The Determinants of University Spinout Formation and Survival: The UK Context of Network, Investment, and Management Team Effects

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Abstract

UK universities attract increasing attention from policy-makers searching for regional solutions to economic development challenges. Consequently, university spinout companies have featured prominently in UK policy-making, as they embody a transfer of knowledge of the most complex and comprehensive character. However, whilst the positive contribution of spinout companies to regional economies is widely accepted, little is known of how to ensure high quality outcomes from such knowledge commercialisation activities. This thesis aims to improve the understanding of this problem by examining the elements that contribute to the success of academic spinouts in the UK context. It investigates dual meaning of success: spinout formation and survival, conceptualised here as embedded in university networks composed of multiple actors. It is set within a post-positivistic paradigm and employs an explanatory sequential mixed methods research design. The quantitative part identifies the elements contributing to the success of spinout companies using data on 870 spinout companies extracted from university websites and supplemented with financial, economic and educational databases; and leads to the qualitative part, explaining differential performance of spinout companies across UK regions with data collected through semi-structured interviews conducted at four illustrative university networks. It is found that the success of spinout companies depends on networks, investment, and management teams. However, the formation and survival of spinout companies differs across a number of elements: technology transfer offices, business incubators, other actors, and geography; suggesting bi-dimensional complexity across space and success measures. The variable spatial performance of university networks determining spinout company outcomes is explained by connectedness, filtration and time: successful spinout companies originate from university networks that have capability to build and exploit network capital. It is suggested that regional innovation systems require designs oriented towards these diverse spinout success outcomes, formation and survival-based, with strong local adaptations.

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List of Abbreviations

AF	Academic Founder
AG	Aggregate Constraint
AIM	Alternative Investment Market
BA	Business Angels
BI	Business Incubator
BI	Business Incubator
C	Constraint
CEO	Chief Executive Officer
CSO	Chief Scientific Officer
CV	Curriculum Vitae
DC	Dynamic Capabilities
EU	European Union
FAME	Financial Analysis Made Easy
FTE	Full-Time Equivalent
GDP	Gross Domestic Product
GVA	Gross Value Added
HEBCIS	Higher Education Business and Community Interaction Survey
HEFCE	Higher Education Funding Council for England
HEI	Higher Education Institution
HERCM	High End Research Critical Mass
HESA	Higher Education Statistics Agency
IP	Intellectual Property
IPO	Initial Public Offering
IT	Information Technology
KBV	Knowledge-Based View
LBI	London Business Incubator
LR	Learning Region
LU	London University
M&A	Merger and Acquisition
MBI	Midlands Business Incubator
MC	Marginal Cost
MD	Managing Director
MIT	Massachusetts Institute of Technology
MR	Marginal Revenue
MT	Management Team
MU	Midlands University
NAFTA	North American Free Trade Agreement
NEG	New Economic Geography
NOS	Number of Submissions
NSI	National Systems of Innovation
NUTS	Nomenclature of Territorial Units for Statistics
ONS	Office for National Statistics
PhD	Doctor of Philosophy
PRO	Public Research Organisation
R&D	Research and Development

RAE	Research Assessment Exercise
RBV	Resource-Based View
REF	Research Excellence Framework
RIS	Regional Innovation Systems
RO	Research Outputs
SIC	Standard Industrial Classification
SME	Small and Medium Enterprise
SNA	Social Network Analysis
SU	Scottish University
TH	Triple Helix
TTO	Technology Transfer Office
UK	United Kingdom
UNI%SCIE	University Science Orientation
URL	Uniform Resource Locator
US	United States
USP	Unique Selling Point
VC	Venture Capital
WU	Welsh University
WWII	World War Two

Chapter 1

Introduction

1.1 University knowledge commercialisation in a region

Although there is a clear consensus between government and academia on universities' important role in regional economic development (Schmuecker and Cook 2012; Department for Business Innovation and Skills 2014), a pivotal question remains as to how universities contribute to regional economic development, especially given the role of knowledge in literatures of endogenous growth theory (Kaldor 1957; Romer 1986; Lucas 1988; Jaffe 1989; Adams 1990). Importantly, universities perform a number of roles in their regional economic environments: as employers for the local labour force; as consumers of products and services from predominantly regional firms; as institutions increasing skills and knowledge of the regional, national and global labour force; as generators of knowledge; and through engagement in local, regional and national entrepreneurial activities.

As universities are spatially fixed, they become perceived as 'anchor institutions' (Schmuecker and Cook 2012; Taylor 2016) with their increasingly critical role redefining regional policymaking (Brown 2016). Universities are firmly embedded in regional knowledge networks, with firms and government co-creating such structures (Cooke 1992; Lundvall 1992; Storper 1993; Florida 1995; Asheim 1996; Morgan 1997; Etzkowitz and Leydesdorff 2000). Consequently, businesses participate in knowledge spillovers from universities (Romer 1986) that stimulate their innovation activity, translating into regional competitiveness outcomes (Huggins et al. 2014). However, it remains necessary to understand the exact architectures of such knowledge networks in determining regional economic development results. Whilst Cooke (1992) identified the importance of adaptation of such setups to regional conditions, there remains limited knowledge of how such a complex task can be achieved. Specifically, it is not clearly understood which regional actors at which stage of firm development regulate firm success. This thesis aims to investigate this link by examining the determinants of success of high technology ventures - university spinout companies, in the UK context.

Recent UK policy emphasis has been clearly steered towards promoting a model of utilisation of university knowledge through collaboration with the business community (Science and Technology Committee 2013; Department for Business Innovation and Skills 2014; Dowling 2015), to improve innovation capabilities of domestic industry, especially of small firms, which typically source knowledge from more proximate universities (Hewitt-Dundas 2013). However, there has been relatively low uptake of such opportunities (Dowling 2015), reduced public funding for universities, and radical policy shifts in this area (Schmuecker and Cook 2012).

Part of the reason for such policy disorientation may be found in inadequate measurement of universities' roles in their respective regional economies (Kitson et al. 2009), with the newly proposed measures further contributing to the problem of competition type comparisons, for example, publishing effectiveness and efficiency indicators of university technology transfer offices (Dowling 2015). Consequently, current centralisation activities orchestrated by the UK government expose a critical lack of understanding of regional differences in university commercialisation activities, oversimplifying geographic effects (Bristow 2005), where regional idiosyncratic contexts are better able to shape innovation systems alongside their strengths (Schmuecker and Cook 2012). These differences are clearly observable from works studying regional innovation networks (Huggins and Prokop 2016) or competitiveness (Huggins et al. 2014).

Whilst university roles are most exemplified by creating knowledge and increasing the ability of a labour force to utilise it, direct and conscious involvement in economic development activities is a relatively recent phenomenon (Etzkowitz and Leydesdorff 2000), signifying university's transition to an entrepreneurial mode (Etzkowitz et al. 2000). This has been specifically attributed to shifts in ownership of university-generated intellectual property (IP) from individuals to the institutions employing them, attributed to the US Bayh-Dole Act 1980 (Grimaldi et al. 2011) inspiring other countries, including the UK, to employ similar IP ownership practices. The meaning of such changes can be observed in the increasing orientation

of universities towards working with industry, and industry with universities (Huggins et al. 2015a, b).

It is critical to note that knowledge created at universities resides within the academics responsible for generating it. Such knowledge has a tacit character (Nonaka 1991, 1994) and remains difficult for others to acquire. Being able to disseminate it to a wider pool of regional 'knowledge consumers' necessitates translation processes and the developed absorptive capacity among knowledge users (Cohen and Levinthal 1990) to capture its economic value through innovation. However, some knowledge remains difficult to 'consume', especially knowledge that is very complex or new, turning universities into repositories of otherwise 'indigestible' knowledge and unrealised innovation and economic potential. One way of releasing such knowledge is to involve its creator - an academic, in knowledge consumption, to directly stimulate the innovative potential of university research. This possibility is offered through a vehicle of a university spinout company.

University spinout companies are one of the key mechanisms for universities to engage in regional economic development, allowing more direct and tangible involvement in such processes (Bower 2003). Dasgupta and David (1994) argue that commercialising university knowledge is a difficult process, as it involves the transfer of tacit and codified knowledge in order to achieve full economic potential. This attribute makes university spinout companies the most effective form of university-generated knowledge transfer, given their ability to envelop both codified and tacit elements of knowledge in a single form. This challenging character attracts both hope of economic impact through the creation of highly-skilled employment opportunities (Shane 2004b), and critique, as universities devote disproportionate amounts of attention to spinout companies (Lambert 2003), which may have limited effects as many remain small businesses (Harrison and Leitch 2010).

The resultant scholarly focus on spinout companies asserted the need to better understand how such companies are formed in the first place (e.g. Harmon et al. 1997; Franklin et al. 2001; Di

Gregorio and Shane 2003; Lockett and Wright 2005; Landry et al. 2006), revealing a continuous interest of academic entrepreneurship scholars (e.g. Bradley et al. 2013; Ramaciotti and Rizzo 2014; Berbegal-Mirabent et al. 2015; Fini et al. 2017). However, given the role played by universities in their respective regional and local environments, it remains unclear as to how such firms prosper beyond registration. Although there is a growing body of research examining the performance of spinout companies (Walter et al. 2006; Clarysse et al. 2007; Van Geenhuizen and Soetanto 2009; Bonardo et al. 2011; Ortín-Ángel and Vendrell-Herrero 2014; Scholten et al. 2015), studies that attempt to understand the survival of spinouts are few in number (Nerkar and Shane 2003; Criaco et al. 2014), based on limited samples (less than 200), and do not examine the UK context (Nerkar and Shane (2003) study spinouts from MIT (Massachusetts Institute of Technology) in US, whilst Criaco et al. (2014) investigate Catalan spinouts).

This thesis is focused on the UK for a number of reasons, and has several implications. Firstly, the UK is one of the few countries where academic entrepreneurship studies have grown in volume, constituting strong foundations to build upon. This is reflected in a significant activity at universities to generate academic spinout companies. As a result, researching UK academic spinouts offers increased validity of findings. Secondly, the Higher Education Funding Council for England (HEFCE) has been collecting data on university knowledge commercialisation activity since 1999, representing a country with consecutive governments (first Labour, then the Conservative-Liberal Democrat coalition) maintaining interest in the complex role of universities in their regional economies. This indicates that policymakers are not indifferent to the economic development outcomes derived from the creation of academic spinout companies. Thirdly, the UK has a strong financial sector, which is an important ingredient for entrepreneurship to thrive, especially for the risky high-technology-based form represented by academic spinout company.

This research is set within core theoretical works on regional innovation systems (Cooke 1992; Lundvall 1992; Storper 1993; Florida 1995; Asheim 1996; Morgan 1997; Etzkowitz and

Leydesdorff 2000), which posit that regional economic development is dependent on a collaboration of actors representing private industry (entrepreneurs, investors), universities, and government (or policymakers). In the case of academic spinout companies, these ventures exist within structures that are part of regional innovation systems. However, these structures are university-centric, as universities pursue independent approaches to their knowledge commercialisation. Therefore, these structures are referred to here as university networks, composed of regions, universities (technology transfer offices), spinout companies, academic founders, investors, management teams, business incubators, and other actors. As this thesis is interested in the success of academic spinouts from university networks, it combines literatures on firm theory and survival to better understand the complexity of the problem at hand.

Therefore, given the UK government's interest in university research commercialisation, three major problems facing UK spinout companies are addressed in this thesis: 1) lack of large sample studies; 2) unknown determinants of spinout survival; and 3) lack of understanding of regional effects on spinout activity. Furthermore, as knowledge is transmitted within dense regional networks (Huggins and Prokop 2016), it becomes critical to understand how various network actors participate in the formation and developmental processes of spinout companies, and how this affects the success of these firms. This thesis aims to identify determinants of spinout company success by studying their university networks. Success is defined through two modes: spinout formation (i.e. birth) and survival (i.e. avoidance of death).

1.2 Research questions and objectives

The aim of this study is to examine success determinants of spinout companies by focusing on elements of university networks. This is achieved by pursuing the following objectives: 1) investigation of determinants of success of spinout companies; 2) identification of regional differences of spinout company success; and 3) examination of the role and effects of networks on spinout success. In order to meet these three objectives, a sequential explanatory mixed methods design was used, incorporating quantitative and qualitative studies of spinout company success. Given the limited knowledge on spinout company success, the comprehensive

approach adopted here is appropriate, particularly due to greater alignment with the pursuit of objective reality, given the triangulation of methods employed, embedded in a post-positivistic research paradigm, as compared to more restrictive single method studies.

This complex methodological approach has been selected to answer the following research question:

What are the key elements contributing to the success of academic spinouts?

In order to provide a comprehensive answer, three additional sub-questions are investigated:

a) What are the factors influencing university spinout formation rates and differences across the UK regions?

b) What are the factors conditioning survival rates of academic spinouts and differences across the UK regions?

c) What are the characteristics of UK regional university networks, and do differences across regions enable or inhibit formation and survival of academic spinouts?

The research questions are answered through three empirical chapters (Chapter 5, Chapter 6, and Chapter 7), with the synthesis of findings in Chapter 8 offering an answer to the core question, as described below.

Two quantitative chapters (5 and 6) examine firstly the success of UK academic spinouts through bivariate analysis, and secondly adopt a multivariate approach to answer questions a) and b) and offer a partial consideration of question c). The analyses conducted in these two chapters consider university network elements: regions, universities (technology transfer offices), spinout companies, academic founders, investors, management teams, business incubators, and other actors, and their effect on spinout company success across all UK regions. Crucially, this investigates two success modes: formation and survival. The formation-based approaches adopt the university as a unit of analysis, whilst survival-oriented approaches use the spinout company as the unit of analysis. The importance of such an analytical approach can be observed from the findings, which report a different combination of university network elements in explaining spinout company formation and survival.

First in Chapter 5, bivariate analysis addresses associations between university network elements and spinout company success, offering a detailed perspective that disregards all other factors. It is found that spinout formation is related to a combination of university network elements, whilst the survival of a spinout requires a broader network environment as well, outlining presence of spatial effects. This means that spinout company survival is greater in more economically developed regions.

Given the limitations of bivariate analysis, which does not control for the influence of other factors, multivariate analysis presented in Chapter 6 uncovers further interesting results. The chapter builds two regression models of university networks, which test spinout company formation and survival. From the analysis, it appears that spinout formation is related to a different combination of factors than that of spinout survival outcomes across the network typology of actors: university network, and broader network environment. In particular, geographical effects can be observed across both success modes, although with different meanings. Spinout company formation is more pronounced in less developed regions, whilst survival in better developed ones.

Finally, qualitative Chapter 7 provides an answer to question c), completing the comprehensive approach applied by the thesis. Whilst the chapter provides illustrative examples of existing UK university networks from: Scotland, the Midlands, London, and Wales, through adopted sampling it studies extreme cases, contributing a critical insight into network processes across and within regions. The research underlying Chapter 7 is based on interviews with university network actors: representatives of spinout companies (management teams); senior representatives of technology transfer offices; directors of business incubators; and senior executives from the venture capital community. It is found that university networks differ in their architectures, with some utilising the strengths of their regions, whilst others struggling to overcome the restrictive effects of periphery. In order to combat negative spatial effects, unfavourably positioned university networks develop more distance unconstrained connections

across regions. Although this chapter provides merely illustrative examples, it offers an explanation for the quantitative findings.

1.3 Structure of the thesis

Chapter 2 introduces the university spinout company, specifically placing it within the literatures of academic entrepreneurship and firm theory. The chapter aims to provide background to the study by explaining the existence of spinout companies. In so doing, it discusses definitional issues, spinout company growth stages, academic entrepreneurial intentions, and firm theories. It concludes that a university spinout company is a unique type of firm that lacks a pertinent singular theoretical lens to explain its existence. Consequently, existing firm theorisations allow understanding of different aspects of spinout companies in a university network context.

Chapter 3 discusses the determinants of spinout company success by reviewing extant literatures on spinout company formation, firm survival and regional economic development, given the limited scholarly research on spinout company survival. The chapter examines different characteristics that explain firm survival, by investigating factors that occupy different network space: university networks and the broader network environment. The chapter concludes with a conceptual model and identification of particular research gaps.

The methodology adopted in this thesis is outlined in Chapter 4. It starts with the research questions pursued and explains the research paradigm the study is set within, namely post-positivism. The chapter explains the research design used, in particular the appropriateness and comprehensiveness of explanatory sequential mixed methods. The chapter then offers a detailed view of two approaches adopted: quantitative and qualitative. Within the quantitative section, data collection, sample selection, and analytical approach are explained. The section ends with a list of variables used in the pertinent analyses, explaining the construction of each measure used in the thesis. In the qualitative section, information on sampling, data collection and analytical

approach is clearly outlined. The chapter ends with a description of limitations, issues of generalisability, validity and reliability, and a statement on the ethics of the study.

