&D's focused on getting more and more protection for our patents, like if the EU appeal fails. So all internal R&D was directed at developing technology so that we can put up new defensive patents. And also cover the patents so that the [partners] do not, maybe, find a loop-hole and manufacture without … ah, find a loop-hole around our existing patent.

Alongside this defensive strategy the concurrent need to collaborate with and actually trust other firms and organisations entails a clear negotiation over the incentives underpinning the involvement of both sides of the agreement. In particular, the need for small life science firms to 'own' their knowledge means that they are unlikely to engage with other organisations that do not (or cannot) agree to such concerns. One Biotech Manager put this rather succinctly as follows:

> Biotech H: I think often it's a case of explaining [to the larger firm] why it is that we need to own that [knowledge]. You can use this but we have to own this, and if we can't own that then there isn't any point in moving forward. And generally, you know they do, they do, companies used to working with small companies will understand the need for that and there won't be a problem.

The negotiation of distinct incentives and motivations behind knowledge production and knowledge ownership represents a good example of governance downscaling in that it shows how coordination is strategically produced and performed at particular scales (i.e. local and regional) rather than others. The social processes that constitute this coordination are embedded in inter-subjective forms of trust (e.g. competence, goodwill) at the same time that they are 'defended' by formal, contractual arrangements. In this sense they do not necessarily objectify relationships because the underlying social relations are subject to judgements about trust-worthiness rather than seeing trust as the property of an object itself. Overall this necessitates the development of closer, personal and direct relationships between individuals, which is less evident in the governance upscaling discussed above.

7 INSTITUTIONAL GEOGRAPHIES OF LIFE SCIENCE COMMODITY CHAINS IN A LESS-FAVOURED REGION

Since the 'institutional turn' in economic geography, there has been a significant growth in the literature highlighting the importance of the institutional environment to regional development (e.g. Amin and Thrift, 1992; Cooke and Morgan, 1998). Largely built around the idea of *embeddedness*, this literature emphasises the idea that economic actions are thoroughly entangled in social relations underpinning the 'new regionalism' agenda that is implicated in the decentralisation of political-economic decision-making (Pike *et al*., 2006). Although not without its critics (e.g. Lovering, 1999), this literature and associated political agenda highlights the role that a region's social, economic and political conditions play in encouraging and supporting – or obstructing – new industrial sectors like the life sciences (see Birch, 2007b; Gertler and Vinodrai, 2009). In order to explore the importance of these institutional geographies in Scotland, and their impact on the life sciences, we focused explicitly on the *institutional arrangements* of the labour market, public sector support, private finance, and regulations; that is, the particular organisational forms of these institutions, rather than the social norms or conventions that they engender (Pike *et al*., 2006).

However, as a consequence of our research design, we also sought to avoid over-determining the 'regional' nature of these arrangements by considering the wider national and global influences on them (MacKinnon *et al.,* 2002; Gertler and Vinodrai, 2009). The reason for this latter point is illustrated particular well by the comment of a Business Angel Trade Association representative:

> BATA: Well, what they're [Scottish Government] saying is we should have power over tax because the reality is that of all the things that we do in terms of economic development - Scottish Enterprise, Scottish Government - they pale into insignificance alongside either tax changes or regulatory changes, both of which rest in London. The EIS [Enterprise Investment Scheme] tax breaks are the single most thing important thing that's created the angel market in the UK. It's as simple as that.

So, although we would argue that Scotland's institutional arrangements (and environment) are unique – and in many ways represent a model of regional development admired across the UK – they are also specifically tied into the national institutional arrangements highlighted in research on *varieties of capitalism* (see Peck and Theodore, 2007). Elsewhere we have illustrated the role played by such national institutional systems, especially in relation to less-favoured regions (LFRs) like Scotland (see Birch *et al*., 2008; Birch and Mykhnenko, 2009). Just as important, however, are the global institutional arrangements, or more precisely the lack thereof, as a Business Angel Syndicate Manager pointed out:

> BASM: What's the point of having an EIS scheme which says you can't get relief for spending money in the US and having a procurement policy in the National Health Service which means that life sciences companies have to sell in the US because the National Health Service won't buy it?

Thus it is essential to consider the inter-relationship between regional, national and global institutional arrangements in order to understand the development of the life sciences, as with other sectors, and the implications of life science commodity chains for LFRs.

As mentioned above, Scotland's institutional arrangements are viewed as a model for regional development elsewhere: for example, a number of interviewees referred to

the positive perception that English regional policy-makers have of organisations like Scottish Enterprise. Such perceptions, however, downplay the historical legacy of Scotland's strong basic science and clinical medicine base in its universities and teaching hospitals, which goes some way to explaining the wealth of university graduates. As a Scottish Government official claimed:

> SGO: Um, we have, through Scottish Enterprise and people who work in the industry, we have a lot of contacts worldwide, um, and the message we get back is, they are absolutely astonished at the numbers and quality of graduates that Scotland produces for its size. So, that's, that's a key element of the USP [unique selling point].

In one sense then, the labour market is particular to Scotland and when married to an autonomous National Health Service (NHS) – from the rest of the UK – it provides a regional advantage that few other parts of the UK have (or could replicate). This is particularly important for firms in life science commodity chains since the international scientific reputation – repeatedly emphasised in interviews – helps to tie Scotland into broader knowledge networks, both national and global. Without this, there would be little opportunity to attract and embed the extra-local knowledge linkages that reinforce this existing advantage. As a Universities Scotland representative put it, "…if we're truthful Scotland's got two things that are genuinely world class. One is our financial services sector, and one is our higher education sector, and that is it".

All such institutional arrangements are underpinned by the public support for a range of activities including basic research in universities and healthcare spending in the NHS, alongside employment and development policy more generally. The first of these, support for basic research, has increasingly been oriented around a cross-university 'pooling initiative' in order to engender research excellence (see Kitagawa, 2009). In part this institutional arrangement is a response to the perceived physical and social geographies of Scotland, as a Life Science Alliance representative suggests:

> LSA: …if they [life science firms] want to compete in that industry, Scotland has only got 5 million or 6 million people in it, and can't compete numerically with these [other] places. But what's become apparent is that the one thing, the advantage for Scotland is, in fact, its size to the extent that it *can allow* collaboration. So, Wyeth came to Scotland, and we'll probably refer to

> this quite a bit because it's a real example, and there is not too many real examples, but Wyeth came to Scotland because it could not do what it wanted to do in the US [our emphasis].

There was a perception that Scottish organisations, whether they were private or public sector and despite existing regional advantages, cannot compete individually and, therefore, that collaboration – built into the latest life science strategy (Life Sciences Scotland, 2008) – and expertise pooling – built into public funding of university research (Gani, 2008) – are necessary for the future of Scottish economic development. Such arrangements can be seen as responses to the Scotland's geography in at least two senses: first, in the argument that Scotland is a certain size that limits its market; second, in the argument that the size of the Scottish life science sector engenders trust.[ii] The first point was made by a Scottish Trades Union Congress representative:

> STUC: I mean the First Minister loves to talk about his comfortable size, you know comfortable size of nations in a globalised economy, and Scotland is, of course, smack bang in the middle, the optimal size. I mean I think I have a substantial degree of cynicism over that whole thing. I mean you look at America if that was managed better and relate the size of the market, and you know, the space it has to develop, I mean factors that Scotland will never be able to duplicate. But having said that, I think devolution, looking for independence, as a small nation, try and develop that sort of cluster approach, is probably not un-helpful.

And the second by a Business Angel Syndicate manager:

> BAS: Well you can't … you're always going to come across the same people in another deal, so you can't be dishonest with them in the previous one; whereas, if you're in a big market like London there is so much going on that people are noticeably less trusting.
>
> Interviewer: Right. So there is a lot more trust.
>
> BAS: I think so.

Alongside collaboration, what became evident in the interviews was that there was an increasingly active engagement between the devolved government and its agencies (e.g. Scottish Enterprise) and universities and private sector firms in support of

the life sciences, in many ways reminiscent of the 'triple helix' model (Etzkowitz and Leydesdorff, 2000). There are numerous examples of this engagement including the following:

- The *Scottish Seed*, *Co-investment* and *Venture* Funds set up by Scottish Enterprise that seek to bridge a number of financing gaps for new firms;

- The *Proof of Concept* programme also run by Scottish Enterprise that encourages technology commercialisation and transfer from universities;

- The 10-year funding for the life sciences through the *Intermediary Technology Institutes* (ITI) to encourage commercialisation of new science and technology; and

- The *Translational Medicine Research Collaboration* (TMRC) established by the large pharmaceutical firm Wyeth in collaboration with several Scottish universities and NHS Scotland.

Interestingly, such institutional arrangements contrast with the national UK government's emphasis on concentrating basic science in 'centres of excellence', a process which has been criticised more generally by Power and Malmberg (2008). Furthermore, these arrangements represent an alternative approach to regional policy-making in which public support is encouraged rather than viewed as 'crowding out' private investment (Birch and Cumbers, 2007). However, what was also notable about such public sector anchoring of the life sciences was the deliberate global orientation of these decidedly regional initiatives. In particular, several of the schemes such as the ITIs and TMRC were designed or established to tie the Scottish life sciences into both global knowledge networks and global markets.

The development of these institutional arrangements goes some way to alleviate the perceived 'peripherality' of Scotland, which also features as an issue in the area of private finance and investment. Most interviewees agreed that there was little institutional

finance or venture capital investment in the Scottish life sciences, but that as a consequence of this, and because of its peripherality, Scotland had developed a particularly strong business angel community. For example, a Business Angel Syndicate manager explained:

> Interviewer: So, what other aspects of the Scottish context do you think are particularly unique to it?
>
> BAS: I think its remoteness and its size. So, there is some statistic, which I couldn't point you to where it came from, but I am aware there is a statistic which was put together by some American research, which suggest that the ideal population size to have a good Angel group working is about 5 million, so that's what we've got here. Um, I think, if you think about it there are other reasons why that should happen. One of them is that it's [Scotland] geographically remote as well. I think that everybody in the sector knows each other in Scotland because of the size of the market, which creates virtue.

In particular, the formation of business angel syndicates pooling their resources into combined funds has created large and ongoing angel investment, which has been reinforced by co-funding schemes set up by the Scottish Government and Scottish Enterprise (e.g. *Scottish Co-Investment Fund*). The strong angel community has an unintended beneficial impact on regional development in terms of 'recycling' money back into new investments when life science firms are sold or go public since the financial return is not lost to institutional or venture capital investors based elsewhere. This was emphasised by a Business Angel Trade Association representative:

> BATA: …shares and the movement of money has got very little to do with where they originate from. Their productivity and their employment are still in the home region, but when they get flogged most of that doesn't come back here, it goes to shareholders and institutions elsewhere. Ironically in terms of recycling wealth in a region there's a point at which selling out isn't necessarily a bad thing. Because a point made to me when I spoke at a conference in Nova Scotia was that of all the asset classes wealthy people can invest in, stock markets, funds, all that stuff, virtually all of them are managed in the very large financial centres, like London. So if you're a wealthy Scot most of your portfolio, most of your assets, are actually going to be managed elsewhere, you may get the benefit of that. The business angel bit is deployed in your economy

and it's the only bit where indigenous wealth is used in an economically productive way in its own right.

Overall it is evident from our research that certain institutional arrangements underpin the life sciences in Scotland. In particular, there is a strong public anchoring of the life sciences, especially in terms of funding for university research (e.g. 'pooling initiative'), start-up commercialisation (e.g. *Proof of Concept* scheme), and early-stage firm growth (e.g. *Co-investment Fund*). Such financial support is accompanied by a growing institutional support through the establishment of new organisations (e.g. ITIs), collaborative structures (e.g. TMRC), and industry-government forums (e.g. Life Science Alliance). These arrangements can be seen as a response to two over-riding imperatives. First, Scottish life science firms are, of necessity, 'born global' in that they have a limited 'home' market (e.g. Scotland, and even the UK) and are therefore always oriented to international markets, especially the USA. Second, the geographical, along with social and economic, peripherality of Scotland was seen as both disadvantageous and advantageous. On the one hand, the problems of peripherality are most obvious in the difficulties that life science firms have attracting certain forms of financial investment (e.g. venture capital), limiting their capacity to grow beyond a certain size in Scotland. However, on the other hand, this peripherality also helped to create a strong business angel community and an apparent greater capacity for collaboration between diverse partners. We consider some of these issues more explicitly in the next section when we return to the three key questions raised in the introduction regarding the positioning of less-favoured regions (LFRs).

8 CONCLUSIONS: IMPLICATIONS FOR LESS-FAVOURED REGIONS

What is evident from the above discussions about the geographies of life science commodity chains, the particular forms of governance along these chains, and the institutional geographies of the life sciences is that less-favoured regions (LFRs) face certain difficulties in re-positioning themselves in the knowledge-based economy (KBE). Whilst this research has focused only on the life sciences, it helps to illustrate the

implications of restructuring in pursuit of a political-economic project dependent on knowledge-based industries. Here we want to return to the questions raised in the introduction: first, can the KBE alleviate uneven development between regions? Second, does the success of a few 'growth regions' and their extra-local linkages reinforce continuing uneven development? Third, how do the power differentials between social actors within growth and less-favoured regions (re-)produce an uneven influence on the arrangements and flows of value between regions?

To start with the first question, it is evident that the KBE does not alleviate uneven development in and of itself – in the life sciences at least – since there is a growing concentration of life science activity in certain regions around the UK (see Birch, 2009). Although Scotland can be seen as one such concentration, it has distinct characteristics that mean it is also positioned at certain points of the commodity chain as a consequence of these features. There is virtually no market for the life sciences in Scotland (or the UK), which means that there are particular problems in both keeping life science firms "grounded" and "growing them bigger" as a BioIndustry Association representative suggested. However, at the same time, this creates a different imperative as the same interviewee went on to explain:

> BIA: I mean it's the complete obverse of building a company in America, and that is why we mustn't copy them too much. They can build really business logistically. Scottish companies have to look to export much, much earlier in their development and so they follow a different development path.

It is therefore too simple to imply that LFRs like Scotland will suffer from continued uneven development. However, LFRs cannot simply follow the example of 'growth' regions, especially when those regions are situated in dominant markets for investment or sales. Thus it is important to bear in mind that in the UK, for example, venture capital funding is largely limited to the South-east of England, which means that, as a Business Angel Trade Association representative points out, in Scotland "…you can only grow a relatively modest business here, and that either it has to break out into other markets quite quickly, or indeed as often happens, it gets bought and taken away somewhere else". Whilst the latter possibility might appear problematic at first glance, it does have one

major benefit in that it leads to the recycling of money back into Scotland rather than the loss of value to major financial centres.

Second, it is also evident, to some extent at least, that 'growth' regions reinforce continuing uneven development. Furthermore, 'growth' nations reinforce this uneven development in that certain countries, especially the USA, have a dramatic impact on LFRs like Scotland. For example, a Life Science Alliance representative pointed out that

> LSA: …the big difference between life sciences and, say, running a tanning parlour, is that in life sciences from day one, as a start up, when you've got one person in the company you are a global company, because you have to compete globally, because someone in Seattle or somewhere else is probably doing something to compete, or you've got a customer there, or whatever.

What this means, first, is that any investment in LFRs by firms from growth regions and countries, in the above interviewee's words: "tends to get de-emphasised to protect what they're doing in the US. So you are at the whim of that kind of thing". Considering the reliance, even dependence, of LFRs on extra-regional linkages and relationships, particularly further along the commodity chain when firms are nearing market sales, this can have a dramatic impact on the level of regional reinvestment and value capture: in the words of an ITI representative, "a lot of the value of an organization is then bleeding out into the US". Second, and perhaps more importantly, growth regions tend to attract skilled workers and managers as individuals are more likely to find certain types of employment (e.g. in marketing, sales, business development etc) in those regions than in LFRs. Consequently, a Medical Devices Trade Association representative suggested that the global nature of sales and marketing – focused especially on the USA – "suck[s] Scottish people out of the system", which is compounded by the fact that "it's really hard to get them back in". It is therefore not enough to embed the life sciences in an LFR through public anchoring because there are other relational processes at work, particularly the exclusion of LFRs from particular global networks.

Finally, it is also evident that power differentials between actors in growth and less-favoured regions contribute to the uneven arrangement of flows of knowledge and, ultimately, value between regions. The need for greater collaboration, and even open innovation practices, has, according to a Scottish Government official, "percolate[d]

down the supply chain" in that both large and, increasingly, small firms "are beginning to understand that, you know, you can't do it all alone". The encouragement of such collaborative activity – especially where it is internationally oriented – could provide an opportunity to attract new resources to Scotland as a Scottish Funding Council official put it:

> SFC: And the sorts of things we've just talked about in terms of Wyeth, and, um, the pan-Scottish, um, biological sciences imaging development, I think, tend to suggest to me that we're now moving into a higher level game, if you like, where we can attract some big investment from other parts of the world, which is obviously and aspiration, both for us and the government.

On the one hand this provides the opportunity for LFRs to connect into broader and often global networks, drawing on knowledge and financial resources that might be limited within the existing social and economic infrastructure. However, on the other hand this implies that firms will increasingly have to tie themselves into these networks and open themselves to certain threats such as buy-outs and mergers, which could lead to a loss of value from Scotland to other regions or countries.

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[i] http://www.scottish-enterprise.com/se/life_sciences/life_sciences_source.htm

[ii] Just as physical and socio-economic geographies were seen as important, health geographies – such as an ideal-size population and centralised NHS – were raised as an important factors in encouraging collaboration. A TMRC representative – who works at Wyeth – pointed out: "And so in a Scottish population you had a good size of population with no new pathologies, so it was a good size, not too large, no new pathologies, and this very convenient system of being able to access the patients and do the studies [because of the centralised NHS]. That combined with some, some very, very strong basic research, both in basic science and also in clinical science in the University medical schools in Scotland … Another element was the willingness of the universities to work together".