Universities, Knowledge Networks, and Regional Competitiveness: Perspectives from the UK

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DECLARATION

STATEMENT 1

Except where indicated by specific reference, the work submitted is the result of my own investigation. The views expressed are my own.

Signed……………………………………………….. (Candidate) Date……………………………..

STATEMENT 2

This work has not been submitted in substance for any other degree or award at this or any other university or place of learning, nor is being submitted concurrently in candidature for any degree or other award.

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ABSTRACT

As the need for regions to convert knowledge within universities into industrial and commercial success is increasingly acknowledged in the knowledge-based economy, universities are no longer considered to be isolated islands of knowledge, but as institutions increasingly engaged with a range of external partners through various types of knowledge networks. Although studies have examined the importance of interactions between academics and businesses in building competitive advantages of regions, there has been much less work considering how the nature of interactions is associated with regional competitiveness. This research explores these issues through a study of the network relationships between universities and businesses in the context of the UK, where uneven regional economic development has long been a feature of the economy. By adopting a critical realist paradigm and employing both qualitative and quantitative methods, this research reveals both 'what' knowledge exchange activities are engaged by universities and 'how' the intensity and performance of those activities are associated with regional competitiveness. National findings suggest that universities in more competitive regions generate higher income from engaging in knowledge exchange activities than those in uncompetitive areas. However, academics in uncompetitive regions are more actively engaged in knowledge exchange activities than their counterparts in competitive areas. It is also found that the intensity of firm-level interaction with universities is associated with the regional location of firms, especially in the case of smaller firms. In particular, firms located within relatively economically competitive regions tend to be more positively engaged with the use of academic knowledge. Firms in uncompetitive regions have lower levels of demand for academic knowledge, even though there is often sufficient supply. Overall, the study indicates that the competitiveness of regions in the UK is positively associated with a strong demand from businesses for knowledge generated by universities. The complexity of the knowledge exchange process is further highlighted in case studies of university initiatives, which show that universities engage with businesses in a diverse spectrum even at the regional level. It is concluded that future policy intervention targeted at fostering university-industry interactions needs to more fully acknowledge territorial patterns of knowledge exchange.

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LIST OF ABBREVIATIONS

3M	Third Mission
A4B	Academic Expertise for Business
AEC	Atomic Energy Commission
AMS	Animal and Microbial Sciences
APG	Advanced Printing Group
BBSRC	Biotechnology and Biological Sciences Research Council
BERR	Department for Business, Enterprise and Regulatory Reform
BeWEHL	Bettering Wellbeing, Education, Health and Lifestyle
BIS	Department for Business, Innovation and Skills
CAGR	Compound Annual Growth Rate
CAT	College of Advanced Technology
CBR	Centre for Business Research
CCS	Commercialisation and Consultancy Services
CE	Continuing Education
CELTIC	Centres of Excellence for Technology and Industrial Collaboration
CIS	Community Innovation Survey
CPD	Continuing Professional Development
CRCE	Centre for Regeneration and Community Engagement
DELNI	Department for Employment and Learning in Northern Ireland
DETR	Department of the Environment, Transport and the Regions
DfES	Department for Education and Skills
DIPLE	Digital, Industrial, Packaging, Lean and Environmental
DTI	Department of Trade and Industry
EC	European Commission
EI	Environmental Impact
ELMS	Enhancing Leadership and Management Skills
ERDF	European Regional Development Fund
ESF	European Social Fund
ESRC	Economic and Social Research Council
F&E	Facilities and Equipment
FAME	Financial Analysis Made Easy
FP	Framework Programme
FTE	Full Time Equivalent
GD	Genome Diversity
GFU	General Fund
GTi	Graduate Teleworking Initiative
GVA	Gross Value Added
HE-BCI	Higher Education-Business and Community Interaction
HEED	Higher Education Economic Development Fund

HEFCE	Higher Education Funding Council for England
HEFCW	Higher Education Funding Council for Wales
HEI	Higher Education Institution
HEIDI	Higher Education Information Database for Institutions
HEIF	Higher Education Innovation Fund
HEROBC	Higher Education Reach-out to Business and the Community
HESA	Higher Education Statistics Agency
HFU	Horizon Fund
I&E	Innovation and Engagement
IBERS	Institute of Biological, Environmental and Rural Sciences
ICT	Information and Communication Technology
IGER	Institute of Grassland and Environmental Research
IP	Intellectual Property
IPO	Initial Public Offering
IWA	Institute of Welsh Affairs
KEF	Knowledge Exploitation Fund
KTG	Knowledge Transfer Grant
KTN	Knowledge Transfer Network
KTP	Knowledge Transfer Partnership
LEP	Local Enterprise Partnership
LKS	Localised Knowledge Spillover
LMD	Leadership and Management Development
LMW	Leadership and Management Wales
MOU	Memorandum of Understanding
NESTA	National Endowment for Science, Technology and the Arts
NI HEIF	Northern Ireland Higher Education Innovation Fund
NIH	National Institute of Health
NIS	National Innovation System
NPF	National Performance Framework
NPI	New Product Introduction
NSF	National Science Foundation
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Co-operation and Development
ONR	Office of Naval Research
ONS	Office for National Statistics
PDR	National Centre for Product Design and Development Research
PRO	Public Research Organisation
PwC	PricewaterhouseCoopers
R&D	Research and Development
RACDV	Research and Commercial Division
RDA	Regional Development Agency
REPI	Regional Economic Performance Indicator
RIS	Regional Innovation System
SFC	Scottish Funding Council

SHEFC	Scottish Higher Education Funding Council
SME	Small and Medium Enterprise
SMS	Short Message Service
SPIRIT	Strategic Priority Investment in Research and Innovation Translation
THE	Times Higher Education
TSB	Technology Strategy Board
TTO	Technology Transfer Office
UCD	User Centric Design
UCL	University College London
UHOVI	Universities Heads of the Valleys Institute
UK	United Kingdom
UKCI	UK Competitiveness Index
UKIS	UK Innovation Survey
US	United States
UUK	Universities UK
WAG	Welsh Assembly Government
WCPC	Welsh Centre for Printing and Coating
WDA	Welsh Development Agency
WG	Welsh Government
WWII	World War II

SECTION I

RATIONALE AND STRUCTURE OF THE RESEARCH

CHAPTER 1

INTRODUCTION

1.1 Universities at the heart of UK regional development

Universities, which demonstrate remarkable longevity with histories extending back to the medieval or Renaissance era, have experienced two notable revolutions that have defined the roles they play in socio-economic development (Lehrer et al. 2009). While the first revolution, dating back to the 19th century, was associated with the full integration of research into the academic mission realm, the second revolution, still in progress, adds knowledge exchange to the agenda of universities in response to environmental changes (Etzkowitz and Leydesdorff 1997; Etzkowitz 1998). By undertaking different types of knowledge transfer activities, universities are no longer only isolated islands of knowledge, as they used to be, but become closely engaged with their external partners, private or public, in the form of knowledge networks which create and distribute knowledge (Fesenmaier and Contractor 2001; Breschi and Lissoni 2004; Cappellin 2009).

These theoretical and practical developments are set within the context of regional policies increasingly recognising university knowledge as a key stimulant of economic development and determinant of regional competitiveness (Jones-Evans and Klofsten 1997; Bok 2003; Lawton Smith 2003; Boschma 2004; Goldstein and Renault 2004). Therefore, universities are portrayed by policy makers as important actors within systems of regional innovation, in particular by providing knowledge for business and the community (Foray and Lundvall 1996; Garlick 1998; Fritsch 2002; Cooke et al. 2004; Kitagawa 2004; Huggins et al. 2008a). A 'developmental' role is played by universities as they establish programmes, facilitate networks, and thus become more banded together with the needs of their regions (Keane and Allison 1999).

One of the main reasons why universities have become a key actor in building innovation capacity, driving economic prosperity, and contributing to national and regional competitiveness lies in the increased importance of knowledge. Our society is said to have shifted from a land-based, labour-based, and capital-based one to a knowledge-based one, where the increasing significance of knowledge networks – the use and transfer of knowledge – for innovation can be seen (Harloe and Perry 2004). The growth of high-technology industries, the expansion of the science base, the development of new information technologies, and the increasing complexity of production processes since the late 1960s all point to an urgent need for universities to be involved in technological advancement, industrial change, and economic development. Indeed, university knowledge exchange practices have been brought to the fore of policy landscape in both advanced nations and, more recently, emerging economies during the last few decades, with universities being encouraged to interact with regional business and innovation.

The United Kingdom (UK) represents an interesting case to investigate how university-industry interactions are associated with regional competitiveness as it is a country which has shown remarkable research excellence but has not always been effective in translating this scientific work into business innovation. On the one hand the UK possesses, by some margin, the second-strongest university system in the world after the United States (US), as suggested by a number of rankings, including the Times Higher Education (THE) and the QS World University Rankings. According to the QS 2013 results, the UK now boasts six of the world's top 20 universities, with the University of Cambridge, University College London (UCL), Imperial College London and the University of Oxford featured in the top 10. On the other hand, as famously espoused by Marshall in the early 20th century, "the small band of British scientific men have made revolutionary discoveries in science; but yet the chief fruits of their work have been reaped by businesses" (Marshall 1920, p. 102). Since the 1990s, the UK government policy has begun to emphasise the inter-relatedness of research and economic benefit (Lambert 2003; Sainsbury 2007; Wellings 2008). The significance of converting scientific progress into economic success was further highlighted when the UK government launched a series of funding schemes to boost knowledge exchange activities in the university marketplace.

Nevertheless, the choice of the UK as the case also poses many challenges for the research. While this thesis chooses the (administrative) region as the unit of analysis, it is vital to acknowledge that the region as a concept and in practice is not without problems, which have been consistently debated by scholars and practitioners. Conceptually, as Keating (1998) summarised that, region is an elusive concept and covers a variety of territorial levels and a range of social contents. In his viewpoint, a minimal definition of region would present it as an intermediate territorial level between the state and the locality, whereas the boundary is vague and difficult to draw. Generally, there has been a move from defining regions on the basis of administrative criteria to defining regions on the basis of functional criteria (Ball 1980; Casado-Díaz 2000; Schmitt-Egner 2002). In reality, however, the identification of region is closely related to the way statistics are produced. Eurostat, the statistical office of the European Union, for instance, introduced the NUTS (Nomenclature of territorial units for statistics) classification as a single, coherent system to produce regional statistics. To account for the role of urban areas in sustaining a critical mass for development, the European Union also defined a harmonised series of metropolitan areas (Dijkstra 2009). In the UK, there are 12 NUTS1 regions and 46 metropolitan regions according to the two definitions of region by the European Union, with each NUTS1 region covering a number of metropolitan regions, an indication that the 12 regions could, to a large extent, represent the geographic concentration of economic activity in the UK. After all, the conceptual move from administrative regions towards functional regions seems to have limited practical impact on the analysis of UK regions, though it does provide a more detailed picture.

While the arguments above have been used to justify the choice of the region as the unit of analysis, there is a further challenge in analysing the 12 regions in the UK. As part of the devolution process since 1997, the status of Scotland, Wales and Northern Ireland became different from that of the English regions, with the establishment of the three devolved legislatures which have been given some power previously held by the UK government. In the UK, although the national government still has a significant influence on science and research policy, some powers and responsibilities related to the higher education policies have now been devolved to regional governments in Scotland, Wales and Northern Ireland that are now responsible for their own systems of higher education (Huggins and Kitagawa 2012; Kitagawa and Lightowler 2012). The four different funding bodies, which are responsible for the distribution of funding to universities and colleges, have been created by the Further and Higher Education Act 1992, including the Funding Councils in England, Scotland, Wales, and the Department for Employment and Learning in Northern Ireland (DELNI). To fund knowledge exchange activities therefore becomes the responsibility of each funding body in the context of devolution. Despite it is beyond the scope of this thesis to examine what impacts the devolution process has on the interactions between universities and businesses, it is an important issue to bear in mind when interpreting the results.

Overall, it is important to determine, after nearly 15 years of intensive government support, how UK universities have improved their performance in knowledge exchange activities, to what extent university knowledge networks are associated with regional competitiveness, and more importantly, which elements have been missing in the current policy approach. This thesis will seek answers to these questions and examine their impact on the direction taken by UK universities whilst yielding policy implications. Despite great efforts, theoretical or empirical, having been made on the topics of knowledge transfer, networks, and regional competitiveness, there still lacks a comprehensive framework integrating all these factors, which this thesis aims to construct.

1.2 Aims, objectives, research questions, and methods

This thesis – an exploratory study which analyses existing datasets in a novel way – aims to examine, in the UK context, the patterns of interactions between universities and businesses in knowledge exchange networks, especially the match or mismatch between the supply and demand of university knowledge across regions. It is considered that a better understanding of this issue will have an influence on the future development of regional innovation systems in the UK. The current approach to regional competitiveness has been found to be too focused on the university supply side of knowledge, leaving the business demand side, to a large extent, unattended. To resolve the imbalance between these two sides thus becomes a crucial task for policy makers. Nevertheless, it is necessary to note that this thesis, mainly due to data limitation, does not seek to identify a chain of causation between regional competitiveness and university-business knowledge exchange relationships, which is an important direction future studies could follow.

The first empirical chapter represents a major effort in achieving the research aim of the thesis. It attempts to fully acknowledge the different relationships between the university supply and business demand of knowledge across UK regions and between regional groups. A further aim of the chapter is, through the analysis of supply-demand relationships, to reveal the main driving force of knowledge exchange activities at the regional level. In general, it is suggested that the competitiveness of UK regions is mainly associated with a strong demand side rather than a strong supply side of university knowledge.

The aim of the second empirical chapter is to examine the associations between the intensity and performance of university knowledge networks. It takes into consideration the regional divergence of collaborations involving universities and their partners. The intention in doing so is to shed further light on the nature and formation of knowledge networks. Furthermore, it carries out a systematic analysis of the performance of knowledge exchange activities in universities across UK regions during a longer period, arguing that performance is associated more intensively with institutional than locational characteristics.

Focusing especially on one UK region – Wales – the last empirical chapter aims to present a set of programmes through which universities engage in knowledge exchange activities with businesses. With the use of a qualitative case study approach, this chapter complements the previous chapters of quantitative analysis. In particular, it illustrates intra-regional differences in knowledge networks and thus expands upon the previous chapters which are focused at the regional level and do not identify differences within the same region. By revealing the stories behind these programmes, it outlines the main factors underlying their success and maps out them in the research framework. It particularly addresses the complexity of understanding the value of knowledge exchange which is shown at the institutional level.

All these aims are to be fulfilled by the following objectives: (1) A regional comparison of the structure of university knowledge supply and business knowledge demand in the UK; (2) An examination of the relationships between the intensity and performance of university knowledge networks in UK regions;

and (3) Examples of Welsh universities engaging in knowledge exchange activities with businesses.

The principal research question to be answered in this thesis is: What are the associations between university knowledge networks and regional competitiveness in the UK? This is detailed into the following sub-questions:

1) What are the relationships between the university supply and business demand of knowledge across UK regions?
2) How differently do businesses in UK regions engage with universities in various types of activities and at different geographical levels?
3) How do the exchange activities encompassing university knowledge networks differ across regions? and
4) What are the success factors of knowledge exchange programmes in force in Wales which enable the universities to reach out to businesses?

Each of the first three questions represents, at the UK level, the aspect of region, business, and university respectively, while the fourth question specifically focuses on one UK region namely Wales.

The thesis has employed a mix of quantitative and qualitative methods, rather than either method alone, in order to best answer research questions. Large-scale quantitative analysis, which is based upon two existing datasets but adds its own value, is the main method used when examining the patterns of university-business interactions across the 12 UK regions. Qualitative analysis, in the form of case studies and interviews, represents a complementary effort in figuring out the complexity of knowledge networks in a specific region. Mixing the research methods has not come without difficulties, which have included how to place them under the same research framework and how to analyse the large amounts of data. As will be discussed in more detail in Chapter 4, these issues are believed to have been dealt with properly. In particular, the quantitative analysis of secondary data is considered to be the primary tool in this study, while the case studies serve to add complementary findings.

1.3 Thesis structure

In Chapter 2, the existing literature relevant to the university knowledge networks debate is reviewed and structured in three broad sets. The first set analyses how knowledge, especially in the form of networks, has become a crucial source of competitiveness for regions. In essence, this body of literature builds the foundation for the arguments of universities becoming an increasingly important part of regional innovation systems. By following the historical evolution of universities around the globe, the second set explains the rising importance of network building for universities. It also examines in what ways the performance of university knowledge networks could be influenced by individual, departmental, organisational and institutional factors. The third set of literature moves from the supply side to the demand side of university knowledge, highlighting the change of business strategy which has become to embrace open innovation. It also investigates the real importance of university knowledge to firms of different types and in different locations.

After identifying the gaps in the literature and establishing the approach that research to address them might take in Chapter 2, Chapter 3 examines the UK policy context for regional competitiveness and university knowledge exchange. It reviews the history of the UK higher education sector, and shows how the role of universities has been redefined by those recent policies that have encouraged universities to leverage their knowledge networks as competitive assets of their region. Chapter 3 also compares the main initiatives of knowledge exchange introduced in the four UK nations over the last 15 years after devolution, with a special focus on the scale and allocation mechanisms of the funding streams. It concludes by addressing the major limitation of the policy landscape and calling for further changes.

Chapter 4 sets out a structure that informs this thesis, presenting the methods employed in undertaking the research. These include the methods used to formulate the research design and to access, select and analyse the secondary data from databases accessible to the researcher. Chapter 4 also explains the methods used to select the knowledge exchange practices that form the subject of investigation, to design the schedules for and undertake the interviews, and to treat the data following collection. In reusing existing resources, special attention is paid to their copyright held by the organisation that commissioned, designed or conducted the original research.

The rationale and structure of the research having been dealt with in Section I, Section II presents the research findings in three empirical chapters. While Chapters 5 and 6 focus on the whole country and conduct quantitative analysis of large-scale secondary data, Chapter 7 shows qualitative evidence of the complexity of university knowledge networks in one UK region.

Chapter 5 takes into consideration the need of knowledge produced by universities in UK firms, which have often been perceived to form an important part of the demand side of academic knowledge. It examines how firms in the UK require and source university knowledge and investigates how size and location of firms are associated with their use of engagement with academics, while suggesting the sectoral effects on patterns of interaction should be examined in future research. This chapter then presents supply-demand relationships of knowledge at the regional level, with the findings showing the extent to which the two sides of innovation are matched or mismatched, and calls for the implementation of more regionally tailored policies aimed at fostering university-business interactions.

Chapter 6 examines the associations between the intensity and performance of university knowledge networks, as the extant literature and empirical studies have tended to examine the (financial) performance of knowledge exchange activities, while the structure of them has not been touched upon extensively. The findings alleviate not only theoretical but practical problems resulting from the imbalance of academic focus on these two aspects of networks.

By using qualitative methods of case studies and interviews, Chapter 7 shows how institutions may differ from each other in developing knowledge networks in the specific context of one UK region (Wales). It examines a set of programmes in Wales that are specially designed to facilitate knowledge exchange between the higher education sector and private sector companies. The findings are presented in two main parts: one describes the history and development of those programmes or initiatives; the other analyses the main factors underlying their success, as well as the key challenges constraining their further impact. As already mentioned, Chapter 7 is intended to expand upon the main arguments in the previous chapters and to highlight the complex nature of knowledge exchange within the same region.

The findings are synthesised in Section III. Chapter 8 summarises the main results, presents the contributions of the study to the literature and the policy debates, before further addressing the limitations of the work. Chapter 8 continues with suggestions for future research areas before concluding with a brief review of the whole research.

CHAPTER 2

THE CONNECTED UNIVERSITY: REGIONS, UNIVERSITIES AND FIRMS

In this chapter, a critical and in-depth evaluation of research already undertaken on the relevant topics is conducted. It is important to identify relevant information and outline existing knowledge when producing a rationale for the study. The first section of this chapter addresses the shift in understanding of the role of knowledge, in particular how, in the form of networks, it is used to build regional competitiveness. The historical evolution of the mission of universities is examined in the second section which then critically analyses what is missing in the conventional wisdom of university knowledge networks. Finally, the third section discusses some of the key factors supporting knowledge sourcing by firms and questions the real importance of university knowledge in business development. This chapter concludes by constructing the analytical framework, identifying the research gaps, and formulating the research questions.

2.1 Knowledge, networks, and regional competitiveness

2.1.1 Knowledge production in the endogenous growth model

Knowledge, as defined by Webster's Dictionary, is the fact or condition of knowing something with familiarity gained through experience or association. In practice, its relationship to information is seen as a key means of understanding knowledge. What distinguishes knowledge from information is the fact that while information merely refers to data arranged in meaningful patterns, knowledge is information that changes something or somebody, either by becoming grounds for action or by making an individual or an institution capable of different or more effective actions (Drucker 1989). According to Stiglitz (1999), knowledge is a global public good as it satisfies the following two critical attributes: non-rivalrous consumption – the consumption of one individual does not detract from that of another – and non-excludability – it is difficult if not impossible to exclude an individual from enjoying the good. This description of knowledge as a public good has increasingly been challenged by scholars such as Oliver (1997) who argued that knowledge could at best be viewed as a quasi-public good rather than a truly public good for, in reality, the reproduction and diffusion of knowledge "cannot be taken for granted" (Huggins and Johnston 2010, p. 458).

This debate about the nature of knowledge is well captured in Gibbons et al.'s (1994) seminal research in which the authors introduced the new production of knowledge approach by distinguishing between 'Mode 1' and 'Mode 2' knowledge. Mode 1 is the traditional mode of knowledge production through hierarchically organised disciplinary science primarily located in university systems. Mode 2, in contrast, is non-hierarchical, seen in the context of application, and is characterised by a transdisciplinary approach and heterogeneous organisational forms constructed for the purposes at hand. In a sense, 'Mode 1' knowledge is what used to be termed as 'science' and could therefore be considered as a 'public good', a good which cannot or should not be appropriated by any single member or group in society, but should be broadly disseminated to maximise its social welfare. Traditionally, this scientific type of new knowledge has been distinguished from knowledge generated by more applied or commercial research which is closer to the market and the 'technology' end of the spectrum. In the 'Mode 2' knowledge production approach, the distinction between science and technology is found to be blurred and less meaningful (Gibbons et al. 1994; Etzkowitz and Leydesdorff 2000).

In particular, the knowledge base of an economy in the 'Mode 2' approach becomes more diversified with scientific knowledge being produced not only by research institutions and universities but also by private sector companies, especially those in research and development (R&D) intensive sectors such as pharmaceuticals and bio-technology. As a result, it is more likely that both scientific and technological knowledge is produced as joint products of the same research activity. This argument addresses the importance of the interaction among all possible sources of knowledge and, more relevantly, the need to increase the variety of exploitable knowledge that might eventually find its way into commercial application. The 'Mode 2' approach of knowledge production challenges the idea that knowledge is a public good and implies that knowledge, be it scientific or technological, can be appropriated.

Indeed, an emerging focus of policy makers in North America and Europe during the last two decades of the 20th century was on how to effectively appropriate knowledge created either from universities or firms. It was a period when our understanding of the role that knowledge can play in productivity and economic growth was significantly redefined. Prior to that, a prevailing theory of economic growth was what became known as the Solow model – named after its founder Robert Solow – in which physical capital and labour were identified as two key factors of production influencing economic growth and standard of living (Solow 1956). Knowledge was left as an undetermined residual in this model with its role in economic growth not being addressed. In the 1980s, Romer (1986), Lucas (1988), and others contributed to the endogenous growth model by acknowledging knowledge, along with the traditional factors of physical capital and labour, as a key factor of production. A main argument of these scholars was that knowledge has a substantial impact on economic growth through two main channels. On the one hand, previous investments in knowledge can stimulate more creation and stock of it. On the other hand, knowledge can spill over from the firm or university creating it to other firms that can appropriate that knowledge and enhance their own productivity.

2.1.2 Constructing regional advantage

The recognition of the importance of knowledge attracts attention from firms to governments at various territorial levels with all seeing investment in knowledge as a key source of innovation and regional/national competitiveness (Nonaka and Takeuchi 1995; Edmonds 2003; Huggins and Izushi 2007). For firms, regions and nations, to sustain competitive advantages may be more crucial than ever, because this has become more difficult to achieve in the surge of globalisation, a process that has triumphed in the second half of the 20th century and fostered competition between firms, and also between territories, in technology and market shares. As Bauernfeind (2005) explained, at least five factors have driven globalisation namely the decline in transport costs, the rapid development of telematics, the gradual removal of market and political barriers to trade internationally, and the entrance of competitive actors.

While governments at different levels were bidding to build knowledge-based economies in the face of global competition, there were debates in academia about the most pertinent level at which to examine economic activities and introduce effective policies. After World War II, nations around the world regained their focus on economic development, with rapid advances in technology and a growth in international trade. The market dominance of American companies was severely challenged by the rise of Japanese firms in the 1970s, which led to many studies on the success of the Asian nation. From a policy perspective, much of the attention then was given to the national level with countries competing with each other in an emerging global marketplace. From the 1980s, attention has increasingly shifted towards regions, and there was "a resurgence of interest in the region as a scale of economic organisation and political intervention" (MacKinnon et al. 2002, p. 293; see also Amin and Thrift 1994; Storper 1995; Scott 1996). As Lundvall and Borrás (1997, p. 39) put it, "the region is increasingly the level at which innovation is produced through regional networks of innovators, local clusters and the cross-fertilising effects of research institutions". This view of the region is also shared by many others claiming that regions should be considered as an important source of economic development and competitive advantage in the knowledge-based economy (Cooke 1998; Cooke and Morgan 1998; Malecki 2004, 2007).

If knowledge has become the driving force of economies, then the distinction between codified and tacit knowledge could largely explain why regions have regained increasing awareness, especially in a globalisation era (Kogut and Zander 1992). Codified (or explicit) knowledge consists of facts and numbers (such as a journal article) and is ready to be transferred without hindrance of communicating. In contrast, tacit knowledge is conveyed by the person who owns the knowledge and cannot easily be communicated or transferred since even that person who has the knowledge may not be aware of it due to the fact that "we know more than we can tell" (Polanyi 1966, p. x; Audretsch 1998). In this regard, the tacitness of knowledge requires oral communication and reciprocity in which distance is a key parameter as interaction takes place more easily, and possibly more effectively, between two close partners (Mowery and Ziedonis 2001; Alcacer and Chung 2007). Howells (2002) highlighted the importance of tacit knowledge in the innovation process and confirmed that geographical location strongly influences the relationship between knowledge and innovation activity. For others, it is not only tacit knowledge that is sensitive to distance, but also codified knowledge, as it is more often the case that knowledge has both the codified and tacit elements (Asheim and Coenen 2006). Furthermore, Nightingale (1998) claimed that the understanding and application of codified knowledge tend to be dependent on tacit knowledge embedded in people.

Researchers have also examined whether local organisations are more capable of transferring tacit knowledge as, although it tends to be localised, there is no guarantee that it would be diffused effectively within a community. It is considered that knowledge is easier to diffuse if agents within a community can read the codes and understand the language (Cowan and Foray 1997). That understanding is facilitated and strengthened when partners belong to the same social, cultural and institutional environment (Cooke and Morgan 1998), which is more likely to exist in the same region or territories in a short distance. In Storper's view, regions could be seen as a locus of 'untraded interdependencies', which include labour markets, public institutions, and locally or nationally derived rules of action, custom, understanding and values (Storper 1995, 1997).

The idea of tacit knowledge diffusing more easily between local partners may make sense in a theoretical perspective, but empirical evidence supporting that hypothesis is relatively rare. In other words, although tacit knowledge is sensitive to geographical distance, it does not necessarily mean frequent face-to-face interactions will definitely enable the transfer of it, possibly due to less effective communication or dissatisfying learning capabilities. At a fundamental level, the measurement of the transfer of tacit knowledge is really difficult, if not impossible, thanks to its tacitness. In fact, Brenner (2007, p. 122) was sceptical about the efficiency of personal contact in diffusing knowledge by asking "whether personal contact really allows for more knowledge exchange than distant contact with the use of current information technology, such as video conferences". Indeed, most studies fail to show what kind of knowledge is mainly transferred locally and why.

Although it has been argued that views on the prominence of knowledge for regional economic development remain contested (Lagendijk and Cornford

2000; MacKinnon et al. 2002; Huggins et al. 2008a), it has come to the fore of regional policies and has become a key factor, in the view of policy makers, of building regional competitiveness through knowledge creation and diffusion. Nevertheless, it is at the firm level, rather than the territorial level – regional or national – that the notion of competitiveness has initially been developed. In his 1979 paper which explains the sources of firms' competitiveness, Porter introduced his 'competitiveness forces' framework and argued that the nature and degree of competition in an industry rely on five forces – entry barriers, substitutes, buyers' and suppliers' bargaining power, and intra-industry rivalry (Porter 1979). In another book entitled *The Competitive Advantage of Nations*, published in 1990, Porter addressed a question which lies at the heart of the economic geography field namely "Why do some social groups, economic institutions, and nations advance and prosper?" (Porter 1990, p. xxiii). This work represents a departure from firm level analysis to the evaluation of territorial competitiveness, using a similar but extended framework.

Therefore, an important issue in understanding territorial competitiveness is to clarify between firm level and territorial level frameworks. While firm level framework focuses on the internal factors, territorial level analysis proposes that competitive advantage of firms resides in the locations where the company is based and it can be argued that competitiveness theory has evolved from an internal perspective to an external perspective. There are also remarkable differences between firms and places in the way they 'compete'. As Huggins and Clifton (2011, p. 1344) explained, "places may 'compete' in trying to provide the best platform for operating at high levels of productivity, but this is very different from the kind of direct competition undertaken by firms.” In other words, nations or regions do not compete against each other but become more competitive if they are able to improve the conditions that will enable firms to compete in local, national, and international markets.

For knowledge-based economies, their knowledge development capabilities are increasingly said to be associated with their systems of innovation i.e. systems of interconnected institutions to create, store and transfer knowledge, skills and artefacts which define new technologies (Lundvall 1992; Nelson 1993; Freeman 1995; Cooke et al. 2004). In the mid-1980s, debates over industrial policy in Europe led to the emergence of the national innovation system (NIS) concept. Later, this concept was developed at a regional level, which led to the rise of the regional innovation system (RIS) approach, as many studies showed that innovation activities and collaborations tend to take place within the same region. In general, innovations in a system approach are carried out through a network of actors (Edquist 1997) and systems serve as interaction networks in which knowledge is created and shared (Kaufmann and Tödtling 2001). As a result, effectively embedded knowledge networks become an important factor driving regional development (Saxenian 1994; Storper 1997; Lawson and Lorenz 1999; Bathelt et al. 2004). Policy makers therefore hope to build knowledge networks by fostering collaboration between firms, universities, government laboratories and public research organisations as part of what has been described as the ‘high road of regional competition’ (Malecki 2004).

Similar to the innovation system approach, the Triple Helix model also recognises the importance of interactions between different innovation actors, but has been developed with special emphasis on inter-relations between three specific kinds of actors namely government, university, and industry (Etzkowitz and Leydesdorff 1997; Klofsten et al. 1999; Etzkowitz 2003; Leydesdorff and Zawdie 2010). An important invention of the Triple Helix model is what the overlaid area of the interactions refers to – a hybrid organisation – as the model maintains the independence of every sphere but also addresses the interactions among the three helices. In a hybrid organisation, the statuses of all spheres are found to co-exist, suggesting the internal transformation of the institutions which take the role of the others in addition to their traditional tasks. Prominent examples include incubators, science parks, collaborative research centres, all of which are established in the aim of developing inter-organisational engagements and knowledge networks.

2.1.3 A network approach to knowledge exchange

In the view of network scholars, knowledge flow within networks of firms, universities and other actors has now become a crucial element underlying the competitiveness of regions (Asheim et al. 2003; Bathelt et al. 2004; Rutten and Boekema 2007). The generic term 'network' refers to a group of entities which are connected to one another; and a network therefore allows material or immaterial elements to be circulated among those entities. As Torrent (2009) claimed, railway networks in the 19th century aided the spread of technology at levels never before seen. In the knowledge-based economy, what is carried through networks is significantly different from that through railway networks in the 19th century. It is knowledge that is more increasingly created and distributed through inter-organisational networks. As such, organisations have been transforming as well as establishing various types of knowledge networks with their external partners (Fesenmaier and Contractor 2001; Breschi and Lissoni 2004; Cappellin 2009).

Knowledge networks can generally be defined as "consisting of the interactions and relationships organisations utilise to access knowledge" (Huggins et al. 2012, p. 478; see also Ahuja 2000; Huggins and Izushi 2007; Huggins 2010). For an organisation, knowledge networks form an inherent part of its institutional environment and are key conduits through which knowledge is exchanged between the environment and itself (Owen-Smith and Powell 2004). The value of knowledge networks to a firm lies in the argument that the competitive advantage of a firm is dependent upon the strength of its partners (Stuart 2000; Ireland et al. 2002; Huggins and Johnston 2009b). This is an important point in the sense that it provides a new way of examining how firms can use knowledge networks to build their advantages over competitors.

Network ties of an organisation may be either formal or informal. Formal ties are normally contractually agreed upon and involve joint ventures, alliances or R&D partnerships while informal ties may refer to personal connections and knowledge sharing (Gulati 1998). There is no straightforward relationship between formal and informal ties as formal ties may be a result of informal ones existing between individuals, or lead to the establishment of informal ties

(Gulati and Westphal 1999). A large body of the literature has emphasised the role of formal ties in organisations, leaving informal ties less well understood (Simard and West 2006). It might be due to the difficulty of measuring informal ties and identifying the position of them in a firm's strategy. Nevertheless, the value of informal ties to firms and organisations should not be overlooked, which has been confirmed by the empirical findings of some studies (see Agrawal and Henderson 2002).

As March (1991) suggested, there is also a delicate balance between exploration and exploitation ties in organisations, representing two distinct approaches of knowledge sourcing and learning. Exploration in organisational learning refers to searching for discoveries and undeveloped ideas, while exploitative learning involves improvements in existing knowledge and resources. When considering the innovation path of each of the two approaches, Huggins et al. (2011) concluded that the explorative mode is associated with the non-linearity process, while the exploitative mode pictures a straight line. It seems that firms that undertake the explorative mode are more likely to introduce radical innovation; in comparison, firms undertaking the exploitative mode may be more concerned about incremental innovation. Furthermore, the adoption of one of the two approaches may be associated with the firm's overall strategy and market needs and would be restricted by its available resources since each approach require different prerequisite strengths. The combination of the two approaches, rather than the separation of them, would maximise the effectiveness of knowledge sourcing (Huggins et al. 2011).

Another stream of research focuses on the strength of network ties, especially distinguishing between strong and weak ties. It began with the famous 'strength of weak ties' hypothesis proposed by Granovetter (1973). In the late 1960s, as part of his PhD research, Granovetter interviewed people who had recently changed employers to learn how they discovered their new jobs. One striking finding was that many people learned information through acquaintances rather than closer friends, showing that weak ties could be more important than strong ties in understanding certain network-based phenomena. The strength of a tie, according to Granovetter (1973), is a combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterise the tie. Weak ties refer to relationships that one may have with people outside her/his own social networks, and provide a perspective outside of the normal groups of which one is a part. It becomes essential to have this outside perspective, since in a network with strong ties, information is likely to be redundant and locked-in when perspectives of members become homogenised over time through learning and sharing mutual beliefs (Huggins 2008; Lorentzen 2008). Therefore, a network with too strong ties may not be best placed to facilitate innovation as new knowledge is better accessed by weak ties which function as local bridges among multiple networks.

Knowledge networks, in essence, are not necessarily territorially based, with networks simply representing relationships among organisations (MacKinnon et al. 2002; Harrison 2013). This is different from those theories of innovation systems discussed earlier which have paid more attention to contextualised learning and territorialised innovation (Lundvall 1992; Lorentzen 2008). There has been a tendency to add a territorial perspective to the network approach (in particular the role of geographically proximate networks) since policy makers now consider knowledge networks to be an important factor driving regional development. On the one hand, as knowledge spillovers are geographically bounded, spatially proximate knowledge networks are more likely to form, function, and consequently benefit regional economies (Malmberg and Maskell 2006). On the other hand, proximity of network actors facilitates the creation, accumulation and utilisation of complex and 'sticky' knowledge grounded in social interaction and face-to-face communication (Gertler 1995; Asheim and Isaksen 2002; Bathelt et al. 2004; Sorenson et al. 2006). In addition, case studies of many exemplar regions around the world seem to confirm that their competitiveness could be partly attributed to the existence of established spatially proximate knowledge networks (Saxenian 1994; Storper 1997; Huggins 2000; Knoben and Oerlemans 2006). From a policy perspective, government policies also aim to embed parts of larger networks in particular localities such as regions (Hess 2004). This may particularly be the case when local authorities attempt to embed multinationals in their region within clusters and networks of economic activity (Whitley 1992; Phelps et al. 2003; Huggins and Johnston 2009b). Indeed, network embeddedness has been found helpful for firms to manage inter-firm relationships and reap the benefits of social exchange, mutual adaptation and trust (Uzzi 1996; Yli-Renko and Autio 1998; Gilsing et al. 2008; Hsueh et al. 2010).

In many ways these arguments about the importance of proximate networks have increasingly been challenged. The large body of literature on the role of spatial proximity for knowledge networks has not quite clearly clarified how geographical distance influences knowledge transmissions (Maillat et al. 1997; Ratti et al. 1997; Döring and Schnellenbach 2006). Whilst the notion of proximity is functional at the fundamental level it tends to leave the organisations involved as black boxes with the question in what situations organisations benefit from proximity being unanswered. For instance, as Watts et al. (2003) have stated, close proximity does not necessarily facilitate face-to-face interactions between firms through either social or business contacts. It could therefore be argued that firms just being located close to each other does not guarantee the formation of effective networks.

With a few exceptions, little is known about in what ways local interactions are more superior to those non-local ones (Markusen 1996; Bathelt et al. 2004). In studies on clusters – which are normally seen as an example of intensive local interactions – there are suggestions that the advantages of local networks in comparison to extra-local ones should be carefully examined as they are not obvious, at least not in all cases (Maskell 2001; Bathelt 2002). When considering a more specific type of knowledge networks – academic-industry partnerships – it has been found that neither universities nor firms perceive knowledge flows to be spatially bounded (Huggins et al. 2008a). Firms in general do not view proximity to local research institutions as a crucial element in establishing interactions (Lawton Smith 2004), which not only questions how important proximate networks are but also implies the rise of non-local knowledge networks between firms, universities and other organisations.

The role of non-proximate networks is increasingly being recognised in the literature which has called for a wider spatial focus integrating distant networks of actors (Bunnell and Coe 2001; MacKinnon et al. 2002; Amin and Cohendet 2004; Huggins and Izushi 2007). An important message to take in is that knowledge networks in an environment are simultaneously local and global (Andersson and Karlsson 2007; Lorentzen 2008; Van Geenhuizen 2008). Although Storper has famously claimed that we are all now living in a 'regional world', the author rightly views regions as the fundamental building blocks of a globally interconnected world (Storper 1997). In the era of globalisation, it becomes difficult, and probably unwise, to separate local and regional networks from wider national and global interactions. Whilst regional innovation systems have their focus on certain territories, they also consist of knowledge generation, transmission and exploitation both within their own systems and across extra-regional, national and global systems (Cooke 2004). Therefore, distant and proximate knowledge networks do not substitute each other but are complementary.

One of the main arguments of the recent literature on non-proximate networks is that more evidence now shows the capability of distant actors in transferring complex and 'sticky' knowledge which, in earlier literature, was considered to be transferred within geographical proximity (McEvily and Zaheer 1999; Lissoni 2001; Davenport 2005; Zaheer and Bell 2005). As Huggins et al. (2008a, p. 478) claimed, "the constraining effect of distance on knowledge flow and transfer is gradually diminishing." Extra-local linkages are likely to be built in order to mitigate the potential negative effects of those too closed and exclusive local networks. For example, Nooteboom (2000) suggested that non-proximate networks may be helpful for local organisations to access diverse knowledge, which will in consequence foster innovation activity. It might also be the case that local networks could not create sufficient knowledge required by all actors within the network. As a result of the increasing globalisation of R&D and knowledge creation, it is not surprising to find that key knowledge is produced by organisations across a wide array of locations (Cantwell 1995; Almeida 1996; Florida 1997; Patel and Vega 1999; Kash and Rycroft 2000).

It can be assumed that a good combination of proximate and distant networks will bring most advantages to clusters and regions. 'Local buzz' and 'global pipelines' are both useful, although in different ways, in offering valuable channels for organisations to access knowledge and learn from others. To extend the earlier focus of the literature on established spatially proximate knowledge networks in places, more recent empirical studies of leading regions have started recognising the role played by non-proximate networks (Huggins and Johnston 2010). Examples include Silicon Valley in the US (Saxenian 2005), Cambridge in the UK (Athreye 2004; Garnsey and Heffernan 2005), and Ottawa in Canada (Doloreux 2004). An emerging, and important, research topic is to examine the relative strengths of proximate and distant networks in these world leading regions, which will shed more light on the sources of regional competitiveness. In particular, it may be possible to ascertain to what extent the competitiveness of a region is reliant on proximate or non-proximate networks, or more likely, on the combination of both.

2.1.4 Knowledge networks and regional competitiveness

In much of the extant literature, what has been taken for granted is that competitive regions should have built embedded regionally proximate networks. This perception is now increasingly being challenged as more detailed analysis tends to show that, in some world leading regions, localised networks are not as well developed as expected. For instance, Huggins (2008) examined university involvement in regional knowledge commercialisation process in London, and found a lack of effective regional networks between higher education institutions (HEIs) and financial institutions. The author explained that London's venture capital system does not have an overreliance on a network of local contacts; instead, those firms may tend to make non-local investments. Therefore, how regions build their comparative advantages is more likely to be on a case-by-case basis.

Apart from a deeper understanding of the source of competitiveness in those exemplar regions, more research is obviously needed on less competitive regions, which have fewer favourable background conditions such as cultures, economic structures and institutional arrangements (Benneworth 2006). In general, these weaker regions "tend to lag behind their more competitive counterparts in terms of headline indicators such as economic output per capita and employment levels, as well as knowledge-based indicators such as innovation, patenting and densities of knowledge-intensive firms" (Huggins et al. 2012, pp. 482-483; see also Huggins and Johnston 2009b). For, without the extraordinary assets of places like Silicon Valley, it might be difficult for ordinary regions to make the leap from an old-economy paradigm to one based on innovation in services and high-technology industries (Benneworth 2007).

What uncompetitive regions tend to lack is a high density of knowledge-based firms and they are accordingly described as being organisationally thin (Benneworth and Charles 2005; Tödtling and Trippl 2005; Malecki 2007; Doloreux and Dionne 2008). They are less developed in terms of the resources and capabilities of firms necessary for innovating and networking, with a strong dependence on small and medium enterprises (SMEs) exhibiting low-growth trajectories. As Landabaso and Reid (1999) found, in those economic 'catch-up' regions there is often an imbalance in science and technology in favour of the public sector, the academic sector in particular. Unsurprisingly, policy makers expect that their universities will serve as an 'anchor tenant' in supporting the regional economic development system (Agrawal and Cockburn 2003; Siegel et al. 2007). In the UK, the promotion of innovation through knowledge transfer from universities to regional businesses has come to the fore of economic policy for weaker regions (DTI 2003). The regional development literature has been discussing the extent to which universities can be transformative agents in economies and how this is related to the specific regional context in which they are situated (Lawton Smith 2007; Huggins et al. 2008b; Power and Malmberg 2008; Christopherson and Clark 2010).

This argument is supported by the so-called regional innovation paradox, which is described by Oughton et al. (2002, p. 98) as, "the apparent contradiction between the comparatively great need to spend on innovation in lagging regions and their relatively lower capacity to absorb public funds earmarked for the promotion of innovation and to invest in innovation related activities compared to more advanced regions". Lagging regions, which refer to less competitive or uncompetitive regions in comparison to competitive ones, may have fewer firms able to assimilate knowledge – science, innovation and technologies – created by proximate universities (Florida 1999; Gunasekara 2006; Christopherson and Clark 2010). In other words, it is crucial for policy makers in lagging regions to alleviate the capacity imbalance between the knowledge supply and demand sides. Huggins et al. (2008b), in their analysis of the role played by universities in Wales (a lagging region in the UK with limited demand for university knowledge) found that the burden being placed on universities to become the bases for knowledge that can be commercialised is too heavy. Indeed, it is difficult to expect that knowledge networks could be established when some important actors, such as firms in uncompetitive areas, are either not interested in, or capable of, collaborating with the other actors. The success of current university-centred approaches undertaken by many governments in lagging regions cannot be guaranteed unless dedicated policies are introduced to level up the absorptive capacity of firms (Cohen and Levinthal 1990).

One direction that future research on lagging regions could follow is to examine the structures of knowledge networks in those areas and compare them with those in competitive regions. For example, what may be the case is that a relatively strong university, in terms of research capacity and engagement, in a lagging region will tend to work with firms in other regions, if local firms cannot utilise the knowledge produced by the institution (Youtie and Shapira 2008).

Without a strong industrial base to absorb advanced knowledge, uncompetitive regions may suffer from a leakage of knowledge and find themselves further behind from competitive regions (Siegel et al. 2007). Clearly it is important not only to map the knowledge networks in the regions, but also to understand their long-term influences and to draw pertinent policy suggestions in order to improve the situations.

2.2 Universities, knowledge exchange, and regions

2.2.1 Missions for universities

From a historical perspective, questions such as how and why the role of universities in society has evolved over time have been asked by many researchers and are of strong relevance to our understanding of the current status of university engagements with stakeholders (Audretsch 2014). The University of Bologna is probably the first university in the Western world, while the University of Oxford is the oldest university in the English-speaking world. These early universities share one common characteristic in emphasising a certain field of study, seen in the three great prototypes then: Salerno, known for medicine, Bologna known for law, and Paris for technology (Lehrer et al. 2009). As Fallis (2004) has explained, key components of those first universities – liberal and professional education – are still with us in modern society, where liberal education is the belief that universities provide knowledge for its own sake whilst professional education meets the economic needs of society.

A university is seen in the view of Newman (1829), who wrote *The Idea of a University*, as an ivory tower of independent scholars producing knowledge and passing it on to students; the knowledge will then enable graduates to develop their full potential. Newman thus considers university as a place of teaching and of undergraduate education rather than research or discovery of new knowledge which might be called advancement. Medieval universities had, from the outset, functions such as teaching priests, public servants, lawyers and so on and providing scholarship in a variety of disciplines (Martin and Etzkowitz 2000). In the coming centuries, these functions were found to evolve through distinct trajectories. Teaching, for instance, gradually included two types: one was to develop the full potential of individual students, and the other was to train people with knowledge and skills useful for society. Scholarship developed along a similar path with some scholarship still stuck to knowledge for its own sake, while another part of it was enlarged to take into account the creation of new knowledge (research) besides the reconstruction of existing knowledge. As a result, these early universities were transformed into diverse types. The Universities of Oxford and Cambridge in Great Britain followed a Cardinal Newman model whereas in Germany there originated the research mission of universities, famously known as the Humboldt University model.

The founding of Humboldt University of Berlin in 1810 is often considered to be the beginning of the modern research university. Freeman (2004) recognised the discovery of the method of invention itself – the professional research laboratory – as the most important invention of the 19th century. This German invention, which combines teaching and research, was at that time referred to as an 'institute' or 'seminar' (Clark 1995). Between 1882 and 1907, as Clark (1995) has reported, 77 seminars in the philosophical faculties (including natural sciences), 86 medical laboratories and clinics, nine seminars in law and four in theology were established in Prussia alone. Thanks to these seminars, Germany enjoyed significant development of research centres and strong competitiveness in various disciplines. Responsibilities of professors also changed through the decades between 1850 and 1870: the chaired professor served simultaneously as a teacher and a research director (McClelland 1980). Adding research to teaching reflects the first shift in the role of universities, which could be viewed as a result of further specialisation of academic disciplines. Indeed, Prussian universities specialised in narrower subjects, e.g. the University of Berlin in archaeology, art and history, the University of Göttingen in mathematics and physics, etc. This shift also witnessed the emergence of more types of universities such as the classical university or the technical university. Many specialised research centres helped Germany build advantages in industries related to organic chemicals and pharmaceuticals through embryonic connections between universities and businesses.

Another type of university – the Land-Grant University – emerged in the US in the late half of the 19th century. In 1862, Abraham Lincoln signed the Morrill Act (also known as the Land-Grant University Act), aiming to educate students in agriculture, home economics, mechanical arts and other practical professions at the time. McDowell (2001) concluded that the social contract of the land-grant universities was to educate the working classes and to engage in research designed to influence the most routine tasks of American life. By then, red brick universities and local technical institutions were also founded in the industrial cities of Britain, with emphasis in the value of practical subjects and the application of research (Youtie and Shapira 2008). The American land-grant universities, in comparison with their German counterparts, moved further in terms of building linkages with industries and government. While the German states did not notice the direct impact of academic research, the US government deliberately funded those institutions in disciplines with wider impact on society. Scholars in American universities thus had more specific research targets related to practice than German professors. In many ways, university-industry linkages have developed from the German universities' nascent partnerships with companies in mechanical engineering and chemical engineering to the US land-grant universities' formal style collaborations with stakeholders in research.

As the higher education sectors continued to expand in the US, the UK, and other European countries in the first half of the 20th century, World War II (WWII) further leveraged R&D activity in universities. During that period, university scientists were seen as crucial intellectual resources, especially in relation to the defence industry. In the age immediately following the war, the US federal government founded a number of major new science and technology agencies, such as the National Science Foundation (NSF), the Atomic Energy Commission (AEC), and the Office of Naval Research (ONR), and reformulated and expanded the National Institutes of Health (NIH), all of which soon became core actors of federal support for academically based R&D. The launch of the Sputnik satellite by the then Soviet Union in 1957 worried the US government and fuelled an even greater increase in defence and space-related research investment. This incident was also recognised as a turning point of university research from military-oriented towards curiosity-driven. As Youtie and Shapira (2008) reported, American university R&D expenditures increased at an average rate of 8.1 per cent per year in real terms between 1954 and 1979, while the annual growth rate of the whole country in R&D was 5.3 per cent. This 'happy' expansion of federal R&D funding in universities was called off in the 1970s amid the budget pressures from the Vietnam War and the economic down-turn that followed in America. The NSF and Defence Department shrank their spending in universities by 50 per cent in real terms between 1968 and 1974 (Scotchmer 2004). Until the late 1970s, American universities received less funding from federal government than from industry, and the share of government support for universities has been further decreasing afterwards to just above 30 per cent by 2004.

A number of factors may have led to the later increase in industry funding of R&D in universities and colleges in the US. First, the ability of science to deliver social and economic benefit was strongly questioned in the US by the 1970s when Japanese companies outperformed their American competitors in global markets. Gradually the focus of US policy makers shifted to how science could be directly applied to solve national problems and to foster economic competitiveness and growth, which essentially requires universities to place great emphasis in building partnerships with industry. Second, in part due to the fast growth of high-technology industries represented by electronics, biotechnology, software and others, there emerged a high demand for R&D

within the private sector. R&D capability became a key competitive advantage for multinational firms as they expanded their business worldwide. The growing complexity of industrial research and increasing pace of technological change in fields like pharmaceuticals both called for closer collaboration between firms and the most abundant research reservoir – universities. Last but not least, a series of legislations passed since the early 1980s encouraged stronger university-industry linkages in the US. The famous Bayh-Dole Act of 1980, for example, enabled universities and small businesses to own and manage patentable inventions developed with government funding (see Aldridge and Audretsch 2011; Grimaldi et al. 2011; Thursby and Thursby 2011a). This Act was subsequently emulated in many other OECD (Organisation for Economic Co-operation and Development) countries as well as in those emerging economies (Mowery and Sampat 2005).

In their work, Mowery and Sampat (2005) gave examples of countries such as Canada, Denmark, France, Germany, Japan and Sweden, where governments were considering, or had adopted, policies emulating the Bayh-Dole Act's provisions. The UK was not mentioned in their study but was actually one of the first European countries to introduce similar policies. The UK Patent Act of 1977, for instance, clearly states that academic researchers in the UK are technically employees of the university at which they work, and therefore patent rights stemming from research results within that employment relationship belong to the university. As will be discussed in the following chapter, the impact of this stream of policies in the UK became substantial in the early 1990s when the UK higher education sector was significantly expanded.

2.2.2 Configuring university knowledge exchange

Universities have to date integrated economic development into their normal agenda and missions, which involve teaching and research (Etzkowitz 1998). One may conclude that, the most notable feature of modern universities is that they are engaged with various types of partners, in different modes of networks, at local, regional, national, and international levels. Knowledge flows between universities and private sector firms have been the focus of a large body of literature, which has tended to further distinguish between different types of firms, in terms of size, research intensity, and geographical location. As Huggins et al. (2008a, p. 333) argued, in comparison to their larger counterparts which are also often internationally-based and R&D intensive, SMEs could be regarded by universities as "inferior and less lucrative collaborators" (see also Cooke et al. 2000). This is in contrast with the fact that small firms, with limited resources devoted to in-house research, might be in greater need of university-produced knowledge than large companies. Although high-technology industries are considered to be the main partners of universities due to closer research focus between the two, it has been suggested that universities are also involved with lower technology industries (Pavitt 1984; Meyer-Krahmer and Schmoch 1998). It might be expected that links between academics and firms in older industries may take different forms from those for high-technology companies. In particular, while firms in high-technology fields tend to build research-based partnerships with universities, lower technology companies may rely on universities to provide consultancy, student placements, and facilities and equipment related services. Apart from businesses, universities and academics also work closely with government bodies and other public and third sector organisations (Abreu et al. 2009; CBR 2009).

The focus of early research on university-industry linkages has been knowledge transfer, e.g. patent licensing, an activity which deploys academic know-how to specific users. More recently, there is recognition that knowledge flows between universities and their partners are essentially a two-way process: from the universities to the partners and vice versa (Kline and Rosenberg 1986; Abreu et al. 2009). Indeed, communication between academia and industry is more like a learning process in which each body builds new knowledge from collaboration with the other, rather than a simple give-and-take relationship (Blind and Grupp 1999; Schartinger et al. 2002). A study by the Economic and Social Research Council (ESRC) claimed that the term 'knowledge exchange', in comparison to 'knowledge transfer', better captures the interactions between academics and the wider community (ESRC 2009). Furthermore, knowledge transfer is too specific (and narrow) to include the much wider channels of communication that academics are involved in (Klofsten and Jones-Evans 2000; Perkmann and Walsh 2007; D'Este and Perkmann 2011; Hughes 2011). In the UK, for instance, the Higher Education-Business and Community Interaction survey (HE-BCIs) – the main government instrument to collect data related to knowledge exchange activities in universities – views interactions from a broad perspective, and considers collaborative research, contract research, consultancy research, facilities and equipment (F&E) related services, as well as intellectual property (IP) channels. This is in line with the approach of many other studies which have argued that the importance of IP-related activities has been overestimated, and that focusing narrowly on IP channels underestimates the comprehensive roles of universities (Jones-Evans et al. 2000; Abreu et al. 2008; Hewitt-Dundas 2012; Huggins et al. 2012).

Whilst universities have been viewed as an important source of competitiveness by regional policy makers, it is necessary to point out that university knowledge networks are not always spatially bounded, but are both local and global (Andersson and Karlsson 2007). In their study of Tel Aviv, Belfast, and Cardiff, Cooke et al. (2002) found the evidence that universities have much stronger interactions with businesses at national and international levels than at regional level. It has also been claimed by many studies that knowledge sourced globally by firms may be superior to that from local sources (Davenport 2005; Johnson et al. 2006), which might help explain the rising levels of distant – national or international – partnerships involving academics and businesses. A possible situation in weaker regions, where the industrial base is dominant with a large number of small firms, is that universities and individual academics may have to find their partners elsewhere, as proximate firms lack absorptive capacity to commercialise the knowledge they can provide. There is still no simple answer however to the question of how the geographical feature of knowledge networks impacts on the effectiveness of academic-industry linkages and fosters the innovativeness of the business partners.

Another theme requiring greater attention in the literature is the relationship between the performance and intensity of university knowledge networks. While the performance of knowledge networks typically refers to the financial income generated by knowledge exchange activities, the intensity measures the degree of strength of network partnerships. Although it could be assumed that universities with high performance are also more actively involved in knowledge networks, the opposite could also be true. In other words, some universities are able to generate a high volume of income from a small number of large collaborative partnerships. One may face a dilemma when attempting to compare a university of this type with another university which is intensively engaged with a large number of small-scale collaborations. The latter situation is more likely to be seen in mid-range universities and in lagging regions dominated by small firms. From a regional policy perspective, to better match what universities can provide and what firms need might be more important than to simply aim for the largest amount of financial outcome from universities.

2.2.3 Antecedents of academic engagement

Factors influencing academic engagement in knowledge networks can be found and examined at various levels ranging from individual, departmental and organisational, to institutional. Studies have identified that individual characteristics such as gender, age and seniority of academics all play an important role in predicting their partnerships. When compared with their female colleagues, male academics are often more actively engaged with industry (Azagra-Caro 2007; Link et al. 2007). The impact of age on academic engagement is somehow ambiguous as the literature has yielded contrasting findings (D'Este and Patel 2007; Boardman and Ponomariov 2009; Giuliani et al. 2010; Haeusslet and Colyvas 2011). Senior researchers are more likely to have larger networks, as shown in many empirical studies, because they may be more reputable in research and have previous experience with industrial collaborators (Van Dierdonck et al. 1990; Landry et al. 2006; Bozeman and Gaughan 2007). Individual academics' decisions to participate in knowledge networks are the outcome of many factors combined, including their motivations, perceptions of opportunities, and barriers to collaboration (Abreu et al. 2009; Goldstein 2010). Caution should be exercised however when analysing what factors could largely motivate academics to build linkages with business, as they might be negative rather than positive. For instance, some previous studies have found that organisation-level academic quality appears to be negatively associated with participation in collaboration activities (D'Este and Patel 2007; Ponomariov 2008). This seems to suggest that academics in lower quality research institutions are more motivated to embrace industry collaboration. In general, such institutions may provide a lower degree of resource munificence for academics, which could motivate, or force, their employees to acquire external research funding by working with business.

Extensive literature has analysed the role of departmental features in deciding academic engagement in knowledge networks (Owen-Smith and Powell 2001; Martinelli et al. 2008). While it is widely accepted that patents and licenses are not a relevant knowledge transfer channel for researchers in computer science, they are among the most important channels for academics in fields such as biomedical and chemical engineering (Bekkers and Bodas Freitas 2008). A general conclusion is that disciplinary affiliation is an important variable predicting academic engagement with industry (Lee and Bozeman 2005;

Boardman 2008). Also, studies on academic collaboration have tended to distinguish between social sciences and applied fields of research, arguing that the importance and intensity of knowledge transfer channels may differ between the two groups (see Lee 1996; Boardman 2009). To include fields such as social sciences, arts and humanities in empirical studies is actually a recent trend, as the early literature did not generally consider academics in those disciplines as entrepreneurial or relevant to engagement. In their survey between 2008 and 2009, Abreu et al. (2009) argued that social scientists participate widely with business and the community, although in different ways to engineers and scientists.

On an organisational level, the research quality and income of the affiliate university are indicators commonly used when analysing academic engagement. Generally, it is argued that the most research intensive universities also "possess greater networks with external organisations" (Huggins et al. 2010b; see also Lockett et al. 2003). World excellent research in these institutions serves as a magnet for large global partners which pursue the best knowledge regardless of its location. The influence of the prestige and reputation of institutions on their external networking capability is rather relevant especially in the UK context, thanks to the hierarchical nature of the UK university system. In particular, UK universities are usually referred to as being established or new, depending on when they were granted the university status. The distinction is also related to the overall quality of universities, with more established universities being more research focused and newer universities often being weaker in research output (Lambert 2003). In areas of spin-offs, patents, and licences, Lawton Smith (2003) found that the four UK universities with the highest research income and quality – the University of Oxford, the University of Cambridge, UCL and Imperial College London – are also the leading performers in technology transfer activities. This echoes the positive correlation between the institutional research performance and the individual participation in knowledge commercialisation identified in many other studies (Jones-Evans et al. 1999; Carlsson and Fridh 2002; Di Gregorio and Shane 2003; Markman et al. 2005; O'Shea et al. 2005; Phan and Siegel 2006). While the role of UK universities in stimulating innovation performance has been highlighted by the government, the review by Sainsbury (2007) has stated that established and new universities cannot be expected to contribute equally to this goal and should focus on different activities.

Again, with a few exceptions, there is a lack of empirical studies examining university knowledge networks from a wider perspective to carefully compare how researchers are involved in activities beyond knowledge commercialisation. Research-intensive universities might outperform their counterparts in IP-related activities, but not necessarily in all other categories of engagement. Indeed, the participation in and promotion of knowledge exchange activities are largely conditioned by missions, strategies, values, and cultures of individual universities (Vorley and Nelles 2009; Kitagawa and Lightowler 2013). Although it is an important task to recognise the diversity of university types, which has not been given much attention by policy makers (Lawton Smith 2007; Abreu et al. 2008; Kitson et al. 2009), the knowledge networks of universities may be best examined on an institution-by-institution basis.

There is little comparative empirical evidence of the role of institutional contexts in academic engagement (e.g. national policies) although a relatively large body of literature has examined those institutional-level factors encouraging commercialisation activity, especially the introduction of policies like the Bayh-Dole Act (Sampat et al. 2003; Mowery and Sampat 2005; Powers and McDougall 2005). At least from these studies, it seems that participation in knowledge commercialisation is positively related to the level of competition that academics face (Goldfarb and Henrekson 2003). Understandably, intense competition for resources would motivate academics to become more active involved in searching for partners and securing extra research funding which would otherwise be unavailable. In a sense, the way in which competition drives academic engagement is similar to how being in a lower quality university motivates researchers to work with business.

2.2.4 University R&D and regional innovation

In general, there has been an increase in the level of policy expectations as to how universities can impact regional development, especially through the establishment of knowledge networks which will embed innovation activity in the territories (Jones-Evans and Klofsten 1998). Less is known about the actual processes of knowledge flows between academics and businesses and how these processes vary across regions (Porter and Ketels 2003; Power and Malmberg 2008; Huggins and Kitagawa 2012). This lack of understanding complicates the design and implementation of policies aiming to fully realise the direct and indirect contribution universities make to economies (Kelly et al.

2002). As the bulk of current literature tends to focus on IP-related activities, empirical studies including a wider spectrum of academic engagement are needed to understand how university knowledge flows; in what ways, between whom, and to where. The concern about the role of regions in knowledge networks corresponds to the arguments made by previous researchers that the impact of universities varies not only over space but also over time (Pavitt 1984; Nelson 1988; Cohen and Levinthal 1990). Directions that future research could possibly follow include examining regional differences in the structure of university knowledge networks and tracking the evolution of knowledge networks within the same region throughout a longer period to identify factors underlying those changes.

Policy interventions to increase territorially focused university-industry interactions are often justified by the claim that university knowledge tends to spill over within a certain geographical distance, showing the phenomenon of the so-called localised knowledge spillovers (Raspe and van Oort 2011; Munari et al. 2012; Giuri and Mariani 2013). A growing body of literature has emerged on the subject, represented by, for example, case studies on US high-technology clusters, Italian industrial districts, and innovative milieus (Breschi and Lissoni 2001a). According to Breschi and Lissoni (2001b), localised knowledge spillovers (LKSs) could be first and foremost defined as knowledge externalities bounded in space which allow companies operating nearby important sources such as universities in order to introduce innovation at a faster rate than rival firms located elsewhere. This stream of studies has by and large attributed LKSs to the fact that knowledge is often tacit and sensitive to the distance between the organisations which attempt to exchange knowledge effectively.

Despite it is the tacitness of knowledge that might make spillovers sensitive to distance, an early focus of such studies has been on examining linkages associated with codified forms of knowledge, such as "patent activity … and innovation rates" (Howells 2002, p. 875). Jaffe's (1989) study assessed the effects of academic research and showed that corporate patent activity at the US state level was influenced by the R&D spending performed by local universities, after controlling for corporate R&D and state size (measured by population). Using patent citations, Jaffe et al. (1993) studied the geography of knowledge spillovers from academic research into corporate R&D. One finding was that firms were more likely to cite research from a co-localised university with relevant research strengths than from universities elsewhere.

Also, the impact of universities on regional innovative output in a number of European countries has been examined by studies which present findings in line with those for the US. For 72 political districts in Austria, the work of Fischer and Varga (2003) provided evidence on the importance of geographically mediated knowledge spillovers from university research activities to regional knowledge production in high-technology industries. The choice of high-technology industries seems to lie in the authors' belief that it is these sectors where knowledge, both technological and scientific, plays a significant role. Applying the Griliches-Jaffe production function at the regional level in France, Ronde and Hussler (2005) confirmed that the interrelationships developed between the actors within the territory determine regional innovativeness. Similar evidence has been found from empirical analysis in Italy (Piergiovanni et al. 1997) and Sweden (Andersson and Ejermo 2004). An innovation survey covering regions across a number of European countries has also shown that most of the private sector cooperation partners of universities are located at a relatively close distance (Fritsch 2003, 2005).

As empirical studies have narrowly focused on patentable knowledge, more theoretical supports are required to clarify the concept of knowledge spillovers. Through a critical survey of the growing literature on the topic, Breschi and Lissoni (2001b) gave two main reasons for the inadequacy of the majority of studies which attempt to interpret the spillover effect through quantitative ways, e.g. patent citations by local firms. On the one hand, the role of geographical distance in the economics of knowledge transmission – which is still rather controversial – has distracted too much research effort; on the other hand, studies could possibly lead to naïve policy implications. At the end of their research, Jaffe et al. (1993) actually pointed out the limitations of their study in relying on patent and citation data and proposed further research to include a wider range of mechanisms of knowledge transfer. From the theoretical perspective it is a sound idea to quantitatively analyse the spillover effect of both codified and tacit knowledge, but the challenge is about how to measure tacit knowledge and track its spillovers in practice.

The literature which assumes a simple causality between university R&D and regional innovation performance has been heavily criticised, especially the proposition that the mere presence of a university is no guarantee of a significant contribution to the performance of an innovation system (Fritsch and Slactchev 2007). In this view, arguments such as that of Jaffe's (1989, p. 968) – "a state that improves its university research system will increase local innovation by attracting industrial R&D and augmenting its productivity" – may be arbitrary without considering it is also possibly the case that increases in university outputs can be caused by increases in industrial R&D. One may find it is more likely that universities' knowledge production and industrial innovation facilities are circular, with an increase in one facilitating and stimulating further growth of the other. Thus it is not hard to see an increasing number of studies questioning the generality of the role of university in fostering regional industrial innovation (see Feldman 1994).

While the majority of studies have focused on knowledge spillovers from academic institutions, spillovers from other types of knowledge creators have been left underexplored. For instance, Greunz (2005) argued that the level of patenting within a region is not just related to the knowledge created by universities, implying the contribution of other sources. The work by Beise and Stahl (1999), based on 2,300 responses to a postal questionnaire, has found that the impact of public research institutes on German firms' innovations to be concentrated in spatial proximity to the respective source. In their exploration of the effect of proximity on knowledge flow from public research organisations (PROs) to Europe's largest innovative firms, Arundel and Geuna (2004) also recognised the importance of proximity for sourcing knowledge from PROs, especially when the respondents regard the research organisation as a highly important source of knowledge. However, proximity does not seem to be so significant for firms that perform high levels of R&D expenditure and rank codified research results as priority.

The significance of taking public research institutes into account lies not only in how firms could source knowledge from them, but also in the sense that public research organisations and universities combined could better drive regional development than either of them alone. Evidence from global leading regions seems to suggest that, in those areas, "while universities can play an important role they are often supported by a dense system of institutions, including publicly funded research institutes and laboratories dedicated to applied research" (Huggins and Johnston 2009a, p. 1101). By contrast, less competitive regions tend to show a lack of this type of established research infrastructure, leaving universities as the most important, but only, source of advanced knowledge. Governments in some such regions therefore further reinforce their expectations on universities by piling new functions and activities onto them, which however often leaves universities with a mission impossible (Jacob et al. 2003; Nedeva and Boden 2006). In other words, the overdependence on the higher education sector in some areas may turn out to be detrimental to those universities.

The structure and impact of university knowledge networks in regions should not be examined alone, but be better investigated together with the technological level of regional industrial base – which conditions the potential demand of academic knowledge – and the innovative strength of public and private research institutes that enlarge the potential impact of academic knowledge. A comprehensive map of regional knowledge sources could also provide a more pertinent interpretation of the role of universities. Indeed, as firms could either source knowledge internally or externally, and could externally source knowledge from universities and public research organisations, an important task is to better understand the need of university knowledge from the demand side – firms.

2.3 Firms, knowledge sourcing, and innovation

2.3.1 Sourcing knowledge for innovation

Firms are analysed in this study to evaluate the need for knowledge produced by universities, as they have often been considered to form an important part of the demand side of academic knowledge (Abreu et al. 2008, 2009). A better understanding of the demand side of the economy for innovation is crucial in the sense that it adds another perspective to regional studies which have tended to focus on the supply side of regional innovation systems, such as investment in higher education research and development. It could be argued that this approach is especially critical in uncompetitive regions where the fundamental challenge is more likely to be the lower capacity of firms to absorb innovation rather than the lower investment in R&D (Lambert 2003). Without addressing the issues that impede the ability of firms to utilise advanced knowledge, policies which merely promote investment in the supply side may almost certainly fail and, more importantly, may lead to further leakage of knowledge to competitive regions which show greater demand from the private sector (Siegel et al. 2007; Youtie and Shapira 2008). Uyarra (2010), for instance, has argued that how to align knowledge producing networks with firms has become an issue which needs to be carefully addressed in regional policy.

A growing body of literature has investigated how knowledge sourcing impacts the business performance, given the fact that firms are organisations specifically planned and run to reap benefits from their behaviours (Belderbos et al. 2004b; Kotabe et al. 2007; Kang and Kang 2009; Öberg and Grundström 2009; Vega-Jurado et al. 2009; Li and Tang 2010). Typically, it has been suggested that knowledge spillovers, either from universities or from other private firms, are key sources for promoting business innovation (Sorenson et al. 2006). This is set within the context that firms are viewed as the innovation engine of the world: they produce better products, design improved processes, and innovate existing services (Scherer 1986; Hagedoorn 1996; Breschi et al. 2000).

Schumpeter has been recognised as a key figure on innovation, and for some he is seen as the 'father' of innovation studies (Freeman 2003). To Schumpeter, innovation consists of any one of the following five phenomena: 1) introduction of a new product; 2) introduction of a new method of production; 3) opening of a new market; 4) conquest of a new source of supply of raw materials or half-manufactured goods; and 5) implementation of a new form of organisation (Schumpeter 1912; see also Wood 1991). An important distinction is made by Schumpeter between invention and innovation: invention is an act of intellectual creativity but without importance to economic analysis

(Schumpeter 1939), while innovation is the first attempt to carry it out in practice and thus is an economic decision. Later classifications of innovation have generally followed the idea of Schumpeter by distinguishing between different 'types' of innovation such as product innovation and process innovation. According to how radical an innovation is there are continuous improvements, which are often named as incremental innovations, and there are radical innovations which, for instance, could refer to the introduction a totally new type of machinery in a specific industry (Ettlie et al. 1984; Dewar and Dutton 1986).

While firms now increasingly compete against opponents with more innovations, e.g. advanced technologies or services, it has been claimed that attracting and maintaining firms with stable or rising market shares in an activity becomes a major source of regional or national competitiveness (Huggins and Johnston 2009a). In the era of the knowledge-based economy, as previously argued, regions outperform their counterparts via a better equipped innovation system, which could make the best use of both internal and external innovation resources. A closer examination of innovation strategies of firms in terms of sourcing knowledge is therefore essential to identify the patterns of knowledge networks involving firms and universities, and to recognise how regions show different territorial innovation patterns.

In a longitudinal view, the combination of internal and external resources has not come to the fore of business innovation strategy until recently. More specifically, firms used to create knowledge, as Nelson and Winter (1982) put it, through in-house R&D efforts, and R&D spending of a firm would accordingly determine the probability of a firm coming up with an innovation. This is not to deny the fact that many companies have been using the input of outsiders to improve internal innovation processes over many decades, much earlier than the publications of Chesbrough's work on open innovation (Chesbrough 2003a, 2003b, 2003c). In his book – *Open Innovation: The New Imperative for Creating and Profiting from Technology* – Chesbrough (2003a) stated that there has been a significant paradigm shift in innovation for major companies. The concept of 'Open Innovation' was introduced to contrast with the idea of 'Closed Innovation' which refers to the used-to-be innovation paradigm. Under the closed innovation theory, companies "generate their own ideas, develop them, build them, market them, distribute them, service them, finance them, and support them on their own" (Chesbrough 2003a, p. xx). By contrast, open innovation assumes that "firms can and should use external ideas as well as internal ideas, and internal and external paths to market" as the firms look to advance their technology (Chesbrough 2003a, p. xxiv).

The search for and collaboration with outside partners by firms could be found in relation to many factors, from the ever-increasing costs of R&D to the shorter periods of technological advancement. One strand of literature associates the growing importance of R&D collaboration with the transaction cost theory, which argues that relationships will help a firm lower its costs in the search for partners and in the diffusion of innovation. As enterprises could be viewed as a collection of contracts and relationships, or networks, it has been suggested that it is “the totality of these contracts and relationships … that defines the firm and creates its distinctive capabilities” (Biggs and Shah 2006, p. 2).

For Howells (2000), a major reason for the deepening reliance of firms on external knowledge is that the complexity of production has increased dramatically. A good example for this is the case of the smart phone. While mobile phones used to have only basic voice, SMS (short message service) and a small number of applications such as an alarm, they have gradually been advanced to integrate a diverse range of technologies, e.g. radio, mp3, camera, email, games, touch-screen and e-book reading, representing an on-going shift from device-oriented to service-oriented as termed by Roivainen et al. (2007). It becomes hard to believe that one company would possess the scientific resources necessary to cope with all the demands and refuse to seek external support to overcome their own technological limitations. DeBresson et al. (1998), who used the rankings of a range of external agents by innovating firms to estimate the importance of information networks for innovation, found only a small minority of innovative achievements have been developed internally.

A swift adaptation of firms to open innovation might not be easy, as the process could be influenced by how a firm is structured, its customs and culture, as well as its business model. Despite the fact that many studies have emerged on open innovation since the work of Chesbrough, there is still a lack of clear understanding as to what ‘openness’ means, further complicating the situation if a firm intends to undertake the strategy. Dahlander and Gann (2010) urged a better definition of ‘openness’ after they found that there exist both upsides and downsides when a firm becomes more open. On the upside, external actors can leverage innovative capabilities of a firm through networking and collaborating, in line with the arguments made by Chesbrough (2003a). Too much openness however may, "result in resources being made available for others to exploit, with intellectual property being difficult to protect and benefits from innovation difficult to appropriate" (Dahlander and Gann 2010, p. 699). Despite these unresolved problems an increasing number of firms have implemented the idea of open innovation and built knowledge networks with external partners.

Whilst the focus of this study is on university-industry interactions, it needs to be clarified that firms could, and actually do, source knowledge from various types of organisations, including other private firms and public research organisations, to secure competitive advantage (Huggins 2000, 2001; Hagedoorn 2002; Lechner and Dowling 2003). Studies have been trying to distinguish the diverse range of networks through which firms source knowledge. For example, Tether (2002) analysed how UK firms interact with suppliers, customers, competitors, universities and consultants. In his analysis of German service enterprises' cooperative R&D partnerships, Kaiser (2002) compared vertical cooperation (that with suppliers and customers) and other types of cooperation. Belderbos et al. (2004a), when examining their sample of Dutch firms, undertook a more comprehensive typology which takes into consideration three types of cooperation: horizontal (with competitors), vertical (with suppliers or customers), and institutional (with universities and research institutes).

Inter-firm knowledge interaction has for a long time been identified as an important way in which firms access needed knowledge. Back in 1920, when Marshall was investigating the agglomeration phenomenon of firms, he ascertained knowledge spillovers between firms as one of the three major driving factors, with the other two being access to skilled labour and access to specialised suppliers (Marshall 1920). Huggins and Johnston (2010) further distinguished inter-firm knowledge networks into two forms: contact networks and alliance networks. Contact networks are used by firms to source knowledge and involve non-formalised interaction and relationships between firms, while networks in the form of alliances usually consist of formalised collaboration, and therefore facilitate firms to innovate (see also Gulati 2007).

2.3.2 Use of academic knowledge by firms

As firms are reliant on a variety of organisations as knowledge sources, the actual role played by university research in firm innovation shall be better understood when examined in comparison to other types of knowledge producing entities. While earlier works such as Charles and Howells (1992) and Lawton Smith (2000) have looked the demand side of university interaction, this topic has still been given relatively little attention in the literature. Based on a survey of firms' perspective of links with HEIs in three European countries, Charles and Howells (1992) assessed the motives, searching procedures and decision to collaborate with HEIs by firms. Lawton Smith (2000) analysed the extent and nature of links which firms in the flow measurement industry and the electronic component industry have with universities and national laboratories. More recently, Cosh and Hughes (2010) concluded that academic knowledge has a rather limited role as a source of knowledge for business innovation. This seems to suggest that, although universities may be the largest knowledge creation body in our society, they are not necessarily creating the type of knowledge firms require (Tornquist and Kallsen 1994; Feldman and Desrochers 2003). The mismatch between what knowledge academics supply and what knowledge firms demand may not be surprising if their different characteristics are acknowledged (Hall et al. 2001). In particular, while academic knowledge may demonstrate a predominantly generic nature, industrial R&D is more likely to be directed towards marketable products or technologies. Whether or not the basic attribute of university research should be diverted to commercial ends has been widely debated; for example, academics have expressed concerns about its potential detrimental effects on the type and quality of the research outputs (Rae-Dupree 2008; Washburn 2008; Thursby and Thursby 2011b).

In Europe, the Community Innovation Survey (CIS) represents an important effort made by policy makers to empirically evaluate the importance of various types of organisations to firms as sources of knowledge. The UK Innovation Survey (UKIS) is the UK arm of this Europe-wide project, with its more recent results published in 2010 by the Department for Business, Innovation and Skills (BIS). The questionnaire of the UKIS 2009 was sent to some 28,000 UK enterprises with 10 or more employees across the manufacturing and service sectors and about half of those firms provided usable responses. Firms which claimed they had cooperation arrangements on innovation activities – around

23 per cent of all respondents – were asked to identify their most frequent partners from a total of eight types of organisations. It turned out that communication with clients or customers was ranked as the most frequent linkage, while communication with suppliers, competitors and consultants were ranked second, fourth and fifth respectively. Universities were only ranked sixth, while public research organisations fell at the bottom of the ranking.

When focusing on university-industry relationships, as claimed in the previous section, there has seen a shift of research focus from the knowledge transfer of intellectual property to multifaceted channels and mechanisms of knowledge exchange (Meyer-Krahmer and Schmoch 1998; Agrawal 2001; Cohen et al. 2002; Schartinger et al. 2002; D'Este and Patel 2007; D'Este and Perkmann 2011). Cohen et al. (2002), for instance, considered the following channels connecting firms and universities: patents, informal information exchange, publications and reports, public meetings and conferences, recently hired graduates, licenses, joint or co-operative research ventures, contract research, consulting, and temporary personnel exchanges. A total of 16 types of knowledge interaction were included in the study by Schartinger et al. (2002) and grouped into four categories, namely: joint research, contract research, mobility and training. The exact categorisation of university-industry linkages is determined by research objectives and may differ according to each investigation. This research follows the approach undertaken by the HE-BCI surveys which collected data related to knowledge exchange activities between UK universities and firms in collaborative research, contract research, consultancy research, facilities and equipment related services, courses for business and the community, as well as IP-related activities (Hewitt-Dundas 2012; Huggins et al. 2012).

2.3.3 Local buzz and global pipelines

Another focus of the literature has been geographical features, i.e. the local, regional, national, and international dimensions, of knowledge networks in which universities or firms are involved. The previous section about university knowledge exchange activity has cast doubt on policy initiatives which aim to develop stronger, but territorially based, university-business linkages, as more recent empirical evidence has recognised an increasing importance of distant knowledge networks for academics (Charles 2003; Lawton Smith and Bagchi-Sen 2006; Coenen 2007; Lawton Smith 2007). In addition to these arguments from the knowledge supply side, it is of value to investigate where firms frequently access knowledge from as it would deepen our understanding of the knowledge demand side.

Many studies have confirmed a co-existence of both local and non-local knowledge networks in which firms get engaged (Kingsley and Malecki 2004). In general, firms may source and acquire applicable knowledge wherever it is available, local or not. However, it is also considered that firms, in particular SMEs with relatively low knowledge absorption capacities, would be more likely to rely on localised knowledge sources (Cohen and Levinthal 1990). For those SMEs whose growth is driven by introducing more innovative products or services, geographically proximate knowledge may not satisfy their demand, therefore they would look elsewhere (Davenport 2005). For example, when examining the regional networks of SMEs in the Metropolitan Area of Ottawa in Canada, Doloreux (2004) found there is not a prevalent localised external networking, especially in the networks for technological development.

In the viewpoint of Bathelt et al. (2004), these more innovative SMEs are the key nodes of knowledge networks linking the global pipelines and local buzz, a feature also shown by many large firms (Gertler and Levitte 2005). Empirical evidence seems to imply that the probability of a firm to get involved with global pipelines of knowledge increases with the size of the company (Huggins et al. 2010a). Indeed, large firms, in comparison to their smaller counterparts, usually own more abundant resources, which could be devoted to building collaborations with partners around the globe. As Bowey and Easton (2007) claimed, smaller firms tend to have a stronger reliance on their social networks – which are probably localised – as sources of knowledge than large firms.

The reason behind the fact that some firms make non-local linkages might be more complicated than expected. As Malecki and Hospers (2007) argued, innovative firms in regionally sparse knowledge environments may be 'forced' to establish distant network links. In such cases, even if leading firms have the intention to source knowledge from proximate universities or institutions, they may face practical difficulties in finding suitable partners with knowledge that matches their requirements. This would suggest that finding distant partners may become more of a necessity for such firms. If policy makers in these types of regions aim to foster local university-business relationships, a fundamental problem to be addressed is the shortage of knowledge supply to meet the demand. Since regions almost certainly differ from each other in the relationships between knowledge supply and demand, specially tailored policies are required to tackle the problems constraining knowledge exchange.

2.3.4 Determinants of firm knowledge sourcing

The literature, which aims to identify important determinants of firm knowledge sourcing, either from universities or public research organisations, has largely confirmed the influence of sector, size and strategy of firms. In general, it has been found that firms those are knowledge-based or in high-technology sectors might be more inclined to source knowledge externally (Audretsch et al. 2005; Huggins and Izushi 2007). An explanation for this, as given by Nagle (2007), could be that university research is more likely to be correlated with the knowledge demanded by high-technology industries. For Woerter (2012), it is not only the sectoral feature of a firm but also the technology (knowledge) proximity – similar technological orientation of partners – that determines the probability of collaboration between two entities, e.g. university and enterprise. While many earlier studies have measured technology proximity between firms by examining their patent activities (Jaffe 1986; Cantner and Meder 2007; Nooteboom et al. 2007), the work by Woerter (2012) is an early effort to understand how technology proximity fosters knowledge transfer from universities to enterprises.

Firm size is also an important factor explaining to what extent enterprises may develop external networks to access knowledge, yet with no straightforward relationship. Whilst it has been suggested that, small and new firms do not possess a large share of resources devoted to their own R&D, and therefore are more likely to use external knowledge produced by either other firms or universities, it is also possible that in reality they would face more difficulties than large firms when networking with partners (Scherer 1991; Bennett 1998; Huggins 2000; Audretsch and Thurik 2001; Hall et al. 2003; Link and Scott 2003). This might help explain why small firms tend to seek help from the social networks of employees, rather than formal types of cooperation (see Aldrich and Zimmer 1986; Lechner et al. 2006; Bowey and Easton 2007). It could also be expected that this dilemma of knowledge sourcing between necessity and capability still holds when small firms attempt to work with universities. In addition to the factors of sector and size, many empirical studies have pointed out the role of business strategy, such as a broader outlook and a willingness to collaborate, in facilitating firms to engage in interaction with universities (Huggins et al. 2012).

For regional policy makers, the evaluation of the structure, intensity and impact of firm knowledge networks should be considered as an important step towards designing effective knowledge exchange policies and programmes. As sector, size and strategy are all crucial factors determining how firms source knowledge externally, one has to pay special attention to all these elements in order to understand at a regional level the capability of firms networking with partners. A further challenge lies in the fact that the industrial base of a region, competitive or uncompetitive, is certainly to be composed of firms from all sectors and of all sizes, although regions may differ from each other in the shares of certain types of firms. Because firms are embedded in networks through a variety of channels (formal and informal, explorative and exploitive) with a wide range of organisations to achieve competitive advantages from the combination of these networks, a crucial question needs to be answered as to how important universities actually are to firms in innovative activities. Answers to this question would definitely help to evaluate the policy approaches undertaken in regions, especially those that have overwhelmingly focused on universities.

2.4 University knowledge as a panacea?

This literature review has examined three broad strands of literature to understand the interrelationships between university knowledge supply, business knowledge demand, and regional competitiveness. In particular, each of the three sections in this chapter has been aimed to focus on one of the above three strands. At the regional level, maximising the potential impact of knowledge, especially through knowledge exchange between academics and businesses, has been top of the agenda for policy makers in more and more places. Although the role of knowledge networks in driving regional competitiveness has been widely recognised, there is little understanding of the features of those networks. These features may refer to if knowledge networks are formal or informal, explorative or exploitative, strong or weak, proximate or distant. In general, the extant evidence has tended to suggest that all these types of networks are important and regions should ideally have a good combination of them. To this end, the literature review questions the universality of the role universities could play across regions, and argues that the specific context of a region, such as its competitiveness, should be deeply understood, and the structure of networks between the supply and demand sides of knowledge should be fully figured out, if any relevant policy instrument is to be really effective, as there is not a 'one-size-fits-all' solution to all regions.

For universities, as our world has now arrived at an era in which knowledge becomes an important source of competitive advantage of firms, regions and nations, they are expected to establish more direct interactions with the practical world to make larger contributions to the process of invention, innovation, and knowledge commercialisation. From a historical perspective, universities have integrated economic development into their normal agenda and missions, which involve teaching and research, and now engage in a wide range of knowledge exchange activities. Nevertheless, much of the literature has focused on measuring the (financial) performance of knowledge exchange activities, with little attention being paid to the intensity of networks. The extent to which academics are engaged in knowledge networks has been found to be influenced by factors at various levels ranging from individual, departmental and organisational, to institutional. While there has been an increase in the level of policy expectations as to how universities can impact regional development, it is important to note that they are often supported by a dense system of other institutions whose role should not be overlooked.

Firms, which are considered to form an important part of the demand side of academic knowledge, have been analysed in the literature review to evaluate the need for knowledge produced by universities. Due to a stronger need of sourcing knowledge from external organisations, firms have been transforming their innovation strategies. While they used to create knowledge mainly through in-house R&D efforts, firms are now more likely to use external ideas as a result of the ever-increasing costs of R&D and the increasing complexity of production. When sourcing knowledge, firms could do so from various types of organisations, such as suppliers, competitors, customers, as well as universities, suggesting that the actual role played by university research in firm innovation needs to be examined carefully. Some empirical evidence has indicated a limited role played by academic knowledge in business knowledge sourcing, implying that there might be a mismatch between the supply and demand sides of knowledge. Furthermore, when working with universities, firms could engage with local, regional, national, and international institutions. The literature has found that sector, size and strategy of firms are important determinants of firm knowledge sourcing activity.

Drawing together the three strands of literature, the literature review has identified a number of research gaps which correspond to the research questions at the heart of this thesis. It is crucial to explain how the three strands of literature are used to construct the analytical framework, which organises the layers of analysis, guides the data analysis, and orientates the interpretation of the findings (see Section 4.5 for the framework). As there are a large number of factors to be considered in the analysis, the analytical framework is vital in deciding, in a comprehensive but straightforward way, what factors are examined, why they are chosen, and how they are examined. The choice and organisation of these factors have largely been guided by the availability of data collected in the analysed datasets. In general, the framework is a supply-demand model of knowledge, with university on the supply side and business on the demand side. For knowledge networks, the framework considers three aspects, namely knowledge exchange mode, type of partner, and location of partner. For firms, the framework examines its size and location, while the sectoral effects on patterns of interaction is not examined but would be in future research. For universities, the framework considers their status and location. For regions, the framework takes into account their competitiveness. Given the complexity of the framework, it is intentionally broken down and each empirical chapter only deals with part of it. In addition, it has to be noted that, to avoid confusion, the analytical framework (Figure 4.1) identified in Section 4.5 covers the factors analysed in the two quantitative chapters and does not show the factors analysed in the case study chapter, as the case study is conducted within the same region. The factors analysed in the case study chapter are also derived from the literature review and are organise in a four-level framework, including the individual, departmental, organisational and spatial levels (Figure 7.1).

The absence of a comprehensive framework considering factors of regions, university supply and business demand is the main gap in the extant literature, and is to be developed within the first empirical chapter and relates to the principal research question: What are the relationships between the university supply and business demand of knowledge across UK regions? Using the supply-demand model, the empirical analysis places a special focus on regions in the UK. The UK is considered to be a good example to examine this phenomenon, as it has a relatively large higher education sector, with universities showing different levels of research intensity. Another important feature of the UK is that regions perform significantly differently in terms of competitiveness. Analysis of university knowledge exchange, business knowledge sourcing, and knowledge supply-demand relationship will be carried out to see if these factors are associated with the competitiveness of regions.

When analysing the knowledge supply-demand relationships in the UK regions, the first empirical chapter also attempts to plug the second gap namely a knowledge deficit regarding how businesses perceive the role of, and utilise, university knowledge. This relates to the research question: How differently do businesses in UK regions engage with universities in various types of activities and at different geographical levels? Whilst the literature has argued that knowledge sourcing by firms is determined by a number of factors, the empirical analysis shows how intensively UK businesses source knowledge from universities, which then contributes to an understanding of the 'real' importance of academic knowledge in business development. The influences that the size and location of firms might have on their interactions with universities are also investigated in this study.

A lack of understanding of the intensity aspect of university knowledge networks is considered to be the third gap in the literature and this is addressed in the second empirical chapter. In particular, this gap relates to the following question: How do the exchange activities encompassing university knowledge networks differ across regions? Much of the literature has focused on measuring the (financial) performance of knowledge exchange activities, with little attention being paid to the intensity of networks. The second empirical chapter draws a comparison between these two aspects of knowledge networks, and intends to search for what underlies the outperformance of universities in competitive regions. The findings are of relevance to policies in those regions that just aim for the largest amount of financial outcome from universities.

The final empirical chapter address a further gap in the literature that there is a lack of studies examining factors that influence academic engagement in knowledge networks at various levels at the same time. As a result of data limitation, these factors are not investigated in the first and second empirical chapters which are focused on the 12 UK regions; the final empirical chapter, focused on a specific region of the UK, aims to address the following question: What are the success factors of knowledge exchange programmes in force in Wales which enable the universities to reach out to businesses? The initiatives analysed via a case study methodology are intended to show the complexity of knowledge exchange activities even at the regional level, and to provide complementary, and qualitative, findings to those from the UK-wide surveys analysed in the previous two chapters. As the programmes selected are based within the same region in the UK, it is considered that institutional factors are of little relevance and thus excluded from the analysis. Therefore, the success factors are identified at the individual, departmental, organisational and spatial levels as already discussed in the literature review.

CHAPTER 3

ANALYSING THE UK POLICY CONTEXT FOR REGIONAL COMPETITIVENESS AND UNIVERSITY KNOWLEDGE EXCHANGE

As an essential way to link theory and practice, this policy context chapter examines the main issues covered in the literature review in the UK context. It is intended to help the understanding of how UK universities may be able to leverage their knowledge networks as competitive assets in their region. In particular, this task is undertaken in the following three steps. By reviewing the long-standing debate over the existence and implications of a 'North-South Divide' in the British economy, the first section shows that there is still wide variation in the competitiveness of UK regions in the knowledge-based economy. The second section discusses the historical development of the UK higher education sector, with a special focus on the recent policy trends which call for greater contributions from HEIs to regional competitiveness. A policy-level analysis of university knowledge exchange initiatives across the four nations that make up the UK is presented in the last section, mainly addressing the following question: What are the main initiatives in the UK made available to catalyse university knowledge exchange performance during the last 15 years? It is found that, although a large number of policies and programmes have been established by the governments, they are more likely to be supply driven, with much less attention being paid to the business demand side of knowledge.

3.1 A north-south divide in economic fortunes

The UK economy is geographically fractured with areas of prosperity and areas of deprivation, a problem famously labelled as the 'North-South Divide' (Martin 1988, 1993). The term generally refers to the spatial, economic imbalance between a more prosperous 'South' and a less prosperous 'North'. It should be mentioned that the divide is not an exact line and depends on the presumptions one may have. Despite that, uneven regional economic development has long been a feature of the UK economy which some studies suggest can be traced back to as early as the Victorian era. Whilst the Midlands and Northern regions were perceived to be the wealthiest areas in those times in the conventional view, Gardiner et al. (2013) found evidence which suggests that London and South East were in fact the leaders in the second half of the 19th century, at least in terms of wages and per capita incomes (Rubenstein 1977; Lee 1986; Crafts 2005). It is on this basis that Gardiner et al. (2013) asserted that something of a 'North-South Divide' existed even then.

The debate resurfaced in the 1980s after a few decades when it was not that evident (Baker and Billinge 2004). While large-scale losses of manufacturing employment, brought on by the deep recession of 1980-82, took place in the weaker industrial economies of the regions beyond the south of England, regions such as the South East, the South West and East Anglia experienced a rapid expansion in the service sector (Gudgin 1995). Furthermore, the extent of regional disparities has increased consistently since the 1980s, as revealed by the data from the Office for National Statistics (ONS). In 2012, London's gross value added (GVA) per head – an indicator of output in different areas of the country – was nearly 75 per cent above the UK average, while that of the least productive region (Wales) was 28 per cent below the average.

In his speech on economic decentralisation given at Mansion House on 18 February 2013, Deputy Prime Minister Nick Clegg addressed the problem of regional disparities in the UK economy since the 1980s. In particular, he argued that the decline of the regions was led by specific historical shifts, with developed nations moving away from heavy industry towards knowledge-driven and service-based economies in order to remain competitive in the globalisation era. One could derive two key concepts from this statement, namely the knowledge-based economy and competitiveness. On the one hand, there has been a growing interest from the UK government in building the knowledge-based economy, the most distinctive and valuable assets of which are increasingly knowledge, skills and creativity rather than traditional factors such as land and other natural resources. Policies towards skills, training, and support for the universities and other higher education and research institutes consequently become crucial in this regard. On the other hand, competitiveness has gained its popularity in the policy domain as it offers a holistic way of assessing the changing constraints on UK productivity and prosperity growth over time (DTI 1998, 2000).

From 1998, the then Department of Trade and Industry (DTI) began regularly publications of its *Regional Competitiveness Indicators*, which were later amalgamated with the Regional Development Agency's (RDA) *State of the*

Region Indicators to form the *Regional Economic Performance Indicators (REPI).* The aim of the *Regional Competitiveness Indicators,* which originally assessed a total of 14 indicators, was to give a balanced picture of all the statistical information relevant to regional competitiveness (DTI 2001), while the *State of the Region Indicators* were originally designed to measure progress towards sustainable economic development, skills and social regeneration. At the same time as combining these two publications a number of changes were introduced, and currently REPI is grouped into 11 sections which either indicate the current performance of the economy or give an indication of future growth potential. Nevertheless, each of these factors is still measured in relative isolation and there is not an overall composite index at either a regional or local level (Huggins 2003).

According to Huggins (2003), area competitiveness is the result of a complex interaction between input, output and outcome factors and thus it cannot be measured by ranking any one variable in isolation. A single index that intends to reflect, as fully as possible, the measurable criteria constituting area competitiveness, is constructed in the *UK Competitiveness Index* (UKCI), which was first published in April 2000. The accessible results benchmark the competitiveness of the UK's localities, cities, and regions, the latter of which is the focus here. Table 3.1 highlights the scores for UK regions in the 1997-2010 period while the findings from the 2013 edition of the UKCI are presented separately later (given there are slight changes to how the index is calculated in the most recent report).

Table 3.1 Regional UK Competitiveness Index 1997-2010 (UK=100)

Rank 2010	Region	2010	2008	2006	2005	1997	Δ 1997-2010
1	South East	110.5	109.7	110.5	114.6	115.1	-4.6
2	London	109.6	112.5	113.9	114.7	119.2	-9.5
3	East of England	108.9	105.6	106.0	109.0	106.4	2.5
4	North West	93.8	94.5	92.3	91.2	89.9	4.0
5	East Midlands	93.5	97.7	96.1	95.5	94.1	-0.6
6	South West	91.8	95.0	94.9	93.2	91.1	0.8
7	West Midlands	90.3	94.4	92.7	91.8	94.0	-3.7
8	Scotland	89.4	94.3	94.2	91.0	94.1	-4.7
9	Northern Ireland	89.0	88.8	88.0	84.0	81.8	7.2
10	Yorkshire and the Humber	87.3	89.6	90.5	86.7	85.6	1.7
11	North East	86.5	83.1	84.2	81.2	79.2	7.3
12	Wales	83.9	86.8	86.7	83.5	81.5	2.4
	UK	100.0	100.0	100.0	100.0	100.0	0.0

With an index score 10.5 per cent above the UK average, the South East leads the UKCI for 2010, followed by London in second position (index score = 109.6) and East of England in third (index score = 108.9). It is the first time since the introduction of the index that London has failed to become the most competitive region of the UK. Since 1997, the relative competitiveness of London has been weakening consistently, with its index score falling by 9.5 percentage points by 2010. Whilst the South East, London and East of England – which are labelled as 'the big three' – remain the only regions performing above the UK average, Table 3.1 tends to suggest that "the economic divide between Southern England … and the less competitive regions is starting to close" (Huggins and Day 2006, p. 6). In particular, the bottom four regions, namely Wales, the North East, Yorkshire and the Humber and Northern Ireland, have all seen improvements in competitiveness compared with the UK average. As Huggins and Thompson (2010, p. 9) concluded, "there has been a closing of the North-South Competitiveness Divide since 1997". Nevertheless, there are still wide disparities in competitiveness of regions. For example, although Scotland has witnessed a significant fall in its competitiveness score since 1997, it still leads Wales by some margin in the 2010 index. A long-term commitment that "goes far beyond policy fads and silver bullet solutions" is required to improve the fortunes of the least competitive areas (Huggins and Day 2005, p. 3).

As mentioned, the recent change in the index methodology makes the direct comparison between the 2013 results and the earlier ones less convenient. The authors of the index implied that the UKCI, which only benchmarked the UK's regions before, is now part of a new *World Competitiveness Index of Regions* (Huggins and Thompson 2013; Huggins et al. 2014). Due to the difference in the level of available data from the more than 500 regions globally, it is an understandable decision that the number of indicators in the research framework has been reduced, with Northern Ireland being excluded from the regional comparison due to lack of compatible data. Table 3.2 below compares the rankings of 11 UK regions between 2010 and 2013.

Although it is beyond the scope of this section to examine the exact methodological changes, it is worth noting that there are mixed effects of these on the rankings, as shown in Table 3.2. The competitiveness score of London in 2010 increases significantly from 109.6 to 132.0 as the methodology changes, while regions such as the South East and East of England show considerable decline in their scores. Nevertheless, the fact of 'the big three' being the only competitive ones remains unchanged. Using the new methods, the 2010 results have been updated and then compared with the recent findings presented in the UKCI 2013. While localities in London and the South East still lead the way, the East of England falls behind the UK average with a score of 98.6. More importantly, London has shown the greatest improvement, with its score rising by three percentage points. With the exception of the North West and North East (the two regions with moderate improvement) all the regions outside the capital have yielded decreased scores. The period 2010-13 has obviously seen further divergence in competitiveness across the UK, contrasting to the convergence found in the earlier years.

Table 3.2 Regional UK Competitiveness Index 2010 and 2013 (UK=100)

		Year (methodology)		**Year (methodology)**	
Rank 2013	**Region**	2013 (new)	2010 (new)	2010 (new)	2010 (old)
1	London	135.0	132.0	132.0	109.6
2	South East	104.7	105.4	105.4	110.5
3	East of England	98.6	100.1	100.1	108.9
4	South West	96.3	97.4	97.4	91.8
5	Scotland	93.7	94.6	94.6	89.4
6	East Midlands	92.8	94.3	94.3	93.5
7	North West	92.0	91.7	91.7	93.8
8	West Midlands	91.9	94.2	94.2	90.3
9	Yorkshire and the Humber	91.8	92.9	92.9	87.3
10	North East	86.8	86.6	86.6	86.5
11	Wales	86.4	87.4	87.4	83.9
	UK	100.0	100.0	100.0	100.0

As this thesis adopts the identification of UK regions in the UKCI, it is essential to address the debates about the measurement of competitiveness. For instance, some scholars have criticised the measurement of competitiveness at a regional level altogether. As argued by Bristow (2005, p. 294), “competitive league tables are inevitably seductive for regional development agencies and the media keen to absorb ‘quick and dirty’ comparative measures of regional economic performance”. Nevertheless, the concept of regional competitiveness is not a zero-sum game, and thus there are not inevitably winners and losers. Less competitive regions could actually compare themselves with those regions they would like to learn from and then identify the gaps. As already indicated, the way nations or regions compete is very different from the way firms compete. In general, the UKCI is a single composite index constructed by a three-factor model which includes factors relating to inputs, outputs, and outcomes. While regional competitiveness inputs consist of human capital as well as physical and financial capital, outputs refer to gross value added per capita, productivity, and employment rates. Competitiveness outcomes represent the result of outputs in the form of rising living standards and include gross weekly pay and unemployment rates. The composite nature of the UKCI is rather different from, and usually compare with, those indices which look into a single aspect of an economy and produce a single index. For example, Porter and Stern (1999) used the number of patents granted as a proxy for America’s innovativeness when constructing an innovation index. As argued by Huggins et al. (2014, p. 18), “although this approach has advantages in the operational ease of benchmarking, the choice of the variable leaves much room for subjectivity concerning the relationship between the variable and the extent of the knowledge base of an economy”. To some extent, the use of a composite index, which considers a wide range of factors, could better capture the overall level of regional economic development.

The measurement of regional competitiveness may only have started after the late 1990s in the UK but the policy efforts to address regional disparities date back to as early as the 1930s. Crowley et al. (2012) argued that regional policy in the UK could be characterised as a series of experiments introduced by successive governments over at least three stages of development. While regional policy between the 1940s and 1970s attempted to geographically steer mobile investment to areas with employment shortages, it became urban policy from the late 1970s aiming to tackle the problems in Britain's inner cities. In the 1980s, according to Crowley et al. (2012, p. 4), urban policy "became property- and market-led and targeted at small geographic areas in the hope that disadvantaged residents would benefit".

To a large extent, these approaches were undertaken before the competitiveness agenda swept across policy domains in the 1990s. On coming to power in 1997 the Labour government spent an unprecedented amount of time and resources on the regeneration agenda, seeking to privilege economic growth through competition between regions. Of the many initiatives of recent regional policy, the RDAs may be the best resourced and extensively evaluated ones. The then Department of the Environment, Transport and the Regions (DETR) set out the proposal to establish RDAs in the 1997 White Paper *Building Partnerships for Prosperity*, which held that, if the UK economic was going to improve as a whole the problems had to be addressed regionally as well as nationally (DTER 1997). Under the Regional Development Agencies Act 1998, eight RDAs were established and formally launched in eight English regions in 1999, with the ninth, the London Development Agency, following in 2000.

As strategic drivers of regional economic development, the RDAs aim to improve each region's relative competitiveness and reduce the imbalance that exists within and between regions. PricewaterhouseCoopers LLP (PwC) was appointed by the then Department for Business, Enterprise and Regulatory Reform (BERR) in 2007 to provide an independent assessment of the impact of spending by each of the nine RDAs and the RDA network as a whole. The focus of the evaluation, which was published in 2009, was on the impact of RDAs' spending over the period 2002/03 to 2006/07. In that period, the RDAs collectively spent around £11.2 billion, of which 32 per cent was spent on regeneration through physical infrastructure, 17 per cent on business development and competitiveness and 8 per cent on activities related to people and skills (BERR 2009a, 2009b). Whilst it was suggested that all RDAs generated regional economic benefits that exceeded their costs, critics have argued that they have been less successful in their aim to reduce regional disparities between regions.

With the change of government in 2010, the Conservative-Liberal Democrat coalition government announced the abolition of the RDAs and instead introduced the Local Enterprise Partnerships (LEPs) as part of the building of a new economic model for the regions. The key argument for the abolition of the RDAs, as the Minister for Business and Enterprise stated in October 2010, was that the economic divide between the Greater South East and the rest of England is as wide as when the RDAs began their work. For the Coalition Government, regions on which the RDA approach to sub-national economic development was based were an artificial representation of functional economies (BIS 2010). LEPs, which are in essence voluntary partnerships between local authorities and businesses to promote local economic development, were perceived by the Coalition Government as functional economic areas to focus on. There are currently 39 local enterprise partnerships in operation with some local authorities being part of more than one LEP. It remains unclear how effectively the LEPs will fulfil the government's economic ambition to create a more balanced economy both in terms of economic sectors and geographically although the existence of spatial disparities has always been a major concern for UK governments.

3.2 UK universities and the region

Policy makers in the UK have increasingly viewed universities as an important source of competitiveness of regions. Nevertheless, it was not until the last three decades that the UK government explicitly addressed this issue, suggesting that it has been unexplored for most of the history of the UK higher education sector. Indeed, what distinguishes the UK higher education sector from others is that it consists of both very old and very new universities. Ancient universities – those medieval universities founded before the 17th century – continue to exist and thrive. The University of Oxford is the oldest university in the English-speaking world and can lay claim to 900 years of continuous existence with teaching in some form dating back to 1096 when it was founded. Well-known examples of other ancient universities include the University of Cambridge, founded in 1209, and the Universities of St Andrews (founded in 1413), Glasgow (1451), Aberdeen (1492) and Edinburgh (1583).

In the Victorian era, six 'civic' universities were founded in the industrial cities of England and achieved university status before WWII. They then became known as the 'Red Brick' universities, a term first used in a publication by a Professor of Spanish, who was inspired by the fact that the Victoria Building at the University of Liverpool was built from a distinctive red, pressed brick with terracotta decorative dressings. The original six civic red brick universities were Birmingham, Bristol, Leeds, Liverpool, Manchester and Sheffield, all of which concentrated on educating their students in 'real-world' skills, often linked to engineering. It was this deliberate emphasis on a practical higher education that distinguished the red brick universities from their ancient counterparts such as the Universities of Oxford and Cambridge.

The size of the UK higher education sector continued to grow in the 20th century, especially in the 1960s when several more universities were founded following the release of the Robbins Report (1963) – the report of the Committee on Higher Education – which recommended immediate expansion of universities through giving all Colleges of Advanced Technology (CATs) the status of universities. In some cases, these so-called 'Plate Glass' universities were older schools with new Royal Charters making them universities. Since the middle of the 1960s, the UK also witnessed the establishment of many polytechnics, which centred on professional and vocational programmes of study and complemented the more academically orientated universities.

By granting university status to 58 HEIs that had previously been known as polytechnics, the Further and Higher Education Act 1992 ended the 'binary divide' and further accelerated the expansion pace of the sector by creating 'post-1992 universities' or 'new universities', although many of them may have an early origin. In Scotland, six higher education institutions – the University of Abertay Dundee, Edinburgh Napier University, Glasgow Caledonian University, Queen Margaret University, Robert Gordon University and the University of the West of Scotland – gained their university status after 1992, a decision that increased the number of Scottish universities by nearly 50 per cent. In Wales, the impact of the Act was even more significant with the total number of Welsh HEIs nearly doubling.

The UK higher education sector is not evenly distributed across the country. For example, London is unique in that its 43 universities form the largest concentration of higher education not only in the UK but Europe. Universities and colleges in London currently employ about 20 per cent of the country's total staff and win around a quarter of the national total research funding. Table 3.3 shows that one key feature of the geographical pattern of UK university locations is that the more competitive the region, the more universities are likely to be found there. In particular, the focus of the analysis is on the 133 members of Universities UK (UUK), for which the most comprehensive information is available. As the ONS released, the estimated populations of the four constituent countries of the UK in mid-2012 were 53.3 million people in England, 5.3 million in Scotland, 3.1 million in Wales and 1.8 million in Northern Ireland. The data of academic staff full-time equivalents (FTEs) was sourced from the Higher Education Statistics Agency (HESA).

Table 3.3 Geographical pattern of UK university location, 2011/12

Region	Number of HEIs: Established	Number of HEIs: New	Number of HEIs per million population	Number of academic staff FTEs per million population
East Midlands	3	5	1.8	1,730
East of England	3	4	1.2	1,364
London	20	12	3.8	2,579
North East	2	3	1.9	2,037
North West	4	8	1.7	1,668
Northern Ireland	2	0	1.1	1,338
Scotland	9	6	2.8	2,362
South East	9	7	1.8	1,747
South West	3	5	1.5	1,247
Wales	5	5	3.3	1,868
West Midlands	4	5	1.6	1,418
Yorkshire and the Humber	5	4	1.7	1,812
Competitive regions	32	23	2.4	1,946
Uncompetitive regions	37	41	1.9	1,720
UK	69	64	2.1	1,802

Source: Author's own elaboration.

As shown in Table 3.3, the three competitive regions housed 55 universities and colleges in 2011/12 while a total of 78 institutions were located in the nine uncompetitive regions. On average, there were 2.4 HEIs per million population in 'the big three', significantly higher than in the rest of the country and highlighting, yet again, the concentration of the education system. The South East, London and the East of England enjoyed 1,946 academic staff FTEs per million population while the other regions lagged behind with 1,720 academic staff FTEs per million population. There are also variations within each regional group with London leading the performance of the South East and the East of England, which actually fall below the national average in the indicators measured in Table 3.3. It should be noted that the data compared in the table is more about the quantity than the quality of higher education resources across the regions. Goddard et al. (2014, p. 311) have found that "the expansion of the UK system has not in general been guided by explicit territorial development concerns", which is in contrast to some countries, e.g. Sweden and Finland, where, the authors argued, regional policy has prompted the creation of HEIs in uncompetitive areas. Nevertheless, it has been widely accepted that UK's universities, regardless of their location, generate a wide range of benefits with a significant impact on the economy, society and the nation's cultural life.

In the 1990s when the UK higher education sector became more diverse than ever, the mission of universities was redefined as a response to the major shifts in expectations that they should make an active contribution to the development of their regions (Chatterton and Goddard 2000). Whilst the introduction of the 1993 *Realising Our Potential Awards* demonstrated the UK government's increased focus on the impact of university-business interactions (Abreu et al. 2008), the first major study into the impact of universities at a regional level did not appear until the Dearing Report (the National Committee of Inquiry into Higher Education, 1997) which noted that UK universities should be seen as a significant force in regional economies and as a source of income and employment. This set off a series of reports over the next 15 years that began to emphasise the inter-relatedness of research and economic benefit.

The 1998 Government White Paper – *Our Competitive Future* – argued that the crucial factor in building the knowledge-driven economy is about "the more effective use and exploitation of all types of knowledge" (DTI 1998, p. 6), with the knowledge created by the university sector accounting for an important share of this resource. In a 2000 White Paper entitled *Excellence and Opportunity*, the government proposed a number of initiatives and programmes to create clusters of innovation that drew universities and businesses together and to ensure that excellence in science was turned into products and services (DTI 2000). The UK *Science and Innovation Investment Framework* for the period 2004-14 further embedded the notion of translating the knowledge base more effectively into business and public service innovation (HM Treasury 2004).

Many more reports were generated which specifically examined how to maximise the impact of universities on knowledge exploitation and economic development. The Lambert Review concluded that government would have to do more to support business-university collaboration and that business would need to learn how to exploit the innovative ideas that are developed in the university sector (Lambert 2003). The Sainsbury Review called for the building of a national innovation ecosystem, to include a wide range of actors extending from universities to research institutes, government funders and regulators, business and investors, and specified the contributions that should be made by each of these parties (Sainsbury 2007).

A review of the current and future role of technology and innovation centres in the UK claimed that, "if the UK is serious about creating a 'knowledge-economy', the gap between universities and industry must be closed through a 'translational infrastructure' to provide a business-focused capacity and capability that bridges research and technology commercialisation" (Hauser

2010, p. 1). Two more recent reports (Wilson 2012; Witty 2013) have continued this thinking suggesting that universities should make the facilitation of economic growth a core strategic goal. While the Wilson Review recommended that universities should firmly be at the heart of our economy if the potential of UK university-business collaboration is to be fulfilled, the Witty Review (2013) – published after the introduction of the LEPs – suggested that universities have extraordinary potential to enhance economic growth at the local level. Back to 2011, the crucial role of the higher education sector was already clearly enshrined in the government's 2011 *Plan for Growth*, which claimed that "higher education is central to economic growth and the UK has one of the most successful higher education systems in the world" (HM Treasury 2011, p. 36).

These nationwide reviews have all addressed the role of universities in the economy and made their contributions to the policy making process under different administrations. The main limitation shared by these reports is that they have paid little attention to the demand side factors, leaving the needs of the regional economy, or the regional roles of higher education institutions, mostly unexplained. To a certain extent, the Sainsbury Review has been an exception. It has, for example, rightly pointed out that government policy typically tends to focus on the supply side factors affecting innovation, and argued that demand side factors, such as procurement and regulation, can also play a critical role in encouraging innovation. It also recommended that the Technology Strategy Board (TSB), whose name was changed to Innovate UK in August 2014 to better express its role and purpose, has a leadership role to play in addressing the fragmented technology and innovation landscape in the UK.

Whilst the TSB may be the prime channel through which the UK government funds and supports innovative businesses to accelerate economic growth, its role in directly fostering business-university collaboration might be limited. In other words, the proposal put forward by the Sainsbury Review might have taken the demand side of knowledge into account, but it still overlooked the gap between universities and industry.

To begin with, the TSB's budget includes provision for expenditure in a wide range of areas, including collaborative R&D programmes, the Smart programme, Catapults (which were previously described as Technology and Innovation Centres), as well as the Knowledge Transfer Partnerships (KTPs). It also provides support for networking and information sharing activities across businesses and the research base through the Knowledge Transfer Networks (KTNs). Of these activities, the KTPs represent the type that explicitly involves collaborative projects between business and the knowledge base (e.g. universities) but account only for a small share of the total budget of the TSB. In 2013, BIS published its triennial review of the TSB in which it was stated that the expenditure on the KTPs was around £29 million in 2011/12, less than 10 per cent of the total expenditure of the organisation (BIS 2013). The policy impact of the KTPs might be constrained by the modest amount of budget invested. Further support for this argument seems to be lent by a closer examination of how the KTPs are operated. Whilst the number of institutions involved with the programme has grown annually, the amount of activity within institutions varies significantly. An independent review of the KTPs found that the top 20 institutions accounted for almost half of active KTPs in 2008/09, with the majority of universities rarely getting involved (TSB 2010). There are therefore many locations without any KTPs, which further questions the capability of the programme in addressing the challenges faced by regions throughout the nation.

A further limitation of these reports is there is a failure to make explicit reference to the needs of the local economy, e.g. the distinguished structures and features of business across regions. Without this recognition, universities have been assumed to have an important, but uniform, role in the recommendations made in those national reviews. This is problematic as the capacity of different types of higher education institutions to contribute to local economic development varies significantly. While the Witty Review was firstly commissioned by the government, its title was *Universities in their Local Communities: Enabling Economic Growth*, implying that it had a spatial perspective on the range of ways that universities contribute to their local economies. Nevertheless, when the final report came out, the territorial perspective was somehow abandoned, with the title being changed to *Encouraging a British Invention Revolution*. The primary recommendation given by the review was that structure of funding should flow by technology/industry opportunity rather than by postcode and it should embrace the country's density of population and institutions (Witty 2013). Goddard et al. (2014, p. 321) noticed this statement and argued that this will inevitably "favour the greater South East of England where the supply of higher education research and private sector demand is concentrated".

3.3 A comparison of knowledge exchange funding incentives

As a consequence of the impact of national policies and reports on universities and economic growth, the UK government has launched a series of funding schemes to boost knowledge exchange activities, further, and maybe more directly, highlighting the significance of converting scientific progress into economic success. Funding for HEIs around the UK includes three main components: funding for teaching, funding for research and funding for knowledge exchange. Table 3.4 reveals the final allocations by the funding councils for 2012/13. Whilst the amount of funding to support knowledge exchange is relatively small compared to funding for teaching and research, it has been increasing significantly over the last decade. As will be discussed below, it is only the main (flagship) programmes operated in each country that the amount of funding for knowledge exchange refers to.

Table 3.4 Final funding allocations for 2012/13, £ million

Country	Funding body	Teaching	Research	Knowledge exchange	Total
England	HEFCE	3,231	1,558	156	5,388
Scotland	SFC	613.4	257.5	15.4	1,022
Wales	HEFCW	136.5	76.4	9.6	367.9
Northern Ireland	DELNI	137	48.7	4	190.9

Notes:

1. 'Total' is the sum of all funding components allocated by each funding body in 2012/13, and is therefore larger than the sum of the previous three columns.
2. SFC funds both higher education and further education sectors in Scotland.
3. Data of teaching funding in Northern Ireland is for the academic year of 2011/12.

Source: Author's elaboration based on HFECE, SFC, HEFCW and DELNI websites.

Before examining the case of each country, it is necessary to briefly introduce the history of those knowledge exchange programmes. In 1999 the Higher Education Funding Council for England (HEFCE) established the Higher Education Reach-out to Business and the Community Fund (HEROBC) for the purpose of enhancing the contribution that universities make to the economy and society (HEFCE 2000b). The Higher Education Innovation Fund (HEIF) succeeded this in 2001, and the current incarnation of the fund runs from 2011 to 2015 (HEFCE 2011b; PACEC 2012b). In 2004, the Higher Education Funding Council for Wales (HEFCW) founded its Third Mission (3M) Fund and later renamed it as the Innovation and Engagement Fund (I&E) (HEFCW 2009, 2011). Northern Ireland runs an adaptation of the HEIF in England, while Scotland offers its own Knowledge Transfer Grant (KTG) (SQW 2009; DELNI 2010).

3.3.1 England

In England, the proposal to establish the HEROBC fund, which was to be allocated in response to applications from HEIs in both England and Northern Ireland from 1999/2000, was set out by the HEFCE in May 1999 (HEFCE 1999a). Following the first invitation to apply for funding, a total of 122 applications were received from 114 HEIs, including eight applications from consortia of HEIs, and funding totalling £60 million was awarded to 87 applicants in the first round (HEFCE 1999b, 2000a). In February 2000, the second invitation to apply for funding was issued, which saw a total of 64 applications from 62 HEIs, out of which 50 applications were successful and awarded a total funding of £22 million. Both the first and second rounds of funding, announced in 1999 and

2000 respectively, were allocated during a four-year period, meaning they overlapped each other between 2000/01 and 2002/03. These developments are summarised in Table 3.5 below. It should also be noted that, each of the two Northern Irish universities (Queen's University of Belfast and the University of Ulster) were awarded £1.1 million in the first round only, while the second round funding was awarded only to universities located in England. More details about Northern Ireland can be found in Section 3.3.4.

Table 3.5 HEFCE knowledge exchange funding (HEIs in England)

Year	Funding programme	Funding awarded (£ million)	Allocation mechanisms
1999-2003	HEROBC first round	60	Competitive bidding
2000-2004	HEROBC second round	22	Competitive bidding
2002-2004	HEIF 1	78	Competitive bidding
2004-2006	HEIF 2	187	Competitive bidding
2006-2008	HEIF 3	238	75% formula based
2008-2011	HEIF 4	404	100% formula based
2011-2015	HEIF 5	600	100% formula based

Source: Author's elaboration based on HEFCE website.

Established in 2001 after the 2000 Spending Review, the HEIF, which incorporates the existing HEROBC fund, represents the government's commitment to knowledge exchange (HEFCE 2001). There have been a series of rounds of HEIF: HEIF 1 (£78 million, 2002-2004), HEIF 2 (£187 million, 2004-2006), HEIF 3 (£238 million, 2006-2008), HEIF 4 (£404 million, 2008-2011) and HEIF 5 (£600 million, 2011-2015). While the amount of available funding has increased significantly round by round, the allocation mechanisms have also been revised since the announcement of the HEIF 3 (Table 3.5). In HEIF 1 and HEIF 2, the funding was awarded to proposed projects based on a competitive process, with 89 and 124 awards being confirmed in each round respectively. Under the HEIF 3, however, only a quarter of the funding was allocated through competition, while the rest three-quarters of the funding was allocated by a formula based on data from the HESA (HEFCE 2006a). The move to allocating the majority of HEIF funding by formula was considered to "result in greater predictability of income of HEIs and allow more strategic institutional planning, as well as reducing the administrative burden associated with a competitive bidding process" (HEFCE 2005a, p. 6). Under HEIF 4 and HEIF 5, all funding moved to the formula funding, reflecting the government's hope that the higher education sector should use the funds more effectively towards achieving higher performance (HEFCE 2008a).

It is not only the process of resource allocation has moved from a competitive bidding to formula funding. There have also been significant changes in the main elements of the formula and approach for allocating the HEIF, as summarised in Table 3.6.

Firstly, the components of the formula used to calculate the allocations for individual HEIs have been reduced and have become solely dependent on the external income which is seen as a proxy for demand. This reflects the consideration by the HEFCE, and its stakeholders, that the focus now should shift towards delivery, rewarding and incentivising performance, after earlier rounds of project funding and formula funding which support and promote capacity building. Secondly, whilst there has always been an absolute cap on an individual HEI's formula allocation, the minimum allocation for each HEI has been replaced by the introduction of an external income threshold, which basically argues that "only HEIs that can demonstrate the most effective performance should receive funding" (HEFCE 2011a, p. 3). As indicated by the HEFCE (2011b), this move reflects the fact that in the context of the fiscal crisis since 2008, there has been mounting pressure on recipients of exchequer funding to ensure value for money, a challenge from which HEIs are not immune. Lastly, instead of using income data for the most recent year, the HEIF 5 calculates the formula allocations based on the previous three years to reflect consistency in performance and data quality.

Table 3.6 Summary and comparison of HEIF 3, HEIF 4 and HEIF 5 methods

	HEIF 3	**HEIF 4**	**HEIF 5**
Formula components	Capacity building (45%) Performance (45%) Other (10%)	Capacity building (40%) Performance (60%)	Performance (100%)
Maximum allocation per HEI	£3 million	£1.9 million	£2.85 million
Minimum allocation per HEI	£200,000	£100,000	n/a
Year of data for calculation	HE-BCI 2003/04	HE-BCI 2006/07	HE-BCIs 2007/08, 2008/09, 2009/10

Notes:

1. 'Capacity building' is a component based on academic staff numbers.
2. 'Performance' is a component using external income as a proxy.
3. 'Other' is a component rewarding performance on measures other than income.
4. Under HEIF 5, there is no minimum allocation of funding. HEIs that are not achieving an allocation of £250,000 get no allocation at all.
5. Under HEIF 5, the three years are weighted 1:2:7 respectively.

Source: Author's elaboration based on HEFCE website.

3.3.2 Scotland

Initially introduced by the then Scottish Higher Education Funding Council (SHEFC) in 2001/02, the Knowledge Transfer Grant has been the main funding stream for knowledge exchange in Scottish HEIs. Its inception was built upon previous work of the Council, including a grant to encourage institutions to expand their provision of Continuing Professional Development (CPD) courses and Professionalisation of the Commercialisation Process, a funding stream established in 1999/2000 to improve institutions' infrastructure for, and management of, the commercialisation process. Between 2001 and 2004, the KTG was allocated formulaically on the submission of outline plans that set out strategically how institutions intended to promote their knowledge exchange activities, with the available funding increasing from £5.7 million (2001/02) to £6.3 million (2002/03) and then to £6.5 million (2003/04). In 2004/05, the KTG funding was, for the first time, allocated against the KTG income metrics, which include weightings towards activities for the public good (SFC 2013). In subsequent years, the funding model was further refined to include better measures of interactions and engagement. Over the period of 2004 and 2009, the KTG was raised from £9.5 million to £21.5 million with the majority of that funding allocated using the KTG metrics although a modest amount (approximately £0.5 million per year) was allocated to support cultural engagement activities.

In 2008/09, the Scottish Funding Council (SFC) created a new grant namely Strategic Priority Investment in Research and Innovation Translation (SPIRIT), with the aim of targeting strategic knowledge exchange projects across Scotland's key industries. These demand-led projects were selected through competition and focused on the six priority sectors of the Scottish economy namely life sciences, creative industries, energy, financial and business services, food and drink, and tourism (PACEC 2008a). The SPIRIT competition originally allocated £8.1 million to 10 projects over a three year period between 2009/10 and 2012/13, although some projects were designed to finish after the end-of-funding date. In 2011 and 2012, the SFC commissioned two evaluation reports to examine the impacts of the SPIRIT programme, which concluded that the programme was on-track to deliver its objectives (PACEC 2011, 2012a).

Following the report of the Joint Future Thinking Taskforce on Universities – *New Horizons* – knowledge exchange funding was restructured in 2009/10 as a result of the creation of the General Fund (GFU) and Horizon Fund (HFU). Under the GFU, set at £1.4 million per year, each institution received a baseline allocation of £70,000 to support a dedicated capacity to deliver knowledge exchange projects. The HFU was originally allocated through a combination of two mechanisms, with the majority distributed formulaically using the KTG metrics and the rest allocated to strategic projects (SFC 2010). For instance, of the £21 million allocated to Scottish HEIs in 2009/10, £15 million was distributed by KTG metrics and £6 million by projects.

Table 3.7 below shows the historical evolution of the knowledge exchange funding schemes in Scotland. Alongside the KTG, GFU and HFU, there are a number of smaller funding initiatives "targeting 'demand-driven' exchange of knowledge" (Kitagawa and Lightowler 2012, p. 9). For example, the Innovation Voucher Scheme – modelled on similar ones across the UK and Europe – was established by the SFC in 2009 to develop relationships between Scotland's HEIs and small and medium-sized enterprises. In any individual case, the Scheme, whose funding came from SFC's budget for the SPIRIT programme, offers funding of up to £5,000 but not more than 50 per cent of the total value of the engagement (BiGGAR Economics 2010). The SFC also funds Interface – the knowledge connection for business – which helps match business to academic partners where the business does not have an existing academic partner.

Table 3.7 SFC knowledge exchange funding

Year	**Funding programme**	**Funding awarded (£ million)**	**Allocation mechanisms**
2001-2004	KTG 1	18.5	Formula based
2004-2009	KTG 2	78.6	KTG income metrics
2009-2012	SPIRIT	8.1	Project based
2010-2013	GFU	4.2	Formula based
2010-2013	HFU	62.0	KTG income metrics and project based

Source: Author's elaboration based on SFC website.

An important feature of knowledge exchange funding schemes in Scotland's HEIs is that their design and implementation have been closely associated with the Scottish Government's agenda. As part of the 2007 Spending Review, the Scottish Government published the National Performance Framework (NPF), which intends to measure and report on progress of the public sector in Scotland in creating a more successful country. The Framework was consequently integrated into the SFC's 2006-2009 Corporate Plan as the Council set out its own performance measurement framework (SFC 2006). The KTG metrics could therefore be seen as a part of a wider set of indicators which are used to evaluate the role of activities by universities and colleges in achieving the goal of building a more competitive economy as a whole. This fact becomes even more evident when knowledge exchange projects were specially funded on condition that they fell into the priority sectors of the national economy. In 2009, the Scottish Government further identified the university sector as the seventh key economic sector and the only public sector (SG 2009).

3.3.3 Wales

In Wales, the history of supporting HEIs' third mission activities could be said to extend back to the early 1990s, when the HEFCW funded training and consultancy services and contract research. In collaboration with the then Welsh Development Agency (WDA), the HEFCW since the mid-1990s also supported a centres of excellence programme in HEIs, which became known as CETICs (Centres of Excellence for Technology and Industrial Collaboration). Realising that the approach to funding in this area was somewhat fragmented, the HEFCW created in 2000/01 the Higher Education Economic Development Fund (HEED), as part of its plan to bring together disparate pots of money into a single stream of funding and to establish a permanent and sustainable stream of third mission funding. When the first HEED allocations were made in 2002/03, they totalled £3.1 million, only accounting for about 1 per cent of HEFCW's annual budget. This amount was viewed as limited by policy influencers such as the Institute of Welsh Affairs (IWA) which, in its 2002 report, recommended that £50 million a year was needed to support this third mission activity properly in Welsh HEIs. In 2003, the outcomes of the consultation exercise held earlier that year on the development of the HEED Fund were reported by the HEFCW, which announced its intention to establish a full-blown third mission fund from 2004/05 (HEFCW 2003).

A new 3M Fund replaced the HEED Fund in June 2004 following the process of consultation with the funds available for these activities increasing significantly. To be able to receive the fund, institutions were asked to submit a 3M strategy to provide an overview of their activities and examine their contribution to the economy. In the first cycle, spanning the period 2004/05 to 2006/07, HEIs received around £12.1 million from the 3M Fund. Due to its success, the Welsh Assembly Government (WAG) announced in 2005 that the 3M Fund would double in size by 2007/08, the same year in which the second cycle of the Fund was launched. In its second three year cycle (2007/08 to 2009/10), the 3M Fund stood at just over £6.3 million per annum. The funding methodologies adopted in these two cycles were similar with both containing foundation funding and supplementary funding. A common level of foundation funding was receivable by all institutions although the amount of that funding doubled from £50,000 in the first cycle to £100,000 in the second. While the supplementary funding during 2004/05 and 2006/07 was fully allocated on the basis of a formula, based on the average of the previous three years HEED allocations, it consisted of two separate parts in the second cycle of the 3M Fund, including £3.9 million each year allocated on the basis of a formula and £1 million reserved to support bid-based collaborative activity (HEFCW 2004, 2007).

In 2009, the HEFCW opened consultation on arrangements for the future of the 3M Fund, and consequently renamed it as the Innovation & Engagement Fund, with effect from the 2010/11 academic year. Similar to the 3M Fund, I&E allocations would only be released on submission of a satisfactory three year I&E strategy for the period 2011/12 to 2013/14, which particularly asked HEIs to consider regional approaches to I&E activities within their overall strategy. Compared with the 3M Fund, the basis on which the I&E Fund was allocated was shifted again, with the practice of paying a common level of foundation funding to all HEIs being ceased. With the annual budget for I&E strategies being increased to £8.2 million, £6 million of the funding was allocated by formula and the remaining £2.2 million via a competitive bidding process (HEFCW 2011). The decision to cease the foundation funding could be viewed as a move by the Council towards rewarding I&E performance within Welsh HEIs, either income related or non-income related.

An evaluation of the 3M Fund first cycle was commissioned by the HEFCW in September 2008 and published one year later. The evaluation was quite thorough and identified a number of important features of the 3M Fund in particular and of the funding approach in Wales in general. What is most interesting is that Wales has deployed a dual 3M funding approach, with core funds provided by the HEFCW and project related funds provided by the then WAG (HEFCW 2009). In comparison, England and Scotland tend to have one major stream of third mission funding, although they also have a few other schemes which are on a much smaller scale. Indeed, the dual-support system in Wales can be traced back to as early as 2000, when the WAG established the

Knowledge Exploitation Fund (KEF), whose principle was to provide support for the effective transfer of knowledge, skill and ideas from universities and further education colleges in Wales to industry (PACEC 2008b).

The KEF was co-financed by both the European Social Fund (ESF) and the European Regional Development Fund (ERDF) through the WAG. A total of £55 million was provided, mainly on a competitive basis, in the first six years, during which period a number of changes were also implemented in the KEF with regard to its management. Originally managed by Education and Learning Wales, the National Council for Education and Training Wales and the HEFCW, in 2004 responsibility for the KEF was transferred to the WDA and then in 2006 to the WAG. In particular, the KEF was allocated under the following mechanisms: Patent and Proof of Concept funding, Collaborative Industrial Research Partnerships, Technology Transfer Centres and Technology Transfer Networks. In 2008, the KEF, as well as a number of other previously separate project activities, was brought under a new funding stream, entitled Academic Expertise for Business (A4B), which was scheduled to operate between 2008 and 2013 with a budget of £70 million.

Table 3.8 captures the evolution of 3M funding streams in Wales as described above. Given the dual-support system of third mission activity in Wales, it is vital to understand the relationships between the two streams of funding. The same concern was raised in the 2009 evaluation of the first cycle of the 3M Fund, which proposed that "the linkages between HEED and KEF should be strategically co-ordinated in order to maximise their impact" (HEFCW 2009, p.

9). In many ways the two streams are complementary to each other, with the 3M Fund being allocated mainly on the formula basis and the KEF on the competitive bidding basis. It might be the intention of the WAG and the HEFCW to provide two related, but differentiated, funding mechanisms, as HEIs could then come up with an effective strategy after considering their own advantages and areas for improvement.

Table 3.8 Knowledge exchange funding in Wales

Year	Funding programme	Funding awarded (£ million)	Allocation mechanisms
2000-2002	HEED	3.1	Formula based and project based
2001-2003	KEF 1	22.5	Project based
2004-2006	3M 1	12.1	Formula based and project based
2004-2006	KEF 2	31.2	Project based
2007-2009	3M 2	18.9	Formula based and project based
2008-2013	A4B	70.0	Project based
2010-2012	I&E	24.6	Formula based and project based

Source: Author's elaboration based on HEFCW and Welsh Government (WG) website.

3.3.4 Northern Ireland

As the primary funding tool for promoting knowledge transfer activity in the country, the Northern Ireland HEIF (NI HEIF) aims to encourage the higher education sector to increase its capability to respond to the needs of business and the wider community, with a clear focus on the promotion of wealth creation. The NI HEIF is unique as it is the only mainstream knowledge exchange funding scheme in the four UK nations which is managed by more than one agency, with its allocation being run by both the DELNI's Higher

Education Research Policy Branch and Invest NI's Knowledge Transfer Team. Before the NI HEIF was introduced in 2004, Queen's University Belfast and University of Ulster were covered by the HEIF, from which the two universities received a total of £2.2 million in the first round of the HEROBC fund.

During the 2004-2006 period, the first round of the programme (NI HEIF 1) delivered an investment of around £3 million per annum, an amount significantly higher than the previous level (Table 3.9). The basis on which the fund was allocated, however, remained unchanged from the HEBORC first round, with the two universities bidding for funding based on their proposals from the two government bodies. This element of competitive funding was retained in the NI HEIF 2, but was suggested to be restricted to a level of approximately 20 per cent of the total funding, with the remaining 80 per cent being metrics driven. Recommended in a 2006 evaluation report of the NI HEIF 1, the move to a primarily metrics informed funding mechanism similarly followed the step of the HEIF in England. Given the 80:20 funding split in principle, the nominal allocations were £2.4 million per annum from the DELNI and £600,000 from Invest NI. In reality, however, Invest NI provided an additional amount of funding, shifting the actual ratio to 75:25. The total funding per annum has been at almost the same level since 2004.

As a condition of receiving the funding, each of the two Northern Irish universities, like their counterparts in Wales, was required by the DELNI to provide an institutional plan, outlining the key indicators against which the HEI's performance would be tracked. The 2006 evaluation report also recommended that the NI HEIF 2 should be delivered as a single, joint DELNI/Invest NI initiative consisting of two distinct but complementary streams, with the DELNI delivering the metrics-derived element and Invest NI delivering the competitive element. Therefore, although the NI HEIF 2 was jointly managed by the DELNI and Invest NI, universities would not struggle too much when applying, as the two streams seemed to have differentiated allocation methods and were separately managed.

Table 3.9 Knowledge exchange funding in Northern Ireland

Year	Funding programme	Funding awarded (£ million)	Allocation mechanisms
1999-2003	HEROBC first round	2.2	Competitive bidding
2004-2006	NI HEIF 1	9.0	Competitive bidding
2007-2009	NI HEIF 2	9.0	80% formula based
2010-2012	NI HEIF 3	9.0	80% formula based

Source: Author's elaboration based on DELNI and Invest NI websites.

3.4 Changing the policy landscape again?

This chapter has shown that there have seen significant shifts in the UK regional policy agenda over the last decades, with universities, knowledge exchange and regional competitiveness increasingly being included in a holistic approach to economic development. An increasing number of national policies and reports have been introduced, clearly defining the role of the higher education sector in building the knowledge based economy. In all of the four UK nations, a great amount of resources has been invested into those knowledge exchange initiatives, which share both similarities and differences, to boost university-business interactions. While there is no doubt that the performance of universities in knowledge exchange activities has increased, the main problem identified is that the policy landscape is imbalanced, with much more attention being paid to the academic supply side of knowledge and much less to the business demand side. Without the recognition of the needs of the local economy, the so-called knowledge exchange policy incentives are still about knowledge transfer, assuming an important, but uniform, role of universities in driving economic development. Further changes to the policy landscape are necessary to strike a balance between the supply and demand sides of knowledge at regional level.

CHAPTER 4

RESEARCH DESIGN AND METHODOLOGY

4.1 A critical realist paradigm

Research, as described by Burns (1997), is a systematic investigation or inquiry in an effort to understand a phenomenon. It has been suggested, however, that the researcher's theoretical framework influences the exact nature of the definition of research (Mertens 2005). It is the theoretical framework, as distinct from the theory, that is also referred to as the research paradigm. For Bogdan and Biklen (1998, p. 274), a paradigm is "a loose collection of logically related assumptions, concepts, or propositions that orient thinking and research". In general, a research paradigm concerns the nature of reality and the way knowledge about reality is interpreted (Mac Naughton et al. 2001; Mertens 2005; Myers 2009). The nomination of a research paradigm sets down the intent, motivation and expectations for the research, and lays out the basis for subsequent choices regarding research methodology and research design. It should be noted that researchers tend to have different values and beliefs, leading them to employ different paradigms.

In the literature of innovation studies, there are a number of commonly discussed theoretical paradigms: positivist, interpretivist, and critical realist. In the viewpoint of Bailey (2007, p. 50), "all research paradigms that guide field research have four major, interrelated beliefs about ontology, epistemology, methodology, and axiology." Table 4.1 presents these elements, with more detailed explanation followed. Importantly, instead of providing a comprehensive account of philosophical arguments of different research paradigms, this section mainly seeks to set the context of the research and establish the paradigm undertaken in this study.

Table 4.1 Research paradigms

	Research paradigms		
Basic beliefs	Positivist	Interpretivist	Critical realist
Ontology (Is there a "truth" that can be known?)	Objective reality exists	No objective social reality but instead multiple realities	There is no single "reality out there"
Epistemology (Is what is learned independent of the researcher?)	What can be learned about the social world exists independently of the researcher	What is learned in research does not exist independently of the researcher	Researcher is not independent from what is researched and that the findings of research are mediated through his or her values
Methodology (How should the research go about findings out about social reality?)	Reliability, validity, and generalizability	Interactions with and observations of participants in the setting	Often takes a macro approach to research
Axiology (What is the role of values in the research process?)	Objective and value-free	Rejects the view that value neutrality is essential to the research process	Values are important to the research and should be clearly articulated in the work and to the participants

Source: Author's elaboration from Bailey (2007).

Positivism usually begins with a theory, holding the belief that there exists a single objective reality. As Mertens (2005, p. 10) has explained, positivism is "based on the rationalistic, empiricist philosophy that originated with Aristotle, Francis Bacon, John Locke, August Comte, and Emmanuel Kant." It is a paradigm often referred to as a scientific method which reflects a deterministic philosophy. Not surprisingly, positivism has predominantly been applied in science studies, but it may also be applied to social science studies on the assumption that "the social world can be studied in the same way as the natural world, that there is a method for studying the social world that is value free, and that explanations of a causal nature can be provided" (Mertens 2005, p. 11). The application of the positivist paradigm in social science research assumes the results are generalisable, and therefore is most frequently aligned with quantitative methods of data collection and analysis.

Different from the positivist approach which tries to determine the objective reality, interpretivist/constructivist approaches to research assert that "the social world is not an entity in and of itself but is local, temporally and historically situated, fluid, context-specific, and shaped in conjunction with the researcher" (Guba and Lincoln 1994, p. 109). Cohen and Manion (1994) claimed that the interpretivist paradigm aims to understand the world of human experience, stressing the importance of interactions with and observations of participants in the research setting. Since there are multiple realities for interpretivist researchers, they are more likely to use qualitative data collection methods and analysis, in order to "generate or inductively develop a theory or pattern of meanings" (Creswell 2003, p. 8).

Critical realism, which is usually associated with Bhaskar (1979), tends to view the world is structured, differentiated, and changing. Although the critical realist paradigm, to a certain extent, shares some ideas of the interpretivist paradigm, it is very different in that it argues that there is no single reality. To be specific, it could be claimed that critical realists, on the one hand agree that there is a world existing independently of our perceptions, and on the other hand accept that our understanding of the world is a construction from our own perspectives. This latter argument is crucial, as perspectives of researchers differ from each other, thus there is no possibility of attaining a single reality that is independent of any particular viewpoint. The goal of critical research is, through a critique of existing social conditions, to bring about social change (Myers 2009). Furthermore, critical realism has a focus on the concept of cause and has the value in the identification of causal mechanisms in social phenomena. The theory of causality in critical realism, however, is different from what is usually known as the 'regularity' theory of causality in positivism (Murnance and Willett 2010). While the 'regularity' theory considers that causality consists simply of regular association between variables, critical realists use mechanisms, or processes, to explain the phenomena.

This study, in examining how academics and firms exchange knowledge via a wide range of activities, adopts a critical realist paradigm as the most appropriate to address the research questions. The rationale behind the adoption of a critical realist paradigm is explained from four aspects. Firstly, in areas such as systems of innovation, academic entrepreneurship or regional development, there is hardly any universal theory that could be applied to all the cases investigated, at least not without adjustment. Admittedly, there are a number of ideas, models, and frameworks in these fields which have extensively been adopted, but they are still far from what one would expect as theories. On the one hand, those models, e.g. the Triple Helix model, are very likely to have been developed from qualitative studies, suggesting they are at best common patterns of social phenomena. On the other hand, studies employing these models also tend to embed them in different contexts, either social or geographical, and thus broaden the application and understanding of the models. While this study seeks to examine the role universities could play across regions, it has clearly been argued in the previous sections that the universality of the role of universities is questionable as it is affected by a combination of factors.

Secondly, when embedding the frameworks in the specific contexts of regions, it is up to the researcher to decide how to interpret the results. One example, as will be discussed later, could be an analysis of the reasons why academics in Wales are much more actively engaged in knowledge exchange activities than businesses are. Some may argue that firms in Wales should put more effort into absorbing the knowledge generated by regionally-based academics, while others could suggest that academics may not be producing the right knowledge that businesses need. It could be seen that what is learned in this research does not exist independently of the researcher; rather, it is achieved by the perception and understanding of the researcher. Thirdly, the theory of causality in critical realism is suitable to understand the complex relationships between the mechanisms and the outcomes in knowledge networks processes. The extant literature, as well as the results of this thesis, confirms that there is no regular association between variables related to universities, firms, and regions.

Lastly, as the literature suggests, research applying the positivist paradigm tends to predominantly, though not necessarily exclusively, use quantitative methods to collect data, while the critical realist paradigm uses predominantly qualitative methods (Glesne and Peshkin 1992; Neuman 2000; Silverman 2000). The forced choice between qualitative and quantitative methods has gradually been abandoned, allowing the researcher to employ mixed methods rather than being restricted to any one method. The depth and richness of a research project may potentially be diminished when the researcher is restricted to one method (Peterson 2005), justifying the decision to combine longitudinal case studies with cross-sectional analysis in this study which seeks explanations for variations in the levels of university-industry engagements. In a critical realist paradigm, quantitative data may be utilised if it expands upon qualitative data.

4.2 Mixed methods

Research methods in social sciences are often divided into the two main types: quantitative and qualitative. This thesis takes a mix of these two methodological approaches as it is regarded to be the most suitable way for gaining an in-depth insight and understanding of university knowledge networks across both time and space. Quantitative research, as defined by Aliaga and Gunderson (2000, p. 1), is about "explaining phenomena by collecting numerical data that are analysed using mathematically-based methods (in particular statistics)". In particular, techniques such as survey questionnaires can also be used to collect data which do not appear to be in numerical form but which can then be transformed for quantitative analysis (Balnaves and Caputi 2001). When aiming for large amounts of data and statistical significance, quantitative researchers are therefore considered to be independent of the context of study (David and Sutton 2004). Unlike quantitative research, qualitative research aims to gather an in-depth understanding of human behaviour and, more importantly, the factors that could explain the behaviour. Berg (2009) explained that qualitative researchers usually work with small samples which are studied in-depth in their context. To gain the in-depth understanding, the researcher could employ a number of approaches including case studies, action research and grounded theory (Silverman 2000; Creswell 2003; Myers 2009).

The decision to undertake a mix of both quantitative and qualitative research approaches is mainly guided by the specific research questions this study seeks to answer. While the qualitative approach is suitable for a longitudinal analysis of university knowledge exchange programmes, the quantitative method is useful to show the institutional and regional variations in university engagements in knowledge networks. Even though a mixed research approach has become increasingly popular, it is not a choice immune from criticism, with the main problems being addressed below. Firstly, thanks to the contrasting features of the two methods, it can be challenging to merge them within the same analytical framework. In this study, the three empirical chapters have been organised to represent two very different levels of analysis: Chapters 5 and 6 undertake the quantitative approach and focus on the 'general' patterns of knowledge networks across the UK, while Chapter 7 uses the qualitative approach and targets the 'specific' experiences in one UK region. Secondly, the mixed method approach means producing increasing amounts of data that can take a lot of time to analyse. Case studies involve documentation, policy analysis and face-to-face interviews, and generate a large amount of qualitative data. Different techniques are required in the analysis of qualitative data from that of quantitative data, possibly requiring the researcher to learn how to use new types of software. After reflecting on the potential risks of combining the quantitative and qualitative approaches, this study is considered to comprise an effective mix of methods.

4.3 Survey

In social science research, the survey has long been a central strategy, with definition of the term 'survey' itself constantly evolving (Sapsford 2007). Yet, Statistics Canada (2003, p. 1) has defined that a survey is "any activity that collects information in an organised and methodical manner about characteristics of interest from some or all units of a population using well-defined concepts, methods and procedures, and compiles such information into a useful summary form". Acknowledging the specific features of survey research, Lesley (2012) stated that a social survey usually encompasses the following: a) data collected in the field, as opposed to in a laboratory setting; b) organisation of the data by individual record but still employing a multitude of methods to gather data on the individual; and c) a means to establish the value or extent of the phenomena under investigation, by either counting or measuring some or all of the information gathered. In essence, surveys are designed to produce statistics about a target population by "inferring the characteristics of the target population from the answers provided by a sample of respondents". (Fowler

2014, p. 8). If the results are to be useful, the researcher should be confident that there exists a representative sample, which has strong external validity in relationship to the target population that the sample is meant to represent.

In this study, as the empirical analysis attempted to cover the whole of the UK based on survey data, it proved to be too difficult for the researcher to conduct the surveys on that scale given the time and funding resources available. Therefore, the study draws upon three large-scale, secondary data sources accessible for research purposes. The first data source is the HE-BCI surveys from 2003/04 to 2011/12, covering an eight-year period, which report the income of knowledge exchange activities raised by almost all UK universities. The second data source is an academic survey conducted in a large research project carried out by the Centre for Business Research (CBR) at University of Cambridge, 2009. The third data source is a business survey conducted by the same project which carried out the academic survey mentioned above.

While the following sections will deal with issues such as data representativeness, it is necessary to explicitly highlight the novelty of the approach to analysing the survey data from secondary sources. With the guidance of the analysis framework, the data from these sources are critically selected, restructured, and analysed in an innovative way to demonstrate the supply-demand relationships of knowledge exchange. In addition, the analysis, which combines the CBR academic survey with the HE-BCI surveys, reveals the missing elements (intensity vs. performance) in the conventional wisdom of knowledge networks that have not been revealed before.

Particularly, the value added of this thesis is to what extent the analysis of the CBR data in this thesis adds to the results already found by the CBR team. In 2009 and 2013, the CBR team released their own reports on the academic survey (Abreu et al. 2009) and the business survey (Hughes and Kitson 2013) respectively. The two reports were organised in a similar structure of chapters, including modes of interaction, types of partners, and motivations and impacts of knowledge exchange. There were a total of 27 modes of interaction identified by the CBR team, who then grouped them into four broad categories: people based, problem solving, community based, and commercialisation. The purpose of these two reports was simply to map, and highlight, the multi-faceted and nuanced interactions between the university sector and the business sector.

This thesis has significantly expanded upon the CBR reports in at least three ways. Firstly, the 27 modes of interaction were selected and re-grouped into six types to match the categorisation of the HE-BCI surveys. This enabled the author to analyse the associations between the intensity and performance of university knowledge networks, which was never conducted before. Secondly, by combining the findings of the two surveys, the author illustrated the match or mismatch between the supply and demand sides of knowledge exchange. As the modes of interaction were significantly re-grouped, the supply-demand relationships shown in the thesis would be rather different from combining the findings of the two reports together. Lastly, this thesis was focused on the regional level, while the results in the CBR reports were only shown at the UK level with little focus on the possible regional differences. Overall, the value added of this thesis is explicit and significant.

4.4 Case study

A case study is "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin 2009, p. 23). According to Hartley (2004, p. 324), the case study allows for "processual, contextual and generally longitudinal analysis of the various actions and meanings which take place and what are constructed within specific social or organisational contexts". With the use of multiple sources and techniques in the data gathering process, case studies could understand how things evolve over time and why they evolve in a particular way (Langley 1999).

While one could claim that the distinct features of the case study are its major advantages in comparison to quantitative strategies, some others have questioned its value as a research method within academic disciplines citing exactly the same reasons (Flyvbjerg 2006). Of those criticisms of case study research, the most frequently cited is probably that the strategy lacks generalisability of findings since the cases may not be representative (Gray 2009; Yin 2009). Van den Hoonaard (1997) argued that case studies are not designed to create generalisability but transferability. In other words, the purpose of case studies is to come to an understanding of a phenomenon which is situated in time and space but can also be used to explain other settings (Mazlish 1998; Orlikowski and Baroudi 2001).

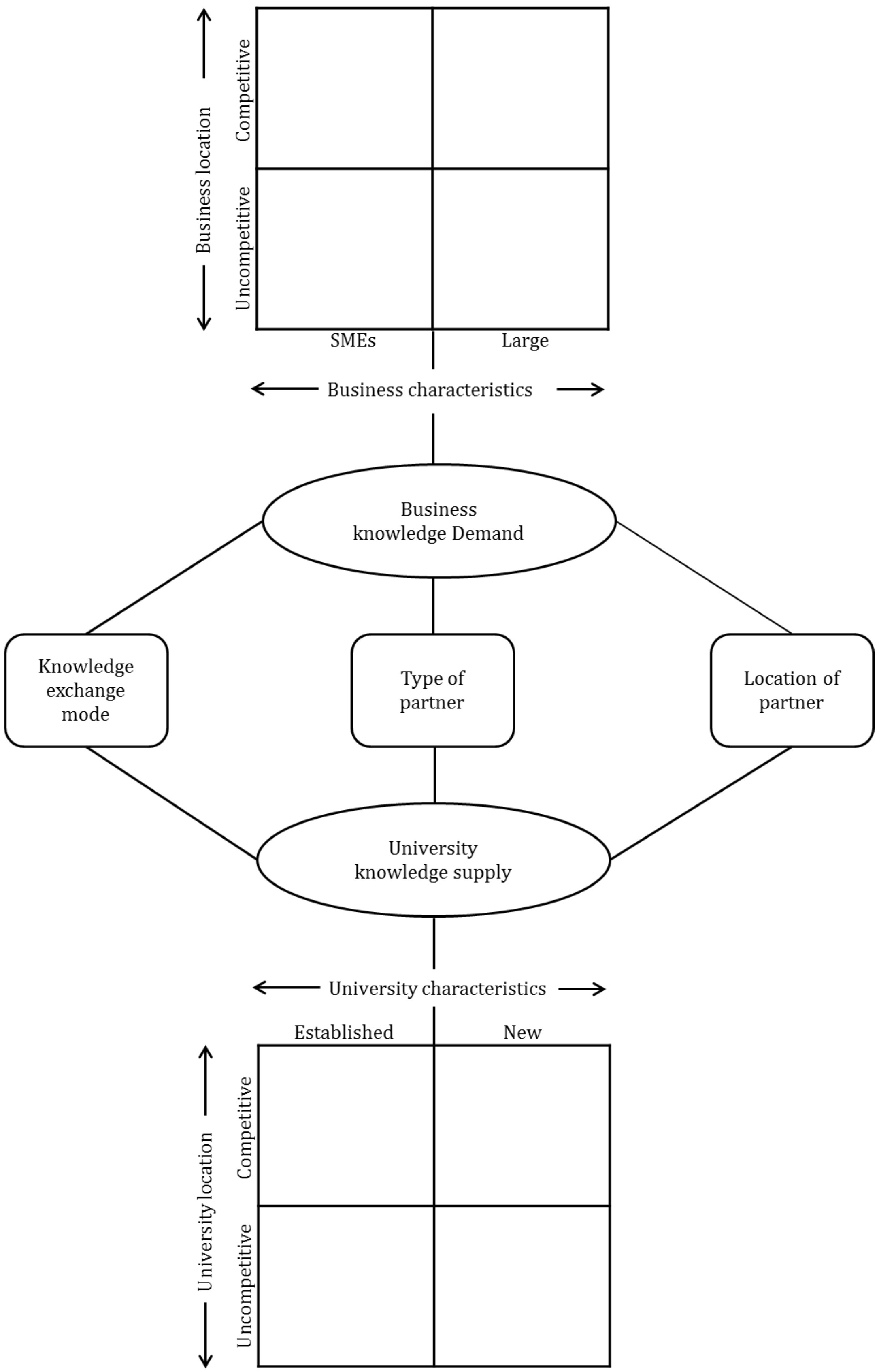
In constructing a case study research design, the researcher encounters a choice between single-case designs or multiple-case designs. As explained by Yin (2009), the choice of a single-case design is justified when it represents a critical case or when it represents an extreme or unique case. In comparison, a multiple-case design is suitable for cross-case analysis and allows the researcher to investigate a particular phenomenon in different settings. When using multiple case studies, an issue in need of consideration is the number of cases to target (Miles and Huberman 1994; Barratt et al. 2010). The systematisation of case studies is further differentiated between holistic versus embedded approaches, depending on the number of unit of analysis involved. The unit of analysis is the level at which the research is conducted and which objects are researched (Blumberg et al. 2011).

Following the typology of the case study approach, it seems that the pursuit of a holistic multiple-case research design is appropriate. In particular, the identification of illustrative examples of knowledge networks was associated with the category of knowledge exchange activity, meaning this study seeks to conduct one case study in each type of knowledge network. Since the case study chapter has been designed to represent 'the very specific', its main focus will be more on within-case analysis than on cross-case analysis, implying that a holistic approach is more appropriate than an embedded approach to reveal the 'specific' factors that influence the success of individual programmes this study aims to investigate. These cases, as already mentioned, are intended to complement the findings of the quantitative empirical chapters and to highlight factors at different levels shaping knowledge exchange activities.

4.5 Analysis framework

The effectiveness of answering the research questions is, to a certain extent, determined by whether there is a constructive analysis framework. An analysis framework is generally understood as the organisation of tools, techniques and methods of analysis. While a conceptual framework explains the concepts, an analysis framework also elucidates the relationships between those concepts. In other words, an analysis framework is used to lay out the basis for how data should be analysed, and therefore requires continuous refinement while data derived from fieldwork is enriched. The overarching framework in Figure 4.1 intends to comprehensively describe all the relevant factors analysed in this study to answer the principal research question. Yet, it is necessary to define some terms in the figure first, in order for them to be more intelligible. First, knowledge networks, a term this study uses equivalently to knowledge exchange activities, refer to the channels through which universities interact with business and the community. In the view of the HE-BCI survey, knowledge exchange takes place in a wide spectrum of activities, including not only intellectual property channels but also research partnerships. The survey assesses the performance of universities by measuring six types of activities: collaborative research, contract research, consultancy research, F&E related services, courses for business and IP-related activities.

Figure 4.1 Analysis framework



Source: Author’s elaboration with inspiration from Huggins et al. (2012).

Second, the classification of UK regions is defined by Huggins' *UK Competitiveness Index* (UKCI), which comprehensively assesses the relative economic competitiveness of the 12 UK NUTS1 (Nomenclature of Territorial Units for Statistics) regions. South East, London, and East of England are categorised as competitive regions, while the remaining nine regions are labelled as uncompetitive. It is on this basis that this study moves on from a regional analysis to examine whether universities in the two types of regions perform differently in building knowledge networks with businesses. A binary divide between competitive and uncompetitive regions has its limitation in that it could not reveal differences within each group, which is the main reason why a more specific analysis at the regional level has also been undertaken.

Third, whilst this study aims to include as many HEIs as possible, the final number within the samples is smaller than the total number of UK HEIs, as not all of them have been able to submit effective results to the HE-BCI survey. In terms of the categorisation of UK universities, prior studies have usually grouped them according to factors such as research intensity and mission statements (Abreu et al. 2009; Huggins et al. 2011; Hewitt-Dundas 2012). Huggins et al. (2011) acknowledged the diversity of UK HEIs, and in particular found that established universities tend to be more research focused and may have a greater attraction for external organisations. With this in mind, this study follows the classification by Huggins et al. and compares the performance of established (pre-1992) and new (post-1992) universities.

Fourth, the analysis illustrates how academics engage with three main types of partners, namely private sector companies, public sector organisations and third sector (charitable or voluntary) organisations. Fifth, it is also of interest to examine to what extent UK academics, if they are involved in knowledge networks, engage with local, regional, national (but not regional) and international partners. In addition, businesses are recognised, by their size, as SMEs (those firms employing more than 5 but less than 250 full-time employees) or large firms (those firms employing more than 250 full-time employees).

It should also be highlighted that, as the overall analysis framework of this study takes a broad perspective, each of the three empirical chapters only deal with part of the framework. This is especially the case for Chapter 7, which aims to identify the underlying factors of university knowledge exchange initiatives, and to map them out in a figure guided by the analysis framework and the literature review. As Chapter 7 focuses on the 'specific' stories in a number of institutions, it does not distinguish universities by type and location as shown in Figure 4.1; rather, it draws on the influencing factors of academic engagement at four different levels which are outlined in the literature review.

4.6 HE-BCI survey

The HE-BCI survey was used for two aims in this study: one was to examine the interrelationships between the intensity and performance of university knowledge networks in a snapshot view, the other was to evaluate the progress of knowledge exchange activities in the UK higher education sector. The institutional level data were made available by the Higher Education Information Database for Institutions (HEIDI), the web-based information system run by the HESA on a subscription basis to UK HEIs. In particular, it has been suggested that the HEIDI has been developed to ease the burden for users in HEIs to access data for reporting.

For the former aim, the 2009 HE-BCI survey which covers the year of 2007/08 was employed to be analysed together with the CBR academic survey. The survey results reported the income of knowledge exchange activities raised by 159 universities across the UK out of 165 (Table 4.2). It should also be noted that, when measuring the financial performance of knowledge networks, this study controlled for the difference of the size of UK universities by considering the number of academics FTEs in the corresponding year, which was also drawn from the HEIDI.

It was necessary to examine the history and evolution of the survey to achieve the latter aim of longitudinal analysis. Whilst the HE-BCI survey was originally published in 1999/2000, there was a major revision of the framework underlying the data collection process in 2002/03. In particular, from the academic year 2002/03 onward, the HE-BCI survey collected data through two pathways: one for strategy and infrastructure and the other for financial, numeric (time-bound) data. Given the main concern about the actual performance of universities, the analysis employed the latter type of data.

The results for 2002/03, however, had to be eliminated as in that year universities did not report their income from courses for business and the community. In contract research, the HE-BCI survey of 2002/03 only collected income contributed by the private sector, rather than that from the public sector or third sector. The absence of these income sources was likely to have a significant impact on the total income generated by universities, with the analysis later revealing that courses for business was the most important source of income for UK universities. Therefore, the longitudinal analysis in Chapter 6 examined the results of the HE-BCI surveys from 2003/04 to 2011/12, covering an eight-year period.

The number of HEIs reporting to the survey varied from year to year, which may be because some universities chose to submit an optional nil return. For the purpose of consistent comparison, this study compared the 133 members of UUK, an organisation which includes virtually all the universities in the UK and some colleges of higher education (Appendix 1). With a few exceptions, most of these universities, or their predecessors, have submitted effective results to the survey over the whole period. The number of universities finally included in the analysis ranges from 128 in 2008/09 to 131 in 2010/11 and 2011/12.

4.7 CBR academic survey

The academic survey, as explained, was conducted as part of a large research project carried out by the CBR at University of Cambridge in 2009. During the autumn of 2008 and the early summer of 2009, the web-based survey was created and then sent to a specially constructed sampling frame of 125,900 individual academics in all disciplines in virtually all UK universities who were active in research and/or teaching in 2008/09. The survey asked academics to indicate their engagements in knowledge networks between 2005/06 and 2007/08. It finally achieved a sample of 22,170 responses, representing a response rate of over 17 per cent. This study selected 18,991 respondents who specified their region, position and academic discipline in the survey.

Table 4.2 Characteristics of academic and university respondents

	Academic respondents		**University respondents**	
Region	*N*	% of sample	*N*	% of sample
East Midlands	1,214	6.4	9	5.7
East of England	1,476	7.8	8	5.0
London	3,324	17.5	41	25.8
North East	884	4.7	5	3.1
North West	1,737	9.1	14	8.8
Northern Ireland	583	3.1	2	1.3
Scotland	2,684	14.1	17	10.7
South East	2,249	11.8	17	10.7
South West	1,069	5.6	12	7.5
Wales	934	4.9	11	6.9
West Midlands	1,156	6.1	12	7.5
Yorkshire and the Humber	1,681	8.9	11	6.9
Competitive regions	7,049	37.1	66	41.5
Uncompetitive regions	11,942	62.9	93	58.5
UK	18,991	100.0	159	100.0

Source: Author's elaboration from HFECE (2009) and CBR (2010a).

Table 4.2 shows the characteristics of academic respondents in the CBR academic survey and universities that responded to the HE-BCI survey, which were analysed for the relationships between the intensity, performance and imbalance of university knowledge networks. Among the academics who indicated their engagements in knowledge networks, London accounted for 17.5 per cent, while Scotland ranked the second with some 14.1 per cent of all responses. Northern Ireland fell at the bottom of this ranking – 3.1 per cent of all responses were from there. As for universities reporting their income of knowledge exchange activities, 41 out of 159 were London-based. Seven other regions, including Scotland and Wales, had between 10 and 20 university respondents. Northern Ireland was the region with the fewest universities.

The academic survey was adapted by the researcher to align it with the analytical framework. In particular, the questions had to be selected and re-grouped to represent the six modes of knowledge exchange activities proposed by the HE-BCI survey (Appendix 2). The sampling frame, response rate and possible responses biases also had to be evaluated to make sure the data was statistically representative. Although the researcher had access to the data, there was no information about the process in which the survey was administrated. Abreu et al. (2009) however have explained these issues in full detail in their report of the survey results, which became the only source the researcher could reference. Understandably, the reliance on external bodies in terms of data collection is a common issue for researchers who use large-scale secondary data. Therefore, the following analysis has been elaborated based on the information provided by Abreu et al. (2009).

The CBR team manually compiled a list of all academics active in teaching and/or research in the sample period in all disciplines in all UK HEIs, which was the sampling frame. Using the Qualtrics survey software suite, the survey instrument was administered in a series of regional waves. The intention in doing so was to take into account the scale of the survey, which was to be sent to over 125,000 academics. One advantage of this process was that, the research team, after the completion of the first regional wave, were able to make an assessment of the functionality of the instrument as well as a few changes.

Table 4.3 Academic survey response

	N	**% of sample**
Completed returns	22,465	17.8
Of which		
Without reminder	12,283	9.8
After reminder	10,182	8.0
No response	101,932	81.0
Refused	1,503	1.2
Total survey sample	125,900	100.0
Out of scope[1]	3,474	
Total usable sample[2]	18,991	

Notes:
1. Of the 3,474 respondents, 295 were excluded by the CBR team and 3,179 were excluded by the researcher.
2. Completed returns minus out of scope returns.

Source: Author's elaboration from Abreu et al. (2009).

Table 4.3 shows the response rate achieved. In 81 per cent of the cases, no responses were received, while 1.2 per cent of the sample refused to take part. In overall, the team achieved 22,465 returns for a response rate of 17.8 per cent. Of these responses, the CBR team excluded another 295 which indicated the academics were not actively involved in either teaching or research. A further 3,179 returns were excluded by the researcher as they were found to fail to fully indicate information about their region, position and academic discipline. It could be the case that, while the CBR team and the researcher used the survey results in different ways, their perceptions of completed returns may differ.

According to Abreu et al. (2009, p. 92), although standard tests of statistical significance were not presented in the results, appropriate parametric and non-parametric methods were used to test “differences in responses across different cross-classifications”. The authors stated that, “all of the results reported in the main text are statistically significant at the 5% level or better” (Abreu et al. 2009, p. 92). Importantly, it was addressed that, in a study of very large sample sizes, economic significance is of more interest than statistical significance, because “the chance of obtaining statistically significant differences is high, even though the actual magnitude of the differences is extremely small” (Abreu et al. 2009, p. 92).

In terms of response bias, the comparison between non-respondents with respondents was not possible; however, the CBR team compared those academics who replied without a reminder with those who replied after receiving one. In general, the quantitative differences were very small, although there were some statistically significant differences between the two groups, the main reason for which was related to the large sample sizes the study contained. The sample was further compared with HESA statistics by position, gender, discipline and age of respondents, and it seemed that the survey would lead to “a somewhat higher likelihood of interactions with external organisations”, which must be borne in mind when interpreting the results.

4.8 CBR business survey

The CBR business survey was conducted by the same project team who carried out the academic survey mentioned above. It used the Dun & Bradstreet Marketing Database and the Financial Analysis Made Easy (FAME) Accounts Database as the main sampling frame (Hughes and Kitson 2012). It collected 2,530 usable responses from 22,478 firms, representing a response rate of 11.3 per cent. Out of the 2,530 responses, 2,416 respondents specified their region, industrial sector and firm size, and were selected for analysis in this study. As Table 4.4 shows, most responding firms were from the North West region of England, accounting for 13.7 per cent of the full sample. Fewest respondents, only 4.8 per cent of all businesses, were located in London.

Table 4.4 Characteristics of business respondents

Region	*N*	% of sample
East Midlands	217	9.0
East of England	184	7.6
London	115	4.8
North East	194	8.0
North West	332	13.7
Northern Ireland	155	6.4
Scotland	193	8.0
South East	185	7.7
South West	218	9.0
Wales	190	7.9
West Midlands	227	9.4
Yorkshire and the Humber	206	8.5
Competitive regions	484	20.0
Uncompetitive regions	1,932	80.0
UK	2,416	100.0

Source: Authors' elaboration from CBR (2010b).

Questions in the business survey were also intentionally selected and re-grouped by the researcher in order to directly compare how UK academics and firms have engaged in knowledge networks and, more importantly, how these patterns differed across regions. Appendix 3 shows the adaptation of the business survey. The sampling design methodology was fully explained in the report by Hughes and Kitson (2013) on behalf of the CBR team.

The authors argued that the required sample size based on their methodology, which was made to ensure that there would be enough regional variation, was 22,800. In order to "provide a margin for other attrition factors due to errors in addresses and other descriptors in the sampling framework database", the total sample was increased to 23,300 firms (Hughes and Kitson 2013, p. 112). Later on, the sample was allocated to sectors and size classes within each region. After an initial pilot survey, the team modified the survey instrument and added a further sample of firms, raising the final sample size to 25,015 firms.

Table 4.5 Business survey response

	N	**% of sample**
Completed returns	2,551	11.3
No response	19,274	85.8
Refused	653	2.8
Surveyed firms	22,478	100.0
Out of scope[1]	135	
Total usable sample[2]	2,416	

Notes:
1. Of the 2,551 respondents, 21 were excluded by the CBR team and 114 were excluded by the researcher.
2. Completed returns minus out of scope returns.

Source: Author's elaboration from Hughes and Kitson (2013).

Out of the 25,015 firms, 2,537 were found to be ineligible due to the reasons such as they had ceased trading or had been acquired, etc. Therefore, the number of surveyed firms was 22,478 (Table 4.5). In general, the response rate of 11.3 per cent was considered to be acceptable, although lower than the estimation in the sampling design (15 per cent).

A total of three sets of response bias analysis were undertaken by Hughes and Kitson (2013) to check the reliability of the data: a) responses versus the sampling frame; b) responses by response wave; and c) comparing the CBR business survey with CIS analysis for potential bias towards replies from innovation active firms. In the first set of analysis, there found no significant difference in the median size or sectoral distribution of respondents compared to non-respondents. Although the analysis showed that respondents were "statistically significantly younger than non-respondents", the actual median age difference between the two groups was found to be very small (Hughes and Kitson 2013, p. 116). The second set of analysis by response wave revealed no significant difference between waves in terms of sector or region, but showed that early waves were more likely to be innovators. This potential bias was removed by the third set of analysis, in which the authors compared the innovative characteristics of the final sample with that of firms responding to the national innovation survey for 2009 conducted by the ONS and found very similar levels of innovation active firms in the two samples. In general, the sample was found to be representative of the whole sample and response bias was not considered to be a problem in this study.

4.9 Case studies of university initiatives in Wales

4.9.1 Selection of cases

An important task, before the selection of cases, was to decide the unit of analysis, as this was the level at which the research was conducted and objects were investigated. Since the main aim of the case studies was to reveal what programmes existed in Welsh universities to enable them to reach out to businesses, the meso-level analysis seemed most appropriate, i.e. the examination of the specific programmes, organisations, or intermediaries which are directly devoted to knowledge exchange between academics and businesses. In general, a meso-level analysis indicates an investigation which falls between the micro- and macro-levels; it is, in this context, meant to differ from the analysis focusing on individual academics (micro-level) or individual universities (macro-level).

Wales was selected as the geographical area where the researcher would search for potential cases due to several factors. Firstly, while based in Cardiff, the capital city in Wales, it was much easier for the researcher to arrange travel and conduct face-to-face interviews within that region than elsewhere. Secondly, during the years of graduate study, the researcher was also involved in a research team working on a NESTA (National Endowment for Science, Technology and the Arts) funded research project. It should be noted that the researcher was looking at illustrative knowledge networks in Wales, not a case study of Wales as a region.

The cases were consequently identified through a two-stage process. Using the HE-BCI survey data, the first stage measured the average performance of Welsh universities in knowledge exchange activities between 2008/09 and 2010/11, in order to identify the institution leading each type of activity (Appendix 4). This enabled the researcher to target the potential programmes within an institution in relation to the type of activity in which the university led the performance. An expert interview was conducted in the second stage, aiming to discuss and select the case studies that would be finally included. Whilst experts have been said to have high insight in specific knowledge, interviews with them have now been widely used as a qualitative approach in the social sciences (Bogner et al. 2009; Flick 2009). Table 4.6 describes the cases chosen, while Figure 4.2 uses Google Map tools to locate them.

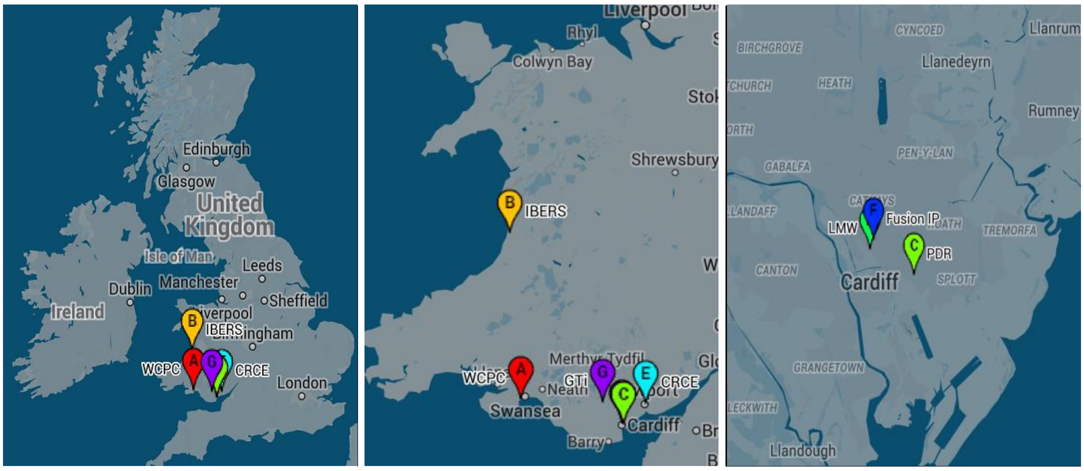
These cases were intended to illustrate the factors underlying their performance, which were identified in the literature review and explained in the analytical framework. In particular, the factors of each case were identified at the individual, departmental, organisational and spatial levels. Combined together these cases were intended to show the multiple variables shaping knowledge exchange activities from institution to institution. While the analysis of this thesis was largely dependent upon the large-scale quantitative analysis of the UK region, the purpose of the case study chapter was to provide complementary evidence which was unable to be analysed at the national level. Therefore, the scope of the case study chapter was admittedly defined in a narrow sense and was about mapping the factors within a four-level framework grounded within the academic literature.

Table 4.6 Examples of Welsh universities engaging with businesses

Institution	Programme	Description
Swansea University	Welsh Centre for Printing and Coating (WCPC)	R&D centre in the area of printing and coating
Aberystwyth University	Institute of Biological, Environmental and Rural Sciences (IBERS)	Research and teaching centre
Cardiff Metropolitan University	National Centre for Product Design and Development Research (PDR)	Undertaking design project with industry
Cardiff University	Leadership & Management Wales (LMW)	Centre for excellence for leadership and management skills in Wales
University of Wales, Newport	Centre for Regeneration & Community Engagement (CRCE)	Promoting inclusion in the local area through community partnerships
Cardiff University	Fusion IP	Intellectual property commercialisation firm
University of Glamorgan	University of Glamorgan's incubator (GTi)	Supporting entrepreneurial graduates

Source: Author's own elaboration.

Figure 4.2 Geographical locations of the seven cases



4.9.2 Semi-structured interviews

The primary method of data collection in the case studies was a series of interviews conducted in Spring 2013. A total of 10 interviews – each lasting between 50 minutes and 2 hours – were carried out with individuals who had been directly involved in knowledge exchange activities in order to gather their views on the performance of those programmes. Scholars such as Weiss (1994) and Merriam and Merriam (1998) have discussed interviews as a form of social research. In general the interview is, as Yin (2009) has noted, one of the most important sources of case study information. Interviews can be undertaken on a spectrum ranging from informal conversation to highly structured (Bauer and Gaskell 2000); in this study, the researcher considered the semi-structured interviews most suitable. The advantage of semi-structured interviews is that it allows the investigator to retain focus on research questions by constantly referring to a topic guide, while at the same time allowing the discussion to go further to yield more useful information for the analysis (Flick 2006).

All of the interviews followed the same topic guide, which formed the core of the case study protocol. Since the interviews were conducted in a semi-structured format, the topic guide used was a set of paragraph headings rather than an extensive series of specific questions (Bauer and Gaskell 2000). A sample of list of questions used is shown in Appendix 5, which included open-ended questions about the profile, implementation, and impact of the specific initiative the interviewee was involved in. It is also important to ask questions in an effective order, as Patton (2002) has advised that an interview should begin with questions about non-controversial experiences, while the more sensitive questions should be asked towards the end of the interview. Before each interview started, the researcher informed the interviewee that she/he did not have to answer any questions considered to be too sensitive.

An email outlining the research purpose of this study was sent to potential interviewees, who were identified by searching the web pages of the programmes. The individuals were either the founders, the managing directors, or the research managers who were familiar with the operation of the initiatives (Table 4.7). In the email, the researcher also explained what questions could possibly be asked (following the topic guide), and informed potential interviewees of the ethical considerations of the study. Interviewees were ensured that their comments would be anonymised and would be sent to them for approval before being presented in the thesis.

Table 4.7 List of interviewees

No.	Title	Organisation
1	Director	Welsh Centre for Printing and Coating (WCPC)
2	Senior Researcher	Welsh Centre for Printing and Coating (WCPC)
3	Director of Enterprise	Institute of Biological, Environmental and Rural Sciences (IBERS)
4	Operation Director	National Centre for Product Design and Development Research (PDR)
5	Director	Leadership & Management Wales (LMW)
6	Business Engagement Officer	Leadership & Management Wales (LMW)
7	Director	Centre for Regeneration & Community Engagement (CRCE)
8	Chief Executive Officer	Fusion IP
9	Project Co-ordinator	Cardiff University Technology Transfer Group
10	Business Incubation Manager	University of Glamorgan's incubator (GTi)

4.9.3 Analysis of interview data

All the interviewees agreed to have their interviews taped, which allowed the researcher to later transcribe the recordings. The transcriptions proved extremely valuable to gain familiarity with the data and enable the initial analysis of the interviews. Recently, there has been much discussion about the convenience and usefulness of using computer software in qualitative data analysis (Creswell 2009). For instance, many studies have mentioned the use of Nvivo, a computer software package designed for qualitative researchers working with text-based and/or multimedia information. Despite the advantage of saving researchers a lot of time, the software, according to Bauer and Gaskell (2000, p. 55), “cannot do the intuitive and creative work that is an essential part of qualitative research”.

In this study, the analysis of interview data was mainly based on the topic guide, rather than the codes generated from computer software. As the case studies were mainly selected to show the complexity and diversity of knowledge exchange activities, there was little necessity to employ computer software that has mainly been used to generate common themes and codes for comparison. The analysis consisted of two parts – within-case analysis and cross-case pattern search – but the main focus was on the first phase. The goal of within-case analysis was to gain in-depth knowledge of, and to create a detailed account about, each knowledge exchange programme. Furthermore, the themes identified by the topic guide were considered to be comprehensive enough to capture the different aspects of each initiative and to allow for the synthesis of interview data from all the case studies.

4.9.4 Triangulation

Although face-to-face interviews can have the advantage of being targeted on research questions, they are prone to common problems of bias, poor recall, and inaccurate articulation (Yin 2009). Thus, interview data is often corroborated with information from other sources, including non-participant observation and documentation (Eisenhardt 1989; Miles and Huberman 1994). Myers (2009) referred to the adoption of multiple sources of evidence as triangulation, a central benefit of which lies in the reduction of inappropriate uncertainty. In addition to interview data, this study also implemented documentary information which was collected from the websites, annual reports, case studies, evaluation documents, and statistics of the practices investigated. Documents, as Bryman (2008, p. 551) suggested, can be used as “a platform for developing insights into the processes and factors that lie behind divergence”. Information provided by the interviewees was constantly cross-checked with that from secondary documents to ensure data validity. On a couple of occasions, the researcher was provided with some publications that had not been known to exist before the interviews, including working papers, conference papers and research reports.

4.10 Research ethics

Ethical issues arising from the conducting of this study were in the following two areas, and were paid much attention by the researcher. The first area was in the collection and use of the interview data. The initial approach to the informants provided information on the research topic and the nature of their voluntary participation. In particular, informants were informed that the study followed the guidelines set by the Research Ethics Committee of the School of Planning and Geography. Key passages from the interview transcripts were provided to informants to ensure validity of the data and the way it was represented. Names of all informants were removed from the draft dissertation to respect their anonymity.

Regarding the re-use of secondary data held by the HESA and UK Data Archive, research ethics were taken into serious consideration to avoid the violation of data protection. It was understood that the data sourced from the above bodies were not in the public domain; instead, their use was restricted to specific purposes after registration or subscription. The researcher was, however, able to access the data as an academic based at a UK higher education institution. The data were used solely for research purposes, and throughout the whole process, the researcher did not disseminate any identifying or confidential information. In addition, the re-use of data did not abuse the copyright belonging to the original authors or organisations.

SECTION II

EMPIRICAL FINDINGS

CHAPTER 5

TERRITORIAL PATTERNS OF UNIVERSITY-INDUSTRY KNOWLEDGE EXCHANGE

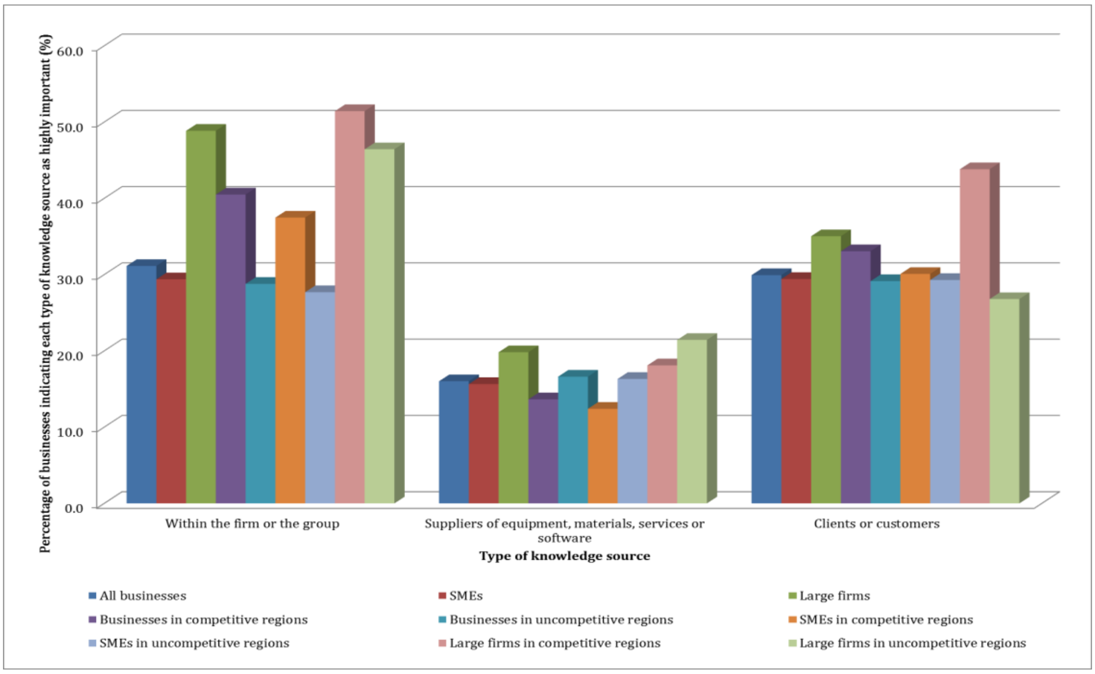
This chapter evaluates the business demand for knowledge produced by universities, as well as the link with supply of knowledge across UK regions. It represents an effort to empirically measure the match (or mismatch) between knowledge supply and knowledge demand aspects, which should be taken into account when regional policy makers design relevant policies. The analysis is presented in two sub-sections: one is to provide firm-level evaluation of knowledge demand; the other is to investigate whether university-industry interactions demonstrate different patterns across the two regional groups and the 12 regions. In order to answer the question concerning relationships between university supply and business demand for knowledge in UK regions, the results of the CBR academic survey have been included in this chapter, although this is examined in more detail in Chapter 6.

5.1 An analysis of firm-level demand

5.1.1 Recognising the 'real' importance of academic knowledge

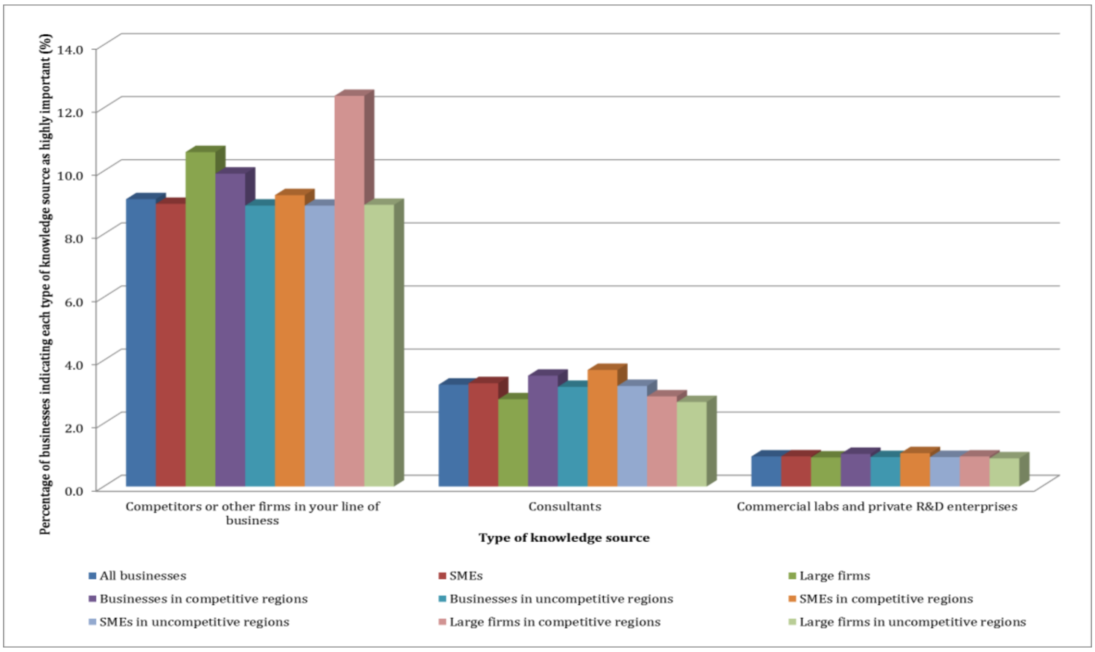
Understandably, the utilisation of academic knowledge for business development is largely based on how firms perceive the importance of that knowledge in comparison to other types of knowledge sources. The CBR business survey asked businesses to indicate the sources of knowledge or information used, and their degree of importance in innovation activities using a 1-to-5 rating scale, with 5 referring to 'highly important' and 1 referring to 'not important'. Businesses could choose from a total of 12 options including clients or customers, consultants, commercial labs, higher education institutions, government or public research organisations and professional and industry networks. The inclusion of a diverse set of potential knowledge sources is thought to be better able to measure the relative importance of academic knowledge to businesses in the UK. Figures 5.1 to 5.4 below illustrate how businesses regarded the 12 types of knowledge sources as highly important.

Figure 5.1 Importance of the same firm, suppliers and customers perceived by businesses as knowledge source



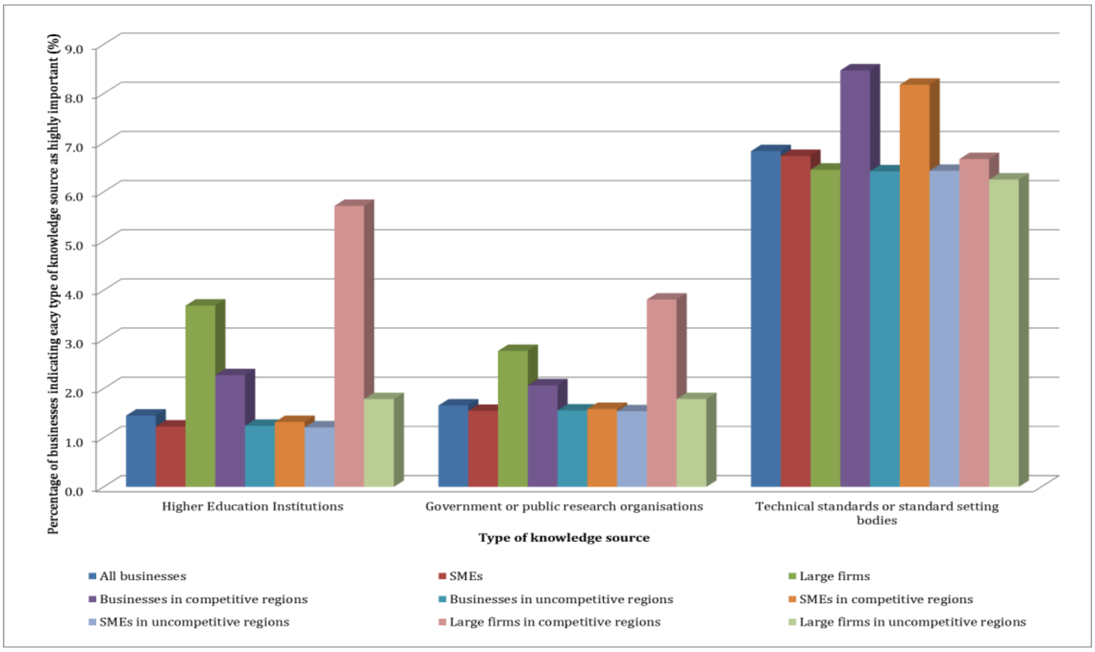
Source: Author's elaboration from CBR (2010b).

Figure 5.2 Importance of competitors, consultants and commercial labs perceived by businesses as knowledge source



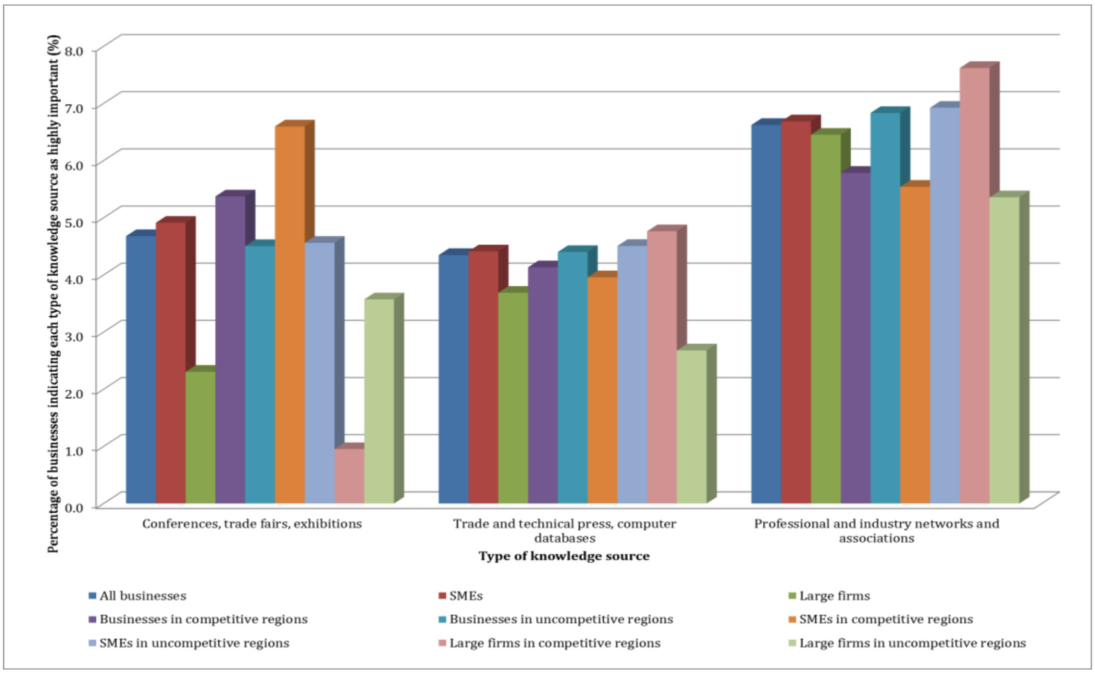
Source: Author's elaboration from CBR (2010b).

Figure 5.3 Importance of HEIs, government or public research organisations and standard setting bodies perceived by businesses as knowledge source



Source: Author's elaboration from CBR (2010b).

Figure 5.4 Importance of conferences, trade and technical press and professional networks perceived by businesses as knowledge source



Source: Author's elaboration from CBR (2010b).

In overall terms, nearly one third of firms stated that the business itself is a highly important knowledge source, while about 30 per cent of the responding businesses regarded customers as a highly important knowledge source. Suppliers of equipment, materials, services or software were considered to be highly important as a knowledge source by 16 per cent of businesses. One in eleven companies considered competitors or other firms in their line of business to be a highly important source of knowledge. Technical standards or standard setting bodies were rated as highly important by 7 per cent of companies. In comparison, less than 2 per cent of the businesses labelled universities as highly important, implying that universities, compared with the other sources, were perceived to be less important for the majority of businesses in terms of knowledge exchange (Cosh and Hughes 2010).

More importantly, this pattern holds for firms across regions and size groups. For example, about 5.7 per cent of large firms in competitive regions – the firm group with the highest recognition of the importance of university knowledge – considered universities to be highly important knowledge sources. But this number is still significantly lower than the percentages of the same firm group reporting the high importance of many other types of knowledge sources. In an era when firms enhance their innovation performance by integrating both internal and external knowledge sources in an open innovation approach, it could be argued that university knowledge has not become an important element in that process.

5.1.2 Making use of academic knowledge

Large firms were found to be more actively involved with universities for knowledge sourcing than smaller firms (Table 5.1). SMEs interacted most closely with universities in courses with 15.8 per cent reporting they had attended courses that may improve specific professional skills of their employees. Less than 3 per cent of SMEs reported engagements with HEIs in collaborative research, contract research, consultancy research and IP-related activities, indicating either their limited needs of, or difficulty of getting access to, scientific and technological knowledge in universities. Academic interactions are to a large extent dominated by UK large firms, which tend to be more innovation intensive and be more capable of accessing and absorbing knowledge from universities (Huggins et al. 2010b).

Table 5.1 Percentage of businesses involved in the six modes of knowledge networks with universities by size group, %

Mode of network	All businesses *N*=2416	Size group: SMEs *N*=2199	Size group: Large firms *N*=217	T-test
Collaborative research	4.3	2.8	19.8	**
Contract research	2.7	1.6	13.4	**
Consultancy research	4.2	2.9	17.1	**
F&E related services	3.9	2.6	16.1	**
Courses for business	18.8	15.8	49.8	**
IP-related activities	2.3	1.5	10.6	**

Notes:

1. Businesses were asked to indicate whether they were involved in each mode of knowledge network between 2005/06 and 2007/08.
2. T-test was used to show whether there were significant differences between the two size groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).

Source: Author's elaboration from CBR (2010b).

Table 5.2 examines how businesses in the two regional groups, competitive and uncompetitive, participated in various types of activities with universities. Businesses in competitive regions showed higher levels of interactions with academics in collaborative research, consultancy research, facilities and equipment related services, courses and IP-related activities than their counterparts located in uncompetitive regions (significant at the $p < 0.01$ level). Professional courses, for firms in both types of regions, were the most frequently engaged interaction. Relatively less difference was found between the two groups of firms in their intensity of involvement in contract research.

Also, Table 5.2 shows that there is a positive relationship between the intensity of businesses sourcing academic knowledge and the competitiveness of the regions where the firms are situated. This might not be an unexpected finding, as competitiveness itself conveys the capability of an economy, a regional economy in this context, in attracting and maintaining innovative firms, which are more likely to use academic knowledge. However, what seems to be striking is the contrasting relationship this study has found in the case of academics; that academics in uncompetitive regions showed significantly higher level of engagement in knowledge networks than those in competitive regions.

Table 5.2 Percentage of businesses involved in the six modes of knowledge networks with universities by regional group, %

		Regional group		
Mode of network	All businesses *N*=2416	Businesses in competitive regions *N*=484	Businesses in uncompetitive regions *N*=1932	**T-test**
Collaborative research	4.3	6.8	3.7	**
Contract research	2.7	5.4	2.0	†
Consultancy research	4.2	6.6	3.6	**
F&E related services	3.9	6.8	3.2	**
Courses for business	18.8	23.3	17.7	**
IP-related activities	2.3	4.3	1.8	**

Notes:

1. Businesses were asked to indicate whether they were involved in each mode of knowledge network between 2005/06 and 2007/08.
2. T-test was used to show whether there were significant differences between the two regional groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).

Source: Author's elaboration from CBR (2010b).

Table 5.3 compares how SMEs in the two regional groups sourced knowledge from universities in various ways. Overall, SMEs in competitive regions were more intensively engaged with academics than those in uncompetitive regions, although those differences were only significant in the areas of contract research and consultancy research. Regional factors seem to be associated with the intensity of knowledge exchange between SMEs and academics. The ability of smaller firms to access scientific knowledge is enhanced by being situated within a competitive environment, which may involve a substantial cluster of SMEs and localised learning networks. It has been suggested that SMEs could gain advantages from localised networks and by learning to offset the advantages of large firms in relation to their size (Cumbers et al. 2003).

Table 5.3 Percentage of SMEs involved in the six modes of knowledge networks with universities by regional group, %

		Regional group		
Mode of network	All SMEs *N*=2199	SMEs in competitive regions *N*=379	SMEs in uncompetitive regions *N*=1820	**T-test**
Collaborative research	2.8	2.9	2.8	
Contract research	1.6	2.6	1.4	†
Consultancy research	2.9	4.2	2.6	†
F&E related services	2.6	3.4	2.5	
Courses for business	15.8	15.8	15.8	
IP-related activities	1.5	1.8	1.4	

Notes:

1. Businesses were asked to indicate whether they were involved in each mode of knowledge network between 2005/06 and 2007/08.
2. T-test was used to show whether there were significant differences between the two regional groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).

Source: Author's elaboration from CBR (2010b).

No significant differences were found between large firms in competitive and uncompetitive regions with respect to their levels of interactions with universities, suggesting that regional profile is not strongly associated with the capability of large firms accessing academic knowledge (Table 5.4). Understandably, large firms tend to be integrated into global, not only regional, innovation networks. They may also have regional profiles but the role of regional linkages in their agenda is more likely to be limited.

Table 5.4 Percentage of large firms involved in the six modes of knowledge networks with universities by regional group, %

Mode of network	All large firms *N*=217	Regional group: Large firms in competitive regions *N*=105	Large firms in uncompetitive regions *N*=112	T-test
Collaborative research	19.8	21.0	18.8	
Contract research	13.4	15.2	11.6	
Consultancy research	17.1	15.2	18.8	
F&E related services	16.1	19.0	13.4	
Courses for business	49.8	50.5	49.1	
IP related activities	10.6	13.3	8.0	

Notes:

1. Businesses were asked to indicate whether they were involved in each mode of knowledge network between 2005/06 and 2007/08.
2. T-test was used to show whether there were significant differences between the two regional groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).

Source: Author's elaboration from CBR (2010b).

5.1.3 Tapping into global academic knowledge

Table 5.5 shows how intensively UK SMEs and large firms were engaged with their university partners at different geographic levels. It appears that large firms were not only more capable of building international linkages, but also were more closely engaged with national and regional institutions than their smaller counterparts. SMEs were more likely to interact with local universities, while at the regional level they only showed higher levels of interactions with universities in contract research and consultancy research than large firms, and these differences were not significant. There were significant differences between SMEs and large firms in their involvements in international contract research and consultancy research with universities. A clear dis-connectivity between SMEs and universities beyond the local proximity could be concluded.

Table 5.5 Percentage of businesses, which were engaged in each activity, involved with local, regional, national and international universities by size group, %

Location of interacting university	All businesses	Size group: SMEs	Size group: Large firms	T-test
Collaborative research				
	N=105	*N*=62	*N*=43	
Local	26.7	27.4	25.6	
Region	40.0	37.1	44.2	
National	45.7	40.4	53.5	
International	17.2	12.9	23.3	
Contract research				
	N=65	*N*=36	*N*=29	
Local	23.0	19.5	27.6	
Regional	38.4	38.9	37.9	
National	44.6	36.1	55.2	*
International	24.6	13.9	37.9	*
Consultancy research				
	N=101	*N*=67	*N*=37	
Local	32.7	36.7	24.3	
Regional	33.7	34.0	32.4	
National	37.6	30.6	51.4	*
International	15.8	9.8	27.0	*
F&E related services				
	N=95	*N*=58	*N*=35	
Local	36.8	37.9	37.2	
Regional	44.2	39.6	54.3	
National	35.8	24.1	60.0	**
International	13.7	8.6	17.1	
Courses for business				
	N=455	*N*=347	*N*=108	
Local	58.4	61.7	47.2	**
Regional	35.2	31.2	48.1	**
National	17.8	9.8	43.5	**
International	3.9	2.3	9.3	**

Notes:

1. Businesses were asked to indicate, if they were involved in each mode of knowledge network, whether they were involved with local, regional, national or international universities between 2005/06 and 2007/08.
2. T-test was used to show whether there were significant differences between the two size groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).

Source: Author's elaboration from CBR (2010b).

Businesses in competitive and uncompetitive regions, as shown in Table 5.6 below, seemed to interact with universities in distinct ways: businesses in uncompetitive regions showed higher levels of engagement in locally and regionally-based activities, while businesses in competitive regions outperformed in nationally and internationally-based activities. In the case of courses for business and the community, firms in less competitive areas were even more inclined to work with local partners. It seems that for businesses situated in uncompetitive regions, their knowledge networks were bounded within the area, and it becomes necessary to understand what are the main factors leading to their choices or preventing them from searching for collaborative partners at a further distance. While firms in competitive regions tended to be integrated into national and global knowledge networks, an important issue to address is whether this further enhances their competitive advantages in the marketplace.

The analysis in Table 5.6 specifically focuses on how a firm's location is associated with its intensity of extra-regional knowledge networks with academics, thus excluding other types of knowledge sources. Huggins et al. (2010a), through their own surveys of UK firms, found limited impact of the locational factor on the degree of international knowledge sourcing when all types of knowledge producing organisations are considered. These two findings combined may suggest that when firms from uncompetitive regions search for partners located outside of their region, they are more inclined to build partnerships with suppliers, clients or competitors, rather than with universities. This is an interesting topic which needs further investigation.

Table 5.6 Percentage of businesses, which were engaged in each activity, involved with local, regional, national and international universities by regional group, %

Location of interacting university	All businesses	**Regional group** Businesses in competitive regions	**Regional group** Businesses in uncompetitive regions	**T-test**
Collaborative research				
	N=105	*N*=33	*N*=72	
Local	26.7	24.2	27.8	
Regional	40.0	27.3	45.8	†
National	45.7	63.6	37.5	*
International	17.2	33.7	9.7	**
Contract research				
	N=65	*N*=26	*N*=39	
Local	23.0	19.2	25.6	
Regional	38.4	34.6	41.0	
National	44.6	57.7	35.9	†
International	24.6	34.6	17.9	
Consultancy research				
	N=101	*N*=32	*N*=69	
Local	32.7	25.0	36.2	
Regional	33.7	25.0	37.7	
National	37.6	56.3	29.0	*
International	15.8	28.1	10.1	*
F&E related services				
	N=95	*N*=33	*N*=62	
Local	36.8	27.3	41.9	
Regional	44.2	39.4	46.8	
National	35.8	66.7	19.4	**
International	13.7	27.3	6.5	**
Courses for business				
	N=455	*N*=113	*N*=342	
Local	58.4	41.6	64.0	**
Regional	35.2	43.4	32.5	*
National	17.8	31.0	13.5	**
International	3.9	9.7	2.0	**

Notes:

1. Businesses were asked to indicate, if they were involved in each mode of knowledge network, whether they were involved with local, regional, national or international universities between 2005/06 and 2007/08.
2. T-test was used to show whether there were significant differences between the two regional groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).

Source: Author's elaboration from CBR (2010b).

In Table 5.7 below, the figures compare how SMEs in the two regional groups collaborated differently with universities at different geographic distances. SMEs in uncompetitive regions were much more likely to work with local or regional institutions than to seek academic partners beyond the region. The competitiveness of a region was found to be positively related to the level of its businesses interacting with overseas academic partners in contract research, facilities and equipment related services and courses for business. In comparison, in the majority of cases, there were no significant differences between large firms in the core regions and the uncompetitive ones, indicating a weak link between the regional profile and the capability of large firms to engage with academics (Table 5.8). The only exception was international collaborative research, in which large firms from competitive regions seemed to have a significant advantage over those large firms situated within lagging areas.

In a way, this finding provides an explanation for the results of Table 5.5 which showed that large firms were the main driving forces behind the regional differences in forming global research collaborations with universities. For example, London could be viewed as an accumulation node of global networks and houses many of the world leading companies (Iammarino et al. 2013). They could, and do, go beyond the boundaries of their own regional territories to work with academics around the world. SMEs in the two regional groups, as Table 5.5 has suggested, showed different levels of international knowledge networks with universities, which should be examined in more detail in future work. In particular, it is hoped that SMEs in uncompetitive regions may draw useful lessons from their counterparts in more competitive areas.

Table 5.7 Percentage of SMEs, which were engaged in each activity, involved with local, regional, national and international universities by regional group, %

Location of interacting university	All SMEs	**Regional group** SMEs in competitive regions	SMEs in uncompetitive regions	**T-test**
Collaborative research				
	N=62	N=11	N=51	
Local	27.4	18.2	29.4	
Regional	37.1	9.1	43.1	*
National	40.4	54.5	37.3	
International	12.9	27.3	9.8	
Contract research				
	N=36	N=10	N=26	
Local	19.5	10.0	23.1	
Regional	38.9	30.0	42.3	
National	36.1	40.0	34.6	
International	13.9	30.0	7.7	†
Consultancy research				
	N=67	N=19	N=48	
Local	36.7	18.8	43.8	†
Regional	34.0	25.0	37.5	
National	30.6	50.0	22.9	*
International	9.8	18.8	6.3	
F&E related services				
	N=58	N=13	N=45	
Local	37.9	23.1	42.2	
Regional	39.6	23.1	44.4	
National	24.1	61.5	13.3	**
International	8.6	23.1	4.4	*
Courses for business				
	N=347	N=60	N=287	
Local	61.7	46.7	64.8	**
Regional	31.2	33.3	30.7	
National	9.8	15.0	8.7	
International	2.3	6.7	1.4	*

Notes:

1. Businesses were asked to indicate, if they were involved in each mode of knowledge network, whether they were involved with local, regional, national or international universities between 2005/06 and 2007/08.
2. T-test was used to show whether there were significant differences between the two regional groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).

Source: Author's elaboration from CBR (2010b).

Table 5.8 Percentage of large firms, which were engaged in each activity, involved with local, regional, national and international universities by regional group, %

Location of interacting university	All large firms	**Regional group** Large firms in competitive regions	Large firms in uncompetitive regions	**T-test**
Collaborative research				
	N=43	N=22	N=21	
Local	25.6	27.3	23.8	
Regional	44.2	36.4	52.4	
National	53.5	68.2	38.1	†
International	23.3	36.4	9.5	*
Contract research				
	N=29	N=16	N=13	
Local	27.6	25.0	30.8	
Regional	37.9	37.5	38.5	
National	55.2	68.8	38.5	
International	37.9	37.5	38.5	
Consultancy research				
	N=37	N=16	N=21	
Local	24.3	31.3	19.0	
Regional	32.4	25.0	38.1	
National	51.4	62.5	42.9	
International	27.0	37.5	19.0	
F&E related services				
	N=35	N=20	N=15	
Local	37.2	30.0	46.7	
Regional	54.3	50.0	60.0	
National	60.0	70.0	46.7	
International	17.1	20.0	13.3	
Courses for business				
	N=108	N=53	N=55	
Local	47.2	35.8	58.2	*
Regional	48.1	54.7	41.8	
National	43.5	49.1	38.2	
International	9.3	13.2	5.5	

Notes:

1. Businesses were asked to indicate, if they were involved in each mode of knowledge network, whether they were involved with local, regional, national or international universities between 2005/06 and 2007/08.
2. T-test was used to show whether there were significant differences between the two regional groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).

Source: Author’s elaboration from CBR (2010b).

5.2 Regional knowledge supply-demand relationships

5.2.1 Regional analysis of business knowledge demand

In this sub-section, the regional analysis of how intensively businesses interacted with universities in various channels of knowledge networks is presented. Table 5.9 summarises the results for all of the six modes of interactions surveyed. Collaborative research was reported by just above 4.3 per cent of business respondents in the UK. Firms in London took part in collaborative research with academics most frequently, followed by those companies situated in the South East and Yorkshire and the Humber. Research collaboration was not that popular in businesses in North West and North East, where less than 3 per cent of samples were involved.

Less than 3 per cent of businesses have been involved in contract research with universities, but there were divergences across regions. London-based firms were nearly three times more closely engaged in this channel than the national average, while the percentage of businesses in the North West reporting their participation in contract research was at just one third of the UK level. It was also found that firms in the South East and Scotland often turned to academics for problem-solving activities by commissioning research contracts.

Consultancy research is another common type of interaction that businesses often build with academics, in addition to the former two types of research partnerships. Firms in London were most actively involved in consultancy research with universities, more than triple the intensity of UK businesses as a whole. In contrast, just 1.6 per cent of business respondents in the East of England reported the use of consulting services provided by academics. An observation from the three types of research collaboration was that businesses in East of England, one of the three competitive regions, lagged far behind those in London and South East in interacting with academics in all the measures.

On average, about 4 per cent of firms have been involved in facilities and equipment related services with universities. At the top of the rankings was London, where nearly one in ten firms reported the use of F&E services provided by academics. This type of interaction was least frequently reported by businesses located in the South West.

Courses for business and the community, e.g. professional training programmes, were the type of interaction in which businesses were most likely to get involved, as revealed by the figures in Table 5.9. About 19 per cent of companies have taken some courses with universities, the length of which may vary from a few days to a few months. For businesses in London, the chance of participating in training programmes delivered by universities was even greater as nearly 30 per cent of firm respondents had done so. By comparison, Scotland saw its firms less likely to participate in university courses with the aim of advancing certain professional skills of managers or employees.

Table 5.9 shows how businesses in the UK regions got involved in IP-related activities with universities. During the recent few decades, universities have been granted the right to license IP to companies interested in commercialising their technology. Among the six modes of interactions, IP was the least popular one for businesses to have with universities. Firms from the South East, the East of England and London – the three competitive regions – were most likely to license IP from universities, while Welsh businesses were least likely to have such an interaction.

Table 5.9 Percentage of businesses involved in the six modes of knowledge networks with universities by region, %

Region	Collaborative research		Contract research		Consultancy research		F&E related services		Courses for business		IP-related activities	
	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank
East Midlands	2.8	9	1.4	10	3.2	8	3.7	6	16.1	10	1.4	9
East of England	3.8	8	2.2	6	1.6	12	3.8	5	19.6	5	3.8	2
London	11.3	1	7.8	1	13.9	1	9.6	1	29.6	1	3.5	3
North East	2.1	12	2.1	7	2.1	11	3.1	10	16.0	11	3.1	4
North West	2.7	11	0.9	12	3.9	6	2.4	11	16.3	9	1.2	11
Northern Ireland	3.9	7	1.9	8	4.5	5	3.2	9	22.6	3	1.9	7
Scotland	5.2	4	4.7	3	4.7	4	4.7	3	14.5	12	1.6	8
South East	7.0	2	7.0	2	7.0	2	8.1	2	23.2	2	5.4	1
South West	2.8	9	2.3	5	2.3	10	0.9	12	21.1	4	1.4	9
Wales	4.7	5	1.6	9	3.2	7	3.7	6	16.8	8	1.1	12
West Midlands	4.4	6	1.3	11	2.6	9	3.5	8	18.1	7	2.2	6
Yorkshire and the Humber	5.8	3	2.9	4	5.8	3	4.4	4	19.4	6	2.9	5
UK	4.3	n/a	2.7	n/a	4.2	n/a	3.9	n/a	18.8	n/a	2.3	n/a

Notes:
1. Businesses were asked to indicate whether they were involved in each mode of knowledge network with universities between 2005/06 and 2007/08.
2. Rank refers to how each region compares against the rest 11 regions in the given index.

Source: Author's elaboration from CBR (2010b).

5.2.2 Territorial patterns of university-industry knowledge exchange

An important task of this sub-section is to investigate whether knowledge networks demonstrated different patterns across the two regional groups and the 12 UK regions. In order to examine this, a 2*2 matrix was drawn (Figure 5.5). The *x* axis refers to the relative value of the intensity of academic engagement in each type of activity to the intensity of the UK average. For academics, interactions were not necessarily with businesses, but also involved the public sector and third sector organisations, thus indicating the overall supply of academic knowledge that businesses could possibly utilise. The *y* axis refers to the relative value of the intensity of business engagement with universities in each type of activity to the intensity of the UK average, meaning the actual demand from businesses for academic knowledge.

Figure 5.5 clearly reveals a distinct 'Competitive-Uncompetitive' divide in terms of the university-business interaction patterns in the two regional groups. For uncompetitive regions, the majority of dots were located in the bottom right quadrant suggesting that, even with the existence of sufficient academic knowledge, businesses were only able to realise a modest share of it. On the contrary, in competitive regions, most dots were found in the top left quadrant, which indicates that the capability of businesses there was not constrained by the lower level of involvement by regionally-based academics, which might be associated to their integration in extra-regional and international knowledge networks. A green oval was drawn to cover four out of six activities for the competitive regions, suggesting that these regions showed an overall 'Low

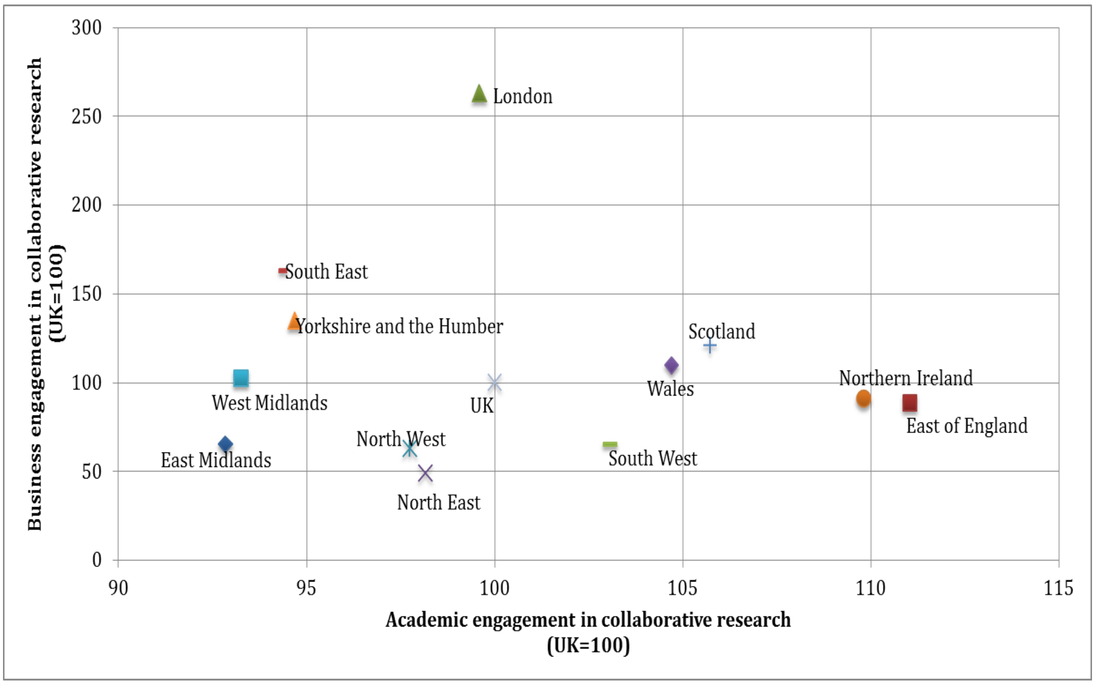
Supply-High Demand' pattern of university-business interactions. Similarly, a red oval was drawn to cover four of six activities for the uncompetitive regions, leading the researcher to label knowledge exchange activities in those areas as 'High Supply-Low Demand'.

Figure 5.5 University-business interaction patterns in the two regional groups

Source: Author's own elaboration.

Figure 5.6 illustrates the university-business interaction patterns in collaborative research at the regional level. This suggests that businesses were the driving force for research collaborations with universities in London and the South East, as they were most capable of developing that relationship even with the low level of engagements by regional academics. The East of England – the third competitive region – told a different story from its other two competitive counterparts. More specifically, whilst academics in the East of England tended to be most actively devoted to collaborative research with businesses, the private sector firms in that region lacked the capability to realise that abundant potential. Building research collaboration with universities seemed not to lie at the heart of strategy for companies located in the East of England. Regions where businesses were also less likely to fully realise the supply of academic knowledge in collaborative research included Northern Ireland and the South West of England. In the East Midlands, the North West and the North East, neither the academic supply nor the business demand side were strong in research collaboration engagements.

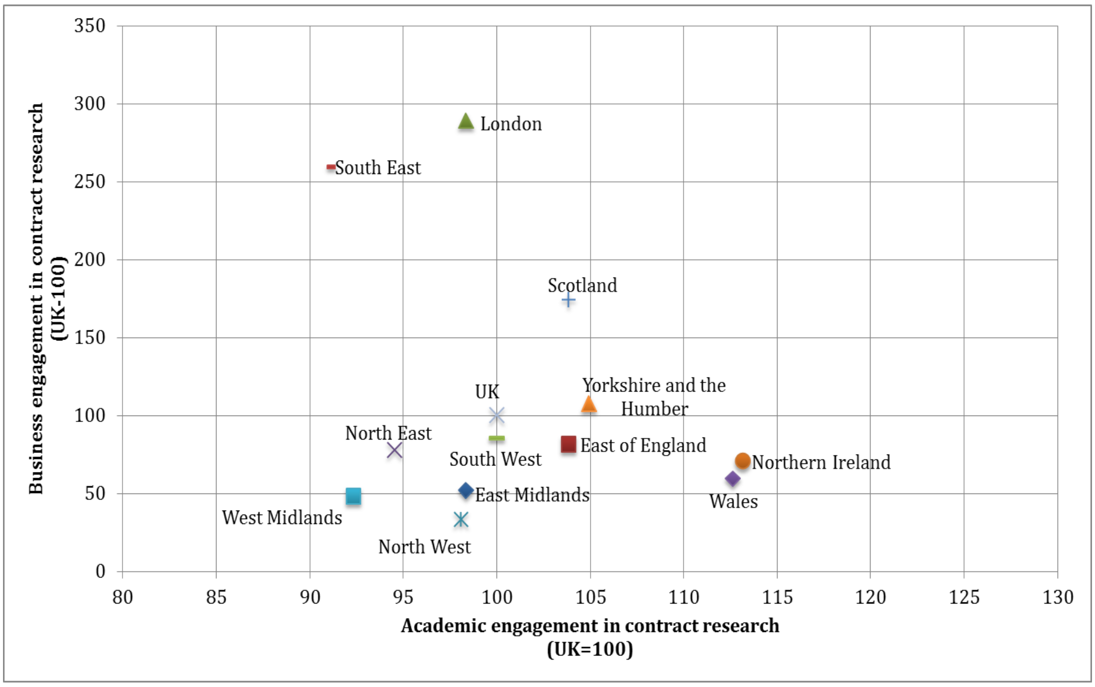
Figure 5.6 University-business interaction patterns in collaborative research in the 12 regions



Source: Author's own elaboration.

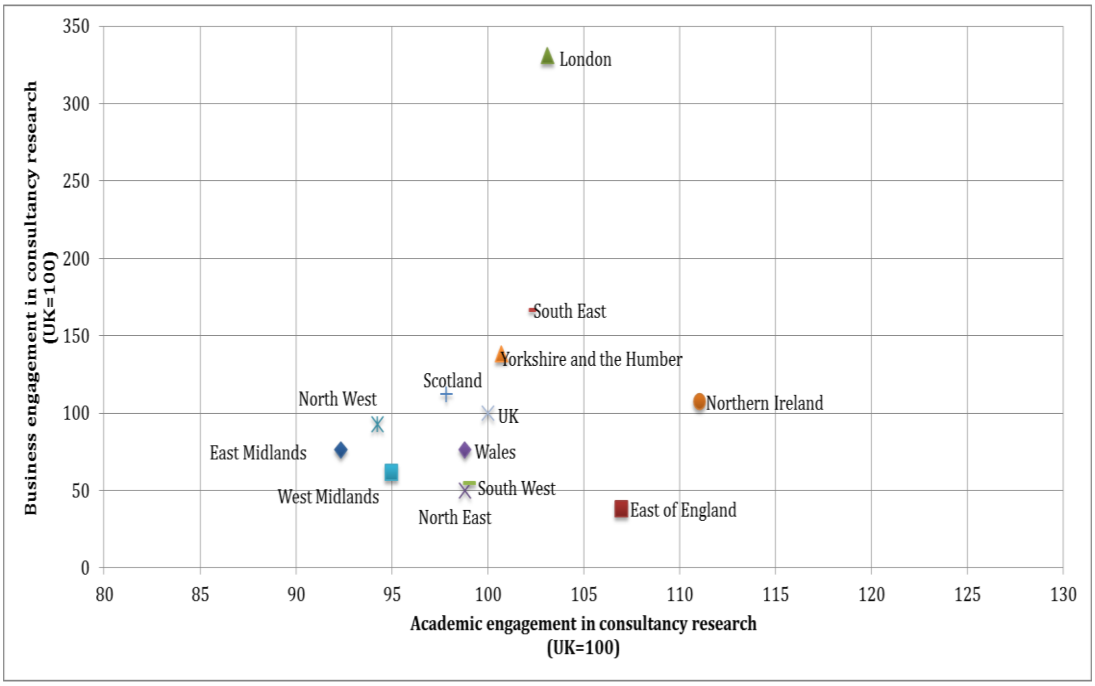
The patterns of university-business interaction in contract research in the UK regions are revealed in Figure 5.7. In line with the findings of Figure 5.6, London and the South East showed business-driven relationships between academics and their private sector partners. The capabilities of firms in the two regions were significantly stronger than those elsewhere in terms of establishing contracts with the academic community. Two regions, namely Scotland and Yorkshire and the Humber, were found in the top right quadrant, suggesting academics and businesses there exerted joint efforts to make collaborations. The other eight regions were all located below the UK level on the *y* axis, an indication that businesses in those places were generally short of the ability to initiate research contracts with academics.

Figure 5.7 University-business interaction patterns in contract research in the 12 regions



Source: Author's own elaboration.

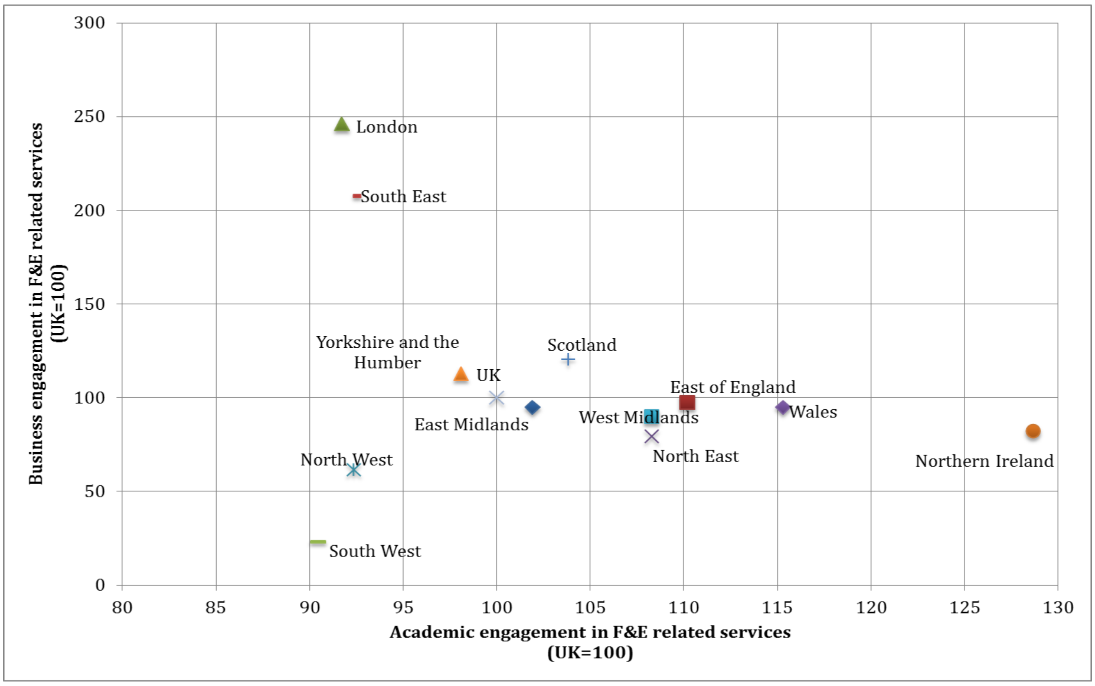
Figure 5.8 University-business interaction patterns in consultancy research in the 12 regions



Source: Author's own elaboration.

Businesses located in London differentiated themselves from those in the rest of the UK by showing great capability for utilising academic knowledge in consultancy research (Figure 5.8). It is also clear that it was not only regional academic expertise but also experts from outside the area with which London-based firms built consultancy relationships. Located in the bottom right quadrant was the East of England, where businesses failed to turn the abundant supply of academic knowledge into use. Further efforts should be put into the examination of the widespread weakness of firms in the East of England in making use of academic knowledge, which seems to conflict with the presumption that they, like those in London and the South East, build their competitive advantage in the marketplace through accessing advanced knowledge and technology in close collaboration with academics. Nevertheless, it might be the case that they successfully created knowledge on their own or sourced it from other organisations rather than universities. Weak consultancy relationships between academics and businesses were witnessed in regions such as Wales and the Midlands. Neither the academic supply side nor the business demand side was strong enough to drive forward collaborations in those areas.

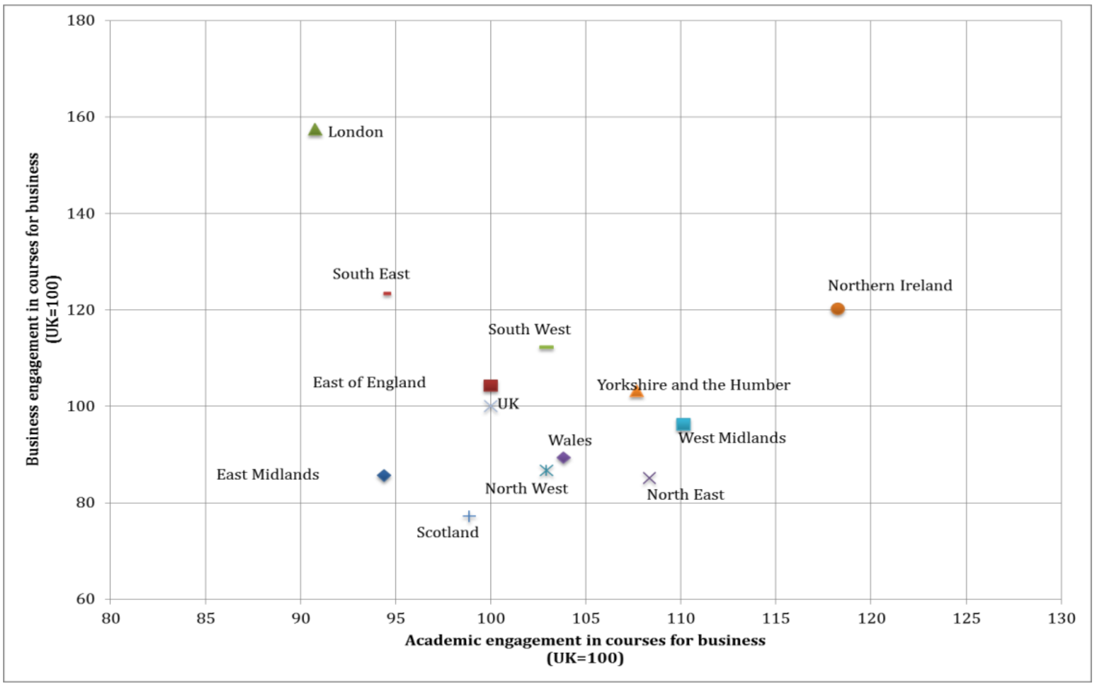
Figure 5.9 University-business interaction patterns in F&E related services in the 12 regions



Source: Author's own elaboration.

The fact that university-business interactions in London and the South East were mainly driven by the business demand side still holds true in the case of F&E related services, as suggested by Figure 5.9. Scotland was the only region where both academics and businesses were more actively involved in F&E activities than the UK average levels. In some other regions, including Northern Ireland, Wales and the East of England, businesses did not successfully realise the amount of academic supply, although academics in those places have been more closely engaged in providing F&E related services to their partners, either public sector organisations or private sector firms.

Figure 5.10 University-business interaction patterns in courses for business in the 12 regions



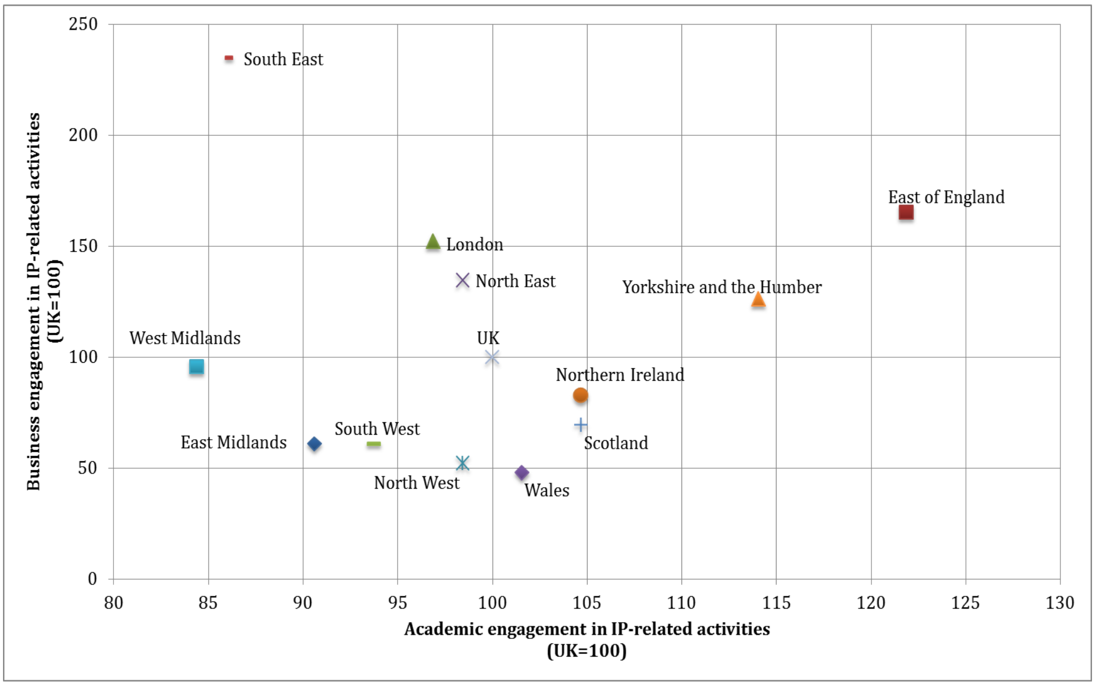
Source: Author's own elaboration.

UK regions are diversely located in Figure 5.10 above, which maps the patterns of university-business interactions in CPD courses. Businesses in London and the South East were most capable of sending their staff on training courses delivered by universities, despite academics in these two regions being less intensively engaged in the activity than the UK average. In contrast, the success of regions like the East of England, the South West, Yorkshire and the Humber and Northern Ireland lay in the mutual interest and effort shown by both the academic supply and the business demand sides in the participation of courses. Another four regions were found in the bottom right quadrant, an area with relatively stronger academic supply but less business demand. Possible explanations include businesses being unaware about the course information or simply finding the courses irrelevant to their needs.

Regions showed different patterns of IP licensing between universities and businesses, as Figure 5.11 below confirms. In the East of England and Yorkshire and the Humber, both academics and businesses showed strengths in engaging in IP-related activities. Therefore, it appears that a well-functioning IP relationship between academics and firms is most likely to form in these two regions. At this stage, however, it is not possible to determine whether firms tended to commercialise IP generated by regional institutions or universities licensed IP to companies located within the same area. The outstanding performance of firms in the South East and London in realising the commercial value of university technologies was probably not strongly associated with the advantages of the academic supply side, as academics in these two regions were less intensively engaged in the activity than the UK average.

In comparison, the three devolved regions – Northern Ireland, Scotland and Wales – were constrained by the limited capacities of businesses in turning university inventions into commercial products. Particularly, academics seemed to have generated a considerable amount of intellectual property in these three areas, but businesses were either not interested or not able to take on the exploitation process of IP assets. That imbalance may point to the fact that there is a gap between what intellectual property academics could supply and what businesses would demand. Universities in the devolved areas may therefore need to find partners outside the region to lead the commercialisation of intellectual property for some commercial gain; otherwise it will be a waste of public resources to keep those IP without them being exploited. In the East Midlands, the South West and the North West, neither academics nor businesses have shown big interest in working with each other on IP-related activities.

Figure 5.11 University-business interaction patterns in IP-related activities in the 12 regions



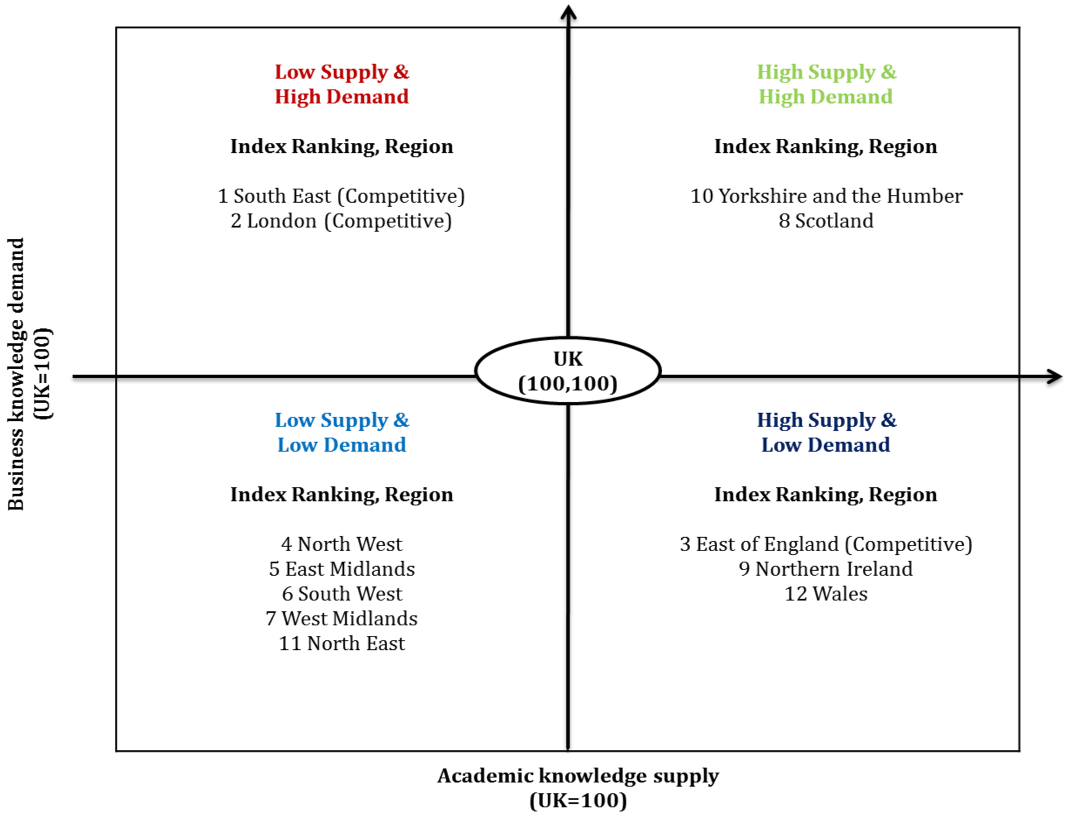
Source: Author's own elaboration.

Figure 5.12 synthesises the overall findings by allocating the regions into the four quadrants according to their position in each type of interaction. In each quadrant, the regions were ranked from top to bottom by the number of times they have been located there. For example, London and the South East have been placed in the top left quadrant four times, followed by Yorkshire and the Humber (twice). The figure also noted the type of activities located in a region. When a region had appeared in the same quadrant three times or more, the name of that region was shown in bold letters to indicate the overall patterns of university-business interaction across regions; which are further summarised in Figure 5.13.

Figure 5.12 University-business interaction patterns in the 12 regions

Source: Author's own elaboration.

Figure 5.13 A summary of university-business interaction patterns in the 12 regions



Source: Author's own elaboration.

In both Figures 5.12 and 5.13, a region was placed in the top right quadrant when it showed a greater intensity of both academic and business participation in an interaction, in comparison to the UK averages respectively (High Supply–High Demand). This could refer to an ideal regional situation in which both the supply and demand sides were actively engaged in a certain type of activity. Effective knowledge transfer, as well as collective learning, becomes possible as academic knowledge supply is more likely to match business demand. Yorkshire and the Humber appeared four times in this quadrant, suggesting that both academics and businesses in the region were positively engaged in building linkages with each other. In contrast with the top right quadrant, the bottom left quadrant refers to the situation when both academics and businesses in a region were less intensively engaged in an interaction (Low Supply–Low Demand). This means neither side – academic or business – were strongly engaged in working with the other.

The top left quadrant contains regions where academics were less actively engaged than the UK average, although businesses were more actively engaged than the national level in an interaction (Low Supply–High Demand). In this scenario it could be argued that the university-business interactions were driven by the demand side, which is not necessarily constrained by the lower level of involvements by regional academics in those networks. Indeed, the shortage of regional knowledge supply may not be an obstacle for those successful businesses that are able to access academic knowledge from outside the region, even sometimes globally. London and the South East appeared in this quadrant five times out of six, suggesting that most types of knowledge networks between academics and businesses there were driven by the greater capability of firms.

The last quadrant – the bottom right one – represents the situation in a region where academics were more actively involved than the national average but businesses were less intensively engaged in an interaction than the UK average level (High Supply–Low Demand). The fact that the East of England appeared in this quadrant four times suggests that the nature of its university-business interactions was quite different to that of the other two competitive regions. In particular, the driving force of the interactions between academics and businesses in this region tended to be the academic supply side, rather than the business demand side, as in the case of London and the South East.

Northern Ireland and Wales also appeared in the bottom right quadrant, suggesting difficulties with not only working with academics in the region but also in accessing knowledge elsewhere. The gap existing between the academic knowledge supply and the business knowledge demand in Wales and Northern Ireland suggests a lack of firms with the capacity, capability or orientation to engage with universities.

5.3 Towards a supply-demand analysis

This chapter has examined the utilisation of academic knowledge by UK businesses for their innovation activities and development. The findings indicate that the intensity of firm level interaction with universities was associated with the regional location of firms, which was particularly the case for SMEs. Firms located within a relatively competitive region tended to be more actively engaged with the use of academic knowledge. Competitive regions were likely to be more capable of nurturing a substantial cluster of SMEs as well as localised learning networks among those firms. Localised learning networks, which fuel collective learning among the stakeholders, are often an effective way for SMEs to enhance their innovativeness (Capello and Faggian 2005). Large firms were generally more closely engaged with universities, and also tended to work with universities outside their geographical regions. These patterns of large companies were shared by both core regions and uncompetitive places, showing that, in this case, regional location was not strongly associated with the capability of large firms to engage with universities.

Combining the findings from the perspectives of academics and businesses together, the analysis also found that competitive regions and uncompetitive regions demonstrated distinct patterns of university-business knowledge exchange. In general, businesses in uncompetitive regions had lower levels of demand for academic knowledge, even though there was often sufficient supply. In contrast, within competitive regions the relatively low levels of academic engagement did not constrain the utilisation of academic knowledge by businesses, as these were mitigated by the effect of forming linkages that extend beyond regional boundaries.

At the regional level, the knowledge exchange activities between academics and businesses have also been found to follow different patterns, suggesting the need for relevant innovation or economic policies to take into account the regional differentiation of university-business linkage patterns. While in London and the South East, the majority types of knowledge networks were driven by the strong capability of firms, the determining force of the interactions between academics and businesses in the East of England tended to be the academic supply side. In addition, companies in regions like Northern Ireland and Wales faced obstacles to realise the knowledge generated by the academic community.

Generally, university knowledge was not perceived to be an important source by enterprises as they tended to view customers or suppliers as highly important sources for knowledge. As the relationships between academic supply and business demand of knowledge vary from one region to another, further analysis of the supply- and demand-side policies facilitating university-business interactions should be carried out at the regional level to fully acknowledge the territorial patterns of knowledge exchange between academics and firms. In particular, while academic knowledge may demonstrate a predominantly generic nature, industrial R&D is more likely to be directed towards marketable products or technologies, and while there have been significant debates as to whether the basic character of university research should be more aligned with commercial ends (Hall et al. 2001; Rae-Dupree 2008), there is still little understanding of what such ends actually encompass in terms of the knowledge required to innovate.

CHAPTER 6

PERFORMANCE, INTENSITY AND IMBALANCE OF UNIVERSITY KNOWLEDGE NETWORKS

This chapter examines the associations between the intensity and performance of university knowledge networks by comparing competitive and uncompetitive regions, as well as by comparing the 12 UK regions. It is considered that the comparison between the two regional groups may draw some aggregate conclusions on how regional competitiveness is linked to the extent and scale of academic engagements with their external partners in knowledge transfer, while the regional level analysis shall demonstrate, in much more detail, the strengths and weaknesses of any given region in a particular type of knowledge exchange activity.

6.1 The paradox of knowledge network intensity and performance

6.1.1 By regional group

Table 6.1 indicates how intensively academics across the UK and within each regional group engaged in the six modes of knowledge networks. In overall terms, the most popular engagement was collaborative research, reported by nearly half of respondents. Some 44.4 per cent of academics were involved in courses for business and the community, while consultancy was reported by just more than 40 per cent of respondents. In contrast, facilities and equipment related services were less popular, in which only 15.7 per cent of academics reported they have participated. The least popular engagement for academics was IP-related activities, indicating the fact that, in the UK at least, academics were much more actively involved in conventional knowledge networks like research than in newly emerged networks such as licensing IP. Furthermore, academics in the two regional groups showed no significant difference in their intensity of engagements in IP. This suggests that IP being the least frequent mode of knowledge network held throughout the country, no matter within which type of region the academics were situated.

Table 6.1 Intensity of the six modes of knowledge networks by regional group, %

		Regional group		
Mode of network	UK academics N=18991	Academics in competitive regions N=7049	Academics in uncompetitive regions N=11942	**T-test**
Collaborative research	48.9	49.1	48.8	
Contract research	36.5	35.4	37.1	*
Consultancy research	41.7	43.2	40.8	**
F&E related services	15.7	15.0	16.1	*
Courses for business	44.4	41.7	46.1	**
IP-related activities	6.4	6.3	6.4	

Notes:

1. Intensity refers to the percentage of academics who indicated that they were involved in each mode of knowledge network between 2005/06 and 2007/08.
2. T-test was used to show whether there were significant differences between the two regional groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).

Source: Author's elaboration from CBR (2010a).

Significant differences were found between academics in the two regional groups, defined by their competitiveness, as regards the intensity of their knowledge networks with external partners. More specifically, it is the academics in uncompetitive regions that showed significantly higher levels of engagement with knowledge networks than their counterparts from competitive areas. Whereas the underlying causes remain ambiguous, this finding explicitly suggests that how intensively an academic is engaged in knowledge networks is not confined by the competitiveness of the region in which an academic is situated. Quite the contrary, it seems that being employed in an uncompetitive region is associated with being more proactive in reaching out to business and the community (Benneworth 2006).

Table 6.2 illustrates how the competitiveness of a region in which a university is located is associated with the overall performance of the institution in knowledge network activity, measured as income per academic FTE, no matter whether the academic is in reality involved in knowledge transfer or not. This can be seen as an attempt to gauge how successful universities on the whole are in commercialising their scientific findings. No significant difference between the two groups in total activity income existed, suggesting that, on average, universities in each type of region generated similar income from engaging in knowledge exchange activities.

When breaking down the income into the six sub-groups, although the mean values of income generated by universities in competitive regions were always higher than those in uncompetitive regions, no significant difference was found in all but one type of activity: F&E related services. Universities in competitive regions reported higher income from F&E related services than those in less competitive areas (statistically significant at the $p < 0.05$ level). Nevertheless, income from F&E related services accounted for only a modest share of total income for universities in both types of regions, meaning it was a relatively minor factor which did not determine the overall pattern. For universities in competitive regions, most income was generated from courses for business and the community, which accounted for 44 per cent of the total income. Collaborative research contributed 27 per cent of the total income for universities in uncompetitive regions.

Table 6.2 Performance of the six modes of knowledge networks by regional group, £000s per academic FTE

		Regional group		
Mode of network	UK universities *N*=159	Universities in competitive regions *N*=66	Universities in uncompetitive regions *N*=93	**Mann-Whitney U test**
Collaborative research	4.6	5.0	4.3	
Contract research	4.4	5.0	3.9	
Consultancy research	2.8	3.2	2.4	
F&E related services	0.9	1.1	0.8	*
Courses for business	7.2	11.6	4.1	
IP-related activities	0.4	0.5	0.3	
All total	20.3	26.5	15.9	

Notes:

1. Performance refers to the average financial income of each mode of knowledge network generated per academic FTE in 2007/08.
2. Mann-Whitney U test was used to show whether there were significant differences between the two regional groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).

Source: Author's elaboration from HEFCE (2009).

Whilst academics located within uncompetitive regions were significantly more actively involved in knowledge exchange activities than those in competitive areas, there was no significant difference between universities in the two regional groups in their financial gains from being engaged with business and the community. This paradox seems to imply that academics in competitive regions, when they were engaged, tended to be more capable of participating in larger scale collaboration that yielded higher financial returns.

It appears that the relatively limited capacity of academics in uncompetitive regions to generate income from knowledge networks largely constrained the impact of their institutions, whereas they were actually more intensively engaged with society in many channels. Possible explanations for this may include their tendency for small-scale collaboration, which often involved SMEs and regional partners, or the difficulties faced by academics in less competitive areas in being part of collaboration on a large-scale.

6.1.2 By region

It is interesting to explore how the 12 regions compared against each other in each mode of knowledge networking for two reasons. First, the categorisation of regions by their economic competitiveness demonstrates the differences between the two regional groups, but fails to detect the possible variances within each group. For instance, it is reasonable to expect that academics situated in the nine uncompetitive regions would show different levels of involvement with partners. Second, from the policy perspective, more tailored regional innovation strategies, which aim to foster collaboration between academics and external partners, can only be successfully designed and effectively implemented through recognition of the full picture of academic knowledge networks. A large body of the literature has addressed the difficulties of expecting that a particular policy that works in one place would also work well elsewhere (Mowery and Sampat 2005), and called for differentiated regional innovation policies that fully consider a range of specific backgrounds for different regions, such as the economic development level, the industrial structure and the presence of universities.

Table 6.3 reveals how closely academics in the 12 UK regions were involved in the six modes of interactions and the financial performance of their engagements in each mode. Collaborative research was mostly frequently reported by academics from the East of England and Northern Ireland, followed by those from Scotland and Wales, where just over half of academics reported their participation in collaborative research. The Midlands, which comprises the East Midlands and the West Midlands, represented the area with the lowest levels of academic research collaboration.

It appears that, in general, academics in the devolved regions were quite intensively engaged in research contracts. Northern Ireland, Wales and Scotland took three positions in the top four, with Yorkshire and the Humber sitting at the third place in the intensity rankings. Contract research was a less frequent involvement for academics in the West Midlands and the South East, as just around one third of the respondents from those two regions reported that they had undertaken research contracts commissioned by other organisations. Some complex relationships between the intensity and performance of academic contract research are revealed by the figures in Table 6.3.

Northern Ireland was the region where academics undertook consultancy research most frequently – more than 46 per cent of academic respondents there had been involved in it. The East of England, London and the South East – the three competitive regions – were ranked second to fourth in the intensity rankings, implying that consultancy was also widely used by their academics. In terms of the performance of university consultancy research, two competitive regions – the South East and the East of England – sat at the top of the rankings, significantly higher than the UK average, while London, the third competitive area, fell just below the national level.

In comparison to the former research linkages, UK academics were less frequently engaged in F&E related services. Nationwide, less than 16 per cent of academic respondents had provided F&E services to external organisations, and that share was just above 20 per cent for academics in Northern Ireland, where the most frequent use of F&E services was found. When it comes to the performance of F&E services delivered by academics, the highest average income generated per academic FTE was found in the North West, followed by the South East and London that ranked second and third in the rankings. The success of these three regions, it seems, could not be simply attributed to the intensity of academic involvement in that activity, as in fact academics situated in these areas were relatively less actively engaged in F&E related services.

In the UK, more than 44 per cent of academics reported that they had been involved in courses for business and the community, making it the second most popular engagement, only after collaborative research, between academics and external partners. On the regional level, Northern Ireland saw its academics being most closely involved in CPD courses or CE, followed by the West Midlands and the North East. Whilst London-based academics were least intensively engaged in courses for business and the community, the share of respondents reporting their involvement was still higher than 40 per cent. Furthermore, in the UK, average income per academic FTE generated from providing courses was higher than both research-related activities or F&E related services. With the lowest level of engagement, academics based at London universities were able to achieve the highest level of financial returns from courses delivered to business, while the situation for Northern Ireland was just the opposite.

Another emerging type of university knowledge exchange activity during the last few decades has been how scientific discoveries at universities, and federal laboratories in many countries like the US, are commercially exploited. Compared with the former types of engagements, IP-related activities were the least popular linkage for academics, indicating the fact that academics were still much more actively involved in more conventional interactions with their external partners. In all the regions, no more than 8 per cent of respondents had been involved in patenting or licensing, and more importantly, the 12 regions showed no significant difference in how closely academics engaged in IP-related activities. The performance of IP-related activities in UK universities was also modest overall, as income generated from intellectual property rights did not exceed £900 per academic FTE across the country, much less than that from the other types of knowledge exchange activities.

Table 6.3 Intensity and performance of academics in the six modes of knowledge networks by region, % and £000s per academic FTE

Region	Collaborative research		Contract research		Consultancy research		F&E related services		Courses for business		IP-related activities	
	%	£000s	%	£000s	%	£000s	%	£000s	%	£000s	%	£000s
East Midlands	45.4	5.2	35.9	2.8	38.5	1.2	16.0	0.6	41.9	4.6	5.8	0.1
East of England	54.3	4.7	37.9	4.9	44.6	4.2	17.3	0.2	44.4	9.6	7.8	0.3
London	48.7	5.5	35.9	5.4	43.0	2.6	14.4	1.2	40.3	14.3	6.2	0.6
North East	48.0	3.6	34.5	5.8	41.2	3.4	17.0	0.3	48.1	4.8	6.3	0.1
North West	47.8	4.2	35.8	2.8	39.3	2.8	14.5	1.7	45.7	4.2	6.3	0.1
Northern Ireland	53.7	8.0	41.3	4.5	46.3	1.2	20.2	1.1	52.5	2.3	6.7	0.6
Scotland	51.7	6.6	37.9	4.8	40.8	2.5	16.3	0.8	43.9	4.3	6.7	0.3
South East	46.1	3.7	33.2	4.1	42.6	4.4	14.5	1.4	41.9	6.1	5.5	0.4
South West	50.4	2.0	36.5	2.6	41.3	2.1	14.2	0.5	45.7	3.8	6.0	0.1
Wales	51.2	4.7	41.1	3.8	41.2	2.0	18.1	0.1	46.1	3.6	6.5	0.1
West Midlands	45.6	3.2	33.7	4.3	39.6	3.9	17.0	1.0	48.9	3.1	5.4	0.9
Yorkshire and the Humber	46.3	3.3	38.3	5.3	42.0	2.0	15.4	0.7	47.8	4.6	7.3	0.3
UK	48.9	4.6	36.5	4.4	41.7	2.8	15.7	0.9	44.4	7.2	6.4	0.4

Notes:

1. Intensity refers to the percentage of academics who indicated that they were involved in each mode of knowledge network between 2005/06 and 2007/08.
2. Performance refers to the average financial income of each mode of knowledge network generated per academic FTE in 2007/08.

Source: Author's elaboration from HEFCE (2009) and CBR (2010a).

6.2 The imbalance of interaction with private and public sectors

6.2.1 By regional group

Table 6.4 illustrates how academics in British universities interacted with various types of partners. Throughout the UK, 54 per cent of academics stated that they had engaged with public sector organisations, while 43 per cent of the responding individuals reported interactions with the third sector. Only 42 per cent of the respondents indicated that they had been involved in knowledge networks with private firms. It could be seen that academics showed higher levels of interactions with their public sector, and even third sector, partners than with private firms, implying the important role of governmental organisations to academics on the one hand, and the needs of improvements of university-business collaborations on the other.

There were some variances between the academics in the two regional groups engaging with different types of organisations. For example, it seems that academics in uncompetitive regions tended to rely more on the collaboration with the public sector than those in competitive regions. An arguable explanation might be that, uncompetitive regions tend to lack a high density of knowledge-based firms and are accordingly organisationally thin, with limited needs of university knowledge from businesses (Asheim et al. 2003; Hewitt-Dundas et al. 2005; Tödtling and Trippl 2005; Malecki 2007; Doloreux and Dionne 2008). Academics in those regions are, therefore, more likely to be inclined to secure funding from government departments.

Table 6.4 Intensity of knowledge networks with private, public and third sector organisations by regional group, %

Type of partner	UK academics N=18991	Regional group: Academics in competitive regions N=7049	Academics in uncompetitive regions N=11942	T-test
Private sector	42.1	42.5	41.9	
Public sector	54.1	53.6	54.4	
Third sector	43.0	44.2	42.3	*

Notes:
1. Intensity refers to the percentage of academics who indicated that they were involved with each type of partner between 2005/06 and 2007/08.
2. T-test was used to show whether there were significant differences between the two regional groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).

Source: Author's elaboration from CBR (2010a).

As shown by Table 6.5, universities in competitive regions secured more income from both private and public sector organisations than their counterparts in uncompetitive areas (though not statistically significant at the $p < 0.10$ level). Non-commercial organisations emerged as the dominant partners for universities in uncompetitive regions, accounting for 63.5 per cent of the total income. For those universities located in competitive areas, private sector firms and public sector organisations contributed comparable levels of income. This suggests that universities in competitive regions generated incomes diversely, and evenly, from both private and public partners, while those in less competitive regions showed a strong dependency on the public sector.

The high dependency on public funding may put universities in uncompetitive regions at risk, as the higher education marketplace in the UK is now undergoing intense spending cuts as, part of the UK government's plan to reduce the country's budget deficit in response to the recession (Greenway and Haynes 2000; HM Treasury 2010; DELNI 2011; HEFCW 2011; SFC 2011). Presumably, universities in competitive areas may be less sensitive to shrinking public spending, due to the fact that their funding sources show a greater deal of variety. The data presented in Table 6.5 suggests that an urgent task for universities in uncompetitive regions is to secure more funding from external sources, the private sector in particular, and to build more resilience amid the recession. More importantly, the competitiveness of a region is not strongly associated with the capacity of an academic to secure funding from public sector organisations. The main difference between academics in the two regional groups is found in their capacities of generating income from businesses, with the performance of an academic in a competitive region more than double that of an academic in an uncompetitive region.

Table 6.5 Performance of knowledge networks with private and public sector organisations by regional group, £000s per academic FTE

		Regional group		
Type of partner	UK universities *N*=159	Universities in competitive regions *N*=66	Universities in uncompetitive regions *N*=93	**Mann-Whitney U test**
Private sector	7.2	11.5	4.1	
Public sector	10.7	11.8	10.1	
Other	2.4	3.2	1.7	
All total	20.3	26.5	15.9	

Notes:

1. Performance refers to the average financial income generated per academic FTE from each type of partner in 2007/08.
2. Mann-Whitney U test was used to show whether there were significant differences between the two regional groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).

Source: Author's elaboration from HEFCE (2009).

6.2.2 By region

Private sector firms

Table 6.6 examines, at the regional level, how UK academics engaged with private sector firms. Four out of ten academics in UK universities reported working experiences with private sector firms, while across the regions that number varied from 39 per cent in the West Midlands to 47 per cent in the East of England. It should be noted that most regions did not show significant difference in the intensity of their academics engaging with businesses. In contrast to the fact that spatial profile seemed an unimportant factor, in the context of the UK at least, of the intensity of academic-business linkages, it is nevertheless obviously associated with the amount of income generated by academics from their collaboration with businesses.

Overall, there was significant difference in the performance of academic knowledge networks with private sector firms among the regions. In particular, while academics in London showed performances nearly double that of the national average, the performance of academics from Yorkshire and the Humber reached only half the UK level. It could possibly be argued that the scale of academic-business engagement in London universities was much larger than that in universities situated elsewhere in the UK. London-based academics, when actually involved with businesses, were most capable of generating financial returns from those linkages, suggesting that they may more often tap into larger funding available.

Table 6.6 Intensity and performance of academic knowledge networks with private sector firms, % and £000s per academic FTE

Region	Intensity		Performance	
	% of sample	Rank	£000s per academic FTE	Rank
East Midlands	41.5	8	3.5	10
East of England	47.0	1	10.0	2
London	41.5	8	13.5	1
North East	41.1	10	3.8	8
North West	42.4	6	4.1	7
Northern Ireland	42.9	3	4.2	6
Scotland	41.8	7	5.5	5
South East	41.0	11	7.8	3
South West	42.5	5	3.1	11
Wales	42.8	4	2.4	12
West Midlands	38.9	12	5.8	4
Yorkshire and the Humber	43.1	2	3.6	9
UK	42.1	n/a	7.2	n/a

Notes:

1. Intensity refers to the percentage of academics who indicated that they were involved with private sector firms between 2005/06 and 2007/08.
2. Performance refers to the average financial income generated per academic FTE from private sector firms in 2007/08.
3. Rank refers to how each region compares against the rest 11 regions in the given index.

Source: Author's elaboration from HEFCE (2009) and CBR (2010a).

Furthermore, it is reasonable to suppose that large collaborative projects tend to involve large firms, especially those multinational companies with abundant financial resources and also a need for university technologies. Multinational companies may be less sensitive to the cost of projects and more concerned about the quality of the research provided by their academic partners (Almeida 1996; Huggins et al. 2010b). Housing a large number of universities, including many world leading ones, London becomes an ideal location for global industry leaders to look for cooperation partners. This finding still holds for the East of

England and the South East, the other two regions where academics reported higher average income from private sector firms than UK academics as a whole.

It is hard to determine whether academics in regions like the South West faced difficulties in joining, or leading, large-scale programmes with businesses or whether their non-involvement was due to path dependence, i.e. they had historically been involved with smaller programmes. However, the clear divergence of the regions suggests that the poor capability of academics in some areas restricted the overall entrepreneurial performance of the university sector. An important feature of academic-business linkage is that it should be understood, and also analysed, as a two-way process, whereby the success lies in the mutual interests of both sides in working together.

Public sector organisations

UK academics were found to be more likely to partner with public sector organisations than private sector firms. In all the regions, more than half of academics had experiences of working together with the public sector, with the share in Yorkshire and the Humber being as high as 57 per cent (Table 6.7). Indeed, a key strength in maintaining the global research position of UK universities has been the strong public sponsorship, from either the Research Councils, or the Higher Education Funding Councils and national and EU governments. Academics in Scotland, the North East and the East Midlands were relatively less actively engaged with public sector organisations, but not significantly lower than the national level.

Table 6.7 Intensity and performance of academic knowledge networks with public sector organisations, % and £000s per academic FTE

Region	**Intensity** % of sample	Rank	**Performance** £000s per academic FTE	Rank
East Midlands	50.4	12	8.6	11
East of England	53.9	8	11.0	4
London	53.0	9	12.5	2
North East	52.8	11	13.3	1
North West	54.5	6	10.6	6
Northern Ireland	55.4	5	10.0	8
Scotland	52.9	10	10.9	5
South East	54.4	7	10.5	7
South West	55.5	4	6.9	12
Wales	56.6	2	10.0	8
West Midlands	55.9	3	9.5	10
Yorkshire and the Humber	57.2	1	11.9	3
UK	54.1	n/a	10.7	n/a

Notes:
1. Intensity refers to the percentage of academics who indicated that they were involved with public sector organisations between 2005/06 and 2007/08.
2. Performance refers to the average financial income generated per academic FTE from public sector organisations in 2007/08.
3. Rank refers to how each region compares against the rest 11 regions in the given index.

Source: Author's elaboration from HEFCE (2009) and CBR (2010a).

Table 6.7 also shows that, with a couple of exceptions, most UK regions showed comparable performance of academic knowledge networks with public sector organisations, suggesting that academics, wherever they were situated, were all capable of securing funding from public bodies. This argument should be understood with caution, as public funding schemes can vary in many aspects such as focus, competition level and spatial coverage. A comparison of two specific government funding initiatives below is to clarify the divergence in existence among the public funding schemes. The Framework Programmes (FPs)

– the EU's primary mechanism for supporting transnational research and development projects – are designed to improve Europe's competitiveness, and to support the creation of the European Research Area, while the European Structural Funds, an alternative EU funding for UK universities to apply for, aim to grant financial assistance to resolve structural economic and social problems in certain regions (Simmonds et al. 2010; EEAC 2011; Zhang and Pugh 2011). FPs are open for application from all member states and even non-EU countries, resulting in strong competitions between applicants. In contrast, the European Structural Funds are allocated by the European Commission but managed by local governments.

A further comparison of Tables 6.6 and 6.7 yields some interesting findings. In general, UK academics were able to secure more income from public organisations than from private sector firms. This might be because they were more familiar, and possibly more comfortable, with working together with government bodies. Some literature has suggested that there are deeply-rooted cultural differences between the academic and business worlds (Cummings and Teng 2003). The three competitive regions were the only areas where private companies contributed in a comparable manner to public sector organisations to the income of academic knowledge networks.

6.3 The divergence of focus on regional and international networks

6.3.1 By regional group

Table 6.8 examines to what extent UK academics engaged with regional and international partners for knowledge exchange. Except for showing a stronger regional tendency in courses for business and the community, academics in the UK were generally more actively involved in international networks than in regional ones, suggesting a growing role of non-proximate networks (Bunnell and Coe 2001; MacKinnon et al. 2002; Amin and Cohendet 2004; Huggins and Izushi 2007). In the case of courses for business and the community, participants are expected to be able to travel frequently to the sites where the courses are held, usually on the university campus. Geographical proximity becomes an important parameter to consider when businesses are to choose the ideal institution for their staff to attend training programmes to expand their knowledge and enhance professional skills. Another possible explanation is that professional training programmes normally convey more general knowledge that could be provided by the majority of higher education institutions. Organisations, public or private, who would like to take on the courses, do not have to go far to find a university providing a course.

Nevertheless, an overwhelming phenomenon observed from Table 6.8 is that, UK academics were closely integrated into global networks, the expansion of which has been a major change in the architecture of world science recently. Similarly this trend was not evenly embraced by all the regions – academics in uncompetitive regions were more inclined towards regional rather than international collaboration. In comparison, academics in competitive regions were more intensively involved in international knowledge networks than they were in regional ones. In other words, regional competitiveness seemed to be related to the structure – regional or international – of academic knowledge networks. To engage with regional or international partners may be the result of personal (Van Dierdonck et al. 1990; Azagra-Caro 2007; D'Este and Patel 2007; Link et al. 2007), departmental (Owen-Smith and Powell 2001; Martinelli et al. 2008) and institutional (Lawton Smith 2003; Lockett et al. 2003) factors.

Table 6.8 Intensity of regional and international knowledge networks by regional group, %

Location of partner	UK academics	Regional group: Academics in competitive regions	Regional group: Academics in uncompetitive regions	T-test
Collaborative research				
	N=9286	*N*=3459	*N*=5827	
Regional	28.7	25.1	30.8	**
International	51.1	55.6	48.5	**
Contract research				
	N=6927	*N*=2497	*N*=4430	
Regional	31.6	26.5	34.4	**
International	34.7	41.5	30.9	**
Consultancy research				
	N=7914	*N*=3044	*N*=4870	
Regional	34.0	30.6	36.2	**
International	34.0	40.2	30.2	**
F&E related services				
	N=2980	*N*=1057	*N*=1923	
Regional	29.5	24.3	32.4	**
International	30.0	36.7	26.3	**
Courses for business and community				
	N=8439	*N*=2937	*N*=5502	
Regional	44.4	38.6	47.5	**
International	34.5	40.4	31.3	**

Notes:

3. Intensity refers to the percentage of academics, those who were actually engaged in each mode of knowledge network, involved with regional and international partners between 2005/06 and 2007/08.
4. T-test was used to show whether there were significant differences between the two regional groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).

Source: Author's elaboration from CBR (2010a).

The HE-BCI survey also collects the amount of income generated within the region in addition to total income, and Table 6.9 compares the capacities of academics in generating regional incomes. Although academics in uncompetitive regions showed better performance in regionally-based consultancy research than those in competitive regions, they still lagged behind in the majority of indicators. The analysis in Table 6.9 also yields a set of results that suggest regional competitiveness was not significantly associated with the overall income of regional knowledge networks. The comparable figures may be partly a result of more efforts being made by academics in uncompetitive regions to focus on regionally orientated collaborations.

Table 6.9 Performance of regional knowledge networks by regional group, £000s per academic FTE

		Regional group		
Mode of network	UK universities *N*=159	Universities in competitive regions *N*=66	Universities in uncompetitive regions *N*=93	**Mann-Whitney U test**
Contract research	0.9	1.1	0.8	
Consultancy research	0.8	0.7	0.9	
F&E related services	0.5	0.5	0.4	
Courses for business	1.6	1.6	1.6	
IP-related activities	0.029	0.033	0.026	
Sub-total	3.8	3.9	3.7	

Notes:

1. Performance refers to the average financial income generated per academic FTE from regional networks in 2007/08.
2. Mann-Whitney U test was used to show whether there were significant differences between the two regional groups († $p < 0.1$, * $p < 0.05$, ** $p < 0.01$).
3. IP-related activities exclude the sale of shares of spin-offs.

Source: Author’s elaboration from HEFCE (2009).

It is also possible to show the extent of locational specialisation of knowledge networks i.e. the share of regionally-based income per academic FTE in total income. A clear distinction emerges, as shown in Table 6.10, between academics in competitive and uncompetitive regions. That is, the competitiveness of the region, where an institution was situated, was negatively related to the share of regional contribution to total financial income. Without any exception, regional funding contributed a larger share of the total income for academics in uncompetitive regions than for those in competitive areas. For example, academics in uncompetitive regions secured 34 per cent of income from courses regionally, compared with just above 27 per cent for their counterparts situated within the South East, London and the East of England.

Table 6.10 Share of income from regional knowledge networks in the total income per academic FTE by regional group, %

		Regional group	
Mode of network	UK universities *N*=159	Universities in competitive regions *N*=66	Universities in uncompetitive regions *N*=93
Contract research	21.5	20.6	22.2
Consultancy research	29.3	25.3	32.1
F&E related services	32.2	30.9	33.2
Courses for business	31.3	27.2	34.1
IP-related activities	11.8	9.1	13.7
Sub-total	27.1	24.2	39.2

Source: Author's elaboration from HEFCE (2009).

Reflecting on the growing body of literature on localised knowledge spillovers (LKSs), at the heart of which lie the spatially-bounded knowledge externalities (Breschi and Lissoni 2001a, 2001b; Alcacer and Chung 2007; Giuri and Mariani 2013), the findings here suggest the existence of regional variations in the localisation of knowledge spillovers. It is the academic knowledge in uncompetitive regions that was more strongly bounded within a certain distance, whilst geographical distance seemed not to be a hindrance for knowledge exchange between academics in competitive regions and their international partners. Whereas it has been found that 'location' matters for knowledge spillovers, it still remains unclear whether that effect is held by different types of universities, which have their own culture and path dependence in working together with regional or international partners.

6.3.2 By region

Table 6.11 reports the intensity of regionally and internationally-based knowledge networks, excluding IP-related activities, between academics and their partners. In the case of collaborative research, academics tended to be closely involved in either regional or international research collaboration – rather than in both types of activities. Northern Ireland and Wales were the regions with higher levels, i.e. higher than the UK average, of academic collaborative research taking place within the same area, accompanied by lower levels of collaboration that was internationally-based.

Similar to the case of collaborative research, academics in the 12 regions had a tendency to focus on either regional or international research contracts. It might be true to argue that, for many UK academics, regionally and internationally-oriented contract research activities were substitutive rather than complementary to each other. The driving forces of that situation could be connected to personal attitudes of the academics or government initiatives promoting a certain type of collaboration.

In the UK, regional and international consultancy research activities were reported by a comparable level of academics, indicating the diverse portfolio of academic consultancy services. The three devolved nations – Northern Ireland, Scotland and Wales – were the places where academics were mostly intensively engaged with regional partners in consultancy. Whilst academics in Scotland were also found to be more actively involved in international consultancy research than the national average, those in the other two devolved nations lagged behind.

It was found that the level of F&E services utilised by organisations, located either in the same region or outside of the country, were reported by a similar number of academics from UK universities. Obviously, this argument did not hold for all the regions across the country; it seemed that some regions were still more in favour of either regional or international relationships.

Unlike the former types of activities, CPD courses or CE demonstrated strong tendencies to be regionally-based, a fact holding for all but two regions. The existence of a substitution relationship for academics between their engagements in regionally-based courses and in internationally-based courses was also found, especially when academics in a region were extremely closely involved in one of the two types.

Table 6.11 Intensity of regional and international academic engagements in the five modes of knowledge networks by region, %

Region	Collaborative research		Contract research		Consultancy research		F&E related services		Courses for business	
	Regional %	International %	Regional %	International %	Regional %	International %	Regional %	International %	Regional %	International %
East Midlands	21.1	46.1	26.1	30.0	27.4	30.6	32.5	22.7	43.0	29.9
East of England	20.8	59.2	24.9	42.4	26.9	42.1	24.7	37.3	37.1	42.9
London	27.0	54.8	26.8	41.7	31.2	42.3	24.3	39.0	36.1	42.8
North East	32.3	52.6	35.4	37.4	38.7	29.4	30.7	28.0	47.3	34.1
North West	28.2	51.4	30.9	30.9	30.3	30.5	29.1	31.1	46.1	34.3
Northern Ireland	44.7	51.1	48.5	33.2	51.9	29.3	44.9	34.7	60.8	25.8
Scotland	35.0	52.8	41.1	35.3	43.2	32.8	30.7	27.7	50.4	32.1
South East	25.6	54.1	27.2	40.6	32.2	35.8	24.0	32.9	43.3	35.2
South West	31.0	44.3	32.6	26.7	36.1	27.2	28.9	23.0	47.0	29.4
Wales	31.4	45.6	41.1	25.5	40.5	27.5	40.2	21.9	45.2	30.2
West Midlands	29.8	45.2	33.1	29.2	33.8	29.7	37.8	17.3	48.5	31.2
Yorkshire and the Humber	27.1	43.4	25.0	27.8	29.2	29.9	26.6	28.6	43.4	30.7
UK	28.7	51.2	31.6	34.8	34.1	34.0	29.5	30.0	44.4	34.5

Notes:

1. Intensity refers to the percentage of academics, those who were actually engaged in each mode of knowledge network, involved with regional and international partners between 2005/06 and 2007/08.

Source: Author's elaboration from CBR (2010a).

6.4 Towards a longitudinal analysis?

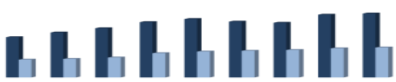
Admittedly, the analysis above only represents a snapshot of the associations between the intensity and performance of knowledge networks, mainly due to the limitations of the secondary data relevant to the intensity of academic engagements. It will be important to circulate the academic survey in years to come in order to view these patterns longitudinally. As argued, the results of the HE-BCI surveys have been available for the last decade, and it will be sensible to examine the performance of universities over a longer period. The first part of the findings is based on the analysis of activities of two different types of university – established and new – within two different types of region – competitive and uncompetitive – during 2003/04 and 2011/12, while the second part of the findings focuses on how the 12 UK regions have developed their performance of knowledge networks in the same period.

6.4.1 By regional group

Established universities vs. new universities

Table 6.12 shows the total income generated by UK universities per academic FTE as well as performance in the six key types of entrepreneurial activities. Column charts were used to demonstrate the evolution trends year by year. In particular, all of the charts were intentionally made by using the same axis format for the convenience of regional comparison. Therefore, any comparison of column charts would only make sense within the same table.

Table 6.12 Established universities vs. new universities in the six modes of knowledge networks, £000s per academic FTE

	Mean 2003/04	Mean 2011/12	Δ 2003/04-2011/12	Trend 2003/04-2011/12	CAGR %
Collaborative research					
Est	6.64	8.75	2.11		3.51
New	2.08	2.39	0.31	 * * * * * * * * * * * * * * * * * *	1.75
Contract research					
Est	5.73	9.67	3.94		6.76
New	1.98	2.20	0.22	 * * * * * * * * * * * * * * * * * *	1.33
Consultancy research					
Est	2.22	3.65	1.43		6.41
New	1.76	2.66	0.90	 *	5.30
F&E related services					
Est	1.05	2.32	1.27		10.42
New	0.34	0.66	0.32	 * * * * * † * * * * * * * *	8.64
Courses for business and the community					
Est	5.89	9.77	3.88		6.53
New	3.50	8.26	4.76	 * * * * * * † * * * * * *	11.33
IP-related activities					
Est	0.36	0.62	0.26		7.03
New	0.04	0.14	0.10	 * * * * * * * * * * * * * * * * * *	16.95
Total income					
Est	21.89	34.78	12.89		5.96
New	9.70	16.31	6.61	* * * * * * * * * * * * * * * * * *	6.71

Notes:

1. 'Est' refers to established.
2. All column figures in this table use the same axis formats (minimum value and maximum value) to reveal regional differences.
3. CAGR (Compound Annual Growth Rate) was used to determine an 'average' annual growth rate over the whole period.

4. Mann-Whitney test was used to test whether the two samples were independent for each variable. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

Source: Author's elaboration from HEFCE (multiple years).

The established universities have been shown to generate much higher income from knowledge exchange activities than their newer counterparts per full time employee, suggesting that old universities are more capable of turning research into tangible economic outcomes. Given that established universities, particularly in the UK context, are more research-intensive and carry out more research as well as committing more funds to it, their stronger performance in knowledge exchange is perhaps unsurprising. The results also show that the two groups of universities were always significantly different (at the $p < 0.01$ level) throughout the period surveyed for income from collaborative research, contract research, IP-related activities and in total income. In all of these measures, it was found that established HEIs outperformed their newer counterparts. Therefore not only did old universities lead their newer counterparts in absolute amounts of average income of collaborative research and contract research. They also showed a higher level of compound annual growth rate, implying that the gap between the two groups has widened further across the years. For example, every academic FTE in established universities had collaborative incomes 3.66 times greater than in new universities in 2011/12, up from 3.19 times in 2003/04.

In categories such as IP-related activities and total income, new universities seem to be catching up although the two groups were still significantly different in income levels in 2011/12. During the period measured, academics in new universities showed a CAGR of 16.95 per cent in IP-related activities – more than double that of academics based at older institutions – although one has to bear in mind that the new universities started at a much lower level than the old ones. In general, the gap between the two groups of universities in total income had slightly narrowed. The ratio of average total income per academic FTE of established universities to new universities shrank from 2.26 in 2003/04 to 2.13 in 2011/12. However, it is worth noting that although new universities in the UK are still lagging behind their older counterparts in making economic returns from community engagements, they should be highly recognised for their efforts and achievements in catching up with those more research-intensive and resource-endowed institutions.

Consultancy research shows a very different pattern than the other two types of research linkages – collaborative research and contract research – as the two groups have not shown significantly different performance in this activity until the most recent year of survey. In F&E related services, established universities always performed significantly better than new institutions even though the level of significance might vary by year. Whilst established universities have always shown better performance than new universities in delivering courses to external organisations, there was no significant difference in the first couple of years between the two groups. The difference became significant (at the $p < 0.10$ level) in 2005/06 and remained so in the years to come (at the $p < 0.01$ level). Even so, new universities have developed their performance at a much higher growth rate than old institutions, which has actually helped to narrow down the real gap between the two groups in business courses.

Universities in competitive regions vs. universities in uncompetitive regions

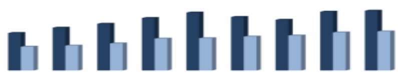
A further question to answer is how the competitiveness of the region in which a university is located is associated with its entrepreneurial activity income. To determine this, the entrepreneurial performance of universities in competitive locations was compared with universities in less competitive regions (Table 6.13). There was a significant difference between the two groups in total income in the years of 2004/05, 2005/06, and 2011/12 (all at the $p < 0.10$ level). In the remaining years, the two groups did not show significantly different performance, although the absolute performance of universities in competitive regions was always higher than that of universities elsewhere. When relating this finding to what is revealed by Table 6.12, it is reasonable to propose that, in the UK, institutional characteristics of universities are more closely associated with their entrepreneurial performance than locational characteristics.

During the whole period, no significant difference was found between the two groups in contract research income and IP income, suggesting that academics in each type of region generated similar income from engaging in these two types of activities. With regard to contract research, universities in uncompetitive regions have been catching up by showing a CAGR of 6.52 per cent, higher than those in leading areas. IP-related activities told a very different and interesting story from the other types of activities. In the beginning of the period, universities in lagging regions actually showed a higher level of IP income than their counterparts situated within the ‘Golden Triangle’ area. With a CAGR of 15 per cent, universities in competitive regions soon took the leading position.

In sub-groups of collaborative research, consultancy research, F&E related services and courses for business, no significant difference was identified in most years. The two groups did not show significantly different income from collaborative research until 2011/12, when universities in uncompetitive regions reported higher income than those in competitive areas (statistically significant at the $p < 0.10$ level). More importantly, they started at a lower level than those in competitive regions but showed a much higher rate of growth over the period. The difference between the two groups in consultancy research was only significant in 2003/04 while in F&E related services the difference became significant only in 2007/08. In these two types of engagements, universities in competitive regions not only always showed higher levels of income but gained higher growth rates than institutions situated in lagging areas.

Universities in competitive regions secured more income by delivering courses for business and the community than those in less competitive areas throughout the period examined. Their difference became significant for the first time in 2010/11 (at the $p < 0.05$ level) and remained so in 2011/12 (at the $p < 0.01$ level). Whilst it is only in recent years that there has seen significant differences between the two groups, universities in less competitive regions showed a higher growth rate over the whole period. Income from business courses generated by every academic FTE at universities in competitive regions increased to £14,650 in 2011/12, much higher than that generated by academics in uncompetitive areas (£5,220). Therefore, although the ratio of the two numbers has narrowed between 2003/04 and 2011/12, the gap between the two groups in the income from courses has actually broadened.

Table 6.13 Universities in competitive regions vs. universities in uncompetitive regions in the six modes of knowledge networks, £000s per academic FTE

	Mean 2003/04	Mean 2011/12	Δ 2003/04-2011/12	Trend 2003/04-2011/12	CAGR %
Collaborative research					
Com	4.64	4.75	0.11	†	0.29
Uncom	4.23	6.25	2.02		5.00
Contract research					
Com	4.50	6.42	1.92		4.54
Uncom	3.47	5.75	2.28		6.52
Consultancy research					
Com	2.04	3.67	1.63	*	7.62
Uncom	1.96	2.82	0.86		4.65
F&E related services					
Com	0.95	2.45	1.50	†	12.57
Uncom	0.54	0.87	0.33		6.14
Courses for business and the community					
Com	8.05	14.65	6.60	 * **	7.77
Uncom	2.49	5.22	2.73		9.69
IP-related activities					
Com	0.17	0.52	0.35		15.00
Uncom	0.22	0.29	0.07		3.51
Total income					
Com	20.35	32.45	12.10	 † † †	6.01
Uncom	12.92	21.21	8.29		6.39

Notes:

1. 'Com' refers to competitive, and 'Uncom' refers to uncompetitive.
2. All column figures in this table use the same axis formats (minimum value and maximum value) to reveal regional differences.
3. CAGR (Compound Annual Growth Rate) was used to determine an 'average' annual growth rate over the whole period.
4. Mann-Whitney test was used to test whether the two samples were independent for each variable. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

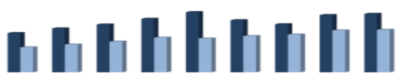
Source: Author's elaboration from HEFCE (multiple years).

Established universities in competitive regions vs. established universities in uncompetitive regions

Analysing the entrepreneurial performance of established universities by type of region yielded a set of results, which suggests that regional competitiveness is not significantly associated with established universities' income level of knowledge exchange activities (Table 6.14). In any given year, no significant difference was found between established universities in the two types of regions in their total entrepreneurial activity income. Again, this is perhaps unsurprising as established universities have, by their nature and by virtue of their age and longevity, a developed (and probably mature) set of business and community networks and relationships both within and outside their respective regional locales, including worldwide partnerships, to facilitate knowledge exchange. Consequently, these types of relationships probably insure them against the negative impacts their regional situations could otherwise have.

In a few indicators such as F&E related services income, the income from courses for business and IP income, established universities in competitive regions and in uncompetitive regions also reported similar performance during the whole period. Among these three types of activities, courses designed for business was the area where established universities in less competitive regions grew faster than their counterparts in competitive regions, while in F&E related services and IP-related activities, regional competitiveness seemed to be positively associated with the annual growth rate shown by established universities.

Table 6.14 Established universities in competitive regions vs. established universities in uncompetitive regions in the six modes of knowledge networks, £000s per academic FTE

	Mean 2003/04	Mean 2011/12	Δ 2003/04-2011/12	Trend 2003/04-2011/12	CAGR %
Collaborative research					
Est in Com	6.74	6.30	-0.44		-0.84
Est in Uncom	6.56	10.75	4.19		6.37
				* *	
				* * *	
Contract research					
Est in Com	6.11	9.18	3.07		5.22
Est in Uncom	5.44	10.07	4.63		8.00
				†	
Consultancy research					
Est in Com	2.50	3.90	1.40		5.72
Est in Uncom	2.00	3.45	1.45		7.05
				†	
F&E related services					
Est in Com	1.30	3.67	2.37		13.85
Est in Uncom	0.86	1.22	0.36		4.47
Courses for business and the community					
Est in Com	10.60	17.15	6.55		6.20
Est in Uncom	2.20	3.78	1.58		7.00
IP-related activities					
Est in Com	0.26	0.72	0.46		13.58
Est in Uncom	0.43	0.54	0.11		2.89
Total income					
Est in Com	27.50	40.92	13.42		5.09
Est in Uncom	17.49	29.80	12.31		6.89

Notes:

1. ‘Est’ refers to established, ‘Com’ refers to competitive, and ‘Uncom’ refers to uncompetitive.
2. All column figures in this table use the same axis formats (minimum value and maximum value) to reveal regional differences.
3. CAGR (Compound Annual Growth Rate) was used to determine an ‘average’ annual growth rate over the whole period.
4. Mann-Whitney test was used to test whether the two samples were independent for each variable. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

Source: Author's elaboration from HEFCE (multiple years).

Significant differences were found in three entrepreneurial activities. The average income from collaborative research generated by established universities in competitive regions declined over the period from £6,740 per academic FTE in 2003/04 to £6,300 in 2011/12. By contrast, with a CAGR of 6.37 per cent, older institutions in less competitive areas not only caught up with their counterparts in competitive regions but also showed significantly higher performance in the most recent years. In 2009/10, the difference between the two groups became significant (at the $p < 0.05$ level) for the first time and remained significant at the 0.01 level since.

What this suggests is that established universities are not constrained by the economic competitiveness of their locale in engaging in collaborative projects. Instead, being situated within a weaker region seems to drive old institutions to seek collaborative research projects more proactively, which could be partly due to a lack of proximate firms that require the knowledge provided by those universities. Academics based at those institutions may put more effort into building external, either national or international, partnerships with the business world. Furthermore, it could be the willingness to make the efforts, in addition to the research capability, that helps established universities in lagging regions outperform their counterparts in more advanced areas.

For both contract research and consultancy research, significant differences were found in a singular year: 2008/09 for the former type and 2011/12 for the latter. Before 2008/09, established universities in competitive regions showed better performance of contract research than those in weaker regions but the difference was not significant. When the difference became significant for the first time (at the $p < 0.10$ level), it was those older institutions in weaker regions that reported higher income than their counterparts in the leading areas. In consultancy research, the income generated by universities was found to be positively associated with the competitiveness of the location where institutions were based, but the difference did not become significant until the most recent year (at the $p < 0.10$ level).

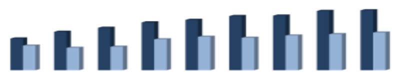
New universities in competitive regions vs. new universities in uncompetitive regions

Results also showed that the performance of new universities is positively associated with regional competitiveness (Table 6.15). The most significant differences between the two groups were found in the level of total income and income from courses for business. More specifically, it was found that in these two measures, new universities in competitive regions performed better than their counterparts in uncompetitive regions. From 2004/05 onwards, the total income per academic FTE of new universities in competitive regions has not only always been significantly higher than those in other places but also has been developing at a higher annual growth rate. Given the assertion that established universities often have connections which go beyond their regional locales, this finding could imply that the regional profile is more important in new universities which, in the absence of an established reputation and mature relationships, may be more dependent on regional collaborations.

Table 6.15 also compares the performance of the two groups in the six categories of knowledge exchange activities and shows that the difference between the two groups in total income was largely due to their varying capabilities of generating income from courses for business and the community. In activities such as collaborative research, contract research and IP, there was no significant difference between the two groups in any given year. Although significant differences were found in consultancy research and F&E related services, they only appeared in a singular year (2003/04 for consultancy research and 2007/08 for F&E services), which suggests that in the most recent four years, the two groups showed comparable levels of performance in both activities.

These patterns can be contrasted to that of courses for business, in which activity new universities in competitive regions and uncompetitive regions have reported significantly different income in all but one year. Interestingly, the years when the two groups showed significant difference in courses are the same as the years when the total income of the two groups were found to be significantly different. During the period examined, the income from courses generated by new universities in competitive regions increased from £4,820 to £11,390 per academic FTE. This increase is much larger than what has been achieved by those academics in weaker regions that were able to improve their average income level of courses by only £3,750.

Table 6.15 New universities in competitive regions vs. new universities in uncompetitive regions in the six modes of knowledge networks, £000s per academic FTE

	Mean 2003/04	**Mean 2011/12**	**Δ 2003/04-2011/12**	**Trend 2003/04-2011/12**	**CAGR %**
Collaborative research					
New in Com	2.00	2.73	0.73		3.97
New in Uncom	2.13	2.20	0.07		0.41
Contract research					
New in Com	2.47	2.81	0.34		1.63
New in Uncom	1.70	1.86	0.16		1.13
Consultancy research					
New in Com	1.46	3.37	1.91		11.02
New in Uncom	1.94	2.26	0.32		1.93
				†	
F&E related services					
New in Com	0.52	0.85	0.33		6.34
New in Uncom	0.24	0.56	0.32		11.17
				†	
Courses for business and the community					
New in Com	4.82	11.39	6.57		11.35
New in Uncom	2.76	6.51	3.75		11.32
				* * *	
				* * * † * * * *	
IP-related activities					
New in Com	0.06	0.26	0.20		20.12
New in Uncom	0.03	0.07	0.04		11.17
Total income					
New in Com	11.33	21.41	10.08		8.28
New in Uncom	8.79	13.45	4.66		5.46
				* * * † * * * *	
				*	

Notes:

1. 'Com' refers to competitive, and 'Uncom' refers to uncompetitive.
2. All column figures in this table use the same axis formats (minimum value and maximum value) to reveal regional differences.
3. CAGR (Compound Annual Growth Rate) was used to determine an 'average' annual growth rate over the whole period.
4. Mann-Whitney test was used to test whether the two samples were

independent for each variable. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

Source: Author's elaboration from HEFCE (multiple years).

What seems more interesting is that the regional competitiveness of the location of new universities is positively associated with the annual growth rate shown by the institutions. As Table 6.15 clearly reveals, new universities in competitive regions showed higher CAGRs in five out of six types of activities as well as in total income than those post-1992 institutions based in lagging regions. The only exception is F&E services in which new universities in uncompetitive areas led their counterparts in competitive regions. However, this is also an activity from which the absolute amount of income only accounts for a very small share of the total income generated by new universities in both types of regions. The higher growth rate of F&E services shown by new universities in uncompetitive regions could not overturn the fact that the gap between the levels of total income of the two groups has further widened across the period.

6.4.2 By region

Collaborative research

The average income from collaborative research made by academics in each of the 12 UK regions is shown in Table 6.16 below. In 2003/04, academics situated within the North East on average generated £7,530 from collaborative projects, the highest amount of income reported by all regions. The South West fell to the bottom of the rankings in that year, with every academic FTE generating only £2,500. The picture became rather different in 2011/12. The top spot was taken by Northern Ireland (£14,250 per academic FTE), while the South East fell behind its counterparts by some margin (£3,020 per academic FTE). The three devolved nations in the UK – Northern Ireland, Scotland, and Wales – have displayed some advantages over their English counterparts in conducting collaborative research as they occupied the top three rankings in 2011/12.

Table 6.16 Collaborative research, 12 regions, £000s per academic FTE

Region	**Mean 2003/04**	**Mean 2011/12**	**Δ 2003/04-2011/12**	**Trend 2003/04-2011/12**	**CAGR %**
East Midlands	4.61	6.22	1.61		3.82
East of England	5.76	6.96	1.20		2.39
London	4.68	5.15	0.47		1.20
North East	7.53	4.96	-2.57		-5.08
North West	4.63	4.48	-0.15		-0.41
Northern Ireland	4.00	14.25	10.25		17.21
Scotland	4.98	7.94	2.96		6.00
South East	4.04	3.02	-1.02		-3.57
South West	2.50	4.83	2.33		8.58
Wales	4.52	7.29	2.77		6.16
West Midlands	3.24	6.51	3.27		9.11
Yorkshire and the Humber	2.54	4.63	2.09		7.79
UK	4.39	5.64	1.25		3.18

Notes:
1. All column figures in this table use the same axis formats (minimum value and maximum value) to reveal regional differences.
2. CAGR (Compound Annual Growth Rate) was used to determine an 'average' annual growth rate over the whole period.

Source: Author's elaboration from HEFCE (multiple years).

When comparing regional performance in the two individual years (2003/04 and 2011/12), three regions have actually seen a decline of income level. The

North East, the leading region in 2003/04, suffered the biggest loss, with its collaborative research income dropping by £2,570 per academic FTE over the period. This leads to a compound annual growth rate of -5.08 per cent. The South East and the North West were the other two regions which also witnessed some negative growth in the average income generated by their academics. Among the other nine regions enjoying improved performance, Northern Ireland was the most successful region, where every full-time equivalent academic increased their average income from £4,000 to nearly £14,250 (CAGR = 17.21%). In absolute terms, the rise in income achieved by Northern Irish academics was much higher than that of any other UK region, including the West Midlands, whose academics on average gained an increase of £3,270 – the second best improvement after Northern Ireland.

Despite the North East suffering the biggest drop over the period, it was not until 2007/08 that the fall actually took place. The performance of academics in the North East was relatively stable between 2003/04 and 2006/07, before being hit by a sudden, and serious, decline in 2007/08. Since then, the level of income was unable to level up to the earlier stage before the drop. In Northern Ireland, academics did not considerably increase their collaborative research income in the first few years but, it was the continuous improvements made from 2006/07 onwards that finally secured the region's leading advantage. In some regions such as Wales, academic income tended to fluctuate from one year to the other, without a clear trend over the period.

Contract research

Table 6.17 below reports the results in the case of contract research. With an average income of £5,480 and £4,880 respectively, the West Midlands and the East of England led the rankings of regions in 2003/04. At the bottom of the table sat the North West, where academics on average generated £1,330 from research contracts, slightly above one third of the national level. In the most recent year, the East of England climbed from the second place to the top, with every academic FTE generating £9,290 from contract research, followed by £8,340 in Yorkshire and the Humber.

The West Midlands became the only region in the UK which recorded a fall of academic income from contract research across the period. Two devolved nations – Northern Ireland and Scotland – saw the biggest rise of their levels of performance, while the third devolved country – Wales – was only able to enjoy a rather modest amount of growth. Between 2003/04 and 2011/12, the CAGR of Northern Ireland was around 16.54 per cent, followed by the North West with 12.69 per cent. The remarkable growth rate shown by academics in the North West could not level up its ranking among the regions as it started from a very low level of performance.

In Table 6.17, one can observe different patterns of growth in contract research shown by the 12 UK regions. London, after incremental development in the first five years, experienced a continuing decline between 2007/08 and 2009/10, after which year the situation was then much improved. Whilst the North West has shown a CAGR of as high as 12.69 per cent in the period, column charts also clearly manifest that, after its level of performance peaked in 2007/08, it has seen modest growth in latter years.

Table 6.17 Contract research, 12 regions, £000s per academic FTE

Region	Mean 2003/04	Mean 2011/12	Δ 2003/04-2011/12	Trend 2003/04-2011/12	CAGR %
East Midlands	2.53	4.66	2.13		7.93
East of England	4.88	9.29	4.41		8.38
London	4.68	6.13	1.45		3.43
North East	4.65	6.48	1.83		4.24
North West	1.33	3.46	2.13		12.69
Northern Ireland	2.24	7.62	5.38		16.54
Scotland	4.15	7.95	3.80		8.47
South East	3.95	5.70	1.75		4.69
South West	3.87	5.38	1.51		4.20
Wales	2.23	3.63	1.40		6.28
West Midlands	5.48	5.41	-0.07		-0.16
Yorkshire and the Humber	4.71	8.34	3.63		7.40
UK	3.88	6.02	2.14		5.64

Notes:
1. All column figures in this table use the same axis formats (minimum value and maximum value) to reveal regional differences.
2. CAGR (Compound Annual Growth Rate) was used to determine an 'average' annual growth rate over the whole period.

Source: Author's elaboration from HEFCE (multiple years).

Consultancy research

Table 6.18 below presents the regional growth patterns with respect to academics' consultancy research income. The rankings in 2003/04 were led by the South West and the South East, where academics on average secured £2,900 and £2,460 respectively from delivering consultancy services. Back then, Northern Ireland failed to keep pace with its counterparts elsewhere in the UK, with its academics generating only £890 from consultancy research. In 2011/12, the South West and the South East not only lost their leading positions but dropped to the bottom of the rankings. With the greatest income increase, the East of England claimed the top spot in 2011/12, replacing the South West, while the West Midlands occupied second place. Out of the 12 regions, the South West was the only one showing some decline in average consultancy research income.

While the East of England made the largest growth in absolute terms, its CAGR – 17.48 per cent – was ranked second to that of Northern Ireland, which showed an annual growth rate of 17.88 per cent. To a certain extent, this could be due to Northern Ireland starting from a lower level of performance than the East of England, which means that the same amount of income growth represents a higher growth rate for the former than for the latter. The South East, with a CAGR of just 0.25 per cent, was the region making the least volume of positive growth. In the South West, the average income from consultancy research per academic FTE has been declining at a compound annual growth rate of 9.54 per cent, and therefore, the region has inevitably seen a sharp drop in its ranking.

An examination of the historical trends of the 12 regions makes clear that Northern Ireland was the one and only region gaining continuous improvements year on year. The performance of academics in the North East culminated in 2004/05 and could not grow further afterwards but tended to fluctuate at a lower level. Subsequent to a long period with modest change, academics situated within the East Midlands have made an impressive increase in performance during recent years. In both the South East and the North West, academics saw their performance first increased and then decreased.

Table 6.18 Consultancy research, 12 regions, £000s per academic FTE

Region	Mean 2003/04	Mean 2011/12	Δ 2003/04-2011/12	Trend 2003/04-2011/12	CAGR %
East Midlands	1.57	2.58	1.01		6.41
East of England	2.13	7.73	5.60		17.48
London	1.80	3.34	1.54		8.03
North East	2.06	2.84	0.78		4.10
North West	1.91	2.75	0.84		4.66
Northern Ireland	0.81	3.02	2.21		17.88
Scotland	1.90	3.37	1.47		7.43
South East	2.46	2.51	0.05		0.25
South West	2.90	1.30	-1.60		-9.54
Wales	2.37	2.63	0.26		1.50
West Midlands	2.25	3.78	1.53		6.70
Yorkshire and the Humber	1.13	2.75	1.62		11.76
UK	1.99	3.16	1.17		5.95

Notes:
1. All column figures in this table use the same axis formats (minimum value and maximum value) to reveal regional differences.
2. CAGR (Compound Annual Growth Rate) was used to determine an 'average' annual growth rate over the whole period.

Source: Author's elaboration from HEFCE (multiple years).

F&E related services

The progress of F&E related services is presented in Table 6.19 below, which indicates that, in the whole of the UK, income from these services more than doubled over the years. The South East and London were the leading regions at the start of the period, with every academic FTE being able to generate £1,400 and £920 from engaging in F&E services respectively. At the other end of the ranking was Northern Ireland, where F&E activity income per academic FTE stood at just £90, marginally above an eighth of the UK average. However this region made significant growth again in this activity and climbed to the top of the rankings in 2011/12, by when its average income level had increased to as high as £2,990, more than 30 times higher than its performance less than a decade ago. London continued to be ranked second, while Wales lagged behind its counterparts in 2011/12 and could only report an amount of £200 income from F&E per academic.

During the period, the largest increase of absolute average income was reported by academics in Northern Ireland (£2,900) and London (£2,020). Wales and the North West on the contrary have suffered some losses. Northern Ireland also led the rankings of CAGR by showing an annual growth rate of 54.95 per cent, followed by the East of England (29.27%) and London (15.63%). The average income of F&E services per academic FTE in Wales however has been dropping at a CAGR of 11.04 per cent across the years.

Table 6.19 also reveals various patterns which have been shown by UK regions for their involvement in F&E services. In the East of England, the level of income showed a modest increase in the first six years before really taking off from 2010/11. For academics in the North West, income from F&E activity improved continuously until 2008/09, since when the uptrend was halted and replaced with constant decline in the recent three years. The performance of Northern Irish academics peaked in 2008/09, and it would take another two years before their level saw any increase again. It seemed that academics employed in Welsh universities have put little focus on providing F&E services during the whole period. As a matter of fact, the average income which Welsh academics could generate dropped severely in 2004/05 and has not recovered since.

Table 6.19 F&E related services, 12 regions, £000s per academic FTE

Region	**Mean 2003/04**	**Mean 2011/12**	**Δ 2003/04-2011/12**	**Trend 2003/04-2011/12**	**CAGR %**
East Midlands	0.91	1.36	0.45		5.15
East of England	0.15	1.17	1.02		29.27
London	0.92	2.94	2.02		15.63
North East	0.28	0.33	0.05		2.08
North West	0.38	0.31	-0.07		-2.51
Northern Ireland	0.09	2.99	2.90		54.95
Scotland	0.54	0.75	0.21		4.19
South East	1.40	2.09	0.69		5.14
South West	0.56	0.81	0.25		4.72
Wales	0.51	0.20	-0.31		-11.04
West Midlands	0.76	1.65	0.89		10.18
Yorkshire and the Humber	0.42	1.25	0.83		14.61
UK	0.70	1.51	0.81		10.09

Notes:

1. All column figures in this table use the same axis formats (minimum value and maximum value) to reveal regional differences.
2. CAGR (Compound Annual Growth Rate) was used to determine an 'average' annual growth rate over the whole period.

Source: Author's elaboration from HEFCE (multiple years).

Courses for business and the community

In Table 6.20 below, the figures reveal how UK academics have improved income from delivering courses to business and the community. A key message is that courses have become the knowledge exchange activity which accounts for the largest amount of income per academic in the UK. Importantly, the gap between the income from courses and that from other activities has broadened across the years, indicating an increased dominance of training programmes as a means undertaken by academics to engage with external partners.

London has always led its counterparts by quite a margin in this area. In 2003/04, every academic FTE situated within London universities generated £10,450 from courses, followed by those in the East of England where the amount was £7,390. Northern Ireland and Wales sat at the bottom of the rankings in 2003/04, with their academics only generating £710 and £1,090 respectively from business courses. London and the East of England continued to take the top two spots in 2011/12, while the South West fell to the bottom.

London has not only successfully maintained its top ranking across the years, but has gained the largest amount of income increase (£8,690 per academic FTE). To a lesser extent, academics in the East Midlands have improved their average income from courses by £7,060. West Midlands and the South West, by contrast, were the two regions seeing the least amount of increase. With a CAGR of 16.50 per cent, the East Midlands was able to show the fastest growth over the period, closely followed by Wales (CAGR = 14.81%) and Northern Ireland (CAGR = 14.24%). The region showing the smallest compound annual growth rate was the South West.

The column figures in Table 6.20 clearly show how universities across the UK regions have grown their income from business courses. London, being the region with the highest level of income, has basically undergone three different stages of development. Between 2003/04 and 2007/08 it saw continuing increase of average income, while the level of performance declined significantly in 2008/09 and then stayed at that level in the next year.

Table 6.20 Courses for business and the community, 12 regions, £000s per academic FTE

Region	Mean 2003/04	Mean 2011/12	Δ 2003/04-2011/12	Trend 2003/04-2011/12	CAGR %
East Midlands	2.95	10.01	7.06		16.50
East of England	7.39	12.42	5.03		6.70
London	10.45	19.14	8.69		7.86
North East	2.43	5.09	2.66		9.68
North West	2.43	5.45	3.02		10.62
Northern Ireland	0.71	2.06	1.35		14.24
Scotland	3.20	6.61	3.41		9.49
South East	3.55	7.21	3.66		9.26
South West	2.28	3.14	0.86		4.08
Wales	1.09	3.29	2.20		14.81
West Midlands	3.60	4.13	0.53		1.73
Yorkshire and the Humber	2.08	4.17	2.09		9.08
UK	4.71	9.03	4.32		8.48

Notes:

1. All column figures in this table use the same axis formats (minimum value and maximum value) to reveal regional differences.
2. CAGR (Compound Annual Growth Rate) was used to determine an 'average' annual growth rate over the whole period.

Source: Author's elaboration from on HEFCE (multiple years).

IP-related activities

IP-related activities, among all the six types of activities, accounted for the lowest income generated by UK academics when networking with partners, as

Table 6.21 below reveals that every academic in the UK generated on average £200 from IP in 2003/04, and that amount increased to £390 after eight years. The regional rankings of 2003/04 were led by the West Midlands and Scotland, with per academic FTE in these two regions generating £530 and £490 from IP respectively. In 2011/12, Northern Ireland claimed the top ranking since every one of its academics was able to yield as much as £2,060 of IP income, more than three times above the average income generated by academics in the West Midlands – the region ranked second after Northern Ireland.

Scotland and the North West were the two regions which have seen their performance of IP-related activities decrease during the period. In particular, the amount of IP income yielded by every Scottish academic dropped by £220 over the years, while the North West saw a relatively modest decrease of £60. With a CAGR of 44.23 per cent, Northern Ireland showed the fastest growth, followed by Yorkshire and the Humber with a CAGR of 21.66 per cent. Three other regions also showed an annual growth rate higher than 15 per cent, including London (18.61%), the East Midlands (17.77%) and the East of England (16.15%). For academics in Scotland and the North West, their average IP income level was declining at a CAGR of 7.18 and 6.19 per cent respectively.

An evident finding from the column charts in Table 6.21 is that, academics in most UK regions have barely participated in IP activity, at least not in the sense of generating large amounts of income. Northern Ireland, where academic IP income started taking off from 2007/08 and peaked in 2010/11, after continuing and remarkable growth during that period, was the most noteworthy region. In spite of its sharp decline in 2011/12, Northern Ireland kept the top ranking and led the others by quite a margin. Whilst academics situated within the South East could only generate a very modest amount of IP income in most years, there was an exception: in 2008/09, its performance skyrocketed to £4,760 per academic FTE. Possibly, a number of patents held by South Eastern universities were successfully licensed to enterprises, which in consequence generated a large amount of license fees. However, that level of performance was just a one-off and academics in the South East were unable to maintain the advantage in the following years.

Table 6.21 IP-related activities, 12 regions, £000s per academic FTE

Region	Mean 2003/04	Mean 2011/12	Δ 2003/04-2011/12	Trend 2003/04-2011/12	CAGR %
East Midlands	0.10	0.37	0.27		17.77
East of England	0.16	0.53	0.37		16.15
London	0.12	0.47	0.35		18.61
North East	0.05	0.10	0.05		9.05
North West	0.15	0.09	-0.06		-6.19
Northern Ireland	0.11	2.06	1.95		44.23
Scotland	0.49	0.27	-0.22		-7.18
South East	0.28	0.61	0.33		10.22
South West	0.08	0.13	0.05		6.26
Wales	0.06	0.14	0.08		11.17
West Midlands	0.53	0.63	0.10		2.18
Yorkshire and the Humber	0.05	0.24	0.19		21.66
UK	0.20	0.39	0.19		8.71

Notes:

1. All column figures in this table use the same axis formats (minimum value and maximum value) to reveal regional differences.
2. CAGR (Compound Annual Growth Rate) was used to determine an ‘average’ annual growth rate over the whole period.

Source: Author’s elaboration from HEFCE (multiple years).

Total income

Growth in the total income generated by academics from knowledge exchange activities across the UK is demonstrated in Table 6.22 below. From this it can be concluded that UK academics are now generating much more income from business engagements overall than they used to. In 2003/04, every academic FTE generated £15,890 and that amount increased to £25,760 in 2011/12.

Table 6.22 Total income, 12 regions, £000s per academic FTE

Region	Mean 2003/04	Mean 2011/12	Δ 2003/04-2011/12	Trend 2003/04-2011/12	CAGR %
East Midlands	12.67	25.19	12.52		8.97
East of England	20.47	38.11	17.64		8.08
London	22.66	37.17	14.51		6.38
North East	16.99	19.79	2.80		1.93
North West	10.82	16.55	5.73		5.46
Northern Ireland	7.96	31.98	24.02		18.99
Scotland	15.26	26.87	11.61		7.33
South East	15.67	21.14	5.47		3.81
South West	12.19	15.59	3.40		3.12
Wales	10.78	17.18	6.40		6.00
West Midlands	15.87	22.11	6.24		4.23
Yorkshire and the Humber	10.93	21.39	10.46		8.75
UK	15.89	25.76	9.87		6.23

Notes:

1. All column figures in this table used the same axis formats (minimum value and maximum value) to reveal regional differences.
2. CAGR (Compound Annual Growth) was used to determine an 'average' annual growth rate over the whole period.

Source: Author's elaboration based on HEFCE (multiple years).

Regions with the highest levels of total income at the start of the period included London (£22,660 per academic FTE) and the East of England (£20,470 per academic FTE), while Northern Ireland was far behind the rest of the UK. In 2011/12, however there was a dramatic change in the regional rankings as Northern Ireland climbed from the bottom to third place, just behind the East of England and London. Not surprisingly, Northern Ireland – the biggest climber over the period – has enjoyed the largest amount of total income increase (£24,020 per academic FTE). With an increase of £2,800 in average total income, academics in the North East made the smallest improvement among all the regions. Furthermore, Northern Ireland also topped the rankings of the annual growth rate by showing a CAGR of 18.99 per cent, a rate more than double what was achieved by academics in the East Midlands (the second ranked region in that regard).

6.5 Configuring university knowledge networks

This chapter has examined the current state of university knowledge networks in the UK, with two main aims: first, to understand how regional context is associated with the relationships between the intensity and performance of knowledge networks; and second to examine the full spectrum of knowledge exchange activities from a longitudinal perspective.

UK academics showed significant differences in how intensively they engaged in various types of networks, except for IP-related activities, which were the least frequent type of interaction. Academics in uncompetitive regions tended to outperform their counterparts in competitive regions in engaging closely in knowledge networks, which has been an unexpected result, and therefore provided new insights into regional comparisons. However, universities in competitive regions generated higher income from engaging in knowledge exchange activities than those in uncompetitive areas. This paradox suggests that the main constraint of academics in uncompetitive regions was their limited capacity in generating incomes from engaging in knowledge networks.

Academics were more closely engaged with the public and third sector organisations than with private firms. As for the income, non-commercial organisations turned out to be the dominant partners of universities in uncompetitive regions, while private sector firms and public sector organisations were both important funding sources to universities located in competitive areas. A less diverse income portfolio of universities in uncompetitive regions might bring about crucial challenges for them, especially in a period of tight public funding as a consequence of the financial crisis. Government policies and university initiatives should be directed to building more linkages with external partners, in particular private sector companies.

Academics in the two regional groups showed a clear divergence in the locational features of their knowledge networks. Academics in uncompetitive areas showed a significantly higher level of engagement in regionally-based activities, while academics in competitive regions overwhelmingly outperformed in internationally-based activities. Further efforts have to be put in place to understand how engaging in regionally-based or internationally-based activities would impact on, for example, academic outputs, and more widely, on regional innovation systems.

The analysis suggests that a key reason why academics in uncompetitive regions generated less income from knowledge networks does not lie in their attitude towards reaching out to businesses and the community (D'Este and Patel 2007; Ponomariov 2008), but in something else, which could be termed as 'income generating capacity'. In general, better income generating capacity is associated with academics involved with large-scale partnerships that tend to involve large firms, especially multi-national companies, and internationally-based partners.

Although academics in uncompetitive regions were more actively engaged in knowledge exchange activities than their counterparts in competitive areas, they tended to do so by relying on public sector funding. In contrast, academics in competitive regions generated income diversely from both private and public organisations. It has been further suggested that the differences in generating income from private sector companies were to a large extent related to the levels of the total performance of university knowledge networks. Following this, the examination of how businesses perceive the role of university knowledge and then make use of it, as shown in Chapter 5, becomes important. Indeed, knowledge exchange is a dual process, and can only be best understood from the perspectives of both sides.

It has also become clear that it was not the regionalisation but the internationalisation of knowledge networks that was strongly associated with the financial performance of universities over the period. To be part of global knowledge networks could mean more than financial returns to academics, including cutting-edge knowledge and advanced knowledge sharing, which can hardly be achieved otherwise. This, by all means, does not deny the importance of regional knowledge networks (Saxenian 1994; Storper 1997; Lawson and Lorenz 1999; Bathelt et al. 2004). It is important, therefore, for a region, especially the academics and businesses within it, to develop both regional and international knowledge networks for the exploitation and exploration of knowledge.

Drawing upon the HE-BCI survey data between the academic years of 2003/04 and 2011/12, longitudinal study has examined the performance of UK universities in knowledge exchange activities with a special focus on the two university groups (established and new universities) in the two regional groups (competitive and uncompetitive regions). The findings suggest that more established universities in the UK have outperformed their younger counterparts in generating income from knowledge exchange activities, thus demonstrating more active involvement in their entrepreneurial missions. Furthermore, the entrepreneurial performance of universities was found to be more strongly associated with their institutional characteristics than locational characteristics. While no significant difference was found in the entrepreneurial activity income generated by established universities in competitive and uncompetitive regions, the entrepreneurial performance of new universities was positively associated with the competitiveness of their regions.

The fact that the gap between the levels of total income of new universities in the two types of regions has actually widened over the years indicates there might exist the so-called 'Matthew Effect' (or accumulated advantage), a sociological phenomenon where the rich get richer and the poor get poorer. Unlike their established counterparts, new universities may be less capable of overcoming the disadvantages of being situated within a weaker region which lacks proximate firms in need of university-generated knowledge. It may be that established universities are better able to take advantage of their superior heritage, dominant research position and reputational capital than newer universities in maximising returns from entrepreneurial activities (i.e. those beyond the more traditional first and second missions).

Universities in the 12 UK regions have also demonstrated various patterns of development in knowledge exchange activities. Over the period, some regions have actually seen their average income from certain types of activities decrease, such as the North East and the South East in collaborative research, West Midlands in contract research and the South West in consultancy research. Northern Ireland could be argued to be the most remarkable region during the last decade in promoting university knowledge exchange activities, as it showed both the largest amount of increase and the highest annual growth rate in four out of the six types of activities. A further reflection could be that policy makers across the regions may have undertaken different approaches in prioritising various types of knowledge exchange activities.

CHAPTER 7

AN ILLUSTRATIVE CASE STUDY OF FACTORS UNDERLYING THE PERFORMANCE OF UNIVERSITY KNOWLEDGE EXCHANGE INITIATIVES

In this chapter, the results of analysis of a set of university initiatives in the knowledge exchange arena are presented in case study form. To be specific, the purpose of this chapter is threefold. First, it is mainly intended to expand upon the quantitative analysis of the UK regions and to examine the diverse nature of university-business interaction within one region. Second, it adopts a four-level framework to map out the factors underlying the performance of each case at the individual, departmental, organisational and spatial levels, which have been discussed in the literature review but not been examined at the UK level. Third, it aims to provide a useful platform for future studies which aim to conduct case studies of knowledge exchange activities. Nevertheless, as already mentioned, the scope of this chapter was narrowly defined and was designed to provide complementary findings to the quantitative analysis in the previous chapters.

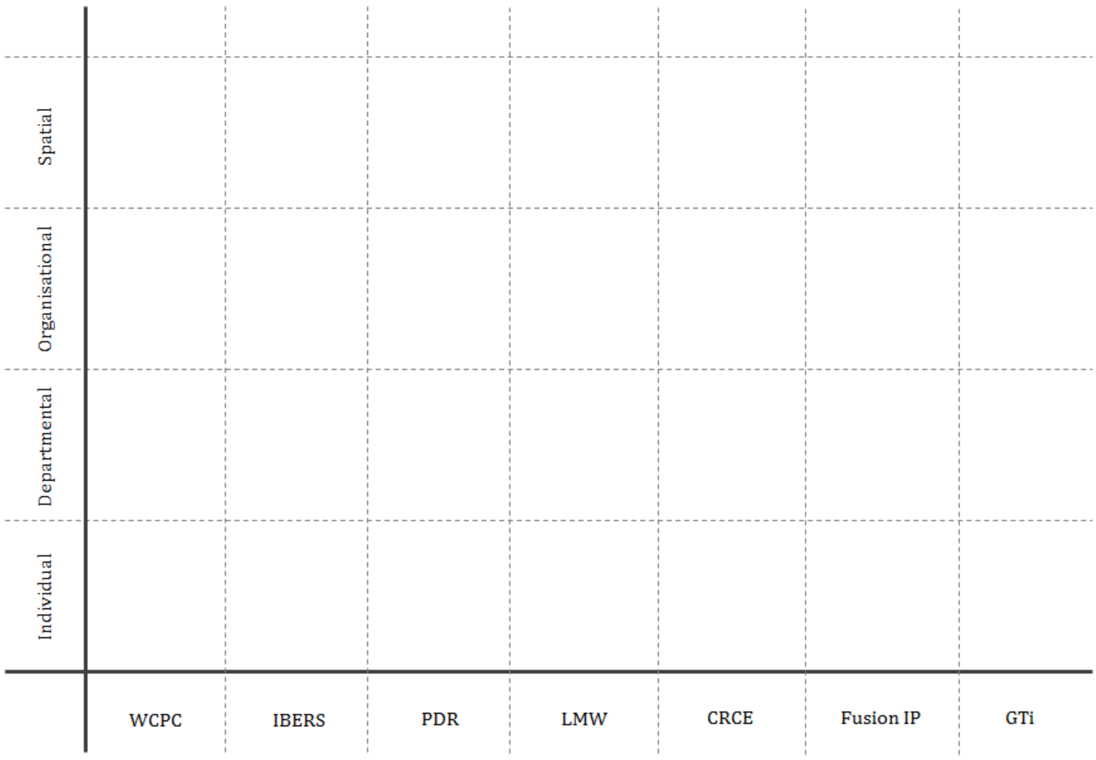
This chapter is organised into the following three sub-sections. The first sub-section outlines the background information of all the case studies, including where they are, how they are funded, what kinds of universities they are based in and their geographical context in relations to the industrial past. While these factors may play a role in the expectations of the impact that the case studies could have, the exact causality relationships between them are beyond the scope of this chapter and could be examined in future research.

The second sub-section then provides further detailed description of each of the seven case studies, a task which involves following the development of the initiatives from a longitudinal perspective, showing the main activities that the initiatives undertake, and explaining their approaches to building collaborations. In particular, the content of this sub-section has been derived from both desk research and face-to-face interviews.

The third sub-section identifies the main factors of the performance of the initiatives based on the interview data. It needs to point out that, although the factors have been identified using the four-level framework – each factor was placed in one of the four levels – they were not necessarily exactly the same as those factor mentioned in the literature review, indicating a further contribution of this thesis. Indeed, this sub-section is about searching for the 'very specific' factors underling the seven case studies while adopting the framework which has directly been constructed from the literature review.

Figure 7.1 below illustrate the four-level framework which was used for the analysis of the case studies. Each factor was identified by the researcher through the analysis of interview data and was connected with the literature review. For each case study, as many as possible factors could be recognised. Nevertheless, while adopting a critical realist approach, which argues that the findings of research are mediated through the researcher's own values, the factors finally identified could only reflect how the researcher perceived the operation of the case studies.

Figure 7.1 A four-level framework



Source: Author's own elaboration.

7.1 Background

Table 7.1 below displays some background information of the seven case studies. Three initiatives, namely the WCPC, IBERS and PDR, are jointly funded by public and private sources. For instance, the WCPC generate incomes from both UK and European research programmes and the delivery of services to firms. It is increasingly common for research centres to build close relationships with both public and private sector organisations. Another three initiatives, namely the LMW, CRCE, and GTi, mainly receive funding from public sources, although they also provide various types of services to commercial companies. The last initiative, Fusion IP, is a company which has an exclusive agreement with Cardiff University to manage all the invention disclosures reported by its staff. Understandably, Fusion IP is self-funded by its own incomes from licensing patents and operating spin-outs.

The seven case studies are based at a total of six Welsh universities, which vary significantly in terms of size. According the HESA data, Aberystwyth University was the smallest, with 11,170 students enrolled and 990 academic staff employed in 2013/14. Cardiff University, not surprisingly, was the biggest higher education provider in Wales, where 30,180 students were enrolled and 3,295 academic staff were employed in 2013/14. While the student number in Swansea University was only slightly higher than that in Cardiff Metropolitan University, the former in 2013/14 employed 1,240 academic staff, nearly double the number employed by the latter.

There are three established universities in Table 7.1, while Cardiff Metropolitan University, University of Wales, Newport, and University of Glamorgan gained their university status after 1992. In the 2015 Complete University Guide, which uses 10 measures to rank the top 125 universities across the UK, Cardiff University was the best-placed Welsh university at 31st, followed closely by Swansea University at 45th. Cardiff Metropolitan University moved up 19 spots to 79th, making it Wales' most improved institution on the list. Aberystwyth University was ranked 87th, while University of South Wales – the merger of University of Glamorgan and University of Wales, Newport – fell from 100th to 102nd. The universities where the case studies are based at show significantly differences in terms of research capacity and overall quality.

Table 7.1 Background information of the seven case studies

Initiative	Funding model	University affiliation	Uni. type
WCPC	Public and private funding	Swansea Uni.	Est
IBERS	Public and private funding	Aberystwyth Uni.	Est
PDR	Public and private funding	Cardiff Metropolitan Uni.	New
LMW	Public funding	Cardiff Uni.	Est
CRCE	Public funding	Uni. of Wales, Newport	New
Fusion IP	Private funding	Cardiff Uni.	Est
GTi	Public funding	Uni. of Glamorgan	New

Notes:
1. Public funding refers to income from university or government bodies, while private funding refers to income from firms.
2. 'Est' refers to established.
3. Fusion IP is a company which is listed on the Main Market of the London Stock Exchange under the code IPO.

Source: Author's own elaboration.

It is also of interest to look at headline figures of the localities where these initiatives are based, as there is huge geographical variation across Wales. In the 1980s, many part of Wales, such as the Valleys, suffered significantly from the decline in heavy industry (e.g. coal-mining). By contrast, Cardiff, the capital city of Wales, and its surrounding areas have experienced big increase in employment in service sector since the 1990s. Table 7.2 below compares the Welsh NUTS3 areas with Wales and the UK in terms of GVA per had and Gross Disposable Household Income per head in 2013. While GVA per head in Cardiff and Vale of Glamorgan was more or less in line with the UK average and much higher than the Welsh level, South West Wales lagged far behind both the regional and the national level. Swansea was the NUTS3 area with the lowest Gross Disposable Household Income per head in comparison to the other three areas. Thus, while Wales itself is a lagging region in the UK, areas within the region still show significant variances of economic development levels.

Table 7.2 Economic indicators of Welsh NUTS3 areas in 2013 (UK=100)

Welsh NUTS3 area	Gross Value Added per head	Gross Disposable Household Income per head
Cardiff and Vale of Glamorgan	98.3	94.1
Monmouthshire and Newport	85.8	91.5
South West Wales	58.6	88.9
Swansea	74.6	82.6
Wales	72.2	87.8
UK	100.0	100.0

Notes:
1. The PDR, LMW, Fusion IP and GTi are based in Cardiff and Vale of Glamorgan.
2. The IBERS is based in South West Wales.
3. The CRCE is based in Monmouthshire and Newport.
4. The WCPC is based in Swansea.

Source: Office for National Statistics (2015).

7.2 Operation

7.2.1 Welsh Centre for Printing and Coating (WCPC)

The WCPC is hosted by the School of Engineering at Swansea University, and is open to any company that uses printing as part of its manufacturing process. Over the last 18 years, the Centre has developed its expertise in a wide range of technologies, including screen, flexographic, digital and pad printing. That expertise comes from its 25 dedicated staff, including post-doctoral and PhD researchers from both academic and industrial backgrounds, together with support staff from other departments in the University. Basically, the advantage of the Centre lies in the combination of its expertise in fundamental science and its practical application to improving process quality and productivity, through offering open access facilities to its private sector partners.

For WCPC, there are three key components – research, technology and industry (partnerships) – which are associated with each other and, more importantly, combined together to support the delivery of services. Fundamental science is considered to be the 'bed-rock' of process development; therefore a better understanding of it enables the Centre to provide solutions to some problems that may not be urgent now, but that the industry may face in the future. Fuelled by its strength in research, the Centre has developed a variety of technologies, spanning a number of industry sectors, from graphics and packaging and printed electronics to medical and biotechnology. Research and support of the graphics and packaging sector are, for instance, considered to be a 'corner-stone' for WCPC. This is partly because of the strong relevance between the sector and the Centre and partly due to the vital role this sector plays in the economy. At the market end, science is utilised in support of industry as WCPC offers various types of services to the private sector, such as consultancy, problem-solving and industry specific courses. Both large and small projects are delivered by dedicated staff working in the open-access laboratories, which are also accessible to firms that are involved in the projects. Working with industry is not simply understood as a process in which scientific knowledge flows from the Centre to firms. Academics also learn from their collaboration with private sector companies. Knowledge is thus exchanged between the partners and, probably, new knowledge can be created through the partnerships, further enhancing the understanding of fundamental science. The Centre uses membership fees for the purpose of funding research into technology, which strengthens the sustainability of the collaboration.

While the Advanced Printing Group (APG) serves as a platform on which academics and businesses may build networks and partnerships, the WCPC annual technical conference is perceived by the Centre as a direct opportunity for delegates to view the latest research outcomes carried out by its academics. In 2011, for example, over 50 delegates from around Europe and the US attended the 7th annual conference. With a combination of these different forms of activities, WCPC is building efficient channels in favour of delivering its research outputs to the business community and improving soft infrastructure to encourage research collaboration.

Besides providing services to the industry, the Centre has also been involved in many research-oriented projects that could be either UK- or European-wide. A good example could be the Digital, Industrial, Packaging, Lean and Environmental (DIPLE), a £2.1m project partly funded by the ERDF since 2004. DIPLE was started as a response to the need for Welsh businesses to be at the forefront of innovation and to be involved with R&D in printing. The project aims to build a toolbox of solutions to common problems and challenges using case studies, and to show best practices to enhance the transfer of knowledge amongst businesses. Businesses from the printing sector in Wales were linked up by the DIPLE team to carry out case studies, and were assured of benefits from getting involved. In an independent review of the project, Virtual Marketing – an industry consultant company – considered DIPLE worthwhile and successful. The review reported a total of 118 collaborative research projects between the Centre and industry, as well as 169 instances of advice given on innovation and R&D, both of which exceeded the project targets.

7.2.2 Institute of Biological, Environmental and Rural Sciences (IBERS)

The foundation of IBERS in 2008 involved the merging of the Institutes of Rural Sciences and Biological Sciences at Aberystwyth University and the Institute of Grassland and Environmental Research (IGER), a BBSRC (Biotechnology and Biological Sciences Research Council) funded research institute with its focus on animal sciences, plant sciences and plant breeding. Currently, there are over 300 research, teaching and support staff in the Institute, conducting both basic and applied research in biology from the level of genes and other molecules to the impact of climate change on sustainable agriculture and land use.

The vision of IBERS is to be one of the top three land-based university departments in the world, with both fundamental and applied biological research forming an important part of this vision. The main aim of the Institute is to deal with some of the most urgent challenges facing the world, such as renewable energy, global food and water security and animal diseases. To tackle these practical problems, IBERS tries to combine research closely with enterprise, in such a way that scientific outputs can be widely implemented by businesses, thus the Institute can make a significant contribution to the changing needs of society both nationally and internationally.

The two main areas through which IBERS tends to build its strength are research and enterprise. On the one hand, IBERS carries out high quality, novel science in plant, animal and microbial sciences. On the other hand, partnerships with the private sector are considered to be crucial in ensuring that research by

IBERS remains responsive and relevant to industrial needs. Entrepreneurial scientists in the Institute, with access to world-class facilities, are dedicated to developing strategic alliances and links with industry.

Research at IBERS is organised into three core themes. Backed by 80 staff and 40 postgraduate students, the AMS (Animal and Microbial Sciences) theme mainly aims to explore the co-evolution of micro-organisms with their environment, enhance the quality of animal production systems and promote human health. The EI (Environmental Impact) theme seeks to provide practical solutions for the mitigation of climate change including the development of high-yielding dedicated energy crops. Researchers working on the third theme – Genome Diversity (GD) – study how the variety of forms of plants and animals is controlled, as well as the biology of the sea, freshwater and the land.

Enterprise activity is performed through a variety of channels at IBERS, such as Research and Strategic Funding, Capital Development Programme, Facilities and Commercialisation and Consultancy Services (CCS). Currently, the Research and Strategic Funding Team comprises five staff, dedicated to building and maintaining partnerships, developing collaborative R&D activity and securing funds for large, multi-partner, strategic projects. The team not only work within IBERS to promote internal dialogue, but also seek to build partnerships with other departments in the University, and with partners outside the University.

The economic and social impact of IBERS, on local, national and international scales, was examined by international consultants DTZ in a comprehensive report in 2009. In particular, it was considered that the activities of IBERS provided benefits to the economy through three channels: operating impact, final market impacts and wider qualitative benefits. In general, the report found that the impact IBERS generates for the Welsh and UK economies is worth billions of pounds for farmers and the environment. The total gross impact of the operation of IBERS is £59.2m of output, supporting 690 FTEs per annum in the UK (DTZ 2009). Whilst these highlights are only a small part of the work being done at IBERS, the DTZ report clearly demonstrates that scientific outputs could well serve society in various ways. One of the key factors, it seems, is the mind-sets that welcome the changing roles of scientific research in the economy and integrate the multiple missions of academics.

7.2.3 National Centre for Product Design and Development Research (PDR)

Established back in 1994, PDR is now a world-renowned design and innovation consultancy and research centre, hosted by Cardiff Metropolitan University. With the support of over 45 full-time staff from a wide range of industries and disciplines, the Centre aims to help both small and large companies around the world to discover, design and develop successful products and services. Over the last 18 years, PDR has provided businesses with the full range of design support, from original research, user insight and analysis to design, prototyping and New Product Introduction (NPI).

As the name suggests, product design has been at the core of PDR's operation for most of its history. Indeed, by encompassing a broad range of technologies and manufacturing processes, the Centre has created hundreds of successful products. PDR is capable of undertaking the full range of product design activities, ranging from conception through to successful market launch and beyond. In the last five years, PDR has helped their private sector partners win more than 16 major international design awards.

Analysis and engineering are also essential factors in making sure a product can move successfully from the concept stage to the marketplace. Typically, PDR can provide the following services: detailed tolerance analysis, engineering analysis, design verification and validation, finite element analysis and 3D scanning and reverse engineering. The Centre can also help in low volume agile manufacturing if required. The team aims to find a cost-effective, quality assured solution no matter what the scale of manufacturing production is. The Centre also has expertise in prototyping and manufacture, which include rapid prototyping, rapid manufacture, metal casting and tooling.

Companies across a broad range of sectors and technologies have got involved in knowledge exchange programmes with PDR, through which they have acquired new specialist knowledge and expertise that has underpinned their growth in both the short and long term. In particular, companies can benefit not only in financial terms but also from having a full-time, highly-skilled graduate based at their premises throughout the duration of the project to deliver the work. Involvement in knowledge exchange initiatives, such as the KTPs, has "*served the partners well*" and has also generated commercial incomes for the Centre, said Interviewee 4. "*We make profit, and we give the University money* *each year.*" The same respondent was satisfied with the performance of the Centre, and added that, "*So we are self-funded, in effect.*" Each year, about half the income of PDR is from research grants and knowledge transfer projects, while the rest is contributed by enterprise consulting services.

7.2.4 Leadership & Management Wales (LMW)

Leadership & Management Wales (LMW), formed in 2008, is the Centre for Excellence for leadership and management skills in Wales, and "*the only one in Europe that is funded by a government*", according to Interviewee 5. The Centre secures funding from both the Welsh Government and the ESF to support Welsh businesses in developing their leadership and management development skills. The main vision of LMW, as clearly stated on its website, is to create an environment where every business in Wales is aware of, understands, engages with and can benefit from leadership and management development (LMD). Furthermore, LMW seeks to achieve the vision through four aims: raising awareness of the benefits of LMD, explaining and promoting LMD in ways which are appropriate and meaningful to businesses of all sizes and in all sectors; positioning LMW as Wales' one-stop-shop for all LMD information and resources; providing evidence of the impact of LMD on individual businesses and the economy more widely; and making the LMD in Wales the best it can be.

The establishment of LMW came about, as recalled by Interviewee 5, "*as a result of the Welsh Government recognising that there was a need for a Centre for Excellence for leadership skills in Wales*". That need may have well expressed the

Government's concern that, according to the same respondent, "*There seems to be a lack of awareness amongst the general public about what leadership and management development were.*" When thinking about the origin of the Centre, Interviewee 6 referred to "*some research undertaken by the London School of Economics, which clearly highlighted the importance of leadership and management skills in economic development and economic performance*". That study, according to the same respondent, not only found correlations between those skills and economic performance but also induced Wales to "*produce its own piece of research called One Wales and set up some funding as well to support the businesses to get the skills*".

In 2008, the Welsh Government published a report entitled *Skills that Work for Wales*, which recognises that "skills and employment are the foundation of a successful life, and they are essential for a more prosperous and more equal Wales" (WAG 2008a, p. 2). It sets out the Welsh Government's strategy to fulfil the 'One Wales' ambition for a highly educated, highly skilled and high employment Wales (WAG 2008b). More relevantly, *Skills that Work for Wales* notices that improving leadership and management development is essential to achieving this ambition, which could serve as the founding concept of the Centre for Excellence in this area.

As a pan-Wales consortium, LMW draws together expertise from a variety of partners, including Cardiff Business School, Aberystwyth University, Glyndŵr University and Tattum Guest Associates Ltd, to benefit businesses of all sizes and sectors across the region. Three local offices operate within LMW and are based in each of the three higher education institutions, where members of staff mainly interface with local businesses. LMW also works closely with 12 training providers who provide leadership and management workshops and programmes to businesses.

Services provided by the Centre range from organising events and undertaking research to sending regular eNewsletters to businesses. Through the events, which are run and hosted by either the Centre or other organisations, businesses have the chance to get a better understanding of LMD activity. Although there are many ways in which businesses become aware of the events, Interviewee 5 indicated that, "*As many as 27 per cent of people turn up at our events because they have met one of the staff out there in the field.*"

LMW provides a range of free resources to companies, such as video, case studies, interviews, guides, course directory and fact sheets. A course directory enables companies to search for leadership and management development courses around Wales, either by location or by course. In addition, the Network Locator Tool is helpful in finding the right network for firms. The Centre also undertakes and co-ordinates research on various aspects of LMD to improve understanding of benefits and inform future policies. In 2012, LMW published a new research report – *Impact of Leadership and Management Development on Organisations* – and tried to identify the impact of well-trained leaders and managers within organisations. The research team undertook a total of 41 individual face-to-face interviews with key stakeholders of businesses in Wales, such as owner-managers and human resource directors. It was found that, LMD was generally viewed as positive, beneficial and strategically important to organisations (LMW 2012).

The main funding opportunity for Welsh businesses in the area of LMD is the Welsh Government's Enhancing Leadership and Management Skills (ELMS) programme, part-funded by the ESF. Led by the Department for Education and Skills (DfES), ELMS aims to deliver projects that contribute towards strategic leadership and management improvements in the Welsh economy. Funding in the ELMS programme is available in the form of the Wales Coaching Initiative and Sector Leadership Fund. The former initiative provides fully-funded training to train coaches and mentors, who will then go back to their organisation and pass on the coaching and mentoring knowledge. The Sector Leadership Fund seeks to deliver sector specific solutions where a specific need may be identified by providing funding to Sector Skills Councils.

In order to keep businesses informed of the latest news and developments in LMD, the team provide online news service and free eNewsletter. As Interviewee 5 explained, "*The team now send out newsletter to 3,500 businesses a month and has 4,500 businesses in the database."* It has also occurred to the Centre that extra work needs to be done to "*get our newsletter looking interesting enough for a business to open*". The same respondent shared that, "*We get about 25 per cent opened, which for a newsletter is really good."*

In December 2011, in the report *Two Years in Review 2009-2011*, LMW looked back on its development and summarised its progress since it was founded. Up to September 2011, a total of 10,661 recipients got eNewsletters from LMW, while the website attracted 35,493 visits. During the same period, LMW had hosted 24 events themselves: 6 in the first year and 18 in the second. For the third year alone (2011/12) a total of 27 events were planned for launch. LMW had also, in the two-year period, presented at 208 networking events, where they got the chance to promote the concept of LMD and build linkages with firms. Moreover, LMW met key business stakeholders 247 times to raise awareness of itself, and in consequence, of the importance of leadership and management skills to business development (LMW 2011).

7.2.5 Centre for Regeneration & Community Engagement (CRCE)

CRCE is an important arm of University of Wales, Newport (now merged into University of South Wales) in the fields of widening access and community engagement. It develops community engagements, research and knowledge exchange partnerships in promoting inclusion. Activities in which the Centre is involved represent the long and established relationship between the University and the community. In particular, the mission statements of the University state that it is an integral part of community life in and around Newport and aims to make important contributions to Newport and the surrounding areas. When asked about the major focus of the University on the knowledge exchange activity, Interviewee 7 answered that, "*I think it's fairly focused on community learning. It's about the community.*" The same respondent continued to explain that, "*I know that [University of Wales] Newport is a very sensible institution, because it's community based.*"

In collaboration with other units of the University, the Centre is also involved in community initiatives that intend to contribute to the regeneration of the Valleys area. UHOVI (Universities Heads of the Valleys Institute) is a newly established education initiative providing opportunities for local people and businesses to study nearby. By providing locally accessible learning opportunities, UHOVI seeks to improve skills and qualifications of people, and ultimately the quality of life for those living and working in the region. The Institute is able to offer a wide range of higher education courses, flexible in length and tailored to meet the needs of local business. Other projects the Centre is involved in include the BeWEHL Initiative (Bettering Wellbeing, Education, Health and Lifestyle) that looks at the impact of learning on the health and wellbeing of women in marginalised areas, and the First Campus Initiative that also encourages the importance of learning.

Activities in which the Centre is involved also show how community engagement is at the centre of the University. In partnership with Newport City Council, the Centre is working on the Communities First Evaluation Exercise. Communities First has been designed to tackle poverty in Wales' most deprived communities. Newport has been one of the areas receiving funding from the programme since 2002. On average, Newport has successfully drawn £2m every year from the programme, which covers ten geographic areas in Newport and one community of interest.

7.2.6 Fusion IP

Fusion IP was founded in 2002 and works in the field of university IP commercialisation. It aims to turn research into valuable businesses through the creation of a portfolio of companies in various fields, such as clean energy, electronics, engineering and medicine. In 2005, an exclusive 10-year agreement was signed with the University of Sheffield, to commercialise all its university-owned medical IP, which was then extended in July 2008, granting the company the right to commercialise all IP from the University. In 2007, the company signed a second exclusive 10-year agreement with Cardiff University to commercialise all of its IP. Fusion IP raised a Cardiff investment fund of £8.2m and owns the exclusive rights to establish new spin-out companies arising from Cardiff University-owned research, while the University became a major shareholder in the company. More recently, in April 2013, a Memorandum of Understanding (MOU) agreement was signed with another two universities: the University of Nottingham and Swansea University. In these new partnerships, the universities focus on innovation and the creation of IP, while Fusion IP undertakes commercialisation of those IP.

Fusion IP has designed its own three-stage funding model that combines its exclusive right to use the universities' IP with a flexible investment strategy. The first stage involves the selection of IP which is thought to have market success potential, with initial funding being invested. A senior management team are recruited in the second stage to develop and grow the business and, while in this stage, the team may attempt to raise third party funding as companies may go through some key steps requiring a larger amount of financial support. In the final stage, Fusion IP gradually reduces its involvement in the sponsored companies through trade sale or initial public offering (IPO), in order to support more newly founded spin-out companies. This demonstrates the balance of short, medium and long-term investment strategies of Fusion IP, ensuring that the model is sustainable and that investors can enjoy steady returns.

Currently, Fusion IP owns shareholdings in over 20 portfolio companies across a range of industry sectors. In particular, there are now 13 companies in the medicine sector, making it the area where Fusion IP owns most spin-outs. The energy and environment sectors have five portfolio companies each, with four companies operating in the engineering sector and three companies in the electric sector. The first major exit for Fusion IP was announced in 2012. One of its portfolio companies – Simcyp – was sold to an American company Certara LP for £32m, making a 200-fold return on its original investment. By January 2013, it was reported that the company had cash of approximately £4m, which will keep the company's portfolio companies well-funded. In addition, Fusion IP has conditionally raised £20m through an issue of 36,363,637 ordinary shares to existing and new institutional shareholders. It is believed that this arrangement will provide the company with the funding to both continue to invest in existing portfolio companies and invest in new portfolio companies.

Nevertheless, Fusion IP is not alone in the process of knowledge commercialisation; it is also in close collaboration with each university's existing technology transfer team. In the case of Cardiff University, Fusion IP has set up a team, based on Newport Road (in Cardiff), working closely with the University's Research and Commercial Division (RACDV) to assess business opportunities. In particular, there are two managers from Fusion IP who work alongside staff from the RACDV. Researchers are also important in the whole process as they are responsible for inventing advanced technologies in the first place. In order to motivate academics to commercialise their research outputs, Fusion IP has agreed with the University that academic founders will receive 40 per cent of the equity in new businesses at inception.

7.2.7 University of Glamorgan's incubator (GTi)

The University of Glamorgan (now merged into the University of South Wales) set up the Graduate Teleworking initiative (GTi) back to 2001 to support entrepreneurial graduates. It came from the consideration that, as Interviewee 10 said, "*We had entrepreneurial graduates with great projects that have commercial viability, but there was nowhere for them to start a business.*" The difficulties students faced when they thought about starting a business were well understood, and the focus of GTi was on removing the barriers. The same interviewee said that, "*For a student starting a business, it was extremely difficult, because they did not have money, they had debt. And they had student accommodation, so where would the post go, and all of these things.*" In GTi, graduates were provided with "shared office facilities (24/7 hot-desking), access to high-speed internet connection and business level information and communication technology (ICT) and software, comparatively much more costly 10 years ago than now" (Voisey et al. 2011, p. 7).

In the beginning, there was an 18-month pilot, which ran successfully and, to a certain extent, enabled the team to be granted "*a three-year Objective One ERDF grant*" and to "*expand the teleworking initiative into an incubator centre*", as Interviewee 10 explained. Under the regulations of the European funding, the team had to "*embrace all entrepreneurs in all Objective One areas, which were West Wales and the Valleys areas in Wales*". Therefore, GTi evolved from a graduate-focused teleworking project to a business incubator that considered applications from non-graduate entrepreneurs as well. Success was achieved in the first three-year period that ended in 2005. That success has certainly helped the team to secure a second round of EU ERDF funding, during which more needs from businesses emerged. In particular, as the same respondent explained, "*Then we had businesses that were outgrowing the hot-desking model…so we created what was called warm-desking, which was a dedicated desk. It was your desk, but still in the shared environment.*"

An interesting observation has been that GTi follows a model that is unlike many other business incubators. Voisey et al. (2011, p. 7) have described that, "The key features [of GTi] were a no-cost option to register; a 'screen-in' rather than 'screen-out' selection policy." The definition of pre-incubation, argued by Interviewee 10, "*says it's time limited, you have a screening process, it's very specific and all of that*". Rents paid from businesses in an incubator normally enable the incubator to continue. For this kind of incubator, the same respondent continued that, *"That is true of incubators that take in people that form their businesses, they are just very small businesses, and while you have a building, and the businesses are going to pay you, it may be a subsidised rate, but* *they are going to pay you rent. Your screening process has to be on the basis of who is most like to be able to pay you the rent, because if an incubator cannot pay its rent, it ceases to exist, because it's a business like any other, which is why most of them are publicly funded."* In comparison, what makes GTi special is that all the entrepreneurs that start their businesses there are not required to pay any initial costs, which may help them focus on their entrepreneurial ideas and creativity. Interviewee 10 explained that, *"We are saying to students and graduates, give it a try, have a go, if you've got a skill, and you'd like to try, try it. There is no way that they were going to pay for that. So we are entirely different, GTi has always been a very different animal from the normal business incubator, which has got a building with so many small businesses in, but they can offer to very small companies, as long as they get a minimum amount of rent."*

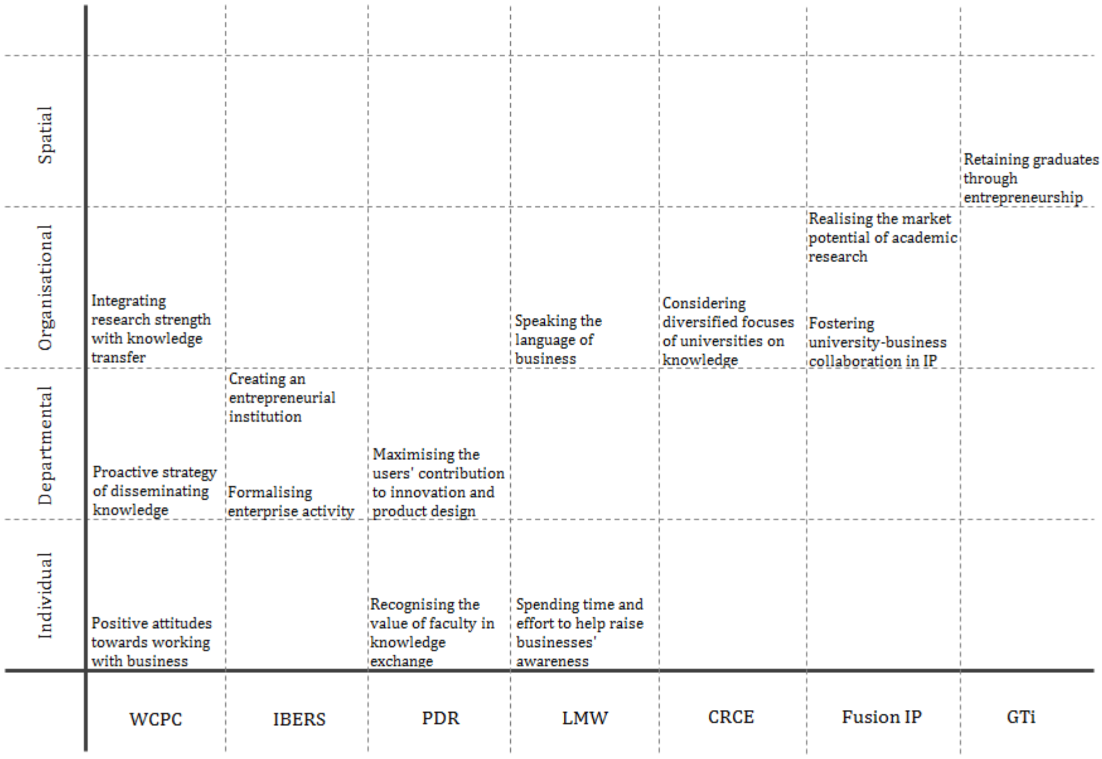
Although GTi was only founded a decade ago, the interviewee suggested that enterprise education has a long history at the University. "*Enterprise education is built into everything*," stated by Interviewee 10, "*Glamorgan is very strong doing that, because we are a practical university*." This may suggest a need for historical examination of the mission statements of a university, if one aims to interpret the special focus of that institution on certain types of knowledge exchange activities. Since the foundation of the GTi incubator in 2001, by July 2011, 360 new businesses ideas had been registered for support. Of those, 52 businesses have left the incubator and are still trading. Currently, there are 54 businesses in pre- and early-start mode in the GTi incubator.

In a longitudinal study of 10 years of the GTi incubator, Voisey et al. (2011) collected data from a total of 26 graduated businesses that were still trading in Spring/Summer 2011. The 26 businesses were established between 2002 and 2010, and operate across a wide range of industrial sectors. In terms of cumulative turnover, the investigated firms have contributed over £25m, while the largest firm has generated £7.5m after it was founded in 2002. The research of Voisey et al. (2011, p. 15) summarises the value of GTi by saying, "Research…demonstrates that a pilot project started in 1999, supported by a period of EU funding and maintained by the University, has had a significant impact upon the survival and growth of over 50 new businesses, and more than 200 jobs in the South Wales region." These achievements may not mean that much in a competitive region like the Silicon Valley. However, for an area like the Valleys in Wales, where the industry base has been declining over the last few decades, what GTi has accomplished means a lot, not only for the businesses in the incubator but also for the local community.

7.3 Analysis

Combining the four-level framework (as shown in Figure 7.1) with the interview data, the key factors which underlie the success of the examples examined in this chapter are outlined in Figure 7.2 below, with each factor being placed in one of the four levels, namely individual, departmental, organisational and spatial. As addressed in the literature review, it is necessary to consider a combination of factors at different levels when attempting to understand the outcome of programmes. What is clearly shown in Figure 7.2 is that the performance of each initiative is more likely to be found as a result of a combination of factors. Within the same region, there is still much complexity existing in how universities participate in knowledge exchange programmes.

Figure 7.2 Mapping out the factors in the four-level framework



Source: Author's own elaboration.

7.3.1 Individual level factors

Positive attitudes towards working with business (WCPC)

The Centre (WCPC) seems to have been founded from the very beginning to meet the needs of industry. In other words, positive attitudes of staff in the Centre towards working with business help remove barriers that might hinder the establishment of partnerships. This is important as, although the university sector is, in general, becoming more entrepreneurial by integrating economic development as an additional function (Etzkowitz 1998; Etzkowitz and Leydesdorff 2000), and UK universities are said to have a “civic duty to engage with wider society on the local, national and global scales” (Goddard 2009, p. 4), not all academics are able to adapt to this in the same way.

In an examination of factors that influence the variety and frequency of interactions between UK academics and businesses, D’Este and Patel (2007) found that individual characteristics of researchers have a stronger impact than the characteristics of their departments or universities. The past behaviour of an individual researcher in participation in knowledge exchange is positively related to continuing knowledge exchange practices (Bercovitz and Feldman 2003). In addition, scientists’ personal values and their beliefs about the benefit of knowledge exchange are also thought to influence their entrepreneurial behaviour (Renault 2006; Krabel and Mueller 2009).

One respondent, who has been closely involved in the foundation of the Centre, confirmed the importance of industry-facing to the organisation, and stated that,

> *If I look at my own research background, I would say that more than 90 per cent of my work has been industry-facing.* [Interviewee 1]

The willingness of the early founders to work with businesses seems to have played a key role in shaping the focus of the Centre, which in later years intends to recruit employees who share the same conception.

Recognising the value of faculty in knowledge exchange (PDR)

The culture of the Centre, in the view of Interviewee 4, has always been more industry-facing than academic-facing. With regards to the staff, the same interviewee felt,

> *They want that when people arrive, they feel like they are coming into a working business environment, rather than an academic environment.* [Interviewee 4]

Cultural differences between the academic community and business world have been extensively addressed in the literature. It is a proactive strategy that the Centre has undertaken in order to promote collaborative relationships with industry partners, who might find pure academic research distant. The industry-facing culture of PDR, which might be related to its "*less-academic*" feature, has precisely been encouraging its staff to work with industry. In the words of the respondent,

> *Our employees and staff have got experience and can communicate well with industry, and have a culture of working with industry, for industry, rather than for academia.* [Interviewee 4]

The respondent continued,

> *That's what we have found successfully responding to the needs of industry.* [Interviewee 4]

More interestingly, it appears that a mixture of academic and business backgrounds is an advantage for the staff working in PDR, partly due to its industry-facing culture. In particular, people who come from the design industry will be highly valued, as suggested by the respondent that,

> *They have got practical experience working in the industry, working as designers, and they are good in knowledge transfer.* [Interviewee 4]

This finding responds well to a long-debated topic in the literature, as well as in practice, about how the evaluation system of the higher education sector considers the value of engaging with industry partners (Jacobson et al. 2004; Siegel et al. 2004). For the majority of universities, practical experiences in collaborating with the business sector are not valued as equal to academic research outputs. This may pose a fundamental challenge to the success of knowledge exchange activities because it is hard to anticipate that most academics would actively engage in them unless they are encouraged to do so.

Spending time and effort to help raise businesses' awareness (LMW)

Immense efforts have been made by LMW, firstly to make businesses aware of their events, and secondly to get them to come to those events. For some staff, their principal objective is to meet as many businesses as possible, during which process they exchange business cards and add those firms to the company database for sending e-newsletters to. It was, for example, stated by one interviewee that,

> *I talk to businesses by attending a number of business network meetings*. [Interviewee 6]

> *I probably go to, some weeks I can go to six of those, some weeks maybe just three.* [Interviewee 6]

This may be the best way to get the attention of businesses, especially those micro ones whose focus tends to be on daily survival, rather than leadership and management. The efforts become even more necessary when considering that most participants in the events work in a small and medium-sized enterprise. Whilst those events organised by LMW do not target any specific type of firm, their statistics show that 54 per cent of the businesses who come to the events have less than 10 employees, indicating that micro-businesses are the majority of attendees. It was also suggested by the same interviewee that,

> *Many of them [micro businesses] see the events as perhaps the only network opportunity they can get. Larger firms may have built their own,*

more mature, networks where they can access the needed information. [Interviewee 6]

In comparison to large firms, SMEs may have limited financial resources, and even motivations, in searching for knowledge sources. Therefore, it is likely that smaller firms are not quite aware of the knowledge that universities could provide, given the missing links between them. To some extent, the efforts from the university side in reaching out to SMEs will bridge the existing gap between the two, although those efforts do come as a cost to the source of knowledge (Hansen 1999; Reagans and McEvily 2003). LMW has done this by providing dedicated staff to attend to the needs of the industry.

7.3.2 Departmental level factors

Proactive strategy of disseminating knowledge and technology (WCPC)

The Centre has adopted a proactive strategy with the aim of disseminating its knowledge and technology to the industrial community. For many universities and research institutions, one approach often taken to manage the intellectual property rights arising from academic research activities has been the establishment of university technology transfer offices (TTOs). TTOs function as technology intermediaries and transmit technological innovations from laboratories to industry. Despite the different organisational forms that TTOs might have, the process of technology transfer normally runs as follows: staff or students disclose their inventions to the office, then the office and inventors discuss the possibility of patenting, and after that the office will try to license the patent to interested companies or sell the patent (Bercovitz et al. 2001; Markman et al. 2005; Anderson et al. 2007).

The main difference between WCPC and most university TTOs in knowledge transfer lies in the fact that WCPC actively creates opportunities, such as the annual technical conferences, for potential collaborations with businesses, while in the case of most TTOs, businesses are expected to make the first move by showing interest in the technologies that TTOs could provide.

Indeed, for WCPC, collaboration relationships with businesses may begin with a company attending their (annual technical) conference, where it finds the opportunity for proposing a project with the Centre. The main aim of the technical conferences, recalled by one respondent, is to

> *Make people aware of what we are doing essentially, and sometimes they [companies] will say, that's very interesting, so they come to talk to us.* [Interviewee 2]

This approach to knowledge transfer is more active, going beyond the commonly responsive pattern of the process, and shows that efforts from both the academic supply side and business demand side are required to make sure the university-business interactions are effective and successful.

Creating an entrepreneurial institution (IBERS)

The merger of a number of organisations to form IBERS itself could probably be seen as an attempt to create an institute that embraces various types of missions that it could serve, as one respondent recalled,

> *So there is teaching, there is research, and there are enterprise activities.* [Interviewee 3]

Therefore, a key challenge for the managing team is to be able to balance the different emphases of the tasks. The same respondent said,

> *University [is] very much teaching focused, and IGER [is] very much research focused. You know, you've got cultural differences there, so there needs to be integration.* [Interviewee 3]

This is an interesting finding as it extends the conventional wisdom of cultural differences, from between academics and the business community (Siegel et al. 2004; Abreu et al. 2008), to between different groups of researchers within the same institution. Many intermediary organisations have been founded to support effective dialogues among the research groups and different levels of management teams. It should be unsurprising that to fully integrate various organisations, which used to have different focuses and objectives, into one dynamic institute is not an easy task. Indeed, as commented by Interviewee 3, the integration has been "*quite a large task*" and it is "*still a work in progress*".

Previous studies have examined how the implementation of entrepreneurial modes occurs in an institution, assuming that the institution is attempting to move itself to an entrepreneurial mode (OECD 2001). The following two dimensions are mostly relevant to the process: the degree of importance of entrepreneurialism and the degree of systematisation. The former element relates to the nature and rate of expansion of entrepreneurial activity from marginal to extensive, while the latter element refers to a situation when "entrepreneurial activities are increasingly set within an explicit policy frame with carefully designed processes and support mechanisms" (OECD 2001, p. 30).

Formalising enterprise activity (IBERS)

Whilst acknowledging that "*the enterprise activities have been existing [in IBERS] for a long time*", Interviewee 3, who was appointed to work with businesses, asked the question, "*What does enterprise mean?*" The same respondent continued, "*For me, it means enterprise and innovation are closely related.*" This more or less reveals the core concept of the institute, that it has always been putting the use of research in the real world as a priority. More importantly, the concept has been further reinforced recently, with the introduction of, for example, the Research and Strategic Funding Team. Interviewee 3 said that, "*My role has been more formalised*." What could be seen in IBERS is a parallel process containing both the reinforcement and the formalisation of enterprise activity. By formalising enterprise activity, resources such as funding and human capital will be more effectively invested into transferring knowledge, which will then improve the efficiency of university-business interactions.

Maximising the users' contributions to innovation and product design (PDR)

Interviewee 4 gave an example of how the UCD (User Centric Design) lab works, which clearly shows that the Centre views clients/users as "*co-producers*" of the design and production process. PDR has successfully included users in the services it provides to companies, creating interactive dialogues among the partners, as well as making room for communication in which all parties build their trust. The literature has more fully recognised the important role of users as developers of new products, while meeting the needs of users has always been the goal of product development (von Hippel 1976; Voss 1985). That role has been investigated through case studies across several industry sectors, such as medical equipment (Shaw 1985; Lettl et al. 2006), applications software (Voss 1985), pharmaceuticals (Smits and Boon 2008), and scientific instruments (von Hippel 1976).

Smits and Boon (2008) have argued that the organisation of innovation in the pharmaceutical industry has shifted from the linear model to a systemic approach, driven by rising costs, new scientific development and more demanding users. The linear model, as the authors discovered, could not respond to those challenges as it generally fails to integrate users' feedback into product development. In comparison, the systemic approach, which puts users at the centre of the innovation process, is well-equipped to cope with the needs of users (Bogers et al. 2010). In addition, good communications are also factors that will have strong impacts on the contributions of users to innovation and product design and development process (Shaw 1985).

7.3.3 Organisational level factors

Integrating research strength with knowledge transfer (WCPC)

While the Centre has been branded as being an industry-facing organisation – which is important for its achievement – it is the combination of advanced research and effective application of scientific outputs that underpins its success. The research strength of an institution has often been acclaimed to be an important factor explaining the existence of considerable differences in the capabilities of universities to transfer their knowledge, and then, to make profit from that activity (Di Gregorio and Shane 2003; Thursby and Thursby 2003; Perkmann and Walsh 2007; Hewitt-Dundas 2012; Huggins et al. 2012). The study by Di Gregorio and Shane (2003), for example, shows that although spin-out activity is increasing worldwide, there are substantial variations at the institutional level, with the more research-intensive universities being more likely to create spin-outs. The knowledge creation capability of an institution is, to some extent, a determining factor of research outputs (Huggins et al. 2012), which decide the potential of knowledge exchange (Lee et al. 2001).

When talking about the relationship between scientific research and industry service, it was commented that,

> *You can argue the pros and cons in terms of whether, you know, it is going to produce highly rated publications. But I certainly think we are going to need publication work in the impact factor journals these days, as well as*

turning around and keeping the industry partners happy as well. [Interviewee 1]

The importance of integrating research strength with knowledge exchange is clearly recognised by the team, as they consider fundamental science to be the 'bed-rock' of the Centre. Dedication to the development of world-leading science is a means for WCPC to keep attracting private sector partners and to build long-term partnerships with companies in the sector around the world.

Speaking the language of business (LMW)

A core concept of the programme seems to be speaking the language of business, i.e. the concepts are explained in a way which sounds more relevant to the businesses, rather than using too academic terms. One respondent gave a good example that,

We do not say leadership, we say running your business. When we say leadership, they would say no, they do not need leadership, when we talk about, not leadership, but running your business, and then they say, oh yeah, that's something to do with us. [Interviewee 5]

The same respondent pointed out that,

Very few higher education institutions speak the language of business, and even fewer speak the language of micro businesses. [Interviewee 5]

LMW has even started a process of designing training sessions by businesses. It was said by Interviewee 5 that a small cohort of eight to ten micro-businesses, were selected for the pilot study. Businesses would be asked to select six out of twelve headings that might be covered by the training sessions, and those six headings were then incorporated into the course design. This move well represents the approach proposed by the strategy and action plan – *Skills that Work for Wales* – that skills and business support services should be more demand responsive.

Considering diversified focuses of universities on knowledge exchange (CRCE)

The particular attention that the Centre, in line with the University, pays to community learning suggests that one should be cautious when trying to compare the performance of knowledge exchange activities between universities, as one respondent said that,

> *Different universities [may] do different kinds of employer engagements*. [Interviewee 7]

> *It [the University] would never have high-level employer engagements like Cambridge [University] or Oxford [University] would have, but it still has a very solid relationship with its surrounding employers.* [Interviewee 7]

Responding to the needs of the surrounding employers, public or private, in addition to its own history and tradition, could play an important role in the knowledge exchange activities undertaken by an institution (Hewitt-Dundas 2012). It could be argued that, in the case of University of Wales, Newport, the combination of these two factors has largely defined the relationship between the institution and its surrounding area. Regeneration is an important task for Newport and the Valleys, where face problems of unemployment and lack of skilled workforce. One respondent finally stressed that,

> *It [the University] is crucial to regeneration because the businesses operating in the specific community have needs of skills.* [Interviewee 7]

Realising the market potential of academic research (Fusion IP)

The concept of Fusion IP – commercialising university IP – becoming successful could be in part attributed to the great market potential that UK academic research shows, which arguably has still not fully been realised. The ineffectiveness of the translation of science into business innovation has historically been a problem in the UK; rather than having a leading place in international academic science output, the interaction between university and industry in the UK has been disappointing (Lambert 2003; OECD 2008). The gap in university commercialisation activities between the UK and US has been highlighted in a series of HE-BCI surveys, with American universities showing better performance.

One respondent shared the view that UK has been really good at scientific research and mentioned that,

> *There is a report from a Japanese think-tank that looked back over the last 30 years and it looked at the best 100 ideas that had been created over that 30 years and found that 40 out of 100 came from Britain*. [Interviewee 8]

The same respondent was concerned about what happens to these great ideas, especially when they are introduced into the market, and commented that,

> *We are outstanding at this, what we haven't always been so good at is making benefit out of it*. [Interviewee 8]

Unsurprisingly, a good proportion of those ideas may have come out of UK universities, given their important role in research and innovation in the country. This view was shared by another respondent, who said,

> *We felt that university is the powerhouse of IP*. [Interviewee 9]

It suggests that there does exist a big chance of market success if those ideas from the university marketplace are transformed into products and services properly and effectively. At least for Fusion IP and Cardiff University, there seems to be some mutual understanding of this idea, which has inspired the company and the University to start dialogues and build partnerships.

Fostering university-business collaboration in IP (Fusion IP)

Universities are inclined to establish their own technology transfer offices to take care of patenting, licensing and spin-out activity. There are many factors however constraining the performance of university TTOs, such as limited capacity and bureaucratic parent organisations (Wolson 2007; Rasmussen 2008). One respondent recalled that,

> *It was, like all universities, slightly struggling with the process of spinning out companies. They are very good at, actually, creating ideas, and pretty good at identifying what might be interesting… Where they struggle a bit more, not surprisingly because it's not a university's core skill, was in building companies, recruiting management teams, getting venture capital investments, floating companies*. [Interviewee 8]

Those areas where universities lack experience are exactly where the strength of the company lies, as considered by the same interviewee that,

> *We've all been in business many years together, doing technology stuff of companies*. [Interviewee 8]

To marry the expertise of academics in inventing novel products and the skill of the Fusion IP in business management is more likely to lead to a win-win situation, compared to universities and academics working alone. Finance is another area where the company could help with the TTOs.

7.3.4 Spatial level factors

Retaining graduates through entrepreneurship (GTi)

The meaning of this programme, to the University and to the local community, can be better understood when examining the region from a historical perspective. One respondent remembered that,

> *At the time, in this area, because it is what we call the Valleys areas, it's poor. Coal mining industry disappeared in the mid-80s. by the late 90s, things were desperate. There were more businesses going out of businesses in this local authority area than start-ups*. [Interviewee 10]

The University of Glamorgan, the only higher education provider in the area, understandably, must have been seen as the engine of talents to the local community and economic development. However, this mission could only be achieved if graduates chose to stay in the area after education, which was probably not common. Students were not very likely to remain there after they completed their studies and there might be practical reasons to explain this (Hatton and Williamson 2005; Bang and Mitra 2011). One respondent concerned about the situation said,

> *So we were creating all of this talent in Glamorgan, and as soon as the graduates finished, they moved to Cardiff, or Bristol or London*. [Interviewee 10]

7.3.5 Synthesis of factors

With the use of the four-level framework, this chapter has identified a wide range of factors which underlie the performance of the seven case studies. In particular, those factors are found to span widely across the four levels: individual, departmental, organisational, and spatial. The identification of the factors has been a result of both analysing the interview data and connecting with the literature review. While many factors have already been identified in the extant literature, this chapter has also revealed a few factors through the case studies. The four-level framework, which has been derived from the literature review, has been found to be useful in investigating the performance of knowledge exchange initiatives, which are often operated in a complex structure and involved with various types of stakeholders. Overall, the results tend to show the problematic nature of regions in that the story of university-business interaction is rather different from one programme to another even within the same region.

The case studies of WCPC, PDR and LMW have all shown how individual level factors determine the success of programmes. For example, positive attitudes of staff towards facing industry could help remove barriers which might hinder the establishment of partnerships. Among others, the past behaviour of an individual researcher in working with industry is found to impact on one's personal values and beliefs about the benefit of knowledge exchange. By spending time and effort to help raise businesses' awareness, LMW is able to reach out to small businesses that would not have got in touch otherwise.

As shown in the case studies of IBERS and PDR, the success of knowledge exchange is also influenced by factors at departmental level. IBERS has both formalised and reinforced enterprise activity in the institution, which may be helpful to resource investment and institution management. On the one hand, the process of formalisation may lead to a clearer job description of anyone involved in knowledge transfer; on the other hand it also makes it easier to manage. Furthermore, as already argued, by formalising the enterprise activity, both finance and human resources can be invested more effectively.

At an organisational level, the success of knowledge exchange of an institution is likely to be found to be related to its research capacity, as shown in the case studies of WCPC and Fusion IP. Staff at WCPC, for example, consider fundamental science to be the 'bed-rock' of the Centre and see the development of world-leading science as a way for the institution to keep attracting private sector partners and to transfer advanced knowledge. Nevertheless, the case of CRCE shows that the history and mission statements of institutions shape their relationship with business and the community.

In addition, how an institution contributes to its locale should be understood by considering the regional context within which it is situated, such as regional industry profiles and economic development level, which is clearly shown in the case study of GTi. It has been found that GTi, by supporting student and graduate entrepreneurs to develop viable businesses, is able to keep wealth-creating talent in the Valleys. The contribution of GTi is significant when considering the many difficulties facing the local economy over the past decades.

7.4 Conclusions

In this chapter, an investigation of seven examples of engagement has sought to reveal the history behind those programmes. The approach of case study has been helpful in extending the wisdom of knowledge networks from pure benchmarking to more comprehensive and qualitative analysis. In particular, the seven cases have been selected from a total of six universities, in the hope of strengthening both the depth and width of the arguments. The analysis of university initiatives revealed the crucial factors underlying the performance of each case study at four levels, further highlighting the complexity of the knowledge exchange process. The analysis showed that, although the success of some cases could be attributed to factors at the same level, those factors still differ between the cases. While the case study approach generated detailed information for specific situations, it does not allow robust scaling up of the results to the national level for broader policy decisions. The approach for national scale assessments in the previous chapters, however, lacks the detail needed for local implementation. By undertaking both approaches, this study intends to show the complexity of the issue examined and to call for a middle way between these two extremes. Nevertheless, where to draw the boundary between generality and speciality depends upon the aims of the given study.

SECTION III

CONCLUSIONS

CHAPTER 8

CONCLUSIONS

The key research question this thesis seeks to answer is: What are the associations between university knowledge networks and regional competitiveness in the UK? In the investigation, the researcher has attempted to use both quantitative and qualitative methods, to connect the supply and demand sides of knowledge, and to reflect the diversity of universities, businesses, and regions. Focusing on factors that are notable in the innovation, entrepreneurship and economic geography literature, this thesis has further explored possible explanations for variation in the levels of university-industry knowledge exchange across the UK regions. The results have generally argued that there is not a one-size-fits-all answer to the research question, which would have implications for both the literature and policy debates. A main finding is that university-industry networks are associated, in a complex way, with the competitiveness of the region where academics and firms are located. The thesis has made a case for including characteristics of universities, firms, and regions more prominently in a comprehensive analysis framework, as these variables have been found to be closely connected with the knowledge exchange process. This chapter firstly synthesises the findings of the policy context chapter and empirical chapters, then considers the contribution of the research to academic debates and policy development, and lastly concludes by providing reflections on the limitations of the study and future research areas.

8.1 Redefining the value of knowledge exchange

8.1.1 From the firm's perspective

In the UK, it has been found that firms in general do not perceive university knowledge as an important source for innovation (Cosh and Hughes 2010). UK businesses are much more likely to consider customers and suppliers as highly important sources for knowledge (Roessner 1993). There have seen discussions about the different characteristics of academic knowledge and industrial R&D which lead to their mismatch (Hall et al. 2001). It remains unclear, however, what is the knowledge proximity between the two and to what extent that impacts on the use of university knowledge by firms. When firms source too much strongly related knowledge, there is a risk of that knowledge being redundant and locked-in as it lacks variety and diversity, which elements university knowledge could provide (Lorentzen 2008). Although it might be true that how firms perceive the importance of academic knowledge would determine whether or not they will source it, one should not assert that academic knowledge is unimportant altogether as it has not been perceived as highly important by UK businesses in general. Indeed, little has been said of the role of academic knowledge by those firms who actually use it to produce better products, design improved processes, and innovate the existing services. Furthermore, firms might source knowledge less intensively from universities than from their industrial partners, but it is important for firms to do so, as argued by the theory of related variety (Boschma 2014). It is therefore not a sound idea to divert the basic attribute of university research to commercial ends, because the two types of knowledge will inevitably become homogenised and 'too close' to each other (Washburn 2008).

When firms do interact with universities, there are complex relationships between the intensity of interactions and factors such as size and location. In the UK, large firms are more intensively involved with universities than SMEs, which could possibly be attributed to the fact that larger firms tend to be more resourceful (Gertler and Levitte 2005). There is no explanation, however, of whether small firms have practical difficulties in networking with universities (Bennett 1998; Link and Scott 2003). Nevertheless, it has been found that SMEs located within a relatively uncompetitive region face more difficulties when engaging with universities than those in competitive regions. One possible answer to that is the existence of localised learning networks in advanced regions, with SMEs benefiting from collective learning from the stakeholders (Rutten and Boekema 2007). In comparison, the capability of large firms to engage with universities seems not to be constrained by their geographical locations. Empirical analysis has also found that large firms are more closely involved with distant universities than with proximate ones, which is in line with the literature suggesting a positive relationship between the size of the company and the probability of it tapping into global networks of knowledge (Huggins et al. 2010a). While large firms search worldwide for the best knowledge, they may serve as key nodes of networks through which that knowledge flows into regional firms (Bathelt et al. 2004). In order for regional firms to benefit, policy makers need to embed multinationals in their region within clusters and networks of economic activity (Phelps et al. 2003). By establishing a dense network of firms and institutions, uncompetitive regions will not only overcome ‘organisational thinness’, but also make the best use of academic knowledge ‘flown in’ through embedded multinationals.

8.1.2 From the university’s perspective

University knowledge networks, i.e. the supply side of knowledge, have been examined from two different perspectives, with one being the intensity and the other being the performance. The analysis broadens the focus of previous studies which examine the antecedents of academic engagement by considering the influence of spatial level factors (Owen-Smith and Powell 2001; Link et al. 2007; Boardman and Ponomariov 2009). A paradox of knowledge network intensity and performance emerges from the case of the UK: academics in uncompetitive regions are more actively engaged in knowledge exchange activities, but universities in competitive regions generate higher income from these activities. Whilst there lacks evidence to argue that the burden being placed on academics to source external incomes in lagging regions is too heavy, it is clear that they show relatively lower income-generating capacity (Huggins et al. 2008b). The term ‘income generating capacity’ is useful in explaining the performance difference between universities in the two regional groups. However more investigation is required to understand what the term is made up of and how the term is determined. In general, academics in the UK are less closely involved with private sector firms; rather, they are more inclined to work with public and third sector organisations (Abreu et al. 2009). While universities in uncompetitive regions are heavily reliant on public sector organisations for third mission incomes, universities in competitive regions show a diverse income portfolio, with both private sector firms and public sector organisations being important funding sources. Universities in the UK are therefore not at the same level of resilience when now facing budget cuts, as those institutions which are dependent on government funding will encounter more difficulties than ones with more diverse income sources.

There is a clear divergence in the locational features of university knowledge networks shown by academics in the two regional groups. In uncompetitive regions academics are more intensively involved in regionally-based activities, while in competitive regions academics show a higher level of engagement in internationally-based activities. Whilst there is a mix of local and global networks in both types of regions, it is the global ones that are positively associated with regional competitiveness, lending support to the arguments that challenge the importance of proximate networks (Ratti et al. 1997; Andersson and Karlsson 2007; Huggins and Izushi 2007). Once focused on the role of geographically bounded networks, the focus of case studies of regions now needs to be shifted again, recognising the role of distant networks (Saxenian 1994; Storper 1997; Huggins and Izushi 2007). Unfortunately, the empirical evidence could not answer the question of why the difference exists between the two regional groups. From the literature review, there appears to be an explanation for the popularity of regional academic networks in lagging regions. Given the imbalance in science and technology in favour of the higher education sector in catch-up regions, universities are considered by policy makers in those places as anchor tenants, with a significant amount of resources allocated to the sector (Landabaso and Reid 1999; Siegel et al. 2007). Clearly, it is important for universities in weaker regions to receive government support to compete against their counterparts from advanced areas. Nevertheless, government subsidies may have both good and bad effects on academics, as intensive support from regional authorities might discourage academics from searching for external funds, in particular those from outside the region (Goldfarb and Henrekson 2003).

In addition to measuring the intensity of academic knowledge networks – an element receiving less attention from the literature – this research also informs the understanding of entrepreneurial performance of universities through a longitudinal analysis. On the one hand, it confirms what previous studies have found of the positive association between research quality and entrepreneurial performance (Lawton Smith 2003 Lockett et al. 2003). On the other hand, it reveals what is termed as the 'Matthew Effect', whereby new universities in lagging areas fall further behind their counterparts in competitive places in generating incomes from entrepreneurial activities (Merton 1968). A possible policy intervention may be needed in order to address this issue, especially given that there has been much debate over the importance of regional policy (Cooke 2013). More prosaically, the complexity of the UK higher education sector, which has been largely absent in the innovation policy agenda, deserves more attention from policy makers. Results from the analysis show that both established and new universities are of importance to regional economic development, albeit in different areas and in different ways (MacKenzie and Zhang 2014). Consequently, recognition of the different roles they play within their regional situation and the third mission activities they are most concentrated in would help them improve their engagement levels. Specially tailored policies are thus required to maximise the potential of universities to contribute to economic development in their various locations that recognise the differences within the broad range of institutions that comprise the sector and thus enable them, irrespective of their age, to contribute more effectively in knowledge exchange activities (Jones-Evans et al. 1999).

There is no doubt that knowledge networks are multifaceted and associated with factors at various levels (Landry et al. 2006; D'Este and Patel 2007). While national empirical studies focus on the regional patterns of knowledge exchange, the seven case studies of university initiatives in one UK region are presented in order to figure out how factors at individual, departmental, organisational and spatial levels underlie the performance of each programme. The analysis in the case study chapter connects with and serves to expand upon the core arguments in a couple of ways. First, it follows the same categorisation of knowledge exchange activities in the previous chapters but examines the examples within the same region in great detail. Acknowledging the potential limitation of a crude divide between competitive and uncompetitive regions, the focus of the case study chapter is on revealing intra-regional differences. Second, it examines the factors at various levels which are identified in the literature review but are not examined in the previous chapters. Therefore, a comprehensive picture is drawn when one combines the results of quantitative and qualitative chapters which, however, further highlight the complex nature of university knowledge networks.

Admittedly, the analysis of case studies is only supported by a small number of interviews with academics, thus it does not take on the viewpoints of other stakeholders such as industry and government. For instance, as cultural differences between the academic community and the business world have been addressed by many academic interviewees as a major barrier to effective collaboration, it would be helpful to gather perspectives from firms on the same issue. It was, however, intended that the case studies were undertaken not to create generalisability but transferability of findings (Mazlish 1998; Yin 2009). In the case of universities in Wales, they were found to be inclined to put their focus on specific types of knowledge exchange, which might be attributed to the history and their mission statements that shape, to a certain extent at least, their relationship with business and the community (Kitagawa and Lightowler 2013). This corresponds to the argument made in the literature that university knowledge networks may be best examined on an institution-by-institution basis (Abreu et al. 2008; Kitson et al. 2009). The most pertinent level to examine knowledge networks, then, is central to studies of university-industry interactions, as evidence from macro- and micro-level analyses is not likely to be comparable but complementary to each other instead.

8.1.3 From a regional perspective

In the literature, there is a general acknowledgement of the role of knowledge exchange, in particular between universities and businesses, in building competitiveness of regions (Cooke and Morgan 1998; Edmonds 2003). This research makes one of the early empirical efforts to examine how knowledge networks are associated with regional competitiveness, employing a supply-demand model (Huggins et al. 2012). The 'Golden Triangle' area and the rest of the country show distinct relationships between supply and demand for academic knowledge. In particular, competitive regions tend to show a 'Low Supply-High Demand' relationship of knowledge exchange, while uncompetitive regions are more likely to show a 'High Supply-Low Demand' relationship. Overall, it is suggested that the competitiveness of UK regions lies not in the sufficient supply of academic knowledge but in the strong demand for it. In lagging regions, the overwhelming pattern of knowledge exchange exemplifies the notion of regional innovation paradox, which basically highlights the lower capacity of firms to absorb advanced knowledge (Florida 1999; Oughton et al. 2002). The capacity imbalance between the knowledge supply and demand sides is still evident in most weak regions in the UK, suggesting that the problem of the innovation paradox remains unresolved and that regional policy makers need to introduce policies and practices to level up the absorptive capacity of firms (Cohen and Levinthal 1990). The difference between the demand for academic knowledge from private sector firms in the two regional groups, more or less falls in line with the conventional wisdom on competitiveness (Huggins and Clifton 2011). Nevertheless, regional competitiveness has been found to be attributed to various forms of network relationships between universities and firms. In London and the South East firms tend to meet the strong demand for academic knowledge by making non-regional contacts and there is a lack of intensive regional networks between universities and firms while, in the East of England, firms only have modest demand for knowledge generated from universities and they are more reliant on knowledge sourced elsewhere.

8.1.4 From a policy perspective

From a policy perspective, the study suggests that policy makers should seek to find a balance between supply- and demand-driven knowledge exchange polices. Successive British governments, in their efforts to address the long-standing spatial disparities within the country, have increasingly envisaged universities as an important source of competitiveness of regions, with the introduction of a series of national policies addressing the relevance between academic research and economic benefit (Martin 1993; Goddard et al. 2014). In comparison to the US, where the main focus of research is on IP-related activities (Thursby and Thursby 2011a), the UK has taken a broader perspective with the view that knowledge exchange is more suitable than knowledge transfer, as it includes a wide range of activities between academics and businesses (ESRC 2009; Hughes 2011). Whilst it is useful to have a better understanding of the different forms that knowledge exchange activities could take, collecting more detailed data will inevitably lead to more costs for universities and authorities. Given their wider perspective on knowledge exchange, nationwide reports have largely failed to address the demand side factors. Clearly, it is problematic to assume an important but uniform role for all the universities in the UK, and the needs of the local economy have to be taken into account. Special funding schemes dedicated to knowledge exchange between universities and businesses have been in place since the early 2000s. As a result of devolution in the UK, funding third mission activities has become the responsibility of each of the four Higher Education Funding Councils. Although titled 'knowledge exchange funding incentives', they are in essence still about knowledge transfer, with the greater amount of resource invested into the knowledge supply side, i.e. universities (Abreu et al. 2009). Without acknowledgement of the actual processes of knowledge flows, the expectations from policy makers for universities to drive regional economic growth might be too high (Porter and Ketels 2003). Overall policy analysis suggests that it has come to the point where the UK government should reconsider its strategy for science and technology. In particular, the focus of UK regional innovation policy should be shifted from burdening universities further to strengthening knowledge demand from firms. The imbalance of policy attention is an urgent matter especially for firms in the lagging regions which fall behind in making use of academic knowledge.

8.2 Contributions of the research

8.2.1 Methodological contributions

The most significant methodological contribution the thesis makes is the design and use of the supply-demand analysis of knowledge exchange at the regional level. Enabled by the large-scale secondary data, which directly measure the demand for academic knowledge from businesses, the empirical evidence has expanded the conventional wisdom of knowledge exchange. The supply-demand model has innovatively concluded that the competitiveness of regions does not lie in the supply side but the demand side of knowledge, which would not have been possible without the employment of the model. A further contribution is related to the distinction between intensity and performance of university knowledge networks. As the results show that there is a paradox between the two aspects, it is essential to acknowledge that academics in uncompetitive regions might already be overburdened with their outreach activities, although they tend not to show high incomes from those engagements.

The analysis framework is rather comprehensive, as it aims to examine the influences of a number of factors such as firm size, university type, and geographic location on the network relationships between universities and businesses. A number of methods have been employed in order to simplify the data analysis process as well as the presentation of results. The original data sources – each using a different framework – are restructured based on the same predefined typologies. In particular, the questions in the surveys are critically selected and regrouped, a process adding further originality to the research, although it is largely based on the public secondary data. The author has also intentionally broken down the unified analysis framework to accustom the specific research aims and questions of each empirical chapter. These measures have been considered useful in dealing with complex research topics such as the ones examined in this research.

The critical realist paradigm as an approach has also been found to be appropriate and useful for this kind of research, with the analysis of this thesis closely following the many features of the paradigm. First, as the critical realist paradigm argues that researcher is not independent from what is researched and that the findings of research are mediated through his or her values, the researcher has in many occasions addressed this issue. For instance, the four-level framework adopted in the case study chapter was constructed based on the researcher's own understanding of the literature. The boundary of the framework led to the fact that the researcher could only reveal the factors within his own knowledge and perception of the case studies.

Second, as the critical realist paradigm rejects the notion that there exists a single reality, the researcher has searched for different explanations to the results from empirical studies. For instance, in the attempt to understand why firms based in the East of England were less likely to source knowledge from academics than their counterparts in the South East and London, the researcher listed a number of possible reasons. For topics such as university-business knowledge exchange, there are usually a wide range of factors at play, which are often intertwined with each other and sophisticate the problem.

Third, as the critical realist paradigm tends to use mechanisms, or processes, to explain the cause of the phenomena, the researcher has tried to view and understand knowledge exchange as a complex and dynamic process. While no strong arguments about the causality relationships between the factors investigated were made in the thesis, the researcher suggested the potential causes of the imperfect operation of the supply-demand knowledge networks in the regions. As uncompetitive regions seemed to show a 'High Supply-Low Demand' relationship, the researcher not only suggested that there is a need to improve the absorptive capacity of the firms in those areas to increase the demand for academic knowledge, but also indicated that universities in those regions may already be overburdened. For the researcher, mechanisms and processes are essential when looking for possible causes of any phenomenon.

8.2.2 Theoretical insights

In line with endogenous growth theory, the analysis has been based on the assumption that knowledge is an important determinant of productivity and innovation (Romer 1986; Lucas 1988). Nevertheless, the argument for university-generated knowledge becoming a driving force of regional competitiveness is critically examined in this study, which concludes that the knowledge universities could supply is not perceived as highly important when businesses source information and knowledge externally. This raises questions about the effectiveness of models, such as the Triple Helix, which are centred on the university sector although meanwhile stressing the knowledge transfer from the university sector to the industry sector (Etzkowitz and Leydesdorff 1997). Without the recognition of the relevance of university knowledge to business, regions could invest a large amount of resources into the higher education system only to find an increasing level of knowledge leakage outside the region.

Regional competitiveness, which conveys the overall conditions of a region in attracting and maintaining competitive firms in markets, has been used as a dependent variable in the research framework (Huggins and Izushi 2007; Huggins et al. 2014). In consequence, this study also contributes to the literature on regional competitiveness by revealing some evidence of knowledge exchange in relation to regional groups defined by their competitiveness. Academics within the weaker regions are more actively engaged with partners than their counterparts from competitive areas, while the opposite is true in the case of businesses. That competitive regions in the UK also show distinct patterns of knowledge exchange highlights that the concept of regional competitiveness itself is the outcome of complex underlying factors and processes (Bristow 2010). It seems to suggest that the term 'competitiveness' should not be taken for granted, and an important task is to figure out what makes certain regions competitive and what lessons could be drawn for those uncompetitive regions.

Whilst the study has not directly implemented the framework of a regional innovation system, the analysis could still throw some light on the literature. On the one hand, universities and businesses - the two sectors examined in the research - are important components of systems of innovation (Edquist 1997; Cooke et al. 2004). On the other hand, knowledge networks represent the ways how innovation systems are essentially connected. Ideally, regions are to be supported by well-functioning knowledge networks, which make the best use of both internal and external knowledge sources, to outperform their counterparts and to become competitive. The analysis argued that the business sector was the key in understanding regional innovation systems in the UK. An urgent task for policy makers in lagging regions is how to alleviate demand-side weaknesses by facilitating firms in engaging with universities.

In relation to the literature on academic entrepreneurship, the analysis examines the nature of entrepreneurial activities and adds the intensity aspect to the performance aspect which has been the focus of much of the literature (Hewitt-Dundas 2012). Universities in more competitive regions generate higher income from engaging in knowledge exchange activities than those in uncompetitive areas. However, academics in uncompetitive regions are more actively engaged in knowledge exchange activities than their counterparts in competitive areas. Reflecting on the literature on localised knowledge spillovers, the findings suggest the existence of regional variations in the localisation of knowledge spillovers (Munari et al. 2012). It is the academic knowledge in uncompetitive regions that is more strongly bounded within a certain distance, whilst geographical distance seems not to be a hindrance to knowledge exchange between academics in competitive regions and their international partners. Whereas it has been found that 'location' matters for knowledge spillovers, it still remains unclear whether that effect is held by different types of universities, which have their own culture and path dependence in working with regional or international partners.

8.2.3 Policy implications

In the UK, mainstream knowledge exchange programmes have been fundamentally driven by the supply side of knowledge, leaving the demand side of knowledge unexplained. Given the fact that academic knowledge has less frequently been perceived by firms as highly important, one may doubt the effectiveness of supply-side policies if there are less policy efforts into the demand side to enhance the absorptive capacity of firms and to foster business engagement with academics. Possibly, a certain level of public resources has been wasted as they fail to achieve their full potential in leveraging collaborations between universities and firms. As the relationships between academic supply and business demand for knowledge vary from one region to another, this research proposes that there should be supply- and demand-side policies facilitating university-business interactions at the regional level.

Policy instruments used by the UK government to measure knowledge exchange activities have their focus on the performance of university knowledge networks, leaving their intensity less well understood. The CBR academic survey is possibly the first to consider the intensity of knowledge networks involved by academics in great detail. Although the HE-BCI survey also collects data on the strategy and infrastructure of institutions, those data are incomparable to the depth and width of the numeric financial data. This study has confirmed that both performance and intensity facets of university-business interactions are important and should be better captured. Since the CBR surveys, which are used to examine the network relationships between universities and businesses in the UK, are just one-off, the analysis provides only a snapshot of the situation rather than a longitudinal view.

8.3 Limitations of the thesis

Whilst this thesis involves both qualitative and quantitative analysis, the main focus has been on the latter, and the researcher has been fully aware of the limitations of the case study chapter. The case studies are set within only one region and are conducted to support the argument of the diversity of university knowledge networks. The interviews are only conducted with key informants based at the universities, rather than with stakeholders from the private sector or the public sector. It is understood that interviews with more individuals or case studies from more regions would enable better comparison. Given the time and resource constraints, it has been practically too difficult to accomplish both the analysis of UK-wide large-scale secondary databases and the interviews with all stakeholders even within one region. Although the qualitative approach was useful in revealing in-depth knowledge of interactions, this thesis has mainly taken the quantitative approach.

The reliance on secondary data has also led to some limitations. There are obvious gaps between the surveys, thus the analysis framework to marry them could not be as comprehensive as expected. The categorisation of knowledge exchange activities, for instance, had to be narrowed down because the HE-BCI survey captures a much smaller number of activities than the CBR surveys. When analysing the CBR academic survey, the researcher was unable to access some key information such as the name of the universities with which the academic respondents were affiliated. Thus, the analysis of academic engagement intensity was only conducted at the regional level and could not be further expanded to consider the influence of university types. A further limitation of using secondary data is that the researcher needs to rely on the response bias analysis carried out by the authors who have conducted the data collection, due to the fact that the sampling frame is inaccessible. There certainly is room for improvement of data validation in this study.

8.4 Future research areas

The thesis has looked at the areas of higher education and regional competitiveness in the UK in the light of the diversification of university knowledge networks. While the thesis has shown a snapshot of university-business knowledge exchange through the supply-demand analysis at the regional level, future research could look at the determinants of the level of academic supply and business demand. It has been argued that the current approach undertaken by the UK government in knowledge exchange is too focused on the supply side. More studies are needed to examine the limitation of the current policies and to provide detailed measures with regards to enhancing the absorptive capacity of firms.

The issue of 'income generating capacity' of academics need more investigation, especially the factors in relation to the collaborations in large-scale projects. It is important to understand the decision making process of academics as to why they are more likely to work with certain types of firms in certain types of regions. The role of government policies, in particular those policies promoting specific kinds of partnerships between academics and businesses, should be examined. The four-level framework which has been adopted in the case study chapter could be analysed at the national level to understand the importance of individual, departmental, organisational and spatial factors in the knowledge exchange processes.

Based on the particular focus of this study, the relevance of university-generated knowledge to business innovation should be further investigated. Surveys collecting relevant information from both academics and businesses should be continued to gather longitudinal evidence, and will build upon the existing work. While this thesis has investigated how the size and location of firms are associated with its intensity of knowledge sourcing from academics, future research could also take into account the sectoral effects on patterns of interaction. Empirical studies are also needed to examine the formation, development and impacts of network relationships built by firms in particular regions, which would help the understanding of their performance.

Case studies of knowledge exchange initiatives are useful to highlight the diversity and complexity of university engagements with stakeholders. Future studies of universities could benefit from conducting interviews with their private and public partners. A wide range of case studies could be integrated as an important part of conventional impact studies of universities which used to consider their economic impacts rather than their social impacts. In addition, government instruments such as the HE-BCI survey could be expanded to include the new dynamic activities emerging from academics. The identification of those new activities is possibly supported by analysing the examples of university-business interactions.

In relation to the relationships between knowledge networks and regional competitiveness, the ongoing processes of globalisation and regionalisation need to be further analysed. While the importance of proximate and distant knowledge networks has been recognised in the literature, there needs to be more research investigating how they function in an increasingly globalised world. More importantly, it is necessary to conduct benchmarking analysis of globally competitive regions across the nations to fully explore how regions construct advantages through building internal and external knowledge networks in this context. With regard to the complexity of relationships between universities and regional development, an essential task is to investigate the links between regional, national, supranational and international science policy, innovation policy and higher education policy. Indeed, regions are increasingly embedded within a multi-level governance structure, which involves top-down and bottom-up processes of decision-making at various geographic levels.

8.5 Final remarks

This PhD dissertation, in essence, aims to investigate the diversity of university knowledge networks, focusing on the match or mismatch between the supply and demand sides of knowledge in the UK regions. It has come up with many findings that have contributions to theories, practices, and policies. In many ways, this study raises more questions than answers and represents an early effort to systematically examine the complex associations between universities, firms and regions.

BIBLIOGRAPHY

Abreu, M., Grinevich, V., Hughes, A. and Kitson, M. 2009. *Knowledge exchange between academics and business, public and the third sector*. Cambridge: UK Innovation Research Centre.

Abreu, M., Grinevich, V., Hughes, A., Kitson, M. and Ternouth, P. 2008. *Universities, business and knowledge exchange.* London: Council for Industry and Higher Education.

Agrawal, A. 2001. University-to-industry knowledge transfer: Literature review and unanswered questions. *International Journal of Management Reviews* 3(4), pp. 285-302.

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(9), pp. 1227-1253.

Agrawal, A. and Henderson, R. 2002. Putting patents in context: Exploring knowledge transfer from MIT. *Management Science* 48(1), pp. 44-60.

Ahuja, G. 2000. Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly* 45(3), pp. 425-455.

Alcacer, J. and Chung, W. 2007. Location strategies and knowledge spillovers. *Management Science* 53(5), pp. 760-776.

Aldrich, H. and Zimmer, C. 1986. Entrepreneurship through social networks. In: Sexton, D. and Smilor, R. eds. *The art and science of entrepreneurship*. Cambridge, MA: Ballinger, pp. 3-24.

Aldridge, T.T. and Audretsch, D.B. 2011. The Bayh-Dole Act and scientist entrepreneurship. *Research Policy* 40(8), pp. 1058-1067.

Aliaga, M. and Gunderson, B. 2000. *Interactive statistics.* Saddle River, NJ: Prentice Hall.

Almeida, P. 1996. Knowledge sourcing by foreign multinationals: Patent citation analysis in the U.S. semiconductor industry. *Strategic Management Journal* 17(Winter Special Issue), pp. 155-165.

Almeida, P. and Kogut, B. 1999. Localization of knowledge and the mobility of engineers in regional networks. *Management Science* 45(7), pp. 905-917.

Amin, A. and Cohendet, P. 2004. *Architectures of knowledge: Firms, capabilities, and communities*. Oxford: Oxford University Press.

Amin, A. and Thrift, N. 1994. Living in the global. In: Amin, A. and Thrift, N. eds. *Globalisation, institutions and regional development in Europe*. Oxford: Oxford University Press, pp. 1-22.

Anderson, T.R., Daim, T.U. and Lavoie, F.F. 2007. Measuring the efficiency of university technology transfer. *Technovation* 27(5), pp. 306-318.

Andersson, M. and Ejermo, O. 2004. Sectoral knowledge production in Swedish regions 1993-1999. In: Karlsson, C., Flensburg, P. and Horte, S.A. eds. *Knowledge spillovers and knowledge management.* Cheltenham, Edward Elgar, pp. 143-170.

Andersson, M. and Karlsson, C. 2007. Knowledge in regional economic growth: The role of knowledge accessibility. *Industry and Innovation* 14(2), pp. 129-149.

Arundel, A. and Geuna, A. 2004. Proximity and the use of public science by innovative European firms. *Economics of Innovation and New Technology* 13(6), pp. 559-580.

Asheim, B. and Coenen, L. 2006. Contextualising regional innovation systems in a globalising learning economy: On knowledge bases and institutional frameworks. *Journal of Technology Transfer* 31(1), pp. 163-173.

Asheim, B., Isaksen, A., Nauwelaers, C. and Tödtling, F. eds. 2003. *Regional innovation policy for small-medium enterprises*. London: Edward Elgar.

Athreye, S. 2004. Agglomeration and growth: A study of the Cambridge hi-tech cluster. In: Bresnahan, T. and Gambarbella, A. eds. *Building high-tech clusters: Silicon Valley and beyond.* Cambridge and New York: Cambridge University Press, pp. 121-159.

Audretsch, D.B. 1998. Agglomeration and the location of innovative activity. *Oxford Review of Economic Policy* 14(1), pp. 18-29.

Audretsch, D.B. 2014. From the entrepreneurial university to the university for the entrepreneurial society. *Journal of Technology Transfer* 39(3), pp. 313-321.

Audretsch, D.B., Lehmann, E.E. and Warning, S. 2005. University spillovers and new firm location. *Research Policy* 34(7), pp. 1113-1122.

Audretsch, D.B. and Thurik, R. 2001. What's new about the new economy? Sources of growth in the managed and entrepreneurial economies. *Industrial and Corporate Change* 10(1), pp. 267-315.

Azagra-Caro, J.M. 2007. What type of faculty member interacts with what type of firm? Some reasons for the delocalisation of university-industry interactions. *Technovation* 27(11), pp. 704-715.

Bailey, C. 2007. *A guide to qualitative field research.* Thousand Oaks: Pine Forge Press.

Baker, A.R.H. and Billinge, M.D. eds. 2004. *Geographies of England: The north-south divide – Imagined and material.* Cambridge: Cambridge University Press.

Ball, R.M. 1980. The use and definition of travel-to-work areas in Great Britain: Some problems. *Regional Studies* 14(2), pp. 125-139.

Balnaves, M. and Caputi, P. 2001. *Introduction to quantitative research methods.* New York, NY: Sage Publications.

Bang, J.T. and Mitra, A. 2011. Brain drain and institutions of governance: Educational attainment of immigrants to the U.S. 1988-1998. *Economic Systems* 35(3), pp. 335-354.

Barratt, M., Choi, T. and Li, M. 2010. Qualitative case studies in operations management: Trends, research outcomes, and future research implications. *Journal of Operations Management* 29(4), pp. 329-342.

Bathelt, H. 2002. The re-emergence of a media industry cluster in Leipzig. *European Planning Studies* 10(5), pp. 583-611.

Bathelt, H., Malmberg, A. and Maskell, P. 2004. Cluster and knowledge: Local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography* 28(1), pp. 31-56.

Bauer, M.W. and Gaskell, G. 2000. *Qualitative researching with text, image and sound: A practical handbook.* London: Sage Publications.

Bauernfeind, M. 2005. *Drivers of globalization: Integration of theories and models.* Atlanta: Georgia State University Press.

Beise, M. and Stahl, H. 1999. Public research and industrial innovations in Germany. *Research Policy* 28(4), pp. 397-422.

Bekkers, R. and Bodas Freitas, I.M. 2008. Analysing knowledge transfer channels between universities and industry: To what degree do sectors also matter? *Research Policy* 37(10), pp. 1837-1853.

Belderbos, R., Carree, M., Diederen, B., Lokshin, B. and Veugelers, R. (2004a) Heterogeneity in R&D cooperation strategies. *International Journal of Industrial Organization* 22(8-9), pp. 1237-1263.

Belderbos, R., Carree, M. and Lokshin, B. 2004b. Cooperative R&D and firm performance. *Research Policy* 33(10), pp. 1477-1492.

Bennett, R.J. 1998. Business associations and their potential contribution to the competitiveness of SMEs. *Entrepreneurship and Regional Development* 10(3), pp. 243-60.

Benneworth, P. 2006. *Creating economic possibilities in old industrial regions: The role of universities.* Newcastle: University of Newcastle.

Benneworth, P. 2007. *Leading innovation: Building effective regional coalitions for innovation.* London: NESTA.

Benneworth, P. and Charles, D. 2005. University spin-off policies and economic development in less successful regions: Learning from two decades of policy practice. *European Planning Studies* 13(4), pp. 537-557.

Bercovitz, J. and Feldman, M. 2003. Technology transfer and the academic department: Who participates and why? Paper presented at the *DRUID Summer Conference 2003.* Copenhagen, 12-14 June, 2003.

Bercovitz, J., Feldman, M., Feller, I. and Burton, R. 2001. Organisational structure as determinants of academic patent and licensing behaviour: An exploratory study by Duke, Johns Hopkins, and Pennsylvania State University. *Journal of Technology Transfer* 26(1), pp. 21-35.

Berg, B. 2009. *Qualitative research methods for the social sciences.* London: Allyn & Bacon.

BERR. 2009a. *Impact of RDA spending – National report – Volume 1 – Main report.* London: HMSO.

BERR. 2009b. *Impact of RDA spending – National report – Volume 2 – Regional Annexes.* London: HMSO.

Bhaskar, R. 1979. *The possibility of naturalism.* Brighton: Harvester.

BiGGAR Economics. 2010. *Evaluation of the first phase of the Scottish Funding Council Innovation Voucher Scheme.* Edinburgh: BiGGAR Economics.

Biggs, T. and Shah, M.K. 2006. African small and medium enterprises, networks, and manufacturing performance. *World Bank Policy Research Working Paper No. 3855.*

BIS. 2010. *Local growth: Realising every place's potential.* London: Department for Business, Innovation and Skills.

BIS. 2013. *Technology Strategy Board triennial review October 2013.* London: Department for Business, Innovation and skills.

Blind, K. and Grupp, H. 1999. Interdependencies between the sciences and technology infrastructure and innovation activities in German regions: Empirical findings and policy consequences. *Research Policy* 28(5), pp. 451-468.

Blumberg, B., Cooper, D. and Schindler, P. 2011. *Business research methods.* London: McGraw-Hill.

Boardman, P.C. 2008. Beyond the stars: The impact of affiliation with university biotechnology centers on the industrial involvement of university scientists. *Technovation* 28(5), pp. 291-297.

Boardman, P.C. 2009. Government centrality to university–industry interactions: University research centers and the industry involvement of academic researchers. *Research Policy* 38(10), pp. 1505-1516.

Boardman, P.C. and Ponomariov, B.L. 2009. University researchers working with private companies. *Technovation* 29(2), pp. 142-153.

Bogdan, R.C. and Biklen, S.K. 1998. *Qualitative research for education: An introduction to theory and methods.* Boston: Allyn and Bacon.

Bogers, M., Afuah, A. and Bastian, B. 2010. Users as innovators: A review, critique, and future research directions. *Journal of Management* 36(4), pp. 857-875.

Bogner, A., Littig, B. and Menz, W. 2009. *Interviewing experts.* Hampshire: Palgrave Macmillan.

Bok, D. 2003. *Universities in the marketplace: The commercialization of higher education.* Princeton: Princeton University Press.

Boschma, R. 2004. Competitiveness of regions from an evolutionary perspective. *Regional Studies* 38(9), pp. 1001-1014.

Boschma, R. 2005. Proximity and innovation: A critical assessment. *Regional Studies* 39(1), pp. 61-74.

Boschma, R. 2014. Towards an evolutionary perspective on regional resilience. *Regional Studies*, DOI: 10.1080/00343404.2014.959481.

Boucher, G., Conway, C. and Van Der Meer, E. 2003. Tiers of engagement by universities in their region's development. *Regional Studies* 37(9), pp. 887-897.

Bowey, J.L. and Easton, G. 2007. Entrepreneurial social capital unplugged: An activity-based analysis. *International Small Business Journal* 25(3), pp. 273-306.

Bozeman, B. and Gaughan, M. 2007. Impacts of grants and contracts on academic researchers' interactions with industry. *Research Policy* 36(5), pp. 694-707.

Brenner, T. 2007. Local knowledge resources and knowledge flows. *Industry and Innovation* 14(2), pp. 121-128.

Breschi, S. and Lissoni, F. 2001a. Localised knowledge spillovers vs. innovative milieu: Knowledge "tacitness" reconsidered. *Papers in Regional Science* 80(3), pp. 255-273.

Breschi, S. and Lissoni, F. 2001b. Knowledge spillovers and local innovation systems: A critical survey. *Industry and Corporate Change* 10(4), pp. 975-1005.

Breschi, S. and Lissoni, F. 2004. Knowledge networks from patent data: methodological issues and research targets. In: Moed, H., Glänzel, W. and Schmoch, U. eds. *Handbook of quantitative science and technology research: The use of publication and patent statistics in the studies of S&T systems.* Berlin: Springer, pp. 613-643.

Breschi, S., Malerba, F. and Orsenigo, L. 2000. Technological regimes and Schumpeterian patterns of innovation. *The Economic Journal* 110(463), pp. 388-410.

Bristow, G. 2005. Everyone's a 'winner': Problematising the discourse of regional competitiveness. *Journal of Economic Geography* 5(3), pp. 285-304.

Bristow, G. 2010. *Critical reflections on regional competitiveness: Theory, policy and practice.* London: Routledge.

Bryman, A. 2008. *Social research methods*. Oxford: Oxford University Press.

Bunnell, T. and Coe, N. 2001. Spaces and scales of innovation. *Progress in Human Geography* 25(4), pp. 569-589.

Burns, R.B. 1997. *Introduction to research methods.* Australia: Longman.

Cantner, U. and Meder, A. 2007. Technological proximity and the choice of cooperation partner. *Journal of Economic Interaction and Coordination* 2(1), pp. 45-65.

Cantwell, J. 1995. The globalisation of technology: What remains of the product cycle model? *Cambridge Journal of Economics* 19(1), pp. 155-174.

Capello, R. and Faggian, A. 2005. Collective learning and relational capital in local innovation processes. *Regional Studies* 39(1), pp. 75-87.

Cappellin, R. 2009. The governance of knowledge networks in industrial clusters and cities. Paper presented at the *Fourth Korean Italian Workshop*, Università di Torino & Università del Piemonte Orientale, 28-29 January, 2009.

Carlsson, B. and Fridh, A.C. 2002. Technology transfer in United States universities: A survey and statistical analysis. *Journal of Evolutionary Economics* 12(1-2), pp. 199-232.

Casado-Díaz, J.M. 2000. Local labour market areas in Spain: A case study. *Regional Studies* 34(9), pp. 843-856.

CBR. 2009. *Evaluation of the effectiveness and role of HEFCE/OSI third stream funding: Report to HEFCE*. Cambridge: Centre for Business Research, University of Cambridge.

CBR. 2010a. *Cambridge Centre for Business Research survey of knowledge exchange activity by UK academics.* Essex: UK Data Archive [Distributor], July 2010. Available at: http://dx.doi.org/10.5255/UKDA-SN-6462-1. [Accessed: 15 August 2014].

CBR. 2010b. *Cambridge Centre for Business Research survey of knowledge exchange activity by UK businesses.* Essex: UK Data Archive [Distributor], July 2010. Available at: http://dx.doi.org/10.5255/UKDA-SN-6464-1. [Accessed: 15 August 2014].

Charles, D. 2003. Universities and territorial development: Reshaping the regional role of UK universities. *Local Economy* 18(1), pp. 7-20.

Charles, D. and Howells, J. 1992. *Technology transfer in Europe: Public and private networks.* London: Belhaven Press.

Chatterton, P. and Goddard, J. 2000. The response of higher education institutions to regional needs. *European Journal of Education* 35(4), pp. 475-496.

Chesbrough, H. 2003a. *Open innovation: The new imperative for creating and profiting from technology.* Boston: Harvard Business School Press.

Chesbrough, H. 2003b. The era of open innovation. *MIT Sloan Management Review* 44(3), pp. 35-41.

Chesbrough, H. 2003c. The logic of open innovation: Managing intellectual property. *California Management Review* 45(3), pp. 33-58.

Christopherson, S. and Clark, J. 2010. Limits to the 'learning region': What university-centred economic development can (and cannot) do to create knowledge-based regional economies. *Local Economy* 25(2), pp. 120-130.

Clark, B. 1995. *Places of inquiry: Research and advanced education in modern universities.* Berkeley: University of California Press.

Coenen, L. 2007. The role of universities in the regional innovation systems of the North East of England and Scania, Sweden: Providing missing links? *Environment and Planning C: Government and Policy* 25(6), pp. 803-821.

Cohen, L. and Manion, L. 1994. *Research methods in education.* London: Routledge.

Cohen, W.M. and Levinthal, D.A. 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly* 35(1), pp. 128-152.

Cohen, W.M., Nelson, R.R. and Walsh, J.P. 2002. Links and impacts: The influence of public research on industrial R&D. *Management Science* 48(1), pp. 1-23.

Cooke, P. 2004. Regional innovation systems: An evolutionary approach. In: Cooke, P., Heidenreich, M. and Braczyk, H. eds. *Regional innovation systems: The role of governance in a globalised world.* London: Routledge, pp. 1-18.

Cooke, P. 2005. Regionally asymmetric knowledge capabilities and open innovation: Exploring 'Globalisation 2' – A new model of industry organisation. *Research Policy* 34(8), pp. 1128-1149.

Cooke, P. 2013. *Reframing regional development: Evolution, innovation and transition.* London: Routledge.

Cooke, P., Davies, C. and Wilson, R. 2002. Innovation advantages of cities: From knowledge to equity in five basic steps. *European Planning Studies* 10(2), pp. 233-250.

Cooke, P., Heidenreich, M. and Braczyk, H. eds. 2004. *Regional innovation systems: The role of governance in a globalised world.* London: Routledge.

Cooke, P., Manning, C. and Huggins, R. 2000. Industrial liaison and academic entrepreneurship in Wales. *Zeitschrift fur Wirtschaftsgeographie [The German Journal of Economic Geography]* 44(3-4), pp. 246-260.

Cooke, P. and Morgan, K. 1998. *The associational economy: Firms, regions and innovation.* Oxford: Oxford University Press.

Cooper, A.C. 1971. Spin-offs and technical entrepreneurship. *IEEE Transactions on Engineering and Management* 18(1), pp. 2-6.

Cosh, A. and Hughes, A. 2010. Never mind the quality feel the width: University-industry links and government financial support for innovation in small high-technology businesses in the UK and the USA. *Journal of Technology Transfer* 35(1), pp. 66-91.

Cowan, R. and Foray, D. 1997. The economics of codification and the diffusion of knowledge. *Industrial and Corporate Change* 6(3), pp. 595-622.

Crafts, N. 2005. Regional GDP in Britain 1871-1911: Some estimates. *Scottish Journal of Political Economy*, 52(1), pp. 54-64.

Creswell, J.W. 2003. *Research design: Qualitative, quantitative, and mixed methods approaches.* Thousand Oaks: Sage.

Cumbers, A., Mackinnon, D. and Chapman, K. 2003. Innovation, collaboration, and learning in regional clusters: A study of SMEs in the Aberdeen oil complex. *Environment and Planning A* 35(9), pp. 1689-1706.

Cummings, J.L. and Teng, B. 2003. Transferring R&D knowledge: The key factors affecting knowledge transfer success. *Journal of Engineering and Technology Management* 20(1), pp. 39-68.

D'Este, P. and Patel, P. 2007. University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry? *Research Policy* 36(9), pp. 1295-1313.

D'Este, P. and Perkmann, M. 2011. Why do academics engage with industry? The entrepreneurial university and individual motivations. *Journal of Technology Transfer* 36(3), pp. 316-339.

Dahlander, L. and Gann, D.M. 2010. How open is innovation? *Research Policy* 39(6), pp. 699-709.

Davenport, S. 2005. Exploring the role of proximity in SME knowledge-acquisition. *Research Policy* 34(5), pp. 683-701.

David, M. and Sutton, C. 2004. *Social research.* London: Sage Publications.

DELNI. 2010. *Evaluation of the Northern Ireland higher education innovation fund 2 (NI HEIF 2)*. Belfast: Department for Employment and Learning.

DELNI. 2011. *Draft budget 2011-15: Budget settlement and proposals to reduce expenditure for the Department for Employment and Learning.* Belfast: Department for Employment and Learning.

DETR. 1997. *Building partnerships for prosperity: Sustainable growth, competitiveness and employment in the English regions.* London: HMSO.

Dewar, R.D. and Dutton, J.E. 1986. The adoption of radical and incremental innovations: An empirical analysis. *Management Science* 32(11), pp. 1422-1433.

Di Gregorio, D. and Shane, S. 2003. Why do some universities generate more start-ups than others? *Research Policy* 32(2), pp. 209-227.

Doloreux, D. 2004. Regional innovation systems in Canada: A comparative study. *Regional Studies* 38(5), pp. 479-492.

Doloreux, D. and Dionne, S. 2008. Is regional innovation system development possible in peripheral regions? Some evidence from the case of La Pocatière, Canada. *Entrepreneurship and Regional Development* 20(3), pp. 259-283.

Döring, T. and Schnellenbach, J. 2006. What do we know about geographical knowledge spillovers and regional growth? A survey of the literature. *Regional Studies* 40(3), pp. 375-395.

Drucker, P. 1989. *The new realities: In government and politics/In economics and business/In society and world view.* New York: Harper & Row.

DTI. 1998. *Our competitive future: Building the knowledge driven economy.* London: HMSO.

DTI. 2000. *Excellence and opportunity – A science and innovation policy for the 21st century*. London: HMSO.

DTI. 2001. *Regional competitiveness indicators.* London: HMSO.

DTI. 2003. *Innovation report-Competing in the global economy: The innovation challenge.* London: HMSO.

DTZ. 2009. *Economic impact of the Institute of Biological, Environmental and Rural Sciences: Research and operational activities.* Aberystwyth: Aberystwyth University.

Edmonds, T. 2003. *Regional competitiveness and the role of the knowledge economy.* London: House of Commons Library.

Edquist, C. eds. 1997. *Systems of innovation: Technologies, institutions and organisations.* London: Routledge.

EEAC. 2011. *Welsh participation in EU research, innovation and lifelong learning programmes.* Cardiff: National Assembly for Wales.

Eisenhardt, K. 1989. Building theories from case study research. *Academy of Management Journal* 14(4), pp. 532-550.

ESRC. 2009. *Strategic Plan 2009-2014* [Online]. Available at: http://www.esrcsocietytoday.ac.uk/ESRCInfoCentre/strategicplan/impact/. [Accessed: 04 August 2014].

Ettlie, J.E., Bridges, W.P. and O'Keefe, R.D. 1984. Organization strategy and structural differences for radical versus incremental innovation. *Management Science* 30(6), pp. 682-695.

Etzkowitz, H. 1998. The norms of entrepreneurial science: Cognitive effects of the new university-industry linkages. *Research Policy* 27(8), pp. 823-833.

Etzkowitz, H. 2003. Innovation in innovation: The triple helix of university-industry-government relations. *Social Science Information* 42(3), pp. 293-337.

Etzkowitz, H. and Leydesdorff, L. eds. 1997. *Universities and the global knowledge economy: A triple helix of university-industry-government relations.* London: Cassell Academic.

Etzkowitz, H. and Leydesdorff, L. 2000. The dynamics of innovation: From national systems and "Mode 2" to a triple helix of university-industry-government relations. *Research Policy* 29(2), pp.109-123.

Fallis, G. 2004. *The mission of the university.* Toronto: York University.

Feldman, M.P. 1994. *The geography of innovation.* Boston: Kluwer Academic.

Feldman, M.P. and Desrochers, P. 2003. Research universities and local economic development: Lessons from the history of the John Hopkins University. *Industry and Innovation* 10(1), pp. 5-24.

Fesenmaier, J. and Contractor, N. 2001. The evolution of knowledge networks: An example for rural development. *Journal of the Community Development Society* 32(1), pp. 160-175.

Fischer, M.M. and Varga, A. 2003. Spatial knowledge spillovers and university research: Evidence from Austria. *Annals of Regional Science* 37(2), pp. 302-322.

Flick, U. 2006. *An introduction to qualitative research.* London: Sage Publications.

Flick, U. 2009. *An introduction to qualitative research (4th edition).* London: Sage Publications.

Florida, R. 1997. The globalization of R&D: Results of a survey of foreign-affiliated R&D laboratories in the USA. *Research Policy* 26(1), pp. 85-103.

Florida, R. 1999. The role of the university: Leveraging talent, not technology. *Issues in Science and Technology* 15(4), pp. 67-73.

Flyvbjerg, B. 2006. Five misunderstandings about case-study research. *Qualitative Inquiry* 12(2), pp. 219-245.

Foray, D. and Lundvall, B. 1996. The knowledge-based economy: From the economics of knowledge to the learning economy. In: OECD. eds. *Employment and growth in the knowledge-based economy*. Paris: OECD, pp. 3-28.

Fowler, F.J. 2014. *Survey research methods.* London: Sage Publications.

Freeman, C. 1995. The 'national system of innovation' in historical perspective. *Cambridge Journal of Economics* 19(1), pp. 5-24.

Freeman, C. 2003. A Schumpeterian renaissance? *SPRU Electronic Working Paper Series No. 102.*

Freeman, C. 2004. Technological infrastructure and international competitiveness. *Industrial and Corporate Change* 13(3), pp. 541-569.

Fritsch, M. 2002. Measuring the quality of regional innovation systems: A knowledge production function approach. *International Regional Science Review* 25(1), pp. 86-101.

Fritsch, M. 2003. Does cooperation behaviour differ between regions? *Industry and Innovation* 10(1), pp. 25-69.

Fritsch, M. 2005. Do regional systems of innovation matter? In: Huebner, K. eds. *The new economy in transatlantic perspective – Spaces of innovation.* Abingdon: Routledge, pp. 187-203.

Fritsch, M. and Slavtchev, V. 2007. Universities and innovation in space. *Industry and Innovation* 14(2), pp. 201-218.

Gardiner, B., Martin, R., Sunley, P. and Tyler, P. 2013. Spatially unbalanced growth in the British economy. *Journal of Economic Geography* 13(6), pp. 889-928.

Garlick, S. 1998. *Creative associations in special places: Enhancing the role of universities in building competitive regional economies.* Canberra: Department of Education, Training and Youth Affairs.

Garnsey, E. and Heffernan, P. 2005. High-technology clustering through spin-out and attraction: The Cambridge case. *Regional Studies* 39(8), pp. 1127-1144.

Gertler, M. 1995. 'Being there': Proximity, organization, and culture in the development and adoption of advanced manufacturing technologies. *Economic Geography* 71(1), pp. 1-26.

Gertler, M.S. and Levitte, Y.M. 2005. Local nodes in global networks: The geography of knowledge flows in biotechnology. *Industry and Innovation* 12(4), pp. 487-507.

Gibbons, M., Limoges, C., Nowotny, H., Schwartman, S., Scott, P. and Trow, M. 1984. *The production of knowledge: The dynamics of science and research in contemporary societies.* London: Sage.

Gilsing, V., Nooteboom, B., Vanhaverbeke, W., Duysters, G. and van den Oord, A. 2008. Network embeddedness and the exploration of novel technologies: Technological distance, betweeness centrality and density. *Research Policy* 37(10), pp. 1717-1731.

Giuliani, E., Morrison, A., Pietrobelli, C. and Rabellotti, R. 2010. Who are the researchers that are collaborating with industry? An analysis of the wine sectors in Chile, South Africa and Italy. *Research Policy* 39(6), pp. 748-761.

Giuri, P. and Mariani, M. 2013. When distance disappears: Inventors, education, and the locus of knowledge spillovers. *Review of Economics and Statistics* 95(2), pp. 449-463.

Glesne, C. and Peshkin, A. 1992. *Becoming qualitative researchers.* Thousand Oaks: Sage.

Goddard, J. 2009. *Reinventing the civic university.* London: NESTA.

Goddard, J., Coombes, M., Kempton, L. and Vallance, P. 2014. Universities as anchor institutions in cities in a turbulent funding environment: Vulnerable institutions and vulnerable places in England. *Cambridge Journal of Regions, Economy and Society* 7(2), pp. 307-325.

Goldfarb, B. and Hensekson, M. 2003. Bottom-up versus top-down policies towards the commercialization of university intellectual property. *Research Policy* 32(4), pp. 639-658.

Goldstein, H. 2010. To what extent is academic entrepreneurship taken for granted within research universities? *Higher Education Policy* 23(1), pp. 1-16.

Goldstein, H.A. and Renault, C.S. 2004. Contributions of universities to regional economic development: A quasi-experimental approach. *Regional Studies* 38(7), pp. 733-746.

Granovetter, M. 1973. The strength of weak ties. *American Journal of Sociology* 78(6), pp. 1360-1380.

Gray, D. 2009. *Doing research in the real world.* London: Sage Publications.

Greenway, D. and Haynes, M. 2000. *Funding universities to meet national and international challenges.* Nottingham: University of Nottingham.

Grimaldi, R., Kenney, M., Siegel, D.S. and Wright, M. 2011. 30 years after Bayh-Dole: Reassessing academic entrepreneurship. *Research Policy* 40(8), pp. 1045-1057.

Greunz, L. 2005. Intra- and inter-regional knowledge spillovers: Evidence from European regions. *European Planning Studies* 13(3), pp. 449-473.

Guba, E.G. and Lincoln, Y.S. 1994. Competing paradigms in qualitative research. In: Denzin, N.K. and Lincoln, Y.S. eds. *Handbook of qualitative research.* Thousand Oaks, CA: Sage, pp. 105-117.

Gudgin, G. 1995. Regional problems and policy in the UK. *Oxford Review of Economic Policy* 11(2), pp. 18-63.

Gulati, R. 1998. Alliances and networks. *Strategic Management Journal* 19(4), pp. 293-317.

Gulati, R. 2007. *Managing network resources: Alliances, affiliations, and other relational assets.* Oxford: Oxford University Press.

Gulati, R. and Westphal, J. 1999. Cooperative or controlling? The effects of CEO-Board relations and the content of interlocks on the formation of joint ventures. *Administrative Science Quarterly* 44(3), pp. 473-506.

Gunasekara, C. 2006. The generative and developmental roles of universities in regional innovation systems. *Science and Public Policy* 33(2), pp. 137-150.

Haeussler, C. and Colyvas, J.A. 2011. Breaking the ivory tower: Academic entrepreneurship in the life sciences in UK and Germany. *Research Policy* 40(1), pp. 41-54.

Hagedoorn, J. 1996. Innovation and entrepreneurship: Schumpeter revisited. *Industrial and Corporate Change* 5(3), pp. 883-896.

Hagedoorn, J. 2002. Inter-firm R&D partnerships: An overview of major trends and patterns since 1960. *Research Policy* 31(4), pp. 477-492.

Hall, B.H., Link, A.N. and Scott, J.T. 2001. Barriers inhibiting industry from partnering with universities: Evidence from the advanced technology program. *Journal of Technology Transfer* 26(1), pp. 87-98.

Hall, B.H., Link, A.N. and Scott, J.T. 2003. Universities as research partners. *Review of Economics and Statistics* 85(2), pp. 485-491.

Hansen, M.T. 1999. The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly* 44(1), pp. 82-111.

Harloe, M. and Perry, B. 2004. Universities, localities and regional development: The emergence of the 'Mode 2' university'. *International Journal of Urban and Regional Research* 28(1), pp. 212-223.

Harrison, J. 2013. Configuring the new 'regional world': On being caught between territory and networks. *Regional Studies* 47(1), pp. 55-74.

Hartley, J. 2004. Case study research. In: Cassell, C. and Symon, G. eds. *Essential guide to qualitative methods in organisational research*. London: Sage Publications, pp. 323-333.

Hatton, T.J. and Williamson, J.G. 2005. *Global migration and the world economy: Two centuries of policy and performance.* Cambridge, MA: The MIT Press.

Hauser, H. 2010. *The current and future role of technology and innovation centres in the UK.* London: Department for Business, Innovation and Skills.

HEFCE. 1999a. *Higher education reach-out to business and the community fund: Funding proposals*. Bristol: HFECE.

HEFCE. 1999b. *Higher education reach-out to business and the community fund: Invitation to apply for special funding*. Bristol: HEFCE.

HEFCE. 2000a. *Higher education reach-out to business and the community fund: Second invitation to apply for special funding*. Bristol: HEFCE.

HEFCE. 2000b. *Higher education reach-out to business and the community fund: Second round funding allocations*. Bristol: HEFCE.

HEFCE. 2001. *Higher education innovation fund: Invitation to apply for special funding.* Bristol: HEFCE.

HEFCE. 2005a. *Higher education innovation fund round 3: Invitation and guidance for institutional plans and competitive bids.* Bristol: HEFCE.

HEFCE. 2005b. *Higher education-business and community interaction survey 2002-03*. Bristol: HEFCE.

HEFCE. 2006a. *Higher education innovation fund round 3: Funding allocations.* Bristol: HEFCE.

HEFCE. 2006b. *Higher education-business and community interaction survey 2003-04*. Bristol: HEFCE.

HEFCE. 2007. *Higher education-business and community interaction survey 2004-05 and 2005-06*. Bristol: HEFCE.

HEFCE. 2008a. *Higher education innovation fund round 4: Invitation and guidance for institutional strategies.* Bristol: HEFCE.

HEFCE. 2008b. *Higher education-business and community interaction survey 2006-07*. Bristol: HEFCE.

HEFCE. 2009. *Higher education-business and community interaction survey 2007-08*. Bristol: HEFCE.

HEFCE. 2010. *Higher education-business and community interaction survey 2008-09*. Bristol: HEFCE.

HEFCE 2011a. *Higher education innovation funding 2011-12 to 2014-15: Consultation on a threshold allocation; and indicative institutional allocations.* Bristol: HEFCE.

HEFCE. 2011b. *Higher education innovation funding 2011-12 to 2014-15: Policy, final allocations and request for institutional strategies*. Bristol: HEFCE.

HEFCE. 2011c. *Higher education-business and community interaction survey 2009-10*. Bristol: HEFCE.

HEFCE. 2012. *Higher education-business and community interaction survey 2010-11*. Bristol: HEFCE.

HEFCE. 2013. *Higher education-business and community interaction survey 2011-12*. Bristol: HEFCE.

HEFCW. 2003. *Future development of the higher education economic development (HEED) fund: A consultation document.* Cardiff: HEFCW.

HEFCW. 2004. *Third mission funding arrangements 2004/05 to 2006/07.* Cardiff: HEFCW.

HEFCW. 2007. *Third mission funding arrangements 2007/08 to 2009/10.* Cardiff: HEFCW.

HEFCW. 2009. *Evaluation of HEFCW's third mission fund 2004/05 to 2006/07*. Cardiff: HEFCW.

HEFCW. 2011. *Innovation & engagement funding arrangements 2011/12 to 2013/14*. Cardiff: HEFCW.

HEFCW. 2011. *Strategic implementation allocations 2011/12.* Cardiff: HEFCW.

Hess, M. 2004. 'Spatial' relationships? Towards a reconceptualisation of embeddedness. *Progress in Human Geography* 28(2), pp. 165-186.

Hewitt-Dundas, N. 2012. Research intensity and knowledge transfer activity in UK universities. *Research Policy* 41(2), pp. 262-275.

Hewitt-Dundas, N., Andréosso-O'callaghan, B., Crone, M., Murray, J. and Roper, S. 2005. Selling global, buying local? What determines the sourcing patterns of multinational plants in Ireland? *Regional Studies* 39(2), pp. 225-239.

HM Treasury. 2004. *Science and innovation investment framework 2004-2014*. London: Stationery Office.

HM Treasury. 2010. *Spending review 2010.* London: Stationery Office.

HM Treasury. 2011. *Plan for growth.* London: Stationery Office.

Howells, J. 2000. Research and technology outsourcing and systems of innovation. In: Metcalfe, J.S. and Miles, I. eds. *Innovation systems in the service economy: Measurement and case study analysis.* Dordrecht: Kluwer Academic Publishers, pp. 271-295.

Howells, J.R. 2002. Tacit knowledge, innovation and economic geography. *Urban Studies* 39(5-6), pp. 871-884.

Hsueh, J.T., Lin, N.P. and Li, H.C. 2010. The effects of network embeddedness on service innovation performance. *The Service Industries Journal* 30(10), pp. 1723-1736.

Huggins, R. 2000. *The business of networks: Inter-firm interaction, institutional policy and the TEC experiment.* Aldershot: Ashgate.

Huggins, R. 2001. Inter-firm network policies and firm performance: Evaluating the impact of initiatives in the United Kingdom. *Research Policy* 30(3), pp. 443-458.

Huggins, R. 2002. *The state of urban Britain: UK Competitiveness Index 2002.* Cardiff: Robert Huggins Business & Economic Policy Press.

Huggins, R. 2003. Creating a UK Competitiveness Index: Regional and local benchmarking. *Regional Studies* 37(1), pp. 89-96.

Huggins, R. 2008. Universities and knowledge-based venturing: Finance, management and networks in London. *Entrepreneurship and Regional Development* 20(2), pp. 185-206.

Huggins, R. 2010. Forms of network resource: Knowledge access and the role of inter-firm networks. *International Journal of Management Reviews* 12(3), pp. 335-352.

Huggins, R. and Clifton, N. 2011. Competitiveness, creativity, and place-based development. *Environment and Planning A* 43(6), pp. 1341-1362.

Huggins, R. and Day, J. 2005. *UK Competitiveness Index 2005: The changing state of the nation 1997-2005.* Cardiff: Robert Huggins Associations.

Huggins, R. and Day, J. 2006. *UK Competitiveness Index 2006.* London: The Work Foundation.

Huggins, R. and Izushi, H. 2007. *Competing for knowledge: Creating, connecting and growing.* London: Routledge.

Huggins, R. and Izushi, H. 2008. *UK Competitiveness Index 2008.* Cardiff: Centre for International Competitiveness, Cardiff School of Management, University of Wales Institute, Cardiff.

Huggins, R., Izushi, H., Clifton, N., Jenkins, S., Prokop, D. and Whitfield, C. 2010a. *Sourcing knowledge for innovation: The international dimension.* London: NESTA.

Huggins, R., Izushi, H. and Prokop, D. 2010b. University-industry networks: Interactions with large R&D performers. Paper presented at the *DRUID Summer Conference 2010.* Imperial College London Business School, 15-18 June, 2010.

Huggins, R., Izushi, H., Prokop, D. and Thompson, P. 2014. *The global competitiveness of regions*. Abingdon: Routledge.

Huggins, R. and Johnston, A. 2009a. The economic and innovation contribution of universities: A regional perspective. *Environment and Planning C: Government and Policy* 27(6), pp. 1088-1106.

Huggins, R. and Johnston, A. 2009b. The knowledge networks of SMEs: Findings from an uncompetitive region. *Growth and Change* 40(2), pp. 227-259.

Huggins, R. and Johnston, A. 2010 Knowledge flow and inter-firm networks: The influence of network resources, spatial proximity and firm size. *Entrepreneurship and Regional Development* 22(5), pp. 457-484.

Huggins, R., Johnston, A. and Steffenson, R. 2008a. Universities, knowledge networks and regional policy. *Cambridge Journal of Regions, Economy and Society* 1(2), pp. 321-340.

Huggins, R., Johnston, A. and Stride, C. 2012. Knowledge networks and universities: Locational and organisational aspects of knowledge transfer interactions. *Entrepreneurship & Regional Development: An International Journal* 24(7-8), pp. 475-502.

Huggins, R., Jones, M. and Upton, S. 2008b. Universities as drivers of knowledge-based regional development: A triple helix analysis of Wales. *International Journal of Innovation and Regional Development* 1(1), pp. 24-47.

Huggins, R. and Kitagawa, F. 2012. Regional policy and university knowledge transfer: Perspectives from devolved regions in the UK. *Regional Studies* 46(6), pp. 817-832.

Huggins, R., Prokop, D., Johnston, A., Steffenson, R. and Clifton, N. 2011. Small firm-university knowledge networks: Evidence from the UK and the US. Paper presented at the *Triple Helix IX Conference.* Stanford University, California, 11-14 July, 2011.

Huggins, R. and Thompson, P. 2010. *UK Competitiveness Index 2010.* Cardiff: Centre for International Competitiveness, Cardiff School of Management, University of Wales Institute, Cardiff.

Huggins, R. and Thompson, P. 2013. *UK Competitiveness Index 2013.* Cardiff: Centre for Economic Geography, School of Planning and Geography, Cardiff University.

Hughes, A. 2011. Open innovation, the Haldane Principle and the new production of knowledge: Science policy and university-industry links in the UK after the financial crisis. *Prometheus* 29(4), pp. 411-442.

Hughes, A. and Kitson, M. 2012. Pathways to impact and the strategic role of universities: New evidence on the breadth and depth of university knowledge exchange in the UK and the factors constraining its development. *Cambridge Journal of Economics* 36(3), pp. 723-750.

Huges, A. and Kitson, M. 2013. *Connecting with the ivory tower: Business perspectives on knowledge exchange in the UK.* Cambridge: UK Innovation Research Centre.

Iammarino, S., Piva, M., Vivarelli, M. and von Tunzelmann, N. 2013. Firm capabilities and cooperation for innovation: Evidence from the UK regions. In: Crescenzi, R. and Percoco, M. eds. *Geography, institutions and regional economic performance.* London: Springer, pp. 281-302.

Ireland, R., Hitt, M. and Vaidyanath, D. 2002. Alliance management as a source of competitive advantage. *Journal of Management* 28(3), pp. 413-446.

Jacob, M., Lundqvist, M. and Hellsmark, H. 2003. Entrepreneurial transformations in the Swedish university system: The case of Chalmers University of Technology. *Research Policy* 32(9), pp. 1555-1568.

Jacobson, N., Butterill, D. and Goering, P. 2004. Organizational factors that influence university-based researchers' engagement in knowledge transfer activities. *Science Communication* 25(3), pp. 212-239.

Jaffe, A.B. 1986. Technological opportunity and spillovers of R&D: Evidence from firms' patents, profits, and market values. *The American Economic Review* 76(5), pp. 984-1001.

Jaffe, A.B. 1989. Real effects of academic research. *American Economic Review* 79(5), pp. 957-970.

Jaffe, A.B., Trajtenberg, M. and Henderson, R. 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. *The Quarterly Journal of Economics* August 1993, pp. 578-598.

Johnson, D.K., Siripong, A. and Brown, A.S. 2006. The demise of distance? The declining role of physical proximity for knowledge transmission. *Growth and Change* 37(1), pp. 19-33.

Jones-Evans, D. and Klofsten, M. 1997. Universities and local economic development: The case of Linkoping. *European Planning Studies* 5(1), pp. 77-93.

Jones-Evans, D. and Klosften, M. 1998. Role of the university in the technology transfer processes: A European view. *Science and Public Policy* 25(6), pp. 373-380.

Jones-Evans, D., Klofsten, M., Andersson, E. and Pandya, D. 1999. Creating a bridge between university and industry in small European countries: The role of the Industrial Liaison Office. *R&D Management* 29(1), pp. 47-56.

Jones-Evans, D., Williams, W. and Deacon, J. 2000. Developing entrepreneurial graduates: An action-learning approach. *Education + Training* 42(4/5), pp. 282-288.

Kaiser, U. 2002. An empirical test of models explaining research expenditures and research cooperation: Evidence for the German service sector. *International Journal of Industrial Organization* 20(6), pp. 747-774.

Kang, K.H. and Kang, J. 2009. How do firms source external knowledge for innovation? Analysing effects of different knowledge sourcing methods. *International Journal of Innovation Management* 13(1), pp. 1-17.

Kash, D. and Rycroft, R. 2000. Patterns of innovating complex technologies: A framework for adaptive network strategies. *Research Policy* 29(7-8), pp. 819-831.

Kaufmann, A. and Tödtling, F. 2001. Science-industry interaction in the process of innovation: The importance of boundary-crossing between systems. *Research Policy* 30(5), pp. 791-804.

Keane, J. and Allison, J. 1999. The intersection of the learning region and local and regional economic development: Analysing the role of higher education. *Regional Studies* 33(9), pp. 896-902.

Keating, M. 1998. *The new regionalism in Western Europe: Territorial restructuring and political change*. Cheltenham: Edward Elgar.

Kelly, U., Marsh, R. and McNicoll, I. 2002. *The impact of higher education institutions on the UK economy.* London: UK Universities.

Kingsley, G. and Malecki, E.J. 2004. Networking for competitiveness: The role of informal linkages for small firms. *Small Business Economics* 23(1), pp. 71-84.

Kitagawa, F. 2004. Universities and regional advantage: Higher education and innovation policies in English regions. *European Planning Studies* 12(6), pp. 835-852.

Kitagawa, F. and Lightowler, C. 2013. Knowledge exchange: A comparison of policies, strategies, and funding incentives in English and Scottish higher education. *Research Evaluation* 22(1), pp. 1-14.

Kitson, M., Howells, J., Braham, R. and Westlake, S. 2009. *The connected university: Driving recovery and growth in the UK economy.* London: NESTA.

Kline, S.J. and Rosenberg, N. 1986. An overview of innovation. In: Landau, R. and Rosenberg, N. eds. *The positive sum strategy.* Washington, DC: National Academy Press, pp. 275-305.

Klofsten, M. and Jones-Evans, D. 2000. Comparing academic entrepreneurship in Europe – The case of Sweden and Ireland. *Small Business Economics* 14(4), pp. 299-309.

Klofsten, M., Jones-Evans, D. and Scharberg, C. 1999. Growing the Linkoping technopole – A longitudinal study of triple helix development in Sweden. *Journal of Technology Transfer* 24(2-3), pp. 125-138.

Knoben, J. and Oerlemans, L. 2006. Proximity and inter-organizational collaboration: A literature review. *International Journal of Management Reviews* 8(2), pp. 71-89.

Kogut, B. and Zander, U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science* 3(3), pp. 383-397.

Kotabe, M., Dunlap-Hinkler, D., Parente, R. and Mishra, H.A. 2007. Determinants of cross-national knowledge transfer and its effect on firm innovation. *Journal of International Business Studies* 38(2), pp. 259-282.

Krabel, S. and Mueller, P. 2009. What drives scientists to start their own company: An empirical investigation of Max Planck Society scientists. *Research Policy* 38(6), pp. 947-956.

Lagendijk, A. and Cornford, J. 2000. Regional institutions and knowledge – tracking new forms of regional development policy. *Geoforum* 31(2), pp. 209-218.

Lambert, R. 2003. *Lambert review of business university collaboration.* Norwich: HMSO.

Landabaso, M. and Reid, A. 1999. Developing regional innovation strategies: The European Commission as animateur. In: Morgan, K. and Nauwelaers, C. eds.

Regional innovation strategies: The challenge for less-favoured regions. London: The Stationary Office, pp. 19-39.

Landry, R., Amara, N. and Rherrad, I. 2006. Why are some university researchers more likely to create spin-offs than others? Evidence from Canadian universities. *Research Policy* 35(10), pp. 1599-1615.

Langley, A. 1999. Strategies for theorizing from process data. *The Academy of Management Review* 24(4), pp. 691-710.

Lawson, C. and Lorenz, E. 1999. Collective learning, tacit knowledge and regional innovative capacity. *Regional Studies* 33(4), pp. 305-317.

Lawton Smith, H. 2000. *Technology transfer and industrial change in Europe.* Basingstoke: Macmillan.

Lawton Smith, H. 2003. Knowledge organizations and local economic development: The cases of Oxford and Grenoble. *Regional Studies* 37(9), pp. 899-919.

Lawton Smith, H. 2004. The biotechnology industry in Oxfordshire: Enterprise and innovation. *European Planning Studies* 12(7), pp. 985-1002.

Lawton Smith, H. 2007. Universities, innovation, and territorial development: a review of the evidence. *Environment and Planning C: Government and Policy* 25(1), pp. 98-114.

Lawton Smith, H. and Bagchi-Sen, S. 2006. University-industry interactions: The case of the UK biotech industry. *Industry and Innovation* 13(4), pp. 371-392.

Lechner, C. and Dowling, M. 2003. Firm networks: External relationships as sources for the growth and competitiveness of entrepreneurial firms. *Entrepreneurship and Regional Development* 15(1), pp. 1-26.

Lechner, C., Dowling, M. and Welpe, I. 2006. Firm networks and firm development: The role of the relational mix. *Journal of Business Venturing* 21(4), pp. 514-540.

Lee, C., Lee, K. and Pennings, J.M. 2001. Internal capabilities, external networks, and performance: A study on technology-based ventures. *Strategic Management Journal* 22(6-7), pp. 615-640.

Lee, C.H. 1986. *The British economy since 1700: A macro-economic perspective*. Cambridge: Cambridge University Press.

Lee, S. and Bozeman, B. 2005. The impact of research collaboration on scientific productivity. *Social Studies of Science* 35(5), pp. 673-702.

Lee, Y.S. 1996. Technology transfer and the research university: A search for the boundaries of university–industry collaboration. *Research Policy* 25(6), pp. 843-863.

Lehrer, M., Nell, P. and Garber, L. 2009. A national systems view of university entrepreneurialism: Inferences from comparison of the German and US experience. *Research Policy* 38(2), pp. 268-280.

Lesley, A. 2012. *Designing and doing survey research.* London: Sage Publications.

Lettl, C., Herstatt, C., Gemuenden, H.G. 2006. Users' contributions to radical innovation: Evidence from four cases in the field of medical equipment technology. *R&D Management* 36(3), pp. 251-272.

Leydesdorff, L. and Zawdie, G. 2010. The triple helix perspective of innovation systems. *Technology Analysis and Strategic Management* 22(7), pp. 789-804.

Li, H.L. and Tang, M.J. 2010. Vertical integration and innovative performance: The effects of external knowledge sourcing modes. *Technovation* 30(7-8), pp. 401-410.

Link, A.N. and Scott, J.T. 2003. U.S. science parks: The diffusion of an innovation and its effects on the academic mission of universities. *International Journal of Industrial Organization* 21(9), pp. 1323-1356.

Link, A.N., Siegel, D.S. and Bozeman, B. 2007. An empirical analysis of the propensity of academics to engage in informal university technology transfer. *Industrial and Corporate Change* 16(4), pp. 641-655.

Lissoni, F. 2001. Knowledge codification and the geography of innovation: The case of Brescia mechanical cluster. *Research Policy* 30(9), pp. 1481-1500.

LMW. 2011. *Two years in review: 2009-2011.* Cardiff: LMW.

LMW. 2012. *The impact of leadership and management development on organisations.* Cardiff: LMW.

Lockett, A., Wright, M. and Franklin, S. 2003. Technology transfer and universities' spin-out strategies. *Small Business Economics* 20(2), pp. 185-200.

Lorentzen, A. 2008. Knowledge networks in local and global space. *Entrepreneurship and Regional Development* 20(6), pp. 533-545.

Lucas, R. 1988. On the mechanics of economic development. *Journal of Monetary Economics* 22(1), pp. 3-42.

Lundvall, B-Å. 1992. *National systems of innovation: Towards a theory of innovation and interactive.* London: Pinter Publishers.

Lundvall, B-Å. and Borrás, S. 1997. *The globalising learning economy: Implications for innovation policy*. Brussels: European Commission.

Mac Naughton, G., Rolfe, S.A. and Siraj-Blatchford, I. 2001. *Doing early childhood research: International perspectives on theory and practice.* Australia: Allen & Unwin.

MacKenzie, N.G. and Zhang, Q. 2014. A regional perspective on the entrepreneurial university: Practices and policies. In: Fayolle, A. and Redford, D.T. eds. *Handbook on the entrepreneurial university.* Cheltenham: Edward Elgar, pp. 188-206.

MacKinnon, D., Cumbers, A. and Chapman, K. 2002. Learning, innovation and regional development: A critical appraisal of recent debates. *Papers in Human Geography* 26(3), pp. 293-311.

Maillat, D., Léchot, G., Lecoq, B. and Pfister, M. 1997. Comparative analysis of the structural development of milieux: The watch industry in the Swiss and French Jura Arc. In: Ratti, R., Bramanti, A. and Gordon, R. eds. *The dynamics of innovative regions: The GREMI approach.* Aldershot: Ashgate, pp. 109-137.

Malecki, E. 2002. Hard and soft networks for urban competitiveness. *Urban Studies* 39(5-6), pp. 929-945.

Malecki, E. 2004. Jockeying for position: What it means and why it matters to regional development policy when places compete. *Regional Studies* 38(9), pp. 1101-1120.

Malecki, E. 2007. Cities and regions competing in the global economy: Knowledge and local development policies. *Environment and Planning C: Government and Policy* 25(5), pp. 638-654.

Malecki, E.J. and Hospers, G.J. 2007. Knowledge and the competitiveness of places. In: Rutten, R. and Boekema, F. eds. *The learning regions: Foundations, state of the art, future.* Cheltenham: Edward Elgar, pp. 143-159.

Malmberg, A. and Maskell, P. 2006. Localized learning revisited. *Growth and Change* 37(1), pp. 1-18.

March, J. 1991. Exploration and exploitation in organizational learning. *Organization Science* 2(1), pp. 71-87.

Markman, G.D., Phan, P.H., Balkin, D.B. and Gianiodis, P.T. 2005. Entrepreneurship and university-based technology transfer. *Journal of Business Venturing* 20(2), pp. 241-263.

Markusen, A. 1996. Sticky places in slippery space: A typology of industrial districts. *Economic Geography* 72(3), pp. 293-313.

Marshall, A. 1920. *Principles of economics: An introductory volume.* London: McMillan.

Martin, B.R. and Etzkowitz, H. 2000. The origin and evolution of the university species. *Vest* 13(3-4), pp. 9-34.

Martin, R. 1988. The political economy of Britain's north-south divide. *Transactions of the Institute of British Geographers* 13(4), pp. 389-418.

Martin, R. 1993. Remapping British regional policy: The end of the north-south divide? *Regional Studies* 27(8), pp. 797-805.

Martinelli, A., Meyer, M. and von Tunzelmann, N. 2008. Becoming an entrepreneurial university? A case study of knowledge exchange relationships and faculty attitudes in a medium-sized, research-oriented university. *Journal of Technology Transfer* 33(3), pp. 259-283.

Maskell, P. 2001. Towards a knowledge-based theory of the geographical cluster. *Industrial and Corporate Change* 10(4), pp. 921-943.

Mazlish, B. 1998. *The uncertain sciences.* New Haven: Yale University Press.

McClelland, C. 1980. *State, society, and university in Germany 1700-1914.* Cambridge: Cambridge University Press.

McDowell, G. 2001. *Land-grant universities and extension into the 21st century: Renegotiating or abandoning a social contract.* Ames: Iowa State University Press.

McEvily, B. and Zaheer, A. 1999. Bridging ties: A source of firm heterogeneity in competitive capabilities. *Strategic Management Journal* 20(12), pp. 1133-1156.

Merriam, S.B. and Merriam, S.B. 1998. *Qualitative research and case study applications in education.* San Francisco: Jossey-Bass Publishers.

Merton, R.K. 1968. The Matthew Effect in science. *Science* 159(3810), pp. 56-63.

Mertens, D.M. 2005. *Research methods in education and psychology: Integrating diversity with quantitative and qualitative approaches.* Thousand Oaks: Sage.

Meyer-Krahmer, F. and Schmoch, U. 1998. Science-based technologies: University-industry interactions in four fields. *Research Policy* 27(8), pp. 835-851.

Miles, M. and Huberman, A. 1994. *Qualitative data analysis: An expanded sourcebook.* London: Sage Publications.

Mowery, D. and Sampat, B. 2005. The Bayh-Dole Act of 1980 and university-industry technology transfer: A model for other OECD governments? *Journal of Technology Transfer* 30(1-2), pp. 115-127.

Mowery, D. and Shane, S. 2002. Introduction to the special issue on university entrepreneurship and technology transfer. *Management Science* 48(1), pp. v-ix.

Mowery, D. and Ziedonis, A. 2001. The geographic reach of market and non-market channels of technology transfer: comparing citations and licenses of university patents. *NBER Working Paper* 8568.

Munari, F., Sobrero, M. and Malipiero, A. 2012. Absorptive capacity and localized spillovers: Focal firms as technological gatekeepers in industrial districts. *Industrial and Corporate Change* 21(2), pp. 429-462.

Murnane, R.J. and Willett, J.B. 2010. *Methods matter: Improving causal inference in educational and social science research.* New York: Oxford University Press.

Myers, M. 2009. *Qualitative research in business and management.* London: Sage Publications.

Nagle, M. 2007. Canonical analysis of university presence and industrial comparative advantage. *Economic Development Quarterly* 21(4), pp. 325-338.

Nedeva, M. and Boden R. 2006. Changing science: The advent of neo-liberalism. *Prometheus* 24(4), pp. 269-281.

Nelson, R. 1988. Institutions supporting technical change in the US. In: Dosi, G., Freeman, C., Nelson, R., Silverberg, G. and Soete, L. eds. *Technical change and economic theory*. London: Pinter, pp. 312-329.

Nelson, R.R. eds. 1993. *National innovation systems: A comparative analysis.* Oxford: Oxford University Press.

Neuman, W. 2000. *Social research methods: Qualitative and quantitative approaches.* Boston: Allyn & Bacon.

Newman, J. 1829. *The idea of a university* [Online]. Available at: http://www.newmanreader.org/works/idea/. [Accessed: 04 August 2014].

Nightingale, P. 1998. A cognitive model of innovation. *Research Policy* 27(7), pp. 689-709.

Niosi, J. 2006. Success factors in Canadian academic spin-offs. *Journal of Technology Transfer* 31(4), pp. 451-457.

Nonaka, I. and Takeuchi, H. 1995. *The knowledge-creating company.* Oxford: Oxford University Press.

Nooteboom, B. 2000. *Learning and innovation in organizations and economies.* Oxford: Oxford University Press.

Nooteboom, B., Van Haverbeke, W., Duysters, G., Gilsing, V. and van den Oord, A. 2007. Optimal cognitive distance and absorptive capacity. *Research Policy* 36(7), pp. 1016-1034.

O'Shea, R., Chugh, H. and Allen, T. 2008. Determinants and consequences of university spinoff activity: A conceptual framework. *Journal of Technology Transfer* 33(6), pp. 653-666.

Öberg, C. and Grundström, C. 2009. Challenges and opportunities in innovative firms' network development. *International Journal of Innovation Management* 13(4), pp. 593-613.

OECD. 2001. *Higher education management: Education and skills*. Paris: OECD.

OECD. 2008. *Main science and technology indicators (MSTI): 2008.* Paris: OECD.

Oliver, C. 1997. Sustainable competitive advantage: Combining institutional and resource-based views. *Strategic Management Journal* 18(9), pp. 697-713.

ONS. 2015. *Regional accounts.* [Online]. Available at: http://www.ons.gov.uk/ons/taxonomy/index.html?nscl=Regional+GVA. [Accessed: 4 September 2015].

Orlikowski, W.J. and Baroudi, J.J. 2001. Studying information technology in organizations: Research approaches and assumptions. *Information Systems Research* 2(1), pp. 2-28.

Oughton, C., Landabaso, M. and Morgan, K. 2002. The regional innovation policy paradox: Innovation policy and industrial policy. *Journal of Technology Transfer* 27(1), pp. 97-110.

Owen-Smith, J. and Powell, W. 2001. To patent or not: Faculty decisions and institutional success at technology transfer. *Journal of Technology Transfer* 26(1-2), pp. 99-114.

Owen-Smith, J. and Powell, W. 2004. Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community. *Organization Science* 15(1), pp. 5-21.

PACEC. 2008a. *A review of the SPIRIT demand-led knowledge exchange competition process.* Cambridge: PACEC.

PACEC. 2008b. *Welsh Assembly Government's evaluation of the knowledge exploitation fund.* Cambridge: PACEC.

PACEC. 2011. *Evaluation of the 2009/10 SPIRIT demand-led knowledge exchange funding programme. Progress report 2011.* Cambridge: PACEC.

PACEC. 2012a. *Evaluation of the 2009/10 SPIRIT demand-led knowledge exchange funding programme. Progress report 2012.* Cambridge: PACEC.

PACEC. 2012b. *Strengthening the contribution of English higher education institutions to the innovation system: knowledge exchange and HEIF funding*. Cambridge: PACEC.

Patel, P. and Vega, M. 1999. Patterns of internationalisation of corporate technology: Location vs. home country advantages. *Research Policy* 28(2-3), pp. 145-155.

Patton, M.Q. 2002. *Qualitative research and evaluation methods.* Thousand Oaks: Sage Publications.

Pavitt, K. 1984. Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy* 13(6), pp. 343-373.

Perkmann, M. and Walsh, K. 2007. University-industry relationships and open innovation: Towards a research agenda. *International Journal of Management Reviews* 9(4), pp. 259-280.

Peterson, R.B. 2005. Empirical research in international management: A critique and future agenda. In: Marschan-Piekkari, R. and Welch, C. eds. *Handbook of qualitative research methods for international business.* Cheltenham: Edward Elgar Publishing, pp. 25-55.

Phan, P.H. and Siegel, D.S. 2006. The effectiveness of university technology transfer: Lessons learned from qualitative and quantitative research in the US and UK. *Foundations and Trends in Entrepreneurship* 2(2), pp. 77-144.

Phelps, N.A., MacKinnon, D., Stone, I. and Braidford, P. 2003. Embedding the multinationals? Institutions and the development of overseas manufacturing affiliates in Wales and North East England. *Regional Studies* 37(1), pp. 27-40.

Piergiovanni, R., Santarelli, E. and Vivarelli, M. 1997. From which source do small firms derive their innovative inputs? Some evidence from Italian industry. *Review of Industrial Organization* 12(2), pp. 243-258.

Polanyi, M. 1966. *The tacit dimension.* New York: Doubleday and Company.

Ponomariov, B. 2008. Effects of university characteristics on scientists' interactions with the private sector: An exploratory assessment. *Journal of Technology Transfer* 33(5), pp. 485-503.

Porter, M.E 1979. How competitive forces shape strategy. *Harvard Business Review* 57(2), pp. 137-145.

Porter, M.E. 1990. *The competitive advantage of nations.* New York: Free Press.

Porter, M.E. and Ketels, C.H. 2003. *UK competitiveness: Moving to the next stage.* London: Department of Trade and Industry.

Porter, M.E. and Stern, S. 1999. *The new challenge to America's prosperity: Findings from the innovation index.* Washington, DC: Council on competitiveness.

Power, D. and Malmberg, A. 2008. The contribution of universities to innovation and economic development: In what sense a regional problem? *Cambridge Journal of Regions, Economy and Society* 1(2), pp. 233-245.

Powers, J.B. and McDougall, P.P. 2005. University start-up formation and technology licensing with firms that go public: A resource-based view of academic entrepreneurship. *Journal of Business Venturing* 20(3), pp. 291-311.

Rae-Dupree, J. 2008. When academia puts profit ahead of wonder. *New York Times* 7 September 2008.

Rasmussen, E. 2008. Government instruments to support the commercialization of university research: Lessons from Canada. *Technovation* 28(8), pp. 506-517.

Raspe, O. and van Oort, F. 2011. Growth of new firms and spatially bounded knowledge externalities. *Annals of Regional Science* 46(3), pp. 495-518.

Ratti, R., Bramanti, A. and Gordon, R. eds. 1997. *The dynamics of innovative regions: The GREMI approach.* Aldershot: Ashgate.

Reagans, R. and McEvily, B. 2003. Network structure and knowledge transfer: The effects of cohesion and range. *Administrative Science Quarterly* 48(2), pp. 240-267.

Renault, C.S. 2006. Academic capitalism and university incentives for faculty entrepreneurship. *Journal of Technology Transfer* 31(2), pp. 227-239.

Roberts, E. and Eesley, C. 2009. *Entrepreneurial impact: The role of MIT.* Cambridge, MA: MIT.

Roessner, J.D. 1993. What companies want from the Federal labs? *Issues in Science and Technology* 10(1), pp. 37-42.

Romer, P. 1986. Increasing returns and long-run growth. *Journal of Political Economy* 94(5), pp. 1002-1037.

Ronde, P. and Hussler, C. 2005. Innovation in regions: What does really matter? *Research Policy* 34(8), pp. 1150-1172.

Rubenstein, W.D. 1977. The Victorian middle classes: Wealth, occupation and geography. *Economic History Review* 30(4), pp. 602-623.

Rutten, R. and Boekema, F. eds. 2007. *The learning region: Foundations, state of the art, future.* Cheltenham: Edward Elgar.

Sainsbury, D. 2007. *The race to the top: A review of government's science and innovation policies.* London: HMSO.

Sampat, B., Mowery, D. and Ziedonis, A. 2003. Changes in university patent quality after the Bayh-Dole Act: A re-examination. *International Journal of Industrial Organization* 21(9), pp. 1371-1390.

Sapsford, R. 2007. *Survey research.* London: Sage Publications.

Saxenian, A. 1994. *Regional advantage: Culture and competition in Silicon Valley and Route 128.* Cambridge, MA: Harvard University Press.

Saxenian, A. 2005. From brain drain to brain circulation: Transnational communities and regional upgrading in India and China. *Studies in Comparative International Development* 40(1), pp. 35-61.

Schartinger, D., Rammer, C., Fischer, M.M. and Fröhlich, J. 2002. Knowledge interactions between universities and industry in Austria: Sectoral patterns and determinants. *Research Policy* 31 (3), pp. 303–328.

Scherer, F.M. 1986. *Innovation and growth: Schumpeterian perspectives.* Cambridge, MA: The MIT Press.

Scherer, F.M. 1991. Changing perspective on the firm size problem. In: Acs, Z.J. and Audretsch, D.B. eds. *Innovation and technological change: An international comparison.* Ann Arbor, MI: University of Michigan Press, pp. 24-38.

Schmitt-Egner, P. 2002. The concept of 'region': Theoretical and methodological notes on its reconstruction. Journal of European Integration 24(3), pp. 179-200.

Schumpeter, J. 1912. *The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle.* Cambridge, MA: Harvard University Press.

Schumpeter, J. 1939. *Business Cycles: A theoretical, historical, and statistical analysis of the capitalist process.* New York: McGraw-Hill.

Scotchmer, S. 2004. *Innovation and incentives.* Cambridge, MA: The MIT Press.

Scott, A. 1996. Regional motors of the global economy. *Futures* 28(5), pp. 391-411.

SFC. 2006. *Corporate plan 2006-09: Helping to deliver Scotland's strategy for the future.* Edinburgh: SFC.

SFC. 2010. *Horizon Fund: Call for knowledge exchange proposals addressing the needs of Scottish industry*. Edinburgh: SFC.

SFC. 2011. *Indicative main grants to colleges and universities for academic year 2011-12.* Edinburgh: Scottish Funding Council.

SFC. 2013. *Knowledge Transfer Grant consultation.* Edinburgh: SFC.

SG. 2009. *An overview of universities as a key economic sector.* Edinburgh: Scottish Government.

Shaw, B. 1985. The role of the interaction between the user and the manufacturer in medical equipment innovation. *R&D Management* 15(4), pp. 283-292.

Siegel, D.S., Waldman, D.A., Atwater, L.E. and Link, A.N. 2004. Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: Qualitative evidence from the commercialisation of university technologies. *Journal of Engineering and Technology Management* 21(1-2), pp. 115-142.

Siegel, D.S., Wright, M. and Lockett, A. 2007. The rise of entrepreneurial activity at universities: Organizational and societal implications. *Industrial and Corporate Change* 16(4), pp. 489-504.

Silverman, D. 2000. *Doing qualitative research: A practical handbook.* London: Sage Publications.

Simard, C. and West, J. 2006. Knowledge networks and the geographic locus of innovation. In: Chesbrough, H., Vanhaverbeke, W. and West, J. eds. *Open innovation: Researching a new paradigm.* Oxford: Oxford University Press, pp. 220-240.

Simmonds, P., Stroyan, J., Brown, N. and Horvath, A. 2010. *The impact of the EU RTD Framework Programme on the UK*. Brighton: Technopolis Ltd.

Smits, R. and Boon, W. 2008. The role of users in innovation in the pharmaceutical industry. *Drug Discovery Today* 13(7-8), pp. 353-359.

Solow, R. 1956. A contribution to the theory of economic growth. *Quarterly Journal of Economics* 70(1), pp. 65-94.

Sorenson, O., Rivkin, J.W. and Fleming, L. 2006. Complexity, networks and knowledge flow. *Research Policy* 35(7), pp. 994-1017.

SQW. 2009. *Evaluation of the knowledge transfer grant (KTG)*. London: SQW Limited.

Statistics Canada. 2003. *Survey methods and practices.* Ottawa: Statistics Canada.

Stiglitz, J. 1999. Knowledge as a global public good. In: Inge, K., Grunberg, I. and Stern, M. eds. *Global public goods: International cooperation in the 21st century.* New York: Oxford University Press, pp. 308-325.

Storper, M. 1995. The resurgence of regional economies, ten years later: The regions as a nexus of untraded interdependencies. *European Urban and Regional Studies* 2(3), pp. 191-222.

Storper, M. 1997. *The regional world.* New York and London: The Guilford Press.

Stuart, T. 2000. Interorganizational alliances and the performance of firms: A study of growth and innovation rates in a high-technology industry. *Strategic Management Journal* 21(8), pp. 791-811.

Tether, B. 2002. Who co-operates for innovation, and why: An empirical analysis. *Research Policy* 31(6), pp. 947-967.

Thursby, J.G. and Thursby, M.C. 2003. *University licensing under Bayh-Dole: What are the issues and evidence?* [Online]. Available at: http://opensource.mit.edu/papers/Thursby.pdf. [Accessed: 14 August 2014].

Thursby, J.G. and Thursby, M.C. 2011a. Faculty participation in licensing: Implications for research. *Research Policy* 40(1), pp. 20-29.

Thursby, J.G. and Thursby, M.C. 2011b. Has the Bayh-Dole act compromised basic research? *Research Policy* 40(8), pp. 1077-1083.

Tödtling, F. and Trippl, M. 2005. One size fits all? Towards a differential regional innovation policy approach. *Research Policy* 34(8), pp. 1203-1219.

Tornquist, K.M. and Kallsen, L.A. 1994. Out of the ivory tower: Characteristics of institutions meeting the research needs of industry. *Journal of Higher Education* 65(5), pp. 523-539.

Torrent, J. 2009. Knowledge, networks and economic activity: Revisiting the network effects in the knowledge economy. *Universitat Oberta de Catalunya Papers,* Issue 8, April 2009.

TSB. 2010. *Knowledge Transfer Partnerships strategic review: A report by Regeneris Consulting*. London: Technology Strategy Board.

Uzzi, B. 1996. The sources and consequences of embeddedness for the economic performance of organizations: The network effect. *American Sociological Review* 61(4), pp. 674-698.

Van den Hoonaard, W.C. 1997. *Working with sensitizing concepts: Analytical field research.* Thousand Oaks: Sage Publications.

Van Dierdonck, R., Debackere, K. and Engelen, B. 1990. University–industry relationships: How does the Belgian academic community feel about it? *Research Policy* 19(6), pp. 551-566.

Van Geenhuizen, M. 2008. Knowledge networks of young innovators in the urban economy: Biotechnology as a case study. *Entrepreneurship and Regional Development* 20(2), pp. 161-183.

Vega-Jurado, J., Gutiérrez-Gracia, A. and Fernández-de-Lucio, I. 2009. Does external knowledge sourcing matter for innovation? Evidence from the Spanish manufacturing industry. *Industrial and Corporate Change* 18(4), pp. 637-670.

Voisey, P., Anjorin-Ohu, O., Jones, P. and Thomas, B. 2011. A longitudinal study of 10 years of university pre-incubation in Wales. Paper presented at the *ISBE 2011 Conference.* Sheffield, 9-10 November, 2011.

von Hippel, E. 1976. The dominant role of users in the scientific instrument innovation process. *Research Policy* 5(3), pp. 212-239.

Vorley, T. and Nelles, J. 2009. Building entrepreneurial architectures: A conceptual interpretation of the third mission. *Policy Futures in Education* 7(3), pp. 284-296.

Voss, C.A. 1985. The role of uses in the development of applications software. *Journal of Product Innovation Management* 2(2), pp. 113-121.

WAG. 2008a. *Skills that work for Wales: A skills and employment strategy and action plan.* Cardiff: Welsh Assembly Government.

WAG. 2008b. *The leading edge for Welsh businesses – Enhancing leadership and management skills.* Cardiff: Welsh Assembly Government.

Washburn, J. 2008. *University Inc.: The corporate corruption of higher education.* New York: Basic Books.

Watts, H., Wood, A. and Wardle, P. 2003. Making friends or making things?: Interfirm transactions in the Sheffield metal-working cluster. *Urban Studies* 40(3), pp. 615-630.

Weiss, R.S. 1994. *Learning from strangers: The art and method of qualitative interview studies.* New York: Free Press.

Wellings, P. 2008. *Intellectual property and research benefits.* Lancaster: Lancaster University.

Whitley, R. 1992. *Business systems in East Asia: Firms, markets and societies.* London: Sage.

Wilson, T. 2012. *A review of business-university collaboration*. London: Department for Business, Innovation and Skills.

Witty, A. 2013. *Encouraging a British invention revolution. Sir Andrew Witty's review of universities and growth: Final report and recommendations.* London: Department for Business, Innovation and Skills.

Woerter, M. 2012. Technology proximity between firms and universities and technology transfer. *Journal of Technology Transfer* 37(6), pp. 828-866.

Wolson, R. 2007. Technology transfer in South African public research institutions. In: Krattiger, A., Mahoney, R.T. and Nelsen, L. eds. *Health and agriculture innovation: A handbook of best practices.* Oxford: MIHR, pp. 24-38.

Wood, J.C. 1991. *Joseph A. Schumpeter: Critical assessment.* London: Routledge.

Wright, M., Clarysse, B., Mustar, P. and Lockett, A. 2008. *Academic entrepreneurship in Europe.* Cheltenham: Edward Elgar.

Yin, R. 2009. *Case study research: Design and methods.* London: Sage Publications.

Yli-Renko, H. and Aitio, E. 1998. The network embeddedness of new, technology-based firms: Developing a systemic evolution model. *Small Business Economics* 11(3), pp. 253-267.

Youtie, J. and Shapira, P. 2008. Building an innovation hub: A case study of the transformation of university roles in regional technological and economic development. *Research Policy* 37(8), pp. 1188-1204.

Zaheer, A. and Bell, G. 2005. Benefiting from network position: Firm capabilities, structural holes, and performance. *Strategic Management Journal* 26(9), pp. 809-825.

Zhang, Q. and Pugh, R. 2011. Impact of government policy on universities: A critical analysis of Wales. Paper presented at the *Regional Studies Association Annual International Conference 2011.* Newcastle University, 17-20 April, 2011.

APPENDIX 1

List of the 133 Universities UK members

Name	University group	Region	Regional group
Anglia Ruskin University	New	East of England	Com
University of the Arts London	New	London	Com
Aston University	Est	West Midlands	UnCom
University of Bath	Est	South West	UnCom
Bath Spa University	New	South West	UnCom
University of Bedfordshire	New	East of England	Com
BirkBeck, University of London	Est	London	Com
University of Birmingham	Est	West Midlands	UnCom
Birmingham City University	New	West Midlands	UnCom
University of Bolton	New	North West	UnCom
Bournemouth University	New	South West	UnCom
University of Bradford	Est	Yorkshire and the Humber	UnCom
University of Brighton	New	South East	Com
University of Bristol	Est	South West	UnCom
Brunel University	Est	London	Com
University of Buckingham	Est	South East	Com
University of Cambridge	Est	East of England	Com

Name	University group	Region	Regional group
Canterbury Christ Church University	New	South East	Com
University of Central Lancashire	New	North West	UnCom
University of Chester	New	North West	UnCom
University of Chichester	New	South East	Com
City University London	Est	London	Com
Coventry University	New	West Midlands	UnCom
Cranfield University	New	East of England	Com
University of Crumbria	New	North West	UnCom
De Montfort University	New	East Midlands	UnCom
University of Derby	New	East Midlands	UnCom
Durham University	Est	North East	UnCom
University of East Anglia	Est	East of England	Com
University of East London	New	London	Com
Edge Hill University	New	North West	UnCom
University of Essex	Est	East of England	Com
University of Exeter	Est	South West	UnCom
University of Gloucestershire	New	South West	UnCom
Goldsmiths, University of London	Est	London	Com
University of Greenwich	New	London	Com
University of Hertfordshire	New	East of England	Com
Heythrop College	Est	London	Com
University of Huddersfield	New	Yorkshire and the Humber	UnCom
University of Hull	Est	Yorkshire and the Humber	UnCom
Imperial College London	Est	London	Com
Institute of Education	Est	London	Com

Name	University group	Region	Regional group
Keele University	Est	West Midlands	UnCom
University of Kent	Est	South East	Com
King's College London	Est	London	Com
Kingston University	New	London	Com
Lancaster University	Est	North West	UnCom
University of Leeds	Est	Yorkshire and the Humber	UnCom
Leeds Metropolitan University	New	Yorkshire and the Humber	UnCom
University of Leicester	Est	East Midlands	UnCom
University of Lincoln	New	East Midlands	UnCom
University of Liverpool	Est	North West	UnCom
Liverpool Hope University	New	North West	UnCom
Liverpool John Moores University	New	North West	UnCom
University of London	Est	London	Com
University College London	Est	London	Com
London Business School	Est	London	Com
London Metropolitan University	New	London	Com
London School of Economics and Political Science	Est	London	Com
London School of Hygiene and Tropical Medicine	Est	London	Com
London South Bank University	New	London	Com
Loughborough University	Est	East Midlands	UnCom
University of Manchester	Est	North West	UnCom
Manchester Metropolitan University	New	North West	UnCom
Middlesex University	New	London	Com
Newcastle University	Est	North East	UnCom
University of Northampton	New	East Midlands	UnCom

Name	University group	Region	Regional group
Northumbria University	New	North East	UnCom
University of Nottingham	Est	East Midlands	UnCom
Nottingham Trent University	New	East Midlands	UnCom
Open University	Est	South East	Com
University of Oxford	Est	South East	Com
Oxford Brookes University	New	South East	Com
Plymouth University	New	South West	UnCom
University of Portsmouth	New	South East	Com
Queen Mary, University of London	Est	London	Com
University of Reading	Est	South East	Com
University of Roehampton	New	London	Com
Royal Academy of Music	Est	London	Com
Royal Central School of Speech & Drama	New	London	Com
Royal College of Art	Est	London	Com
Royal College of Music, London	Est	London	Com
Royal Holloway, University of London	Est	South East	Com
Royal Veterinary College	Est	London	Com
University of Salford	Est	North West	UnCom
University of Sheffield	Est	Yorkshire and the Humber	UnCom
Sheffield Hallam University	New	Yorkshire and the Humber	UnCom
SOAS, University of London	Est	London	Com
University of Southampton	Est	South East	Com
Southampton Solent University	New	South East	Com
St George's, University of London	Est	London	Com
Staffordshire University	New	West Midlands	UnCom

Name	University group	Region	Regional group
University of Sunderland	New	North East	UnCom
University of Surrey	Est	South East	Com
University of Sussex	Est	South East	Com
Teeside University	New	North East	UnCom
Trinity Laban Conservatoire of Music and Dance	New	London	Com
University of Warwick	Est	West Midlands	UnCom
University of the West of England, Bristol	New	South West	UnCom
University of West London	New	London	Com
University of Westminster	New	London	Com
University of Winchester	New	South East	Com
University of Wolverhampton	New	West Midlands	UnCom
University of Worcester	New	West Midlands	UnCom
University of York	Est	Yorkshire and the Humber	UnCom
York St John University	New	Yorkshire and the Humber	UnCom
University of Aberdeen	Est	Scotland	UnCom
University of Abertay Dundee	New	Scotland	UnCom
University of Dundee	Est	Scotland	UnCom
University of Edinburgh	Est	Scotland	UnCom
Edinburgh Napier University	New	Scotland	UnCom
University of Glasgow	Est	Scotland	UnCom
Glasgow Caledonian University	New	Scotland	UnCom
Glasgow School of Art	Est	Scotland	UnCom
Heriot-Watt University	Est	Scotland	UnCom
Queen Margaret University	New	Scotland	UnCom
Robert Gordon University	New	Scotland	UnCom

Name	**University group**	**Region**	**Regional group**
University of St Andrews	Est	Scotland	UnCom
University of Stirling	Est	Scotland	UnCom
University of Strathclyde	Est	Scotland	UnCom
University of the West of Scotland	New	Scotland	UnCom
Aberystwyth University	Est	Wales	UnCom
Bangor University	Est	Wales	UnCom
Cardiff Metropolitan University	New	Wales	UnCom
Cardiff University	Est	Wales	UnCom
University of Glamorgan	New	Wales	UnCom
Glyndŵr University	New	Wales	UnCom
Swansea Metropolitan University	New	Wales	UnCom
Swansea University	Est	Wales	UnCom
University of Wales, Lampeter	Est	Wales	UnCom
University of Wales, Newport	New	Wales	UnCom
Queen's University Belfast	Est	Northern Ireland	UnCom
University of Ulster	Est	Northern Ireland	UnCom

Notes:

1. Universities are categorised as either new ('New') or established ('Est'); regions are categorised as either competitive ('Com') or uncompetitive ('Uncom').
2. Universities UK now has 132 members, one institution less than what we have included here. This is because, in 2012/13, two Welsh universities – University of Wales, Newport and University of Glamorgan – merged into University of South Wales. Since the merge took place after the period considered for data analysis, these two universities were still seen as individual institutions.

Source: Universities UK.

APPENDIX 2

Adaptation of the CBR academic survey

Region

Q1. For the purposes of this study, please refer to one of the following as your administrative "region".

O	East Midlands	O	Scotland
O	East of England	O	South East
O	London	O	South West
O	North East	O	Wales
O	North West	O	West Midlands
O	Northern Ireland	O	Yorkshire and the Humber

Position

Q2. What is your position within your institution?

O	Professor	O	Research Fellow, Research Associate
O	Reader, Senior Lecturer	O	Research Assistant, Teaching Assistant
O	Lecturer	O	Other (please specify)

Age

Q3. Please indicate your age group:

O	Under 30
O	30-39
O	40-49
O	50 and over

Gender

Q4. Please indicate your gender:

O	Male
O	Female

Subject

Q5. Please indicate your main subject area:

O Health Sciences	O Architecture, Building, Planning
O Biological Sciences	O Law, Social Sciences, Economics
O Chemistry	O Business, Financial Studies
O Veterinary Science, Agricultural Studies	O Languages
O Physicals, Astronomy, Earth Sciences	O Creative Arts
O Mathematics, Computing	O Education
O Engineering	O Other Humanities
O Materials Science	O Other mass communication and documentation
	O Other

Collaborative research

Q6. Have you engaged in the following activity with external organisations within the past three years? Please indicate whether you have engaged in the activity, and where applicable indicate the geographic location of the organisations involved.

	Engaged in activity?		Location of partner			
	Yes	No	Local area (10 miles)	Region	Rest of UK	Overseas
Joint research with external organisations (original work undertaken by both parties)	O	O	O	O	O	O

Contract research

Q7. Have you engaged in the following activity with external organisations within the past three years? Please indicate whether you have engaged in the activity, and where applicable indicate the geographic location of the organisations involved.

	Engaged in activity?		Location of partner			
	Yes	No	Local area (10 miles)	Region	Rest of UK	Overseas
Contract research with external organisations (original work undertaken by academic partner only)	O	O	O	O	O	O

Consultancy research

Q8. Have you engaged in the following activity with external organisations within the past three years? Please indicate whether you have engaged in the activity, and where applicable indicate the geographic location of the organisations involved.

	Engaged in activity?		Location of partner			
	Yes	No	Local area (10 miles)	Region	Rest of UK	Overseas
Consultancy services (no original research undertaken)	O	O	O	O	O	O

F&E related services

Q9. Have you engaged in any of the following activities with external organisations within the past three years? Please indicate whether you have engaged in the activity, and where applicable indicate the geographic location of the organisations involved.

	Engaged in activity?		Location of partner			
	Yes	No	Local area (10 miles)	Region	Rest of UK	Overseas
Prototyping and testing for external organisations	O	O	O	O	O	O
Setting up new physical facilities with funding from external organisations (such as labs, campus building etc.)	O	O	O	O	O	O

Courses for business

Q10. Have you engaged in any of the following activities with external organisations within the past three years? Please indicate whether you have engaged in the activity, and where applicable indicate the geographic location of the organisations involved.

	Engaged in activity?		Location of partner			
	Yes	No	Local area (10 miles)	Region	Rest of UK	Overseas
Training company employees through teaching or personnel exchange	O	O	O	O	O	O
Joint curriculum development with external organisations	O	O	O	O	O	O
Involvement with Enterprise Education	O	O	O	O	O	O

IP-related activities

Q11. How frequently, if at all, have you participated in any of the following in the past three years?

	Very frequently (7+ times)	Frequently (3-6 times)	Infrequently (1-2 times)	Never
Licensed research outputs to a company	O	O	O	O
Formed a spin out company	O	O	O	O

Private sector companies

Q12. Have you undertaken activities with private sector companies in the last three years?

O	Yes
O	No

Public sector organisations

Q13. Have you undertaken activities with any public sector organisations in the past three years?

O	Yes
O	No

Third sector organisations

Q14. Have you engaged in activities with any charitable or voluntary organisations in the past three years?

O	Yes
O	No

APPENDIX 3

Adaptation of the CBR business survey

Region

Q1. For the purposes of this study, please refer to one of the following as your administrative "region".

O	East Midlands	O	Scotland
O	East of England	O	South East
O	London	O	South West
O	North East	O	Wales
O	North West	O	West Midlands
O	Northern Ireland	O	Yorkshire and the Humber

Size

Q2. Please indicate the size of your firm:

O	SMEs (more than 5 but less than 250 full time employees)
O	Large (more than 250 full time employees)

Sector

Q3. Please indicate the industrial sector of your firm:

O	Mining and quarrying	O	Retail trade and repair
O	Food, clothing, wood, paper, publishing and printing	O	Hotels and restaurants
O	Fuels, chemicals, plastics, metals and minerals	O	Transport and storage
O	Electrical and optical equipment	O	Post and courier activities
O	Manufacturing of transport equipment	O	Telecommunications
O	Manufacturing not elsewhere classified	O	Financial intermediation
O	Electricity, gas and water supply	O	Real estate
O	Construction	O	Renting
O	Wholesale and commission trade	O	Computer and related activities
O	R&D (natural sciences)	O	Architectural and engineering
O	R&D (social sciences)	O	Technical testing and analysis
		O	Other business activities

Source of knowledge

Q4. Please indicate the sources of knowledge or information used, and their degree of importance in your innovation activities in the last three years.

	Not used (0)	Not important at all (1)	Slightly important (2)	Somewhat important (3)	Important (4)	Highly important (5)
Within the firm or group	0	0	0	0	0	0
Suppliers of equipment, materials, services or software	0	0	0	0	0	0
Clients or customers	0	0	0	0	0	0
Competitors or other firms in your line of business	0	0	0	0	0	0
Consultants	0	0	0	0	0	0
Commercial labs and private R&D enterprises	0	0	0	0	0	0
Higher Education Institutions	0	0	0	0	0	0
Government or public research organisations	0	0	0	0	0	0
Technical standards or standard setting bodies	0	0	0	0	0	0
Conferences, trade fairs, exhibitions	0	0	0	0	0	0
Trade and technical press, computer databases	0	0	0	0	0	0
Professional and industry networks and associations	0	0	0	0	0	0

Collaborative research

Q5. Has your firm engaged in the following activity with Higher Education Institutions (HEIs) within the last three years? Please indicate whether the firm has engaged in the activity, and where applicable indicate the geographic location of HEIs involved.

	Engaged in activity?		Location of partner				
	Yes	No	Local area (10 miles)	Your admin. region	Rest of the UK	Rest of Europe	Rest of the world
Joint research with academics/HEIs (original research work undertaken by both partners)	O	O	O	O	O	O	O

Contract research

Q6. Has your firm engaged in the following activity with Higher Education Institutions (HEIs) within the last three years? Please indicate whether the firm has engaged in the activity, and where applicable indicate the geographic location of HEIs involved.

	Engaged in activity?		Location of partner				
	Yes	No	Local area (10 miles)	Your admin. region	Rest of the UK	Rest of Europe	Rest of the world
Contract research by academics/HEIs (original research work done by HEIs)	O	O	O	O	O	O	O

Consultancy research

Q7. Has your firm engaged in the following activity with Higher Education Institutions (HEIs) within the last three years? Please indicate whether the firm has engaged in the activity, and where applicable indicate the geographic location of HEIs involved.

	Engaged in activity?		Location of partner				
	Yes	No	Local area (10 miles)	Your admin. region	Rest of the UK	Rest of Europe	Rest of the world
Consultancy services by academics/HEIs (no original research is undertaken)	O	O	O	O	O	O	O

F&E related services

Q8. Has your firm engaged in any of the following activities with Higher Education Institutions (HEIs) within the last three years? Please indicate whether the firm has engaged in the activity, and where applicable indicate the geographic location of HEIs involved.

	Engaged in activity?		Location of partner				
	Yes	No	Local area (10 miles)	Your admin. region	Rest of the UK	Rest of Europe	Rest of the world
Use of HEIs for prototyping and testing	O	O	O	O	O	O	O
Joint creation of physical facilities of HEIs (such as new labs, etc)	O	O	O	O	O	O	O

Courses for business

Q9. Has your firm engaged in any of the following activities with Higher Education Institutions (HEIs) within the last three years? Please indicate whether the firm has engaged in the activity, and where applicable indicate the geographic location of HEIs involved.

	Engaged in activity?		Location of partner				
	Yes	No	Local area (10 miles)	Your admin. region	Rest of the UK	Rest of Europe	Rest of the world
Training staff through enrolment on HEI courses or through personnel exchange	O	O	O	O	O	O	O
Joint curriculum development with HEIs	O	O	O	O	O	O	O
Involvement with Enterprise Education	O	O	O	O	O	O	O

IP-related activities

Q11. How frequently, if at all, has your firm undertaken any of the following in the past three years?

	Never	Infrequently (1-2 times)	Frequently (3-6 times)	Very frequently (7+ times)
Acquisition of patents and licences owned by HEIs	O	O	O	O
Collaboration with a spin-out firm formed by an HEI to exploit research	O	O	O	O

APPENDIX 4

Average income of knowledge exchange activities of Welsh universities, 2008/09 to 2010/11, per academic FTE, £000s

Institution	Collaborative research	Contract research	Consultancy research	Courses for business	Regeneration and development	Licensing and sales of shares in spin-offs	Turnover of active spin-offs	Turnover of active start-ups
Aberystwyth University	7.90	**15.07**	0.38	2.19	3.54	0.29	8.06	0.38
Bangor university	8.53	9.02	4.01	3.63	2.36	0.24	5.36	5.06
Cardiff University	6.99	5.65	2.15	**10.70**	1.76	**0.65**	**9.24**	10.35
Cardiff Metropolitan University[1]	1.90	1.87	**5.17**	3.28	0.64	0.01	0.04	0.00
Glyndŵr University	4.50	4.39	0.34	2.28	2.11	0.00	0.00	0.00
Swansea University	**25.52**	2.24	2.41	2.27	4.55	0.01	1.44	1.84
Swansea Metropolitan University	1.93	0.00	0.90	2.28	3.58	0.00	4.64	18.26
Trinity University College	0.00	0.00	1.09	3.35	0.79	0.00	3.42	3.20
University of Glamorgan[2]	2.00	0.33	1.51	5.97	2.56	0.02	2.97	**28.22**
University of Wales, Lampeter	0.00	2.14	0.36	0.02	2.40	0.00	1.70	5.78
University of Wales, Newport	1.01	0.17	4.28	1.88	**9.34**	0.01	0.26	0.00
University of Wales Trinity Saint David[3]	0.00	0.57	0.32	1.10	2.07	0.00	0.74	1.89

Wales	8.63	4.98	2.30	5.96	2.80	0.29	5.39	8.41

Notes:

1. University of Wales Institute, Cardiff renamed itself as Cardiff Metropolitan University in 2010/11, a change that did not impact the data analysis in this table.
2. The merger of the University of Glamorgan and University of Wales, Newport in 2013 to form the University of South Wales was not taken into account as it took place after the data collection periods.
3. In 2010/11, University of Wales, Lampeter merged with Trinity University College and subsequently changed its name to University of Wales Trinity Saint David. Therefore, for the case of University of Wales Trinity Saint David, only the data of 2010/11 was available and included here. For University of Wales, Lampeter and Trinity University College, the income was an average of their financial performance in the first two years – 2008/09 and 2009/10.

Source: Author's elaboration from HEFCE (2010), HFECE (2011a), and HFECE (2012).

APPENDIX 5

Sample of interview questions

Question to Mr./Ms.	N/A
Title	Director
Organisation	Leadership & Management Wales (LMW)
Date	03 January, 2013

Background

1) How was the Centre established?
2) What were the main considerations to bring about this programme?
3) How is the Centre funded? In what ways is the Centre affiliated with Cardiff University?
4) What are the main objectives of the Centre?

Operation

5) What are the main activities undertaken by the Centre to reach out to business?
6) How does the Centre bring the awareness of the importance of leadership and management skills to firms?
7) How does the Centre get involved with firms in the first place, and then invite them to the relevant workshops?

Co-ordination

8) What are the relationships between the Centre and the training service providers that run the workshops for firms?

9) How are the training providers selected and how does the Centre co-ordinate the activities?
10) When were the local offices established? What were the main considerations of their foundation? How does the Centre co-ordinate the offices around Wales?

Collaboration

11) What are the main characteristics of the firms that attend the workshops provided by the Centre? Are they more likely to be large firms or SMEs? Are they distributed across sectors?
12) What are the geographical characteristics of the firms that attend the workshops? Is that anything to do with the Centre's mission statements?

Impact

13) For those businesses, in particular micro firms, who have attended the workshops, how have the events been received?
14) How does the Centre monitor the impact of its services to firms? Is there any follow up study to examine that area?
15) What has been the wider impact of the Centre on promoting the ideas of leadership and management skills?

Future perspectives

16) What has been the main factor driving the success of the Centre?
17) What is the biggest challenge?
18) What do you think is the role of the Centre in the next 3 years?