The first quantitative analysis is contained in Chapter 5, which describes the characteristics of the variables and examines bivariate associations between spinout company formation, survival, and explanatory variables. In particular, this chapter adopts a distinction between variables that characterise university networks and the broader network environment, and is structured accordingly. The chapter begins by discussing university network characteristics that influence spinout company formation and survival, followed by a section that investigates broader network environment of spinout success. It is found here that spinout company formation is determined by elements that constitute university networks, yet spinout survival is related to aspects of both university networks and the broader network environment. Consequently, the chapter finds limited evidence for spatial effects, except for economic development and the survival of spinout companies.

In Chapter 6 a more comprehensive quantitative analytical approach is adopted by controlling for a number of factors associated with university networks, leading to interesting findings on spinout company success. Unlike Chapter 5, this chapter aims to take a more holistic view by building models that are composed of the characteristics of both university networks and the broader network environment. Consequently, the chapter is structured around two success modes: spinout company formation and survival. In the first part, negative binomial regression is used to explore factors that influence spinout company formation, whilst in the second part, logistic regression is performed to examine spinout company survival. The results indicate that spinout formation and survival require different configurations of university network elements. Furthermore, geographical effects are found to have a paradoxical character on spinout company success, with less developed regions proving more fertile ground for spinout formation, whilst better developed regions improve the survival outcomes of spinouts.

Chapter 7 provides qualitative empirical findings by looking at four illustrative examples of university networks: the Scottish University Network, the Midlands University Network, the London University Network, and the Welsh University Network. The chapter starts by introducing each university network, leading to detailed description of the four unique examples. Chapter 7 identifies success factors that typify spinout company formation and survival. In particular, as a consequence of the in-depth approach adopted here, it finds that university networks are characterised by different architectures. Specifically, peripherally positioned university networks may overcome their locational disadvantages by improving the reach of their networks across regional boundaries. In effect, the chapter points to idiosyncratic regional differences that require consideration in designing university networks. The chapter concludes by identifying three dimensions of success in spinout companies: filtration, connectedness, and time.

Finally, Chapter 8 concludes the thesis. It begins with a synthesis of quantitative and qualitative findings across the conceptualised university network elements, indicating the implications of the results observed. Furthermore, the chapter explains the contributions of this research, in particular to theory, methodology, and policy. Specifically, this thesis has contributed to improved understanding of spinout company success by exploring university network elements. The chapter ends by making recommendations for future studies, and describing the major limitations of this thesis.

Chapter 2

University spinout companies: origins, definition, development, existence

The key aim of this chapter is to explain the existence of university spinout companies, with a particular focus on the formation of such firms. Consequently, the chapter expounds the origins of university spinout companies, introducing definitional clarity and idiosyncratic developmental stages, and the entrepreneurial intentions of academic staff. This is followed by a review of existing major theories of the firm and how these contribute to understanding spinout companies, with the limitations uncovered pointing to the uniqueness of these firms.

The chapter is structured as follows: Section 2.1 provides an overview of the background to university spinout company emergence; definitions used in the literature and this thesis; stages of spinout development; how these firms are formed by non-commercially-oriented entrepreneurs; and their success characteristics inferred from firm survival literature. Section 2.2 takes on a challenge of explaining the existence of spinout companies with major theories of the firm, in particular engaging with transaction costs, managerial theory, resource-based view, knowledge-based view, and dynamic capabilities. Finally, the chapter draws conclusions in Section 2.3.

2.1 Understanding university spinout companies

As knowledge is the core ingredient of innovation, academics have historically engaged in commercialising it (Doutriaux 1987; Shane 2004a). However, due to different national institutional intellectual property (IP) arrangements and lack of incentives to exploit university-generated knowledge, the intensity of this activity was rather low. The global breakthrough in the university knowledge commercialisation activity is commonly ascribed to the US Bayh-Dole Act of 1980 (Shane 2004b; Kenney and Patton 2009; Grimaldi et al. 2011; Fogelberg and Lundqvist 2013), which decentralised the IP ownership of federally-funded research in the US, allowing the organisations in receivership of federal grants to retain the IP to resultant inventions, with similar policies appearing in other countries (e.g. Knie and Lengwiler 2008). A

notable exception is Sweden (Bourelos et al. 2012; Politis et al. 2012; Farnstrand Damsgaard and Thursby 2013; Fogelberg and Lundqvist 2013), which already had a highly decentralised IP-ownership system with the rights to invention retained by individual academics. Many, however, attribute changes in IP to the need for universities to respond more proactively to continually shrinking institutional budgets (Clarysse et al. 2007; Grimaldi et al. 2011) to generate extra revenue (Bower 1993), as governments pursue short-term vote-winning policies. Some studies go even further, suggesting that the squeeze on university budgets can also affect the knowledge commercialisation capability of universities (Chrisman et al. 1995), a very much unintended consequence.

Since this highly interventionist policy was put into place, universities started to engage more actively in knowledge commercialisation (Shane 2004b). This is also referred to as the third mission of universities (Etzkowitz and Leydesdorff 2000) – the first two being teaching and research, and the third has a focus on academic entrepreneurship (e.g. Fini et al. 2010; Grimaldi et al. 2011). In particular, universities have devoted increased attention to academic spinout companies (e.g. Bower 2003; Wright et al. 2006; Fini et al. 2010), as they are found to generate greater financial returns than other modes of university knowledge transfer (Bray and Lee 2000; Shane 2004a), e.g. patents, licenses, collaborative research, consultancy, and so on. This focus is well captured in UK government attempts to capture third mission activity through exercises such as HEBCIS (Higher Education Business and Community Interaction Survey) or at university level by increased formation of technology transfer offices (TTOs) to stimulate such commercialisation activity.

The following subsections explain what university spinout companies are, with particular attention devoted to definitional aspects, seeking to distinguish university spinouts from other forms of academic entrepreneurship. A particular development trajectory of university spinouts is discussed in order to progress into theoretical issues concerned with formation of these companies.

2.1.1 Defining 'academic spinout'

The literature utilises a number of academic spinout (or spinoff) definitions (Shane 2004a), consequently leading to two core problems: 1) inconsistency in findings and building imprecise knowledge in the field; and 2) confusion in understanding and interpreting the effects of the academic spinout firms. There are two further important yet peripheral issues that arise from these problems: critique of academic spinouts, and 'naturally occurring' national differences. In view of these serious issues, it is crucial to clarify the following three concepts: a) technology transfer, b) academic entrepreneurship, and c) academic spinout.

Technology Transfer & Academic Entrepreneurship

From a review of literature on academic entrepreneurship it appears that technology transfer is also referred to as academic entrepreneurship (Klofsten and Jones-Evans 2000), which could have been broadly accepted in the early stages of the development in the field, were it not for the fact that terms such as entrepreneurial university (Slaughter and Leslie 1997; Clark 1998; Etzkowitz 2003), third mission (Etzkowitz and Leydesdorff 2000) or university knowledge commercialisation (e.g. Bozeman and Crow 1991; Rosenberg 1992; Rosenberg and Nelson 1994) already existed before the field of academic entrepreneurship expanded significantly, which could be attributed to the last decade (Perkmann et al. 2013).

University technology transfer embraces various forms of knowledge diffusion, e.g. patenting, licensing, contract research, consultancy, and academic entrepreneurship (Alexander and Martin 2013). In contrast, academic entrepreneurship, being just one of these modes of knowledge transfer (Toole and Czarnitzki 2007), encapsulates all entrepreneurial activities of the academic staff of the university (Fini et al. 2010).

Academic Entrepreneurship and Academic Spinout

Whilst the above terminology is used in most of the studies on university knowledge transfer, the distinction between academic entrepreneurship and academic spinout is where most of the confusion occurs in the literature (e.g. Fini et al. 2011; Grimaldi et al. 2011). A number of

studies define spinouts as broadly based on research conducted by students and staff (Brooksbank and Thomas 2001) or as indicated by Bathelt et al. (2010, p. 522): *some literature considers every firm as a university spin-off, so long as it is founded by a university graduate. This definition […] implies that the majority of all existing firms should be classified as university spin-offs*.

Fini et al. (2010) make a clear distinction between academic entrepreneurship and academic spinout based on the importance of the IP generated by the academic inventor. This largely concurs with many studies on academic spinout firms, where IP that originated from university-based academic work is a crucial determinant of the nature of the company created (Harmon et al. 1997; Di Gregorio and Shane 2003; Lockett et al. 2003; Degroof and Roberts 2004; Shane 2004a; Vohora et al. 2004; Lockett and Wright 2005; Wright et al. 2006; Bathelt et al. 2010; Rasmussen 2011). Moreover, Bathelt et al. (2010) propose a number of typologies of spinout firms in order to organise the literature findings, stressing the importance of university knowledge and engagement in the start-up phases.

This study is closer to the definition of academic spinout used in Shane (2004a, p. 4):

> *…a new company founded to exploit a piece of intellectual property created in an academic institution. […] Thus university spinoffs are a subset of all start-up companies created by the students and employees of academic institutions.*

This definition is also applied in many UK spinout studies. However, this thesis defines academic spinouts in a narrower sense, as companies that are formed on the premise of commercialisation of university-generated IP by academic staff. The key reason for this lies in the knowledge generation processes, which are critically performed by primarily academic staff. Such activities are typically governed by employment contracts, aligning them with the post-Bayh-Dole Act's transfer of IP ownership to universities. Whilst students, especially postgraduate, also participate in some knowledge generation, this has different legal/contractual arrangements. As such, the term ‘academic spinout company’ is used here synonymously with university spinout, academic spinout, spinout company, spinout firm, or spinout.

It is acknowledged that in the discussions below it is impossible to completely discriminate between confusing definitions, as many studies presented in the literature do not offer definitions of academic entrepreneurship or academic spinouts. However, where possible, such distinctions will be made in accordance with the above terms. Hence, academic spinout company is a form of academic entrepreneurship, which itself is a mode of transferring university knowledge.

2.1.2 Stages of spinout development

Understanding academic spinout development is crucial to discussions of university spinout productivity and performance, as each stage of development of a spinout poses a different set of challenges. The literature (Degroof and Roberts 2004; Shane 2004a; Vohora et al. 2004; Clarysse et al. 2005; Markman et al. 2005; Rasmussen 2011) clearly agrees on three distinct stages: 1) opportunity recognition, in which theoretical intellectual property is assessed against possible applied or commercial purposes; 2) proof of concept, in which the theoretical IP has been developed to a level where it can be proved to be a workable/practical IP; and 3) start-up, in which various core resources are accumulated/assembled to create a separate legal entity to develop the IP into a finished product or service and generate revenue. With the exception of Degroof and Roberts (2004), Shane (2004a), Clarysse et al. (2005) and Markman et al. (2005), scholars recognise another stage that provides a clear link of the to-be-developed IP to the university it originated from: research (Vohora et al. 2004; Rasmussen 2011).

Although some elements are clearly inspired by the original growth model of high-technology firms (Galbraith 1982), scholarship is focused on the early life of the spinout company. Even the 'late-stage' models (Shane 2004a; Vohora et al. 2004) end immediately after the firm starts selling the product, breaks even or attracts major investment. One could argue that this is a point at which the firm starts to grow, and remains, however inflated by venture capital (VC) investments, in its infancy. This is especially paradoxical when taking into account the studies that focus on a spinout's initial public offering (IPO) (Bonardo et al. 2011), or those that point out that a spinout's significant contribution to economic development starts after firms become

publicly listed, as this is when they actually start to grow (Lawton-Smith and Ho 2006; Lawton Smith et al. 2008). It is worth stressing, nevertheless, that many spinouts do not even sell their products/services even after reaching the IPO stage, suggesting considerable heterogeneity (Wright et al. 2006; Siegel et al. 2007), and an increased difficulty in capturing their development in a single stage-based model. This is further exacerbated by the fact that while the models overzealously focus on the early stages until the spinout firm is formed, they only account for a very short and intensive period of time in the life of a spinout, leaving a vacuum between company formation and achieving Vohora et al.'s (2004), although also early set – sustainability.

An alternative model could be proposed by combining the models discussed into one coherent, all-encompassing model. The first four stages are well-established in the literature as noted above: 1) research, 2) opportunity recognition, 3) proof of concept, and 4) start-up. At the start-up phase it would be necessary to add incubation, as right after becoming a legal entity the company needs a physical location, and this would normally be a university department or business incubator. The next stage – 5) stability, is what Vohora et al. (2004) term as 'sustainable returns', yet as a company just started to make profits or attract larger investments, it has not achieved the required scale of operations (Bigdeli et al. 2015) and therefore is still subject to a high degree of risk, where the company's status could change. Sustainability stage (6) can only be achieved once stability phase is successful over a period of time, which could be captured by modelling the growth of the firm. Once growth loses its exponential character and begins to slow, this represents a firm entering the sustainability stage. Although this proposition fails to capture the full scale of development stages after the company is formed, it clearly suggests a need for more research in the area.

2.1.3 Academic entrepreneurial intentions

Since universities attract a different type of workforce than private companies, and operate under different motivations that have more to do with wider socio-economic effects than immediate utility maximisation, it would be difficult to expect the academics to exhibit

entrepreneurial behaviour. This implies that academic spinout companies would be rare, and require different support than firms created by an entrepreneurially-minded individual. Quite counter-intuitively, academics have been found to be rather entrepreneurial (Chrisman et al. 1995; Fini et al. 2010), many of them running private consultancy firms alongside their university jobs (Fini et al. 2010; Astebro et al. 2013). In fact, it is often found in studies of academic entrepreneurship that publishing (Haeussler and Colyvas 2011; Bourelos et al. 2012), academic seniority (Krabel et al. 2009; Clarysse et al. 2011a), scientific breadth (D'Este et al. 2012) and research experience (Landry et al. 2006) are correlated with faculty entrepreneurship. However, Chrisman et al. (1995) report that capturing the full extent of entrepreneurial activity of faculty is problematic as university staff are not obliged to disclose such activity.

In their study on the UK academic entrepreneurship Clarysse et al. (2011a) find that apart from factors related to academia, personal attributes such as entrepreneurial capacity and entrepreneurial experience (also: Krabel and Mueller 2009; Krabel et al. 2009; Goethner et al. 2012; Abreu and Grinevich 2013) are crucial to explaining a faculty propensity to entrepreneurship, with additional evidence from Krabel et al. (2009; and Krabel and Mueller 2009) indicating that mobile academics are more entrepreneurial. Psychological traits (D'Este et al. 2012), such as self-efficacy, are also found to be positively related to faculty entrepreneurship (Prodan and Drnovsek 2010). Furthermore, a growing body of literature recognises faculty's social capital to be one of the major predictors of their engagement in entrepreneurial activities (Landry et al. 2006; Prodan and Drnovsek 2010; Aldridge and Audretsch 2011), in particular links with industry (Krabel and Mueller 2009; Bourelos et al. 2012; Goethner et al. 2012).

Interestingly, academic entrepreneurial motivations are not always found to be related to financial incentives, but rather a range of goals (Fini et al. 2009; Goktepe-Hulten and Mahagaonkar, 2010; Hayter 2011; Goethner et al. 2012), e.g. knowledge diffusion, career enrichment, and wider socio-economic benefits. In fact, Astebro et al. (2013) found that academics who leave academia to become entrepreneurs earn no more than those that remain;

however they are at greater risk of losing that ‘entrepreneurial’ income. Faculty patenting is also found to be positively related to entrepreneurial intentions (Krabel and Mueller 2009; Prodan and Drnovsek 2010), indicating that the stock of potentially commercially-attractive codified knowledge can be more easily transmitted through the vehicle of a company. In the particular case of academic spinout companies, the high level of novelty in faculty research and greater engagement in consulting activities are further predictors of academic entrepreneurship (Landry et al. 2006). Similarly, faculty conducting applied research have a higher propensity to generate spinout companies (Abreu and Grinevich 2013).

However, there are a number of factors that affect such entrepreneurial motivations. A study by Siegel et al. (2004) reveals that university knowledge commercialisation policies favouring more bureaucratic organisation of such activity, especially those with less supportive TTOs, may lead some academics to engage more in private consultancy work in order to bypass this process. This suggests a number of problems, including limiting the creation of spinout companies.

Another important concern identified by Toole and Czarnitzki (2010) relates to ‘brain drain’ as a consequence of academic entrepreneurship (i.e. spinout) activity. Toole and Czarnitzki find that academic entrepreneurship, particularly when the inventor leaves academia to work in the company, has a significant negative effect on university typical productivity measures (i.e. number of journal publications) or stock of commercialisable knowledge (i.e. patents). In order to prevent 'brain drain', universities need to offer a supportive environment, especially at a departmental level (Nicolaou and Souitaris 2016). These findings are especially important given the studies suggesting that faculty quality, reflected in university standing (Shane 2004a; O'Shea et al. 2005; Powers and McDougall 2005; Lawton Smith et al. 2008), is typically related to a greater volume of university spinout company creations. The study is a warning sign of some of the crucial aspects that have not been investigated before, given almost total focus on intensifying university knowledge transfer. If these effects are observable beyond Toole and Czarnitzki’s (2010) US sample, with no change in direction over a longer term, in the most

pessimistic scenario there might be little knowledge of any significant (commercial) value to be found at universities.

Finally, another (less prevalent but non-trivial) matter is related to predominantly US universities taking legal action against academics who do not disclose their inventions to university TTOs (Loewenberg 2009; Grimaldi et al. 2011), preventing such institutions from generating third-stream income. Whilst this does not happen very frequently, what emerges from such incidents is the dominance of financial focus of university administrators over the altruistic role of university-generated knowledge being diffused to the wider public. Furthermore, these situations might turn universities into unattractive work environments, particularly for highly talented/reputable academics, and potentially deter younger PhD students from academic careers, suggesting a set of rather degenerative alternative futures for universities.

2.1.4 Determinants of success of spinout companies

Academic spinouts are mainly small companies, many of which do not reveal high-growth characteristics as is often expected of them; consequently, in real terms, they make a rather negligible contribution to the economic development (Harmon et al. 1997; Benneworth and Charles 2005; Harrison and Leitch 2010; Brown 2016). Although this may appear plausible, it is rather premature, and as such indicates important issues to consider relating to academic spinouts.

Most of the studies on academic spinouts, especially those of quantitative character, focus on small samples (fewer than 200 observations) and typically these would try to explain university spinout rates. The remaining literature that takes an interest in spinout performance (Czarnitzki et al. 2014; Lundqvist 2014; Ortín-Ángel and Vendrell-Herrero 2014; Rasmussen et al. 2014; Visintin and Pittino 2014; Bigdeli et al. 2015; Iacobucci and Micozzi 2015) or survival (Mustar 1997; Nerkar and Shane 2003; Bolzani et al. 2014; Criaco et al. 2014; Epure et al. 2016) consists of either case studies (with even fewer observations) or are in a short supply,

suggesting another problem. There is a dearth of empirical literature, particularly quantitative in character, investigating growth, survival, or simply the later stages of venture development (Salvador and Rolfo 2011), as has been indirectly indicated in the above discussion of academic spinout stage-based model literature (Section 2.1.2), highly focused on the early development phases only.

Furthermore, the heterogeneity of spinout companies indicates a broad distribution of outcomes (Mustar et al. 2008), some of which could be easier to measure in terms of economic development (e.g. employment growth) than others. Moreover, Berbegal-Mirabent et al. (2015) report that the formation process itself is heterogeneous in nature, with different combinations of institutional factors leading to spinout formation. This high level of variance in spinout companies across their lifecycle adds a layer of complexity to understanding their success.

University spinout companies are disadvantaged compared to other private companies, given the employment of academic entrepreneurs and related social costs of lost research, teaching and so on (Czarnitzki et al. 2014). Consequently, spinouts are found to pay a 'performance premium' by overcoming such initial costs with greater employment growth (Czarnitzki et al. 2014). This is supported by Ortín-Ángel and Vendrell-Herrero (2014), who observe that, initially, spinout companies underperform compared to other new technology firms, but from their fifth year, spinouts outperform them.

In order to understand these issues in relation to the success characteristics of the spinout company, it is necessary to learn from the more established firm survival literature. Furthermore, such an approach may yield further insight previously neglected in the literature on spinout companies. The following discussion focuses on three core firm-centric areas: demographics, business strategy, and innovation.

Demographics

A significant body of literature measures a firm's attributes in relation to its survival, even though this may be directly related to an entrepreneur's background and decisions. One of the most prominently studied factors – a firm's age – which could be a reflection of an entrepreneur's experience, is generally found to be positively related to firm survival (Dunne et al. 1989; Kalleberg and Leicht 1991; Holmes and Schmitz 1996; Gimeno et al. 1997; Quadrini 1999; Shane and Foo 1999; Agarwal and Gort 2002; Cefis and Marsili 2005; Bridges and Guariglia 2008; Baggs et al. 2009; Bordonaba-Juste et al. 2009), and it is non-linear in character (Agarwal and Gort 2002; Bayus and Agarwal 2007). Hence, some studies find it having a negative relationship overall (e.g. Kangasharju and Pekkala 2002; Cottrell and Nault 2004; Bayus and Agarwal 2007; Bridges and Guariglia 2008 (for new firms only)). This could be observed more clearly in a study by Baggs (2005) on Canadian manufacturing firms, who found that in their first two years of operation firms experienced lower failure rates than older firms. Such findings could be explained partly by the 'honeymoon' effect (Hudson 1987; Murray 1988) where early starts tend to have lower failure rates in their initial years; or, especially in the manufacturing sector context, this could be due to initial sunk costs/high capital investment (Hudson 1987; Murray 1988; Duchesneau and Gartner 1990; Bruderl et al. 1992; Gimeno et al. 1997; Fotopoulos and Louri, 2000; Oberschachtsiek 2010) or capital reinvestment at a later stage (Wennberg et al. 2010), both of which motivate the entrepreneur to run a business for longer due to invested efforts.

On the other hand, resource fungibility could act as a survival-enhancing characteristic, especially for firms intending to internationalise their operations (Sapienza et al. 2006). The age effect is also found to be important in the case of international operations, as Mudambi and Zahra (2007) found in their study of the UK firms, whose probability to survive improved over time. When firms face insolvency, older firms were found to typically select to continue operations rather than dissolution (Wennberg et al. 2016), indicating an accumulation of experience and sunk costs. However, in a century-spanning study of Dutch accounting firms,

Pennings et al. (1998) found no significant effect of age on firm survival, suggesting a sectoral variety of age-related outcomes.

As firms age, it is expected that they will also grow, and therefore it comes as little surprise to find the positive relationship between a firm's size and its survival prospects (Dunne et al. 1989; Bruderl et al. 1992; Dunne and Hughes 1994; Audretsch and Mahmood 1995; Gimeno et al. 1997; Quadrini 1999; Shane and Foo 1999; Staber 2001; Agarwal et al. 2002; Mata and Portugal 2002; Cefis and Marsili 2005; Bayus and Agarwal 2007; Mudambi and Zahra 2007; Bridges and Guariglia 2008; Jensen et al. 2008; Musso and Schiavo 2008; Baggs et al. 2009; Holmes et al. 2010), whether measured by employment (e.g. Baggs 2005), assets (e.g. Heiss and Koke 2004), or sales (e.g. Borghesi et al. 2007). Nevertheless, there is some evidence of an inverse relationship (Agarwal and Gort 2002; Baggs 2005 (when measured by assets); Kauffman and Wang 2008), perhaps suggesting a more complex picture (e.g. non-linearity). Finally, a firm's growth itself is positively associated with its survival (Phillips and Kirchhoff 1989; Cefis and Marsili 2005; Coad et al. 2013; Rauch and Rijsdijk 2013; Pe'er et al. 2016), although it has an exponential character and has been found to be inversely related to firm size and age (Evans 1987).

Other factors, which tend to be fixed in nature, also seem to impact on a firm's success. For example, Cressy (1996) found that the number of company founders at start-up is positively related to firm's success, albeit in a non-linear way. Furthermore, firm's legal status also exerts an effect on firm's survival, probability with the more formalised forms such as incorporation (Kalleberg and Leicht 1991 (for male-led firms only); Wennberg et al. 2010), limited liability (Mata and Portugal 2002), public limited companies (Baggs 2005), observed to be positively related compared to sole traders (Pfeiffer and Reize 2000). Finally, new UK firms that are subsidiaries of other companies were found to have increased chances of survival (Bridges and Guariglia 2008); however, this attribute was observed to have an inverse effect among Australian start-ups (Jensen et al. 2008), suggesting perhaps the importance of geography and related macro-economic or regulatory climates.

Business strategy

Following a particular strategy could have a great effect on firm's success, a well-known fact in business management. Firms that choose to run a traditional type business (e.g. a grocery store) were found to survive better than affiliated firms (e.g. franchises) (Bruderl et al. 1992). Among US e-firms those that traded as interaction platforms for internet users, acted as transaction brokers, or based their business model on advertising revenue enjoyed a lower risk of failure (Kauffman and Wang 2008). Furthermore, businesses selling nationally (Bruderl et al. 1992) and internationally (Lee et al. 2012) had a greater probability of survival, although when the geographic scope of a sample of US new firm sales was measured as a radius, it was found to increase chances of failure (Gimeno et al. 1997).

Overall, diversified firms tend to be better at survival (Agarwal and Gort 2002; Agarwal et al. 2002; Bayus and Agarwal 2007; Borghesi et al. 2007; Bordonaba-Juste et al. 2009), clearly emphasising the importance of risk minimisation strategies. Additionally, firms with larger portfolios of products and/or services also enjoy a greater probability of success; however, this was found to be relevant to female-led firms only (Kalleberg and Leicht 1991), whilst evidence from software companies suggests a contrary situation (Cottrell and Nault 2004). Furthermore, companies that follow a low-price strategy have an increased risk of failure (Saridakis et al. 2008), suggesting that race-to-the-bottom strategies are counter-productive. Finally, late entry into a developing market (Musso and Schiavo 2008) and financial constraints (e.g. unavailability of external finance) (Bayus and Agarwal 2007) are found to contribute to the likelihood of failure.

Innovation

Firms endowed with greater absorptive capacity (Cohen and Levinthal 1990) in the form of a more educated workforce experience greater success (Mata and Portugal 2002), as firms need to utilise new knowledge and process it into new products and services. The importance of innovation to firm survival is crucial with successful firms being more R&D (research and development) intensive (Mudambi and Zahra 2007), holding more patents (Jensen et al. 2008;

Helmers and Rogers 2010; Löfsten 2016), having a broader patent scope in less concentrated markets (Nerkar and Shane 2003), greater trademarking activity (Helmers and Rogers 2010) or generally being innovators (Cefis and Marsili 2006). This is clear when considering Geroski et al.'s (1993) study, which reveals that innovation contributes significantly to firm's profits. Nevertheless, small firm innovation rate was found to be positive (Audretsch 1991) and negative (Audretsch and Mahmood 1995) within two samples of similar new US firms studied between 1976-1986, providing inconclusive evidence, although the time of the study could be playing a role as more recent studies finding generally positive effects of firm innovation (except Agarwal and Gort's (2002) firm technology intensity measure improving the risk of firm failure).

Another explanation could be found in Agarwal's (1998) study, which identified that high technology firms located in high technology environments enjoy higher survival rates only when they are younger, and this effect decreases with age, pointing to a complex picture of knowledge obsolescence. Furthermore, new firms' survival chances are greatly improved by patent applications (Jensen et al. 2008; Gimmon and Levie 2010), trademark applications (Jensen et al. 2008), or use of their own technology (Gimmon and Levie 2010). Therefore, nearly any form of innovation (Kalleberg and Leicht 1991), including process (Cefis and Marsili 2005) or product innovation (Cottrell and Nault 2004; Cefis and Marsili 2005), increases a firm's probability of success. Nonetheless, it is essential to note that incremental product innovation (i.e. improvements to existing products) was found to contribute to failure (Cottrell and Nault 2004); this is a form of innovation on a different scale. On the other hand, firms in industries characterised by radical innovation have positive survival outcomes, higher than firms in incremental innovation sectors (Kim and Lee 2016). Hence, firms offering the latest technology products (Bayus and Agarwal 2007) and generally those with a higher proportion of new product sales (as of all sales) (Sharif and Huang 2012) tend to remain longer in the market. Finally, in their innovative activities, firms that engage in R&D alliances, whether domestically or internationally, have an increased probability of survival (Lee et al. 2012), stressing the importance of innovation networks.

Whilst there appears to be good knowledge on predictors of spinout company formation and some 'borrowed' understanding of characteristics critical to success, little is known about how the existence of such companies is explained, and whether standard theoretical approaches extend to this unique type of firm. Hence, in the following section the understanding of formation of university spinout company is approached from a perspective of key firm theories.

2.2 Theoretical insights to university spinout company formation

This section reviews the theories of the firm and considers their relevance to studying and understanding academic spinout companies as a special case of firms. The theory of the firm is an important aspect in economics and strategic management, as without clear understanding of (the parameters influencing) firm's behaviour, it remains difficult to predict the behaviour of the economy overall, and similarly, identify firm's decisions to secure sustainable growth. The theories considered divide into two broad groups: 1) those focusing on the firm; and 2) those focusing on the individuals in/forming the firm. It must be noted that before the firm became first theorised, the concept of the firm (and even entrepreneur) was already used in the main works of Smith (as a capitalist, manager), Schumpeter (as an innovator), Marshall (as a risk-taker, innovator, manager), and Knight (as a risk-taker) (Harbison 1956).

Profit maximisation paradox

The economics of the twentieth century (especially pre-WWII and onwards) has burdened itself trying to resolve the neoclassical problem of firms as utility/profit maximising entities, which was then a dominant assumption explaining the aim of the firm. In short, the marginal costs (MCs) of producing one extra unit needed not to exceed the marginal revenue (MR) gained through the sale of this one extra unit, the point beyond which any further production is deemed unprofitable, and also the point at which profits are maximised. This is simply expressed as:

$$MC = MR$$

Many supported this idea (Hillmann 1939; Machlup 1946, 1967), and many counter-argued the assumption (Simon 1962; Winter 1964), while others just offered (usually with a critique of marginal analysis) alternatives (Hall and Hitch 1939; Alchian 1950; Boulding 1952; Simon

1955; Harbison 1956; Simon 1959; Margolis 1960; Marschak 1960; Monsen and Downs 1965). The main argument against firms as utility maximisers was based on how unrealistic the assumption was (Higgins 1939; Reder 1947; Simon 1955; Harbison 1956; Simon 1959, 1962; Winter 1964). This critique is especially vivid in the motivations of academic founders who form spinout companies for reasons other than utility maximisation (Fini et al. 2009; Goktepe-Hulten and Mahagaonkar, 2010; Hayter 2011; Goethner et al. 2012).

Thus, this section reviews five core theories in order to better understand the existence of university spinout companies: transaction costs, managerial theory, the resource-based view, the knowledge-based view, and dynamic capabilities. The subsections employ a dual structure, where a particular theory is discussed first and then applied to the university spinout company scenario. Such an approach enables greater understanding of the university spinout and the complexity of its existence. In essence, the theoretical explanations lend multiple perspectives that offer a greater insight into the spinout company. Thus, whilst profit maximisation is revisited new developments in theorising the firm's existence are also outlined.

2.2.1 Transaction cost theory

Although the profit maximisation theory could be portrayed as a plausible explanation of a firm's goal, it clearly fails to explain why firms exist in the first place, and how the profit maximisation or earning of revenue is achieved. Undisputedly, the most influential responses to those questions were given by Coase (1937), who first posed such problems. For Coase the firm is formed when there is an opportunity to produce a product below the cost of what is currently available on the market. The firm achieves its cost advantage by being organised under an entrepreneur/owner who is capable of managing firm's resources (inclusive of human, equipment etc.) at below market costs (Coase 1937). The way the firm collects revenue is based on transactions (i.e. contracts) (Coase 1937). The firm grows when the entrepreneur secures additional transactions, and shrinks (or exits the market) when the entrepreneur either abandons or starts securing fewer transactions (Coase 1937).

Coase also notes that there is a diminishing return to organising additional transactions, limiting the growth of the firm, although innovation would have the opposite effect, influencing growth. Therefore, he suggests that smaller firms have an advantage over larger ones with reference to Kaldor's (1934) and Robinson's (1934) diminishing returns to management concept, i.e. at some point in the firm's growth, management becomes erratic or too costly (due to administrative burden). This notion was contested by Florence (1934), who noted that firms achieve growth by enlarging their product portfolio, and that management could actually play a crucial role in growth through using top management techniques to achieve efficiencies, as well as by splitting managerial roles into general (e.g. line manager) and specialist (e.g. technical manager) functions. When a firm intends to reduce its costs, it can either start producing in-house or merge with/acquire its supplier (referred to as 'combination') (Coase 1937). He also introduced the concept of 'integration', which is horizontal merger/acquisition between firms. Coase's (1937) transaction cost theory of the firm was revisited nearly four decades later by Alchian and Demsetz (1972), Klein et al. (1978), Williamson (1979, 1981), and Hart (1988), who built on it.

Alchian and Demsetz (1972) dealt with Coase's (1937) central question of 'why' firms are formed. The existence of economic organisations (firms) as theorised by them is a more detailed picture of Coasian firm: a transaction-based entity, which utilises the transactions (or 'contracts', to use their term) to efficiently manage productivity within an internal organisation's market (Alchian and Demsetz 1972). This internal market is composed of employees and the transactions governing their work are employment contracts, which are flexibly executed (Alchian and Demsetz 1972, p. 793):

> *Promotion and revision of employee assignments (contracts) will be preferred by a firm to the hiring of new inputs.*

The key to their theory is the measurement of productivity, which is performed more precisely and cost-effectively within an organised entity (Alchian and Demsetz 1972).

Klein et al.'s (1978) contribution focused on firms dealing in vertical transactions, specifically earning rent on investments. In their theorising, firms that are linked through low quasi-rents (e.g. one firm earning quasi-rents from another for the use of their assets) are more likely to remain in contractual transaction-based relationships; conversely, those that are involved in high quasi-rents tend to integrate/merge (Klein et al. 1978).

However, perhaps the most recognised contribution was by Williamson (1979, 1981) who stressed the importance of dimensionalising transaction cost theory to develop a workable practical model. He focused on three core dimensions of transactions: 1) uncertainty, 2) frequency, and 3) the degree of specificity (Williamson 1979, 1981). The context within which transactions occur differs across transactions and firms; however, Williamson admits himself that his dimensions are not exhaustive in defining a firm's behaviour (Williamson 1979). The transactions of unspecialised assets (or in the case of human resources, unskilled) tend to be related to low uncertainty and higher frequency, which characterises markets with many actors (Williamson 1981), pointing towards a monopolistic market structure (Chamberlin 1933; Robinson 1933). The character of such assets/resources is substitutable (Williamson 1981). Conversely, transactions of highly specialised assets (e.g. skilled human resources) are related to high uncertainty and lower frequency, suggesting a market of a few actors only, with assets of this kind being hardly substitutable (Williamson 1981). Such transactions are indicative of oligopolies (or in extreme cases, monopolies). Finally, Williamson (1981) stressed that human assets need to be considered in a network form due to their relational aspect.

Since markets are imperfect (Knight 1921), the transactions/contracts between firms would reflect a similar character. Hart (1988) introduced an elaboration on Coasian theory in the concepts of incomplete contracts and residual right of control. An incomplete contract is one that does not account for all possible terms, as some eventualities might not be easily planned in advance, at times leading to revision of the contract (Hart 1988). When one of the parties wishes to change the contract, it must seek the agreement of the other. The party that needs to agree has the bargaining power, and hence retains the residual right of control (Hart 1988).

The transaction cost theory, although very attractive at explaining the behaviour of firms, nevertheless is subject to many limitations. Notably, all scholars considered manufacturing firms, and based the theories on very limited assumptions. This simplified the theory for comprehension, but excluded the parameters required for the complexity of the real world. Furthermore, the human element was rather suppressed in the considerations (with an exception of Alchian and Demsetz 1972), as the behaviour of individuals could play an essential role in the behaviour of the firm, as the next theory suggests.

In particular, it remains difficult to utilise transaction cost theory to explain academic spinout companies. First of all, spinout companies have a long product or service development path, and as a result their manufacturing activities (for a portion of spinouts) become important after a transitionary period of knowledge translation. Second, the products and services the spinouts transact have never been(and perhaps would never be) traded in an open market exchange, following original Coasian theorisation, due to the complexity of knowledge involved, strongly limiting the number of potential individuals or firms. Williamson (1979, 1981) suggested that such high specificity of transactions could point to oligopoly or monopoly market structures, which could explain IP-based short- to medium-term monopolies enjoyed by spinout companies thanks to patenting (Shane 2004b). However, internal transactions (Alchian and Demsetz 1972), especially related to personnel, open an uncharted territory of spinout company complexity with regards to academic founders. They straddle the internal/external boundary of the firm (Williamson 1979), as they typically retain their university employment while simultaneously working in the spinout company. Although their engagement with the spinout company could be contract-based (Alchian and Demsetz 1972), cross-boundary existence is not necessarily explained by Williamson's (1979) theorisation, which has a strong binary character. Finally, as spinout companies internalise innovation market based on university IP, they become intermediaries between public and private sector markets. This connecting role of spinout companies appears to have no particular explanation in transaction cost deliberations.

2.2.2 Managerial theory

The interest in the individuals running the firm was very much part of the scholarly considerations within the theory of the firm (Florence 1934; Kaldor 1934; Robinson 1934; Coase 1937; Machlup 1946; Reder 1947; Harbison 1956; Monsen and Downs 1965; Machlup 1967). However, it was never put together into a clearly-expressed separate theory of the firm; rather, its 'floating' existence in the literature was observed by Machlup (1967), and then Bartlett and Ghoshal (1993) observed this theoretical gap. Although Coase (1937) is regarded as the father of the theory of the firm and wedded to the transaction cost theory, his theorising also took account of the importance of managers in the firms, as the entrepreneurs were responsible for organising and managing resources at below market costs. Nevertheless, Coase (1937) did not provide the foundations of the managerial focus, as such debate had already started in earlier works (Florence 1934; Kaldor 1934; Robinson 1934). In general, it was noted that there are diminishing returns to management (i.e. limiting a firm's growth) (Kaldor 1934; Robinson 1934; Coase 1937; Hillmann 1939), although this was contested by Florence (1934; to some extent followed by Harbison 1956), who pointed to management's functional specialisation and the use of the newest management techniques: clearly more relevant and understandable now than in the pre-war times. However, with reference to the neoclassical profit-maximisation assumption, Machlup (1946, p. 524) noted that in reality:

> *Business men do not always "calculate" before they make decisions, and they do not always "decide" before they act. For they think that they know their business well enough without having to make repeated calculations; and their actions are frequently routine.*

In other words, the actual behaviour of the firms might not coincide with the expected behaviour of the firm due to firm's management, i.e. individuals. As referred to by Reder (1947, p. 451), a firm's output is dependent on *the effort and skill of the management*, adding a vital element of individual personal motivations to the understanding of the firm's behaviour. This in turn could lead to the perception of economic inefficiency of the firm (Harbison 1956). In other words, firms might be acting more in a satisficing rather than efficient way (Monsen and Downs

1965). As Monsen and Downs (1965), who focused on large firms, outline top managers that are only partial (i.e. minority shareholders) or non-owners of the firm might focus on uninterrupted steady growth, avoid making any radical decisions or investing heavily in radical innovations, as those could disrupt the firm's stable performance and undermine their job prospects. In a similar fashion, they describe lower-rank managers pursuing their own employment stability and progression goals by *pleasing their superiors in the firm* (Monsen and Downs 1965, p. 236).

In a similar vein, Bartlett and Ghoshal (1993) engaged in the task of theorising the firm from the managerial perspective by examining a multinational enterprise. In particular, they observed that firms are shaped through the roles played by different layers of management, and specifically, by redesigning these roles the traditional inefficiencies of management could be mitigated. They proposed that front-line management should have a degree of empowerment to induce entrepreneurial behaviour among them, leaving the middle management with information brokerage and capability integrative roles, and top management with leadership roles.

Clearly, the behaviour of the firm deviates from the profit-maximisation assumption. Therefore, the role of human actors within the firm is crucial to understanding this behaviour, which might have a whole distribution of effects on the firm's performance. However, within this contextualisation of the firm's existence, it is important to note that managerial theorisations relate to large firms, in which management roles can be developed. Thus, these theories fail to take account of young or small firms, which may have no managerial levels or mainly owner-manager.

In the context of spinout companies, individuals involved in the formation and running of these firms could perhaps shed light on their behaviour, in particular related to company development, leading to sustainability issues. Particularly, spinout companies are founded by non-market-oriented individuals (Fini et al. 2009; Goktepe-Hulten and Mahagaonkar, 2010; Hayter 2011;

Goethner et al. 2012) - i.e. academics, whose ownership of the firms is only partial due to stakes held by parent universities and investors. Thus, it is expected that spinout companies led by academic founders would have a limited focus on economic efficiency (Reder 1947; Monsen and Downs 1965), which could translate into lower growth compared to spinouts managed by market-oriented individuals, for example, experienced management team (Franklin et al. 2001), or investors.

Furthermore, as spinout companies typically involve the academic founder, in cases when a professional management team leads the firm, a conflict of interests and motivations in terms of the direction of spinout's development might arise between owners (i.e. academic founders, universities, investors) and managers (Reder 1947). Some of these inefficiencies could be overcome through the use of skilled management or investment in training and development (Harbison 1956). However, it is not stipulated whether training and development should focus on minimising the decision-making role of non-market-oriented owners, rather than transforming them into a skilled management team. Finally, managerial theorisations fail to capture small firms and rely on the development of management levels (Monsen and Downs 1965; Bartlett and Ghoshal 1993). As such, it becomes impossible to apply managerial theory to infant firms, as many spinout companies tend to be small (Harrison and Leitch 2010). Consequently, the theory provides some understanding of the behaviour of individuals within the spinout company, specifically around those who lead the firm, regarding motivations and productivity. Nevertheless, it does not permit understanding of firms that have complex ownership structures that span private and public sectors, organisations and individuals.

2.2.3 Resource-based theory

An alternative approach to the firm theory was presented by Wernerfelt (1984). His theory, more commonly known as resource-based view (RBV) of the firm, considered the firm's resources, both intangible and tangible (including human actors and equipment, etc.), as the basis for understanding the firm. In other words, firms exist by managing their resources in an efficient way that secures them market advantage (Wernerfelt 1984), which undoubtedly has

Coasian roots (Coase 1937), with management of resources to increase productivity pointed out by Harbison (1956). Wernerfelt (1984) states that four dimensions characterise a firm's competitive position in terms of resources: 1) resources need not be imitable, 2) nor substitutable, 3) resources should be unique to the firm, and 4) they need to build the firm's strength – thus be valuable. As Wernerfelt puts it (1984, p. 173):

> *What a firm wants is to create a situation where its own resource position directly or indirectly makes it more difficult for others to catch up.*

The RBV of the firm was later discussed and 're-theorised' by other scholars (Prahalad and Hamel 1990; Barney 1991; Conner 1991; Conner and Prahalad 1996), who put it against the existing strong foundations of the Coasian (followed by Williamson 1979, 1981) transaction cost theory (Conner 1991; Conner and Prahalad 1996). Nevertheless, their contribution was more in 'translating' (Prahalad and Hamel 1990; Barney 1991) or 'converting' (Conner 1991; Conner and Prahalad 1996) this theory, rather than building on it.

Undisputedly, the strongest point of the theory is the departure from the simplistic ignorance of the role of the firm's endowments in what the firm is, and recognising that without those resources it would be difficult to describe the behaviour of the firm. As noted by Conner (1991), RBV of the firm connects all other theories by its more comprehensive treatment of firm's parameters/factors. Nevertheless, firms develop and accumulate such resource strengths over time, and as a result RBV's main weakness lies in explaining the existence of infant firms (i.e. start-ups) that may have no strengths developed at the time, as Wernerfelt (1984) focuses on established firms. This is especially true for academic spinout companies, whose only resource at company registration is its knowledge of untested applicability or usefulness. Furthermore, it remains difficult to establish whether having a university parent is a spinout's unique resource, i.e. reputation (Grandi and Grimaldi 2003) or weakness, i.e. inefficiency stemming from academic's non-profit motivations (e.g. Goethner et al. 2012).

Finally, whilst spinout companies accumulate resources by first acquiring and then developing them, RBV poses a particular paradox for explanation: early stage spinout companies equipped with untested and undeveloped knowledge (i.e. non-resource) receive investment (i.e. resource). From a resource-based point of view, this exchange should be impossible, as only established firms that have proved they possess unique inimitable and valuable resources could convey a message about their strengths to radiate credibility with which they attract investment, for example, by exchanging equity in a firm for funding. For spinout companies, this unusual feature prompted public intervention in market failure, by establishing publicly-sourced early stage funding (Huggins 2008b). Whilst RBV becomes useful once spinout companies acquire some resources, its early stages cannot be accurately captured by the theory.

The following theories, although treated as extensions to the RBV, have an unmistakably distinct character and thus are presented separately.

2.2.4 Knowledge-based theory

Although the RBV of a firm is very much an all-inclusive theory, what consistently transpired from the scholars until the RBV was first formed was the increasingly important attention devoted to knowledge in various aspects related to markets and firms: uncertainty and risk in markets/knowledge asymmetry (Knight 1921; Higgins 1939), knowledge distance and decay in hierarchies (Robinson 1934), knowledge as commodity (Coase 1937), knowledge and uncertainty in firm survival theory (Alchian 1950), knowledge/innovation as infinitely produced good (Penrose 1952), asymmetric knowledge and its variable effect on decision-making (Simon 1955), diminishing returns to information/knowledge and a 'learning'/'adapting' firm (Winter 1964), and the contract/transaction cost relative to knowledge (Klein et al. 1978). Although in the RBV theory knowledge seemed to be regarded as one of a firm's many endowments, the turning point in the approach to understanding of the firm came with the 'knowledge-creating company' (Nonaka 1991, 1994). The firm was portrayed not as a resource-holder, but rather as a knowledge-endowed entity (knowledge-based view (KBV)), whose primary goals are to create and exploit knowledge, which provides it with a market advantage (Nonaka 1991, 1994).

Hence, the core interest has been drawn to the individual in the firm, as the unit that possesses the knowledge (Grant 1996), although some debate remained over the firm being responsible for knowledge creation (Spender 1996), knowledge application (Grant 1996) or both (Nonaka 1991; Kogut and Zander 1992; Nonaka 1994). The core agreement in the versions of KBV of the firm is that the knowledge of individuals is managed at firm level (Nonaka 1991; Kogut and Zander 1992; Nonaka 1994; Grant 1996; Spender 1996) and *the central competitive dimension of what firms know how to do is to create and transfer knowledge efficiently within an organizational context* (Kogut and Zander 1992, p. 384). Thus, the firm's ability to efficiently manage the knowledge of individuals is its main purpose, and how much more efficient it is than other firms in the market determines its competitive position.

Although knowledge and individuals in the RBV are regarded as firm's resources, their dynamics are only acknowledged in the KBV of the firm. The distinction between explicit and tacit knowledge with relation to its respective codifiability and transmissibility (Nonaka 1991; Kogut and Zander 1992; Nonaka 1994; Grant 1996; Spender 1996) adds the necessary dimension that starts to consider the knowledge in a more networked sense. Kogut (2000) points to markets being nothing but networks of firms that trade knowledge, and the structure of the network and each particular firm's position in it determines its behaviour. This view could be further expanded by looking at it from the actor network perspective (Spender 1996, p. 55):

> *The actor network is not made up only of individuals. Social entities, people, firms, governments, and social institutions are also involved as identifiable actors.*

Hence, firms could be posited to be embedded in highly complex multi-unit-actor networks, which for Spender (1996) would return quality and complexity to firm theory considerations.

Although the KBV of the firm appears to be a very appealing and even more all-embracing theory than RBV, it is clearly closely related to other theories, and the complimentary character is difficult to ignore (Grant 1996; though this has been really spotted early on by Machlup 1967). Although the theory seems to be broadly presented, as previously discussed it still appears to be

interested mainly in multi-person firms, clearly leaving some theoretical gaps in excluding one-person firms, which exist in large numbers.

In the context of university spinout companies KBV allows to resolve issues around placing knowledge of limited utility as an underlying resource of the firm. Firm's knowledge applicability and creation (Nonaka 1991; Kogut and Zander 1992; Nonaka 1994) lends understanding of the untested IP spinout company has been formed to exploit. Furthermore, KBV posits that knowledge resides in individuals (Grant 1996), pointing to the core role played by academic founders of spinout companies as tacit knowledge holders. Furthermore, the existence of other actors involved in spinout company formation and development processes finds a clearer explanation here: experienced management teams employed in spinouts hold knowledge of business operations, whilst investors contribute their knowledge of the future value of the spinout company. Although theory development has been based on large established firms (e.g. Nonaka 1991), Spender's (1996) multi-unit-actor networks contribute to understanding the complex positioning of a spinout company between public and private sectors. Specifically, spinouts appear to exist as connectors between universities that generate knowledge, and the private sector that typically applies knowledge. Nevertheless, there remain unexplained aspects of spinout companies, such as how a firm emerges in such networks, how it develops its network position, or how different structuring of its network position influences a spinout's survival.

2.2.5 Dynamic capabilities

Although dynamic capabilities (DC) are not precisely a separate theory of the firm, such aspirations could be sensed (e.g. Teece et al. 1997), hence it would be mere intellectual complacency to place DC with RBV as competing theories of the firm. RBV has a very strong focus on the endowments of the firm; however, these endowments being somewhat efficiently managed, however ambiguous it sounds, would seem to beg for an element that would complement the RBV’s existence as a theory. Therefore, DC offers a missing theoretical element that defines what was not defined before in the behaviour of the firm. The dynamic

capabilities of the firm are about managing firm's competencies: 1) managerial and organisational processes, 2) specific (idiosyncratic) resources, and 3) evolutionary paths, in such a way that the firm's long-term competitive advantage can be secured (Teece et al. 1997; Teece 2007). A slightly discounted DC view is presented by Eisenhardt and Martin (2000), who argue that *effective dynamic capabilities are necessary, but not sufficient, conditions for competitive advantage* (p. 1117), and could be *best conceptualized as tools that manipulate resource configurations* (p. 1118).

It is essential to note that in order to provide it with the competitive advantage, the DC of a firm must be purposeful, unique and inimitable (Teece et al. 1997). This is not far from the preconditions of the core competencies in the RBV of the firm (Wernerfelt 1984; Prahalad and Hamel 1990). Thus, the proponents of the DC argue rather cautiously that the DC are an extension of the RBV (Teece et al. 1997; Eisenhardt and Martin 2000; Teece 2007). Finally, it appears essential to notice the geographical elements briefly mentioned by Teece et al. (1997, p. 525):

> *Some routines and competences seem to be attributable to local or regional forces that shape firms' capabilities at early stages in their lives.*

Overall, the contribution of the DC appears to position them as an element that strengthens the RBV, and yet it is a distinct piece of the puzzle in the theory of the firm. Its contribution to understanding spinout companies can be derived from two core aspects: 1) evolutionary (Teece et al. 1997; Teece 2007), and 2) geographical (Teece et al. 1997). From the evolutionary point of view, a spinout company's metamorphosis from academic research into an untested IP-equipped firm and then into a successful business through the accumulation and development of dynamic capabilities expands the theoretical focus from pure knowledge or resource importance to less tangible processes. Furthermore, dynamic capabilities draw attention to geography ignored by other theories (Taylor and Asheim 2001), which could play a role in spinout companies differential existence and survival outcomes across UK regions, especially if sector

clusters, financial and support institutions are considered. As such it allows to capture the complexity (Maskell 2001) that lies at the heart of economic geography.

2.3 Conclusion

The existence of university spinout companies is primarily based within knowledge transfer activity, clearly separating it from traditional theorisations of firms. As spinout companies involve both public and private sector spheres within a region and multiple actors that cross traditional firm boundaries, it remains difficult to understand how they come to be, and their early stages in particular. Whilst some transitional processes are well captured by KBV, none of the theories depicted in this chapter were designed to explain university spinout companies, especially as the behaviour and development of these firms differs from typical private, manufacturing or large enterprises, as can be observed from extant research, e.g. performance premium behaviour (Czarnitzki et al. 2014; Ortín-Ángel and Vendrell-Herrero 2014). Each one, however, seems to illuminate a different aspect of a firm's existence and activity. The attempt to combine those complementary theories seems like a natural answer to growing scholarly dissatisfaction with over-theorisation and division in the area of the theory of the firm (Machlup 1967; Hart 1989; Maskell 2001).

A summary of this chapter's main theoretical contributions to understanding a university spinout company is depicted in Table 2.1 across eight dimensions identified in the literature discussed. Spinout companies exist as intermediary vehicles in the structure of university knowledge transfer. This process starts at the level of the university, passing through the medium of spinout companies to reach the wider external environment of private industry or region. As such, stages of a university spinout company's development distinguish the ownership divide of the underlying knowledge. Initially publicly-owned IP, originating from research activity, undergoes a process of ownership transfer through a spinout company until that knowledge becomes privatised. Consequently, the development of a spinout company has a translatory character where knowledge becomes externalised with the firm's growth. The theoretical insights suggest the boundaries of the networks in which university spinout companies exists.

These include a spectrum, with spinout companies positioned within a university network, but also reaching out to a broader network environment.

Spinout companies' existence can be further elaborated from transaction cost theory, which considered firm boundary (Williamson 1979). The academic founder is identified as an intermediary between a university and a firm. In essence, the academic founder's university is a separate organisation bordering her/his spinout company in the university network. As a connecting entrepreneur, the academic founder acts to reduce transaction costs of knowledge transfer between university and industry, or university network and broader network environment.

Managerial theory of the firm provides two vital insights to understanding spinout companies: efficiency (Reder 1949; Monsen and Downs 1965) and management (Monsen and Downs 1965; Bartlett and Ghoshal 1993). Given that academic founders are characterised by non-financial motivations to form spinout companies (Fini et al. 2009; Goktepe-Hulten and Mahagaonkar, 2010; Hayter 2011; Goethner et al. 2012), it is expected that with such university-skewed non-market orientation spinout companies would be operating at sub-efficient levels. To overcome this inefficiency problem, the spinout companies require a commercially-focused management team to pursue utility maximisation (Franklin et al. 2001). Furthermore, as the spinout company develops its management, it would transform from a single-person (i.e. academic founder) or a small management team towards a hierarchical managerial structure. This transformative process results in management specialisation, further strengthening the company's efficiency and alignment with private industry, or firms in the broader network environment.

From RBV (Wernerfelt 1984), spinout companies appear to be poorly endowed at the initial development stages, with IP representing the core resource strength of the firm. However, due to the untested nature of such knowledge, spinout companies are vulnerable to failure. As the firm grows, it develops and accumulates resources that define its competitiveness. In order to achieve this, the spinout company requires its main resource endowment of IP and the academic

founder to have the ability to convince investors to spark that growth. As a result, the IP needs to consist of inimitable and unique characteristics that allow the spinout company to transform from a knowledge-endowed fragile entity into a competitive firm with developed resources.

At the outset of spinout company formation, its knowledge has a tacit character, residing in the academic founder. KBV (Nonaka 1991) offers an understanding of the development and translation of knowledge into externalised codified knowledge. As such, the translation process allows knowledge to be shared with the spinout company's employees, increasing the probability and efficiency of transforming it into a marketable product or service. Essentially, university knowledge undergoes externalisation processes, strengthening the spinout company's competitive position. Furthermore, all actors engaged in these processes are connected, allowing for the exchange of knowledge. Consequently, through applying a network-centred approach adopted here, these connections become university networks that reach out to all market actors.

Since a spinout company starts as an inward-oriented firm, it focuses on dynamic capabilities (Teece et al. 1997) that control the process of knowledge translation and development. With time, each company approaches sustainability stage, when its dynamic capabilities shift towards market development and become outward-oriented. In other words, spinout companies develop dynamic capabilities that are region-specific, utilising geographical strengths to further firm growth.

Whilst these theoretical contributions clearly allow greater understanding of a university spinout company, this chapter still exposes a number of theoretical gaps. Firstly, it remains unclear as to the role university networks play in spinout company formation, and how they assist in understanding the existence of spinouts beyond KBV. Secondly, the managerial theory points to other actors' involvement; however, together with transaction costs it cannot explain the involvement or role of academic founders, who lack utility-maximisation orientation. The engagement of other actors in spinout company formation, such as professional management teams, investors or others, is not captured by transaction costs, managerial theory, RBV, KBV

or DC, yet these actors play strong roles in the existence of spinout companies. Whilst these theories allow insights to predict the necessity for multiple actors' involvement, they do not state why, which actors or what role they would play in spinout company's existence. Finally, although the geographical complexity has been considered by DC, it has been largely absent from the remaining bodies of literature considered here. This leads to questions whether geography plays other roles in a spinout company's existence.

Firm survival literature illuminated a number of aspects that could potentially shed some light onto success outcomes of spinout company development. For example, spinout companies are typically small firms (e.g. Harrison and Leitch 2010), however they achieve greater growth (Czarnitzki et al. 2014; Ortín-Ángel and Vendrell-Herrero 2014), which is inherently related to greater survival prospects (Coad et al. 2013; Rauch and Rijsdijk 2013; Pe'er et al. 2016). As the UK university spinouts typically take on a formalised incorporated form as limited companies, they are expected to have improved chances to survive (e.g. Wennberg et al. 2010). Furthermore, it is anticipated that spinout companies would be more successful if they undergo an M&A event becoming a subsidiary of another established firm (Bridges and Guariglia 2008), suggesting improved capital access for growth. Since spinout companies are technology-based and engage in innovative activities (Shane 2004b) there is an expectation they would survive longer than other firms (Cefis and Marsili 2006; Mudambi and Zahra 2007).

However, these characteristics focused on the spinout company require further empirical confirmation, given how unique these firms are. Moreover, there remains a gap in understanding how university network actors contribute to the survival of spinout companies, in particular TTO, business incubators, investors and management teams. Finally, the geographical context or broader network environment in which spinout companies operate stimulates further questioning of determinants of their survival.

In the following chapter the issues that relate to university spinout company success, with a particular focus on survival, are explored by examining non-spinout determinants. Specifically, Chapter 3 engages with literatures on university spinouts and firm survival.

Table 2.1 Summary of theoretical underpinnings of university spinout company

Theoretical Dimension	Theoretical Foundation	Note	Theoretical Gap
Structure	University knowledge transfer	A spinout company is an intermediary in knowledge transfer from university to industry. As such, it spans the boundary between university environment (university network) and private industry (broader network environment).	The role of geography.
Ownership	Stages of development	The knowledge transferred from university to industry through spinout company begins its journey as publicly-owned, and through the vehicle of spinout company it becomes privatised.	The role of geography.
Boundary	Transaction Costs	In transaction costs considerations, academic founders cross the boundary between university and spinout company. Whilst TC is firm-centric, in boundary considerations of university knowledge transfer, academic founders are intermediaries between university and spinout company.	The role of various actors. The role of geography.
Efficiency	Managerial theory	Academic founders are inherently non-market-focused business managers. This leads to inefficient management, which can only be reversed by the employment of individuals motivated by utility maximisation to lead the spinout companies.	The role of various actors, especially academic founders.
Management	Managerial theory	As the management of spinout companies is typically either based on an academic founder or small management team, in order for the spinout to transfer its focus towards external private industry connections, it has to build a management hierarchy during its development.	The role of geography.
Resources	Resource-Based View	Spinout companies' resource endowment in early stages is either non-existent or very low, except for IP. As the company grows it develops and accumulates resources that allow it to remain competitive.	The role of various actors. The role of geography.
Knowledge	Knowledge-Based View	The original knowledge that a spinout company is based on has a tacit character, which requires the engagement of the academic founder. As this knowledge becomes translated and codified, the academic founder's role reduces and becomes partly substituted with company personnel. As such the development of knowledge transitions it from being the university's asset, and becomes the spinout company's endowment. The transfer of knowledge involves networks, which connect all actors in the market.	The role of university networks in spinout company formation. The role of various actors. The role of geography.
Capabilities	Dynamic Capabilities	Spinout companies begin with inward-oriented capabilities related to knowledge creation and development, and reliance on the university endowment of capabilities. During a spinout company's progression towards sustainability, the company employs more capabilities that exist in its region, in essence becoming more outward-oriented in the development of its capabilities.	The role of various actors.

Chapter 3

Determinants of university spinout success

The previous chapter attempted to explain the existence of spinout companies using extant literatures on academic entrepreneurship and firm theory. The core outcome of that review is identification of a spectrum across eight dimensions, namely: structure, ownership, boundary, efficiency, management, resources, knowledge, and capabilities. The major theoretical gaps detected are the roles of: a) university networks in the existence of spinout company, b) actors participating in these networks, and c) geography. This chapter aims to inspect the role of university networks and broader network environment in the success of spinout companies, as defined by firm formation and survival. Specifically, the chapter examines the following elements: networks, university, TTO, business incubator, investors, management team, and geography. In particular, the chapter connects two core literatures, on academic spinouts and firm survival. Furthermore, the chapter expounds on the role of geography, building on Chapter 2 that identified the influence of spatial aspects on spinout companies' existence. While the previous chapter had a clear theoretical focus, the premise of this chapter is to ground further spinout company deliberations in mostly empirical work, strengthening the understanding of broader network environment, university networks, and spinout company success, defined here as firm survival.

When discussing university networks it is often found that studies either broadly suggest their supportive character (Klofsten and Jones-Evans 2000; Benneworth and Charles 2005; Braunerhjelm 2007) or single out particular elements of them (Lockett et al. 2003; Moray and Clarysse 2005; Bekkers et al. 2006; Mosey and Wright 2007; Fini et al. 2009; Grimaldi et al. 2011), yet little attention has been devoted to a coherent system of support (e.g. Degroof and Roberts 2004; Clarysse et al. 2005; Fini et al. 2011) as their role. These elements are studied in relation to: university-level academic spinout rates (Lockett et al. 2003; Degroof and Roberts 2004; Shane 2004a; Siegel et al. 2004; Clarysse et al. 2005; Markman et al. 2005; Moray and

Clarysse 2005; Bekkers et al. 2006; Wright et al. 2006; Mosey and Wright 2007; Fini et al. 2009; Fini et al. 2011; Bourelos et al. 2012; Hayter 2013), faculty entrepreneurship (Chrisman et al. 1995; Klofsten and Jones-Evans 2000; Braunerhjelm 2007), and performance of such ventures (Bekkers et al. 2006; Djokovic and Souitaris 2008; van Geenhuizen and Soetanto 2009; Clarysse et al. 2011b). However, it is vital to take a broader view, as only when these elements form a set of systematised, or proposed here – networked, resources is it possible to attempt to comprehend the academic spinout activity at universities. In a networked perspective these resources do not have to be constrained to any single institution, and currently, to use any of these resources no more than one new link of cooperation is required. In a review of these resources presented below, each is discussed as a separate element. When conclusions are drawn, a conceptual model of these resources linked together is offered for further empirical exploration, referred to as a university network.

The chapter has the following structure: Section 3.1 introduces firm survival by briefly examining firm's formation and exit; Section 3.2 discusses networks and their role in spinout company success, and offers a disambiguation of core network terminology used; Section 3.3 looks at university networks, examining particular actors of these architectures: university, TTO, business incubator, investors, and management team; Section 3.4 devotes its attention to broader network environment, considering aspects of geography. Finally, Section 3.5 concludes the chapter with a conceptualisation of university networks and identification of the research questions of this thesis.

3.1 Firm's entry and exit

Although one of the aims of this chapter is to consider factors related to firm survival, it would be impossible to do so without considering the birth of the firm – in other words – individual's decision to become self-employed. In short, a person's decision to switch occupation is related to the value of their time. Ignoring the social welfare system (due to its distorting effects), time would have a lower value for the unemployed than those in employment (Becker 1965), whilst

self-employment is related to the expected value of profits (Geroski 1995) or in other words the expected value of time. When the expected profits reach a certain threshold, a person decides to enter into self-employment (Geroski 1995). Although Murray (1988) indicates that this happens when the expected profits are equal to opportunity costs, Geroski (1995) goes further, claiming that the threshold is actually higher – i.e. there is a minimum level of expected profits exceeding the opportunity costs that influences this decision. This very simplistic view of entry noticeably limits nearly all other motivations beyond financial (entrepreneurship is indeed related to wealth (Quadrini 1999)) to enter self-employment, and, as Santarelli and Vivarelli (2007) note, entrepreneurs have a variety of motivations for setting up a business, some of which are non-financial in nature. This is well-evidenced in the case of academic spinout founders discussed in the preceding chapter.

In a similar way, an entrepreneur might decide to exit self-employment and choose between unemployment and employment for a number of reasons, such as business failure or retirement. Again, such a decision is more likely to be financially motivated, as noted by Jovanovic (1982, p. 649): *efficient firms grow and survive; inefficient firms decline and fail*. Overall, self-employment and other occupation choices are cyclical in nature: exiting A leads to B or C, whilst exiting C leads to A or B, and so on. This is particularly well portrayed by Geroski (1995), who indicates that there is a high and positive correlation between business start-up rates and business failure rates, which clearly shows that while *entry appears to be relatively easy, survival is not* (p. 435).

3.2 Networks

Relationships between social actors portrayed as networks are not a new concept in the literature (Granovetter 1973, 1985; Burt 1992; Lin 1999, 2001), and neither is the importance of such networks or relationships to economic activities (Granovetter 1985; Burt 1992; Lin 1999, 2001; Granovetter 2005). It is often not what one knows, but rather who one knows that plays a crucial role in society, and by some degree of extrapolation, in the economy. Therefore, much of the

literature discussed below referring to networks has a particular understanding of them, related to the concept of social capital: investment in social relations with expected returns in the marketplace (Lin 2001, p. 19), without any rigid specification of which marketplace.

In fact, there is an emerging argument that the networks based on interactions between pure social actors should be separated from more economically-oriented interactions between organisations, which tend to be more deterministic and calculative (Huggins 2010a, b). Huggins (2010a) separates those using the term of 'network capital'. As such, it aims to advance strategic goals of firms, where the size of the network is determined by the business needs at a particular moment in time, reflecting dynamism, while the quality of the network depends on the returns from those relationships. Interestingly, Huggins (2010a) suggests that individual-level relationships (i.e. social capital) are a by-product of network capital, demonstrating the interdependent character of the two forms of capital. He further explains that this interdependence can be observed in the evolutionary aspects of inter-firm networks, with small or early stage firms relying typically on social capital. As firms develop and mature, their network reliance transitions towards network capital (Huggins 2010a). This, then, indicates that all forms of networks from the micro-level to the more aggregated macro-level (which differ mostly in their perceptual/contextual idiosyncrasies) are crucial to the economic development debate (Storper and Harrison 1991; Storper 1992, 1995b; Asheim 1996; Keating and Loughlin 1997; Morgan 1997; Krugman 1999; Cooke 2001; Storper 2009; Storper 2011; Malecki 2012).

There appears to be a dichotomy of views on how networks add to economic development subject to distance parameter. One side of the argument is heavily influenced by Krugman's (1991b) agglomerations, arguing that networks have a regional dimension since this is the geography at which they are densely formulated (Storper 1992, 1995b; Storper and Scott 1995; Storper 1997; Howells 2002; Scott and Storper 2003). On the other hand, the more 'progressive' work gives more credit to technological advancements and human mobility, arguing that networks are continually less constrained by distance (Asheim and Isaksen 2002; Wolfe and

Gertler 2004; Boschma and ter Wal 2007; Huggins 2008a; Huggins et al. 2010; Asheim 2012). Nevertheless, some scholars argue both sides, that networks have both local and global reach, and that distance conditions both the type of relationship and what is being transferred in those relations (Asheim and Isaksen 2002; Asheim 2012). Additionally, the strength and growth of local or globally-reaching networks could indicate regional policymaking becoming oriented towards resilience or competitiveness in development discourse (Bristow 2010). Both distance extremities, however, have their differences embedded in what seems slightly contrasting explanations of knowledge and its production and diffusion, one of the grounding imperatives for economic growth (Romer 1986).

Networks are critical to understanding spinout companies in a university-centred environment, as indicated by much of the academic entrepreneurship literature (Brooksbank and Thomas 2001; Franklin et al. 2001; Grandi and Grimaldi 2003; Vohora et al. 2004; Moray and Clarysse 2005; Mosey and Wright 2007; Aldridge and Audretsch 2011; Grimaldi et al. 2011; Bourelos et al. 2012; Fogelberg and Lundqvist 2013; Hayter 2013), typically mentioned as part of university support for spinouts (Djokovic and Souitaris 2008; Patzelt and Shepherd 2009; Grimaldi et al. 2011). Particular attention is paid here to the importance of the networks provided by TTO professionals (Lockett et al. 2003; Shane 2004a; Farnstrand Damsgaard and Thursby 2013), especially those linked to venture capitalists, entrepreneurs (Franklin et al. 2001; Lockett et al. 2003), senior management talent (Shane 2004a), or other university TTOs (Lockett et al. 2003). In particular, Franklin et al. (2001; as well as Lockett et al. 2003) found that the UK universities that were more successful in developing academic spinout companies had greater network capital (Huggins 2010), due to a more open-minded approach to technology transfer. This resonates with Roper and Hewitt-Dundas's (2013) research that identified universities holding more central positions in networks.

Furthermore, university spinout productivity is related to academic entrepreneurs having stronger links with external entrepreneurs or industry (Bourelos et al. 2012). These networks

accessible to academic spinouts could be strongly related to their university's reputation effect, as Grandi and Grimaldi (2003, p. 339) indicated:

> *The fact of being spun off from a credible university ... represents, in the eyes of external agents, a guarantee for the quality of the knowledge-based companies.*

Thus, the university's internal characteristics, related to the volume of potential entrepreneurial opportunities, are quite closely interlinked with the university's ability to endow an academic spinout company with more intangible characteristics crucial to its future success. What is more, Grandi and Grimaldi (2003) point out that the first networks that spinouts build are in fact inherited from their parent organisations, indicating how critical university resources are for these companies. As spinouts develop, their university/parent-centred networks shift their orientation towards customers (Pérez Pérez and Sánchez 2003). Furthermore, at an internal university level, this early support starts from institutionally-arranged networks of cooperation between TTOs, science departments and business schools (Wright et al. 2009), to maximise the utilisation of the university's existing resources and capabilities.

Business incubators are frequently mentioned to facilitate firm's network-building activity (Grimaldi and Grandi 2005; Wynarczyk and Raine 2005; Bruneel et al. 2012) or connect to the right actors that could aid their business development (Carayannis and von Zedtwitz 2005; Rothaermel and Thursby 2005; Bruneel et al. 2012). Similarly, networking is also indicated to be an integral part of science parks, although as Chan et al. (2010) found in their study of South African science parks, the firms located in the parks engaged more frequently with off-park firms than those on the park.

Networking allows firms to overcome the liability of newness (Chan et al. 2010), build credibility/legitimacy (Bower 2003; Grandi and Grimaldi 2003; Bruneel et al. 2012), secure necessary funding and further opportunities for growth (Grandi and Grimaldi 2003; Chan et al. 2010; Bruneel et al. 2012) and survival (Mustar 1997). In other words, academic spinouts develop networks primarily to access resources otherwise not available to them (Grandi and

Grimaldi 2003; Hayter 2013). This is, however, far from an exhaustive list of what networks bring to academic spinouts. Vohora et al. (2004) stress that networks with industry and external entrepreneurs play a key role in opportunity recognition, at the very early stage of spinout formation. This is further supported by Landry et al. (2006), who found that the likelihood of spinout company formation is significantly influenced by the academic's social capital, whilst Prodan and Drnovsek (2010) indicate that the academic entrepreneurial intentions are also positively related to personal networks.

Overall, networks with a range of actors can be clearly recognised as critical to a spinout's success (Vohora et al. 2004; Walter et al. 2006; Politis et al. 2012). In particular, an academic spinout's network capability is significant for its growth, performance and sustainability (Walter et al. 2006), suggesting that networks are equally important at every stage of the spinout's development. The crucial difference between the networks at different stages of development is found in its orientation, where they transition from academically- to more commercially-oriented networks (Pérez Pérez and Sánchez 2003). However, it is critical to recognise that such a connectedness transformation is not a uniform process across all spinout companies, with Treibich et al. (2013) finding that there is a diversity of spinout network behaviours towards their institutions, with some maintaining a close relationship and others seeking independence, and both approaches possibly reversing with time. In fact spinouts need to adapt their networks by building and restructuring their network positon, aligning it with changing needs and expectations over time (Rasmussen et al. 2015), especially as a spinout's strong network position is related to its performance (Scholten et al. 2015). Furthermore, Mustar (1997) reports that among the French spinouts studied, those that were generally better connected achieved full survival, compared to firms with poor network positions, where approximately half of the spinouts ceased trading.

Despite the many advantages academic spinouts may enjoy by developing their networks, Patzelt and Shepherd (2009, p. 324) warn that e*fficient networking can be costly and requires*

that academic entrepreneurs have sufficient financial resources available. Apart from the resources, empowering the faculty to build networks is equally crucial (Walter et al. 2006), as found in a study of Canadian 'repeat commercialisers' (Hoye and Pries 2009) where academics who frequently engage in knowledge commercialisation, apart from simply having an entrepreneurial mindset, are also characterised by having greater networks with industry. The entrepreneurial academics' social capital could be then utilised to support their entrepreneurially-inexperienced colleagues (Mosey and Wright 2007), especially where university TTOs are unable to provide such a resource.

Since proximity of firms induces networks, and networks lead to opportunities (Fini et al. 2011) it is clear that the geographic/spatial character of networks cannot be ignored. This importance of local social capital has played a fundamental role in the development of the high-tech cluster, and consequently, the economy of Cambridgeshire (Garnsey and Heffernan 2005). Not far off, Oxfordshire's biotechnology cluster and distinct entrepreneurial culture also owe their development to local networks (Lawton Smith et al. 2008). Similarly, the successful development of academic spinouts at Halmstad University in Sweden is linked to the networks developed by the first generation of spinouts, which provided access to these networks to subsequent generations of spinout companies (Berggren and Lindholm Dahlstrand 2009), thus ensuring a continuous stream of knowledge-based entrepreneurship contributing to the local/regional economic development. These examples clearly indicate that evolutionary aspects play a central role in academic entrepreneurship considerations (Lawton Smith et al. 2008), as networks are built over time (Siegel et al. 2007). Benneworth and Charles (2005) go even further, describing the university as a central regional innovation agent, which could utilise spinout companies to diffuse knowledge in underperforming regions, transforming its innovative capability. Thus, academic spinout companies could play the role of regional knowledge brokers.

Creating a university disclosure is largely regarded as commercial or entrepreneurial opportunity (Lockett et al. 2003; Degroof and Roberts 2004; Vohora et al. 2004; Clarysse et al. 2005; Clarysse et al. 2011a; Haeussler and Colyvas 2011; D'Este et al. 2012) which might be translated into a spinout company. Furthermore, academic entrepreneurship scholars describe the availability of finance as an investment opportunity (Grimaldi and Grandi 2005; Wright et al. 2006), which can be accessed by spinout companies to obtain growth capital. This contextual framing clearly necessitates a network concept pertaining to opportunity, and as such Burt's (1992) structural holes have a capacity to contain such information. Structural holes measure the level of opportunities available in the actor's immediate proximity of connections, or in other words, the extent to which an actor is constrained within its most immediate network to utilise the existing opportunities or gaps in other actors' relationships.

Although much of the academic spinout company literature stresses the role of networks (e.g. Mosey and Wright 2007; Aldridge and Audretsch 2011; Grimaldi et al. 2011; Bourelos et al. 2012; Fogelberg and Lundqvist 2013), little use has been made of appropriate techniques and measurements, namely applying social network analysis. A number of different measures could be used to describe network positions of spinout companies: centrality-based characteristics (e.g. degree centrality) (Freeman 1978; Wasserman and Faust 1994), betweenness centrality (Freeman 1977) or substructures (e.g. k-cores) (Seidman 1983; Hanneman and Riddle 2011). However, few concepts could capture entrepreneurial contexts as well as structural holes (Burt 1992).

Networks clearly play a critical role in the development of spinout companies, and in particular, as this thesis reveals, a specific set of key actors is important to spinout's success. These actors form a university network, composed of university, TTO, business incubator, management teams, and investors. As such it is essential to offer clarity between what constitutes a *network* and a *university network*. The term *network* is used here as a generic expression meaning groups of actors, links between actors, or relationships of different actors. It has no pre-defined

expectation of a particular construct that involves specific actors with their designated roles and could represent both social and network capital (Huggins 2010a). Conversely, *university network* is a term that has a specific meaning in terms of what its relational composition is. When using this term the thesis refers to an exact meaning that includes university, TTO, business incubator, management teams and investors. As *university network* includes actors that have a more deterministic function, this embeds them in a network capital conceptualisation (Huggins 2010a). Although university networks appear to share a similar construct in terms of actors, these architectures and their functionality may differ across regional contexts (Bristow 2010). This geographical aspect of university networks is referred to here as the *broader network environment*, in essence capturing characteristics of university networks based on space.

The following sections link university networks, their elements, and firm survival.

3.3 University network

This section outlines the elements of a university network: the university, TTO, business incubator, investors, and management team.

3.3.1 University

As faculty primarily focus on teaching and research in their daily jobs, commercialisation activities added on top of their duties contribute an additional pressure (Lehrer and Asakawa 2004). With the third stream activity being distant from typical academic work it would be unthinkable to demand a non-market- and non-profit-oriented workforce to suddenly re-orientate completely. This is where university support is necessary (Chrisman et al. 1995; Klofsten and Jones-Evans 2000; Shane 2004a) to both facilitate the evolution of the entrepreneurial university and stimulate knowledge commercialisation activities (Fogelberg and Lundqvist 2013). A wider picture of knowledge diffusion and increased income should also be considered, as concluded by Lehrer and Asakawa (2004, p. 63): *any additional state incentives to encourage scientists to start their own firms would involve taxpayers having effectively to*

"bribe" state employees to pursue private profit. Such a paradoxical situation indeed takes place when early stage private spinout companies utilise subsidised university laboratory space (Festel 2013). Importantly, universities differ in their knowledge commercialisation activity, as recognised by Hewitt-Dundas (2012), in relation to university's research intensity, illuminating the critical role of institutional context for spinout companies.

Academic Career Goals

One of the more sensitive problems raised in the literature on academic spinouts is the fact that academic careers are research/publication-based (Kenney and Patton 2009), and faculty engagement in entrepreneurial activities is seen as detrimental to their jobs (Chrisman et al. 1995) or career prospects, especially for junior faculty typically found to be less engaged in academic entrepreneurship (Krabel et al. 2009; Clarysse et al. 2011a). This could be further exacerbated by faculty's own perception of what their priorities should be (i.e. typical Ivory Tower argument). As Hayter (2011, p. 347) notes, there are university environments *where commercialization is looked down upon by colleagues, if not discouraged*. Nevertheless, as can be seen from the case of Katholieke Universiteit Leuven, these obstacles can be overcome, and it is possible to establish a supportive environment understanding the nature of academic jobs (Van Looy et al. 2004), striking a balance between the typical academic role focused on publishing and entrepreneurial activities (Siegel et al. 2007). Such a holistic culture of commercialisation instigated at universities is found to contribute positively to academic entrepreneurship (Krabel et al. 2009).

Incentives

Nevertheless, the understanding and recognition that academics might receive from university administrators for being part of the entrepreneurial university (Slaughter and Leslie 1997; Clark 1998; Etzkowitz 2003) hides a more complex picture, where appropriate incentives needed to be brought in place to stimulate the interest and participation of the faculty in knowledge commercialisation activities (Siegel et al. 2004; O'Shea et al. 2005). The importance of

incentives becomes apparent when considering the fact that university-created knowledge is often embryonic and requires further development before being commercially useful, which requires the original inventor to be engaged in the process (Jensen and Thursby 2001; Farnstrand Damsgaard and Thursby 2013).

To ensure the commitment of the faculty, universities need to make sure there is a strategic link between the inventor's effort and the commercial success of his/her invention, which is most frequently exercised by inventor royalty or equity schemes (Jensen and Thursby 2001; Siegel et al. 2007; Berbegal-Mirabent et al. 2013). This by no means differs from private company incentives for senior managers, whose commitment to achieving greater business performance is usually maintained by similar approaches. Indeed, such approaches were not only found to be crucial to the commercial exploitation of university inventions (Link and Siegel 2005) through spinning out companies and the success of such endeavours (Lockett and Wright 2005), but also widely used in higher education institutions (HEIs) (Bower 1993; Grimaldi et al. 2011), which, coupled with the previously discussed academic entrepreneurial motivations, suggest a very complex paradox. On the one hand, studies of academics and their entrepreneurial motivations seem to indicate that financial incentives are of lesser importance to them (Fini et al. 2009; Goktepe-Hulten and Mahagaonkar, 2010; Hayter 2011); yet on the other, studies of academic spinout rates (Jensen et al. 2003; Lockett and Wright 2005) and university licensing (Link and Siegel 2005) and their underpinning factors indicate the importance of financial incentives.

This paradox could have a number of possible explanations, with a major one being related to a simple response bias, where faculty avoid indicating financial incentives as their core motivation for fear of breaking the academic ethos. However, an equally strong alternative explanation could be related to the fact that studies of university spinout productivity do not measure other motivation factors, as they often look at university policies only. Yet another alternative and more plausible explanation could be found in the heterogeneity of faculty's

personalities, where entrepreneurial motivations could be a mixture of extrinsic and intrinsic incentives (Lam 2011).

Selectivity and Support

There is also a growing recognition in academic spinout literature that universities engage in support activities on a number of dimensions that could categorise universities into low or high supportive contexts (Degroof and Roberts 2004; Clarysse et al. 2005), managerialist or bottom-up/networked commercialisation approaches (Fogelberg and Lundqvist 2013), that either nurture formation of academic spinout companies or stifle and inhibit such activity. The low or high supportive contexts are also low or high selectivity environments, where spinout companies are either allowed to be set up in a non-discriminatory environment, which should result in a greater number of spinout companies with poorer support infrastructure, or in a highly selective one, which would focus on a small number of high quality spinout opportunities nurtured in a highly supportive professional setting (Degroof and Roberts 2004; Clarysse et al. 2005).

A very different conceptualisation is offered by Fogelberg and Lundqvist (2013), who portray the very top-down nature of high selectivity and high support context as managerialist, suggesting it should be aiming to transform into a new generation of university support infrastructure, becoming a networked structure. As such it is based on the evolution of complex networks between faculty and private industry, with integrated commercialisation and entrepreneurialism goals, yet still this bottom-up approach is set in a highly supportive institutional environment. Rasmussen et al. (2014) find that it is departmental level support, with a history of working with industry, which influences spinout performance, potentially leading to firm's sustainability.

Policies

Unsupportive environments characterised by high levels of bureaucracy (Siegel et al. 2004) make the situation even more difficult for the commercially-oriented faculty. Overcoming such difficulties is a clear role for the institutional policy (Patzelt and Shepherd 2009) as set by university administrators. The literature on academic entrepreneurship clearly identifies the importance of institutional policies that focus on simplifying contractual arrangements (Lockett and Wright 2005; Bekkers et al. 2006) and assist in 'deal' negotiations (Lockett and Wright 2005; Moray and Clarysse 2005), freeing up time for faculty to focus on knowledge commercialisation, in particular forming spinout companies. However, Chrisman et al. (1995) warn that policy-makers squeezing higher education funding might impact such support services at universities, resulting in a vicious circle of university 'deprivation': lack of resources, an unsupportive environment, inability to attract high quality faculty and degrading academic outputs.

Thus, the importance of university resources in academic entrepreneurship support is unquestionable, as these play a crucial role in expanding a university's abilities to be fully engaged in forming academic spinout companies. These resources are further strengthened through university networks that include a number of actors. These actors are discussed in the subsequent sections.

3.3.2 Technology transfer office

After the intensification of university knowledge commercialisation efforts (i.e. post-Bayh-Dole Act), most universities around the world set up additional departments that would look after their new entrepreneurial side – technology transfer offices. Their core task is to act as an intermediary between the university/academics, private industry and not-for-profit organisations. In terms of academic spinout companies, TTOs provide IP opportunity identification (Macho-Stadler et al. 2007), IP protection (Shane 2004a; Bercovitz and Feldman 2008), licensing and forming spinout companies (Alexander and Martin 2013), networks of investors, external

entrepreneurs (Lockett et al. 2003; Shane 2004a), and other necessary support services (Shane 2004a). This is, nevertheless, a very traditional view of TTOs, as some universities organise them as separate legal entities either for-profit or not, giving them greater freedom to attract high-quality professionals and making TTOs less dependent on university budgeting (Markman et al. 2005). A good example of this is Wisconsin Alumni Research Foundation, which, thanks to its autonomy from Wisconsin University, could engage with a range of regional actors, including policy-makers, to help commercialise stem cell research, which was controversial at the time (Jain and George 2007).

Although the original role of the TTOs is to provide support, there is a growing body of literature which suggests that TTOs are necessary for other knowledge commercialisation activities (Bourelos et al. 2012), beyond forming spinout companies (Di Gregorio and Shane 2003; Vohora et al. 2004; Lockett and Wright 2005; Fini et al. 2009; Aldridge and Audretsch 2011; Clarysse et al. 2011a; Bourelos et al. 2012; Fini et al. 2017). This is particularly important as TTOs are traditionally associated with creating spinout companies, and yet they appear to be poor doing so. Clarysse et al. (2011a) indicate that faculty entrepreneurial intentions are independent of the presence of TTOs, therefore it is unlikely that TTOs have any major impact on academic entrepreneurship. Instead, they suggest focusing on nurturing entrepreneurial skills in academics. This concurs with Vohora et al. (2004), who found that it is frequently the inventor who recognises the commercial opportunity of a piece of research. This is clear when looking at studies which suggest that TTOs focus on licensing technologies to established businesses more often than on building academic spinouts (Chrisman et al. 1995; Markman et al. 2005; Farnstrand Damsgaard and Thursby 2013), due to the associated lower risk and resource requirements.

A number of scholars suggest that this underperformance could be mitigated if TTOs, especially those that are part of university departments, could hire more experienced professionals and were better resourced (Degroof and Roberts 2004; O'Shea et al. 2005; Powers and McDougall

2005; Wright et al. 2006; Macho-Stadler et al. 2007; Mosey and Wright 2007; Farnstrand Damsgaard and Thursby 2013; Gonzalez-Pernia et al. 2013). Nevertheless, some studies indicate that TTOs are unnecessary for spinout formation, and could cooperate with other TTOs to access the resources that they lack (Degroof and Roberts 2004) or focus only on prospecting and nurturing research with commercial potential (Leitch and Harrison 2005).

However, there is a growing negativity towards TTOs, which tend to overreact by suing academics who do not disclose their inventions (Loewenberg 2009; Grimaldi et al. 2011) and focus on pure utility-maximisation (Markman et al. 2005; Kenney and Patton 2009) rather than more altruistic goals originally intended for them. Furthermore, when measuring their productivity in patents per TTO employee, it appears that on average UK TTOs are not performing well, but are rather large university departments (Clarysse et al. 2011a).

It seems then that the role of TTO is controversial in forming spinout companies, and the existing evidence suggests that only large and already well-performing (i.e. experienced) TTOs provide crucial support to academics in exploiting their inventions by creating an IP-based company (Degroof and Roberts 2004; Fogelberg and Lundqvist 2013). Therefore, while it is crucial not to discount the role of the TTO, there is a need to reframe its value proposition. Specifically, there is a question mark over the effect of such an actor on spinout company survival. The limited spinout formation role discussed above could perhaps be indicative of a later-stage engagement, given network connectedness ascribed to TTOs.

3.3.3 Business incubators

Business incubators

Among the factors that play a core role in the academic spinout formation, business incubators are crucial and widely discussed (Brooksbank and Thomas 2001; Degroof and Roberts 2004; Clarysse et al. 2005; Bekkers et al. 2006; Djokovic and Souitaris 2008; Fini et al. 2009; Gilsing et al. 2010; Fini et al. 2011; Grimaldi et al. 2011; Bourelos et al. 2012) as one of the key modes

of organisational or governmental intervention in nurturing entrepreneurship (Wynarczyk and Raine 2005; Tamasy 2007; Gilsing et al. 2010) or simply contributing to economic development (Grimaldi and Grandi 2005) through creation of jobs (Wynarczyk and Raine 2005). In particular, Benneworth and Charles (2005) mention that such infrastructural support targeted at academic spinout companies could further contribute to regional economic development by being utilised at a broader level to support other local small and medium-sized enterprises (SMEs). Tamasy (2007), however, warns that business incubators are highly politicised, offering a possibility of resolving a range of economic development issues, and at the same time being potentially *utilised for their media impact … so that political activities achieve visibility* (p. 464).

The key role of business incubators is to accelerate business development and reduce the chance of a firm failing (Carayannis and von Zedtwitz 2005; Grimaldi and Grandi 2005). Business incubators also play an important role in creating local employment opportunities, enhancing the local entrepreneurship climate, retaining businesses in a local economy, commercialising technologies, and diversifying the local economy (Wynarczyk and Raine 2005). Carayannis and von Zedtwitz (2005, p. 103) expand on the incubator role as being:

> *…in the business of facilitating entrepreneurs and early-stage start-up companies and* [to] *compete with consulting firms, real-estate agents, and other companies for the most interesting and valuable start-ups. Incubators differentiate themselves through their particular competitive scope, strategic objective, and service package.*

These facilities offer a list of business support services: office space, administration, training, investment, consultancy and professional business management support (Grimaldi and Grandi 2005; Wynarczyk and Raine 2005; Bruneel et al. 2012). As well as providing access to networks (Wynarczyk and Raine 2005), these services define business incubators (Carayannis and von Zedtwitz 2005). In other words, business incubators isolate start-ups/new firms from immediate market risks, allowing them to focus on building the business rather than struggling for survival (Carayannis and von Zedtwitz 2005).

Grimaldi and Grandi (2005) in their study of Italian business incubators identified four distinct types of facilities: business innovation centres, university business incubators, independent private incubators, and corporate private incubators. Whilst the first two are clearly supported by public funds, they only offer very generic, low-cost services to start-ups/new businesses within a medium to long-term incubation period, with the university business incubators also offering access to research and knowledge, and typically exerting *no financial pressure to return a profit* (Carayannis and von Zedtwitz 2005, p. 104). Privately-run business incubators offer more specific services and comprehensive support (including management consultancy), which includes pre-seed and seed capital investment, taking equity stakes in incubatees, direct management support, with a strong focus on short-term incubation, but all at an unsubsidised rent price. Grimaldi and Grandi (2005) stress that the private incubators, although more costly, focus more aggressively on venture growth.

Another distinction of business incubators is offered by Bruneel et al. (2012), who identified three generations of incubators from their study conducted in Netherlands, Germany, Belgium, Sweden, France and the UK, with the first generation focused on infrastructure provision, the second adding softer services such as training and coaching, and the third providing access to networks. Although they identify the first two generations as focused on weaker support offered to businesses that require medium- to long-term incubation, whilst the latest generation focuses on accelerating business growth through high support and short-term incubation of the younger ventures, quite contrary to the above described classification (i.e. Grimaldi and Grandi 2005), third generation business incubators here are those that charge lower rent and require more public subsidies. Since the studies differ in geographical focus, these contradictory differences could be expected, highlighting the importance of national, and perhaps regional, focus in understanding these processes. This is further stressed by Bruneel et al. (2012), who suggest that there might be a relationship between the incubator location and its firms' performance, especially since the business incubators play a crucial part in a local/regional cluster of support for academic spinouts (Bekkers et al. 2006). Nevertheless, if the regional economy and actors

do not provide substantial evidence, for example a developed regional innovation system, to justify the existence of business incubators, such structures should be reconsidered due to their potentially poor performance or lack of contribution to economic development (Tamasy 2007).

Although a more recent study found Swedish university spinout rates to be positively related to using business incubator services (Bourelos et al. 2012), such findings are not consistent across the literature. For example, Salvador and Rolfo (2011) report that there are more spinout companies in regions with more business incubators and science parks, but when deconstructing their data they find that the majority of spinouts are not based in these facilities. University business incubators are not always found to be helpful to academic enterprises, with mixed results reported in some research (Doutriaux 1987; Rothaermel and Thursby 2005), suggesting a complex relationship. Furthermore, in studies of university spinout rates (Di Gregorio and Shane 2003; Gonzalez-Pernia et al. 2013), they were not found to be significantly influenced by the university access to business incubators, even non-university affiliated incubators (Fini et al. 2011). In a broader UK study profiling spinout companies it was reported that the majority of spinout companies have never been incubated in such facilities (Hewitt-Dundas 2015).

Perhaps an explanation for this could be found in the spinouts' inherent heterogeneity, which could be resolved by the provision of a variety of incubator models specifically tailored to the needs of different spinouts (Siegel et al. 2007). Alternatively, these mixed results could be explained by how business incubators are funded, with Tamasy (2007) suggesting that they should be only privately-funded to depoliticise them and to give them a sharper focus on venture development. Moreover, particularly in the US case, this could be linked to a greater university focus on licensing out technologies, rather than building spinout companies (Markman et al. 2005), suggesting a lack of coherent policy coordination (i.e. focusing on licenses, yet building incubators). Finally, it is also suggested that successful business incubators should be larger to achieve economies of scale and offer a more exhaustive and

flexible range of services for firms, including easy rental arrangements and 24/7 access (Wynarczyk and Raine 2005).

Overall, it appears that the role of business incubators is either an extension of university-offered services, or acts to a certain degree as a substitute for those services. In fact, there appears to be a lack of conceptual clarity on how university networks operate, and which elements of it are responsible for access to particular resources. Perhaps it should be the business incubators in which support for academic spinouts is concentrated, relieving universities of the necessity to develop a range of direct support resources.

Science parks

Although science parks are found to have no significant effect on academic spinout rates (Lockett and Wright 2005), they are considered crucial to support university-based start-up companies (Bower 1993). In fact, many scholars find no particular difference between business incubators and science parks, suggesting that both serve the same role of business incubation (Clarysse et al. 2005; Tamasy 2007). Tamasy (2007, p. 463) describes them as:

> *...property-based initiatives that have formal and operational links with a university or other higher educational institutions (or major centres of research). They are designed to encourage the formation and growth of knowledge-based businesses and other organisations normally resident on site, and have a management function actively engaged in the transfer of technology and business skills to the organisations on site.*

However, Bruneel et al. (2012) suggest that science parks are the next stage of development for the previously incubated firms, in a natural progression, giving them a clearly separate yet still very much connected character. Tamasy (2007, p. 463) adds that *science parks are more prestige-oriented*, and are often occupied by subsidiaries of multinational corporations (MNCs), which is consequently reflected in a higher rent, effectively deterring start-up companies. Siegel et al. (2003a, b) note that all UK science parks have university links and are built in close proximity to universities. Whilst, Siegel et al. (2003a) found that firms located on these science

parks are slightly more productive in research than 'outside' firms, Siegel et al. (2003b, p. 180) conclude that the benefits of being located on a UK science park are negligible.

Although it appears that there is a link between business incubators and science parks, these facilities seem to be playing slightly different roles, especially given the university connection. It is also interesting (and perturbing) that both facilities have been found to be rather ineffective, essentially signifying ill-spent, mostly public money. This in turn suggests that there is a more complex inherent problem with such facilities, which could be related to inadequate support provided, or unrealistic expectations. Start-up support from public sources appears to be counterproductive in its effects, as German experience of firms started up by the unemployed shows (Pfeiffer and Reize 2000), since it can create a culture of dependency, rather than intended independent entrepreneurship. However, when new start-ups manage to sell at an early stage it appears to be a very early sign of possible future success, as in the case of Israeli high-tech start-ups (Gimmon and Levie 2010), which could suggest criteria-based business incubation as a solution to these problems.

3.3.4 Investors

Although scholars indicate other external sources of investment for university knowledge-based companies, such as business angels (Mosey and Wright 2007; Huggins 2008b) or public funds (Huggins 2008b), much of the literature on academic spinouts has focused on the critical role of the private VC industry (Doutriaux 1987; Di Gregorio and Shane 2003; Lockett et al. 2003; Shane 2004a; Vohora et al. 2004; Clarysse et al. 2005; Powers and McDougall 2005; Rothaermel and Thursby 2005; Bekkers et al. 2006; Wright et al. 2006; Clarysse et al. 2007; Mosey and Wright 2007; Siegel et al. 2007; Toole and Czarnitzki 2007; Huggins 2008b; Bonardo et al. 2011; Fini et al. 2011; Politis et al. 2012; Gonzalez-Pernia et al. 2013; Hayter 2013) in facilitating and accelerating the spinouts' growth. However, this type of funding is mainly available at the post-proof-of-concept stage (Wright et al. 2006), and often after the company is formed, when much of the initial knowledge asymmetry is resolved. For a research

output to reach the proof-of-concept stage there is a need for funding that could establish if the disclosure has any commercial potential, which bears the greatest level of risk (Huggins 2008b).

Mustar et al. (2008) suggest that the non-funded spinouts do not have technology novel enough to be viable for market-based competition. This is where pre-seed and seed capital (Moray and Clarysse 2005; Fini et al. 2011), also known as proof-of-concept funding (Mosey and Wright 2007) can play a crucial role, with the core sources of such funding being universities. In fact, the literature suggests the importance of universities running more comprehensive internal investment funds (Shane 2004a; Wright et al. 2006), which also focus on early stage funding (Degroof and Roberts 2004; Grimaldi et al. 2011). This is particularly pertinent as start-up funding provision is crucial to the creation of academic spinout companies (Brooksbank and Thomas 2001) and ensuring their growth (Clarysse et al. 2011b). To bridge such early funding gaps, a new type of support structure has come to life: proof of concept centres, with at least 32 such centres reported in the US (Bradley et al. 2013). These new innovation agents have been found to be related to increased numbers of spinout companies (Bradley et al. 2013).

However, the funding for academic spinout companies presents a more complex set of issues. Huggins (2008b), in his study of London's knowledge networks between local universities and financial community, indicates that, due to low interest from private investors in commercialising academic research by means of a company (in particular concerning the early stages of such ventures), public sector funding intervenes to counteract such market imperfections. Furthermore, he finds that despite of the proximity of the two actors (i.e. knowledge-producers, private finance) and the greatest intensity of activity when such actors are co-located, the networks that connect them are poor. His findings concur with previous research in the area, which suggested a need for universities to better prepare/develop academic spinouts prior to seeking private equity finance (Wright et al. 2006). This is especially well expressed by Vohora et al. (2004): *Many of the VCs … expressed frustration that universities still had some way to go in learning how to present viable investment propositions*. Furthermore, it appears

that the initial public funding of the academic spinouts might have an unexpected effect of deterring VC investors due to overvaluing the companies, resulting in stifled growth (Clarysse et al. 2007).

This suggests that the academic spinouts' funding issues are skewed towards universities; however, as Wright et al. (2006) find, VCs are partly responsible for private equity market imperfections. As VCs tend to employ mostly professionals with a financial background, they are unable to understand and evaluate technology, suggesting a need to better diversify the skillset of human resources they manage, an approach that is found to be more prevalent among the larger VC firms (Wright et al. 2006). Evidence of a mismatch between expectations of TTOs, spinouts and the VC community is clearly portrayed in a BVCA/Library House (2005) report, where the top three VC priorities are identified as: the ability to satisfy a customer need with applications of technology; the likelihood of achieving an exit; and the level of motivation and commitment of the founding team, compared to the main focus of spinouts and TTO on the experienced management team. Overall, it appears that solutions to the above issues could be found in enhanced collaborations or network-building between universities and venture capitalists (Wright et al. 2006), which might require individuals or institutions to playing a boundary-spanning role (Wright et al. 2006; Siegel et al. 2007; Huggins 2008b), in part pointing to TTOs (Siegel et al. 2004; Alexander and Martin 2013).

Once an academic spinout secures much-needed VC funding, there are other issues related to how VCs overinflate the spinout value for successful exits. In early biotechnology spinouts, the investors' exited the invention/investment with high returns long before the companies developed an end-product (Bower 2003), partially giving heritage to the perception of how successful and attractive academic spinouts are. This excessive value-building is, however, easily observed once the academic spinout company reaches an IPO stage, after which its valuation falls (Bonardo et al. 2011), perhaps due to exposing the company to a market where asymmetries of information are much less prevalent. It is important to point out that whilst IPOs

are highly stressed in academic spinouts literature, M&As are much more prevalent among UK firms (BVCA/Library House 2005).

The financial situation of a spinout company is undeniably core to its survival. Although Cressy (1996) argued that the human capital of the entrepreneur is more important than firm's financial performance in business survival, in a sample of UK firms he found that firms with financial capital that came from entrepreneur's own savings or a bank (also Saridakis et al. 2008, who studied UK firms) had better chances of survival, yet those that were financed from the entrepreneur's family and friends or received finance from a governmental source had an increased risk of failure. The importance of private industry finance appears to translate clearly to spinout companies, which could be related to strict control exercised by such capital sources.

Furthermore, firm's success is dependent on its performance measured through a number of financial indicators: profits (Musso and Schiavo 2008), profitability (Borghesi et al. 2007; Bridges and Guariglia 2008; Wiklund et al. 2010), gross earnings (Kalleberg and Leicht 1991 (male sample only)), cash reserves (Wiklund et al. 2010), return on assets (Heiss and Koke 2004), total assets (Helmers and Rogers 2010), capital expenditures to sales (Borghesi et al. 2007), gross margin, labour expenses, residual cash flow (Huyghebaert et al. 2000), liquidity (Holtz-Eakin et al. 1994; Huyghebaert et al. 2000; Wiklund et al. 2010), collateral (tangible assets to total assets ratio) (Bridges and Guariglia 2008), labour productivity (Baggs et al. 2009), or total factor productivity (Musso and Schiavo 2008). Finally, high levels of leverage (Baggs 2005; Bridges and Guariglia 2008; Wiklund et al. 2010), financial debt (Huyghebaert et al. 2000), and capital-to-labour ratio (Audretsch 1991; Audretsch and Mahmood 1995; Agarwal and Gort 2002), approaching insolvency (Wennberg et al. 2016), or simply having financial difficulties at start-up (Saridakis et al. 2008) unsurprisingly tend to lead to firm failure.

3.3.5 Management team

Although academics are found to be rather entrepreneurial (Chrisman et al. 1995; Fini et al. 2010), it is only a proportion who have the right mindset and skills to develop their own company. Studies suggest that the successful creation of an academic spinout company (Franklin et al. 2001; Lockett et al. 2003; Vohora et al. 2004; Hayter 2013), further growth (Vohora et al. 2004; Walter et al. 2006; Djokovic and Souitaris 2008; Lundqvist 2014), and entrepreneurial orientation (Diánez-González and Camelo-Ordaz 2016) are positively influenced by engaging an experienced entrepreneur, also referred to as surrogate entrepreneur (Franklin et al. 2001). These effects are especially visible when looking at the strategies employed at the universities most successful at creating spinout companies (Franklin et al. 2001; Lockett et al. 2003). Franklin et al. (2001) observed those to be flexible and open (p. 138), *recognizing the differences they brought as opportunities rather than threats*.

The core benefits external entrepreneurs bring to the academic spinout include business experience, networks (Franklin et al. 2001), and commercial (Wennberg et al. 2011) and management skills (Grandi and Grimaldi 2003). Furthermore, these entrepreneurs are crucial in securing investment for academic spinouts (Vohora et al. 2004), not only by presenting a business opportunity to investors, but also by tapping into their networks of potential investors and adding credibility to spinouts' management teams (Wright et al. 2006). Additionally, Visintin and Pittino (2014) observe that it is the diversity of the founding team (i.e. one that includes academic and non-academic entrepreneurs) that is crucial to spinout's performance, noting that the size of the team has a negative effect on performance.

Politis et al. (2012) distinguish between two spinout models based on the type of entrepreneur: the inventor entrepreneur model, and the external entrepreneur model. They indicate that the inventor entrepreneur model of academic spinout is characterised by a focus on accessing mostly public sources of finance, as these typically allow the academic inventors to keep the equity of the business, preferring to invest more effort in developing the technology, and retain

control of the firm. Conversely, they find that external entrepreneur-based academic spinouts concentrate on securing private equity finance to accelerate the growth of the company, commercialising the technology, and controlling the future of the business. Clearly, this categorisation could be expressed as distinguishing the high-growth characteristics of the academic spinouts.

However, accessing such entrepreneurs is not an easy endeavour, as a case study of the Inter University Micro Electronics Centre (Moray and Clarysse 2005) showed, which decided on employing the entrepreneurs to upskill in-house the academic inventors to run academic spinouts, as a practical solution to the short supply of external talent. Whilst seemingly a practical solution, this could add extra pressure to commitments of academic founders and potentially conflict with their motivations for founding spinout companies, as discussed in Chapter 2. Essentially, such training would aim to transform non-profit-motivated individuals into utility-maximising entrepreneurs. These considerations are critical to the sustainability of spinout companies, as the characteristics of the entrepreneurs (or management teams) are strong predictors of firm survival.

Entrepreneur's demographics

As the core ‘component’ of the firm, the entrepreneur is often directly responsible for a firm’s survival. This is not just due to his/her decision-making, but his/her characteristics that influence those decisions. By far the most studied component here is entrepreneurs’ demographics. The age of the entrepreneur is consistently found to be significantly related to firm’s survival prospects, in most cases positively relationship (Holtz-Eakin et al. 1994; Cressy 1996; Van Praag 2003; Wiklund et al. 2010), although it is found to be non-linear (Holtz-Eakin et al. 1994; Cressy 1996; Agarwal et al. 2002), and less frequently, but also importantly, negative, as in the case of Swedish firms studied by Wennberg et al. (2010), although it should be noted that the study was interested in different exit routes rather than survival.

When a continuous variable such as age becomes decomposed into particular groups, the non-linearity is clearer, pointing at the 35-49 age group at start-up stage being most successful at operating a firm, a result observed across firms in different European countries (Pfeiffer and Reize 2000; Kangasharju and Pekkala 2002), including the UK (Taylor 1999). Bates (1990) also points to the 45-54 age group, although his study is limited to US male entrepreneurs only. Furthermore, Kangasharju and Pekkala (2002) find that in their Finnish sample of entrepreneurs, those aged 54-62 had a greater tendency to exit, which could be related to the effects observed by Wennberg et al. (2010), where retirement was potentially a contributory factor, otherwise explained by the increasing cost of time as it became a scarcer resource.

Gender also plays a role, as female entrepreneurs are found negatively related to firm survival (Pfeiffer and Reize 2000; Kangasharju and Pekkala 2002); however, this could be related to the fact that generally entrepreneurship is less prevalent among women, who have to compete in more male-dominated markets and typically are less endowed with time due to greater family commitments. In a separate US study of small firms from 1982 (albeit rather dated), Holmes and Schmitz (1996) identified that entrepreneurs from ethnic minority backgrounds tended to have better survival chances. Furthermore, entrepreneurs with family history of business ownership also tended to be more successful at running their businesses (Gimeno et al. 1997), although this evidence is rather limited as none such relationship was found by Bates (1990), however intuitively appealing and rational this might appear.

Human capital

Since the demographic characteristics of an entrepreneur are factors one cannot control, it is essential to look at what might better characterise the entrepreneur, notably human capital, which in general is positively related to firm survival (Bates 1990; Cressy 1996; Holmes and Schmitz 1996; Gimeno et al. 1997; Pennings et al. 1998; Kangasharju and Pekkala 2002; Bosma et al. 2004; Acs et al. 2007; Gimmon and Levie 2010; Unger et al. 2011; Rauch and Rijsdijk 2013; Criaco et al. 2014), although Storey and Wynarczyk (1996) in their UK study found that

firm demographics are better predictors than human capital (also reported as insignificant in Coad et al. 2013). Among the human capital components, education is perhaps the most commonly measured, and unsurprisingly education is positively related to firm survival (Bates 1990; Bruderl et al. 1992; Holmes and Schmitz 1996; Kangasharju and Pekkala 2002; Rauch and Rijsdijk 2013). However, a British study found that overall there was no significant effect of education, and the only significant effect was negative and for male entrepreneurs only (Taylor 1999), once again signifying the importance of entrepreneur's gender. Moreover, in a study of Israeli high-tech start-ups Gimmon and Levie (2010) found that entrepreneur's skills enhanced his/her success chances, in particular general technological and/or business management expertise, as might be expected given the nature of those firms.

Another vital part of an entrepreneur's human capital is experience, which has been widely studied in the literature and generally reported to have a positive relationship with firm survival. Specifically, entrepreneurs with experience in the industry of their new firms (Bruderl et al. 1992; Cressy 1996; Gimeno et al. 1997; Van Praag 2003) or industry in general (Bosma et al. 2004) have an increased probability of success. Furthermore, those who were in paid employment prior to starting their own ventures also tended to be at a lower risk of failure (Gimeno et al. 1997; Taylor 1999), as well as those with greater accumulated work experience (Bruderl et al. 1992). Although it might be expected that unemployed people would be more motivated to run a successful business, the evidence is unconvincing, with a recent German study finding indeed a positive effect (Oberschachtsiek 2010). However, the UK and US studies found the opposite to be true (Taylor 1999 (albeit for female sample only); Van Praag 2003).

Similarly, scholars studying the effects of prior self-employment on entrepreneur's firm's success provide rather inconclusive evidence, with UK (Taylor 1999) and Dutch (Bosma et al. 2004) studies finding a positive effect, whilst German and US studies a negative one (Kalleberg and Leicht 1991 (although for male-led firms only); Oberschachtsiek 2010). Male entrepreneurs involved in running another business (Kalleberg and Leicht 1991) or affiliated with another firm

(Bosma et al. 2004) are at a greater risk of failure, perhaps signifying over-commitment rather than self-employment experience. Finally, Holmes and Schmitz (1996) find that entrepreneurs' managerial experience is related in a non-linear way (U-shaped) to firm survival, suggesting that there is a threshold point of accumulated experience, after which it begins to have an adverse effect on the likelihood of a firm's success.

Other factors

Entrepreneurs' choice of entry appears to play a vital role in the venture's survival, with those who acquire an existing business (Bates 1990; Cressy 1996; Gimeno et al. 1997) or simply inherit a business (Gimeno et al. 1997) having greater chances of success. Nevertheless, the acquisition of a business may not be such a clear-cut story, as more qualitative evidence suggests that such entrepreneurs are at a greater risk of failure due to being more inexperienced in running a business, or simply not considering the financial risks (Duchesneau and Gartner 1990). Holtz-Eakin et al. (1994) also find that an entrepreneur's wealth is positively related to firm survival, clearly pointing to the necessity for capital backing. Social capital was found to be positively related to firm survival (Pennings et al. 1998; Bosma et al. 2004), indicating the importance of networks. In terms of the personality traits, it appears that those entrepreneurs that are motivated intrinsically to start-up a business (Gimeno et al. 1997) and male entrepreneurs with greater confidence levels (Kalleberg and Leicht 1991) have higher probabilities of success. However, in Caliendo et al.'s (2010) study it is reported that entrepreneur's risk attitude has a U-shaped relationship to firm survival, with low and high-risk attitudes threatening firm's existence. Finally, Taylor (1999) found that British entrepreneurs who decide to be self-employed in a professional or skilled manual (male sample only) occupation enjoy a reduced risk of failure.

3.4 Broader network environment

3.4.1 Geography

Within economics, geography has re-emerged to play a crucial role (Krugman 1991b; Krugman 1991a, 1995; Keating and Loughlin 1997; Storper 1997; Krugman 1999; Storper 2009; Krugman 2011), as demonstrated by Krugman (1991b), who was discontented with economists over-simplifying development, as if human activity was homogenously scattered around the globe. In fact, in the 1980s Storper (1984) pointed that there was a serious diversity of views among economists and geographers, with the former ignoring the geography, and the latter taking geography for granted without inquiring into its effects. Krugman, first in his 1990 working paper (Krugman 1990), then in 1991 in a peer-reviewed journal, underpinned this by his theoretical model explanations, proving that there are a number of factors contributing to localised concentrations of economic activities, the majority of which relate to evolutionary aspects (path-dependent) (Nelson and Winter 1982). However, it was Krugman's 1991a monograph which subsequently marked the emergence of New Economic Geography (NEG) (Krugman 1999, 2011) as a development in the field. His work is, nevertheless, a development of Marshall's agglomeration theory (Malmberg 1996), with a more powerful modelling of what had been usually presented in a descriptive form. Much of the economic geography debate in the last two decades seemed like an attempt to legitimise the marriage of the two disciplines (Krugman 1991b; Krugman 2011; Storper 2011), each characterised by a very distant idiosyncrasy: economics – quantitative/parsimonious, and geography – qualitative/complex. These debates continue, given difficulties in finding the 'right' balance between economics and geography (Bristow 2005; Bristow and Healy 2014).

Other scholars observed that the economic success is more apparent in certain well-known regions (Cooke 1992; Storper 1993; Florida 1995; Storper 1995b, a; Asheim 1996) that specialised in particular economic sectors. However, paying attention to the regions themselves, and especially these exemplary regions did not start with or after Krugman's 1991 work, as other scholars were already studying regions and their underlying success conditions (e.g.

Malecki 1984; Malecki 1987). The exemplary regions that attracted (and still attract) frequent attention in the literature are mostly: Silicon Valley, Route 128, Hollywood, Emilia-Romagna, Baden-Württemberg, Lombardy, Catalonia, Rhône-Alpes, London, Tokyo, Los Angeles, New York, Ile-de-France, Toyota, and many more, all praised for specific characteristics that contributed to their economic development.

Whatever sparked the regionalism debate and related it to economics, however intentional or not, it would be hard to separate regionalism from politics. The role regions played in the politics was quite well captured in Keating and Loughlin's (1997) edited book. They note that regionalism emerged around the 1980s when the European integration debate started, although others claim an even earlier date (such as the 1960s), more focused on tackling the underdevelopment of urban and rural areas (Bachtler 1997). However, this localises regionalism to the European continent, and such political moves are reported to have been taking place outside of the old continent, e.g. among the US, Canada and Mexico under NAFTA (North American Free Trade Agreement). Although this was not free of economic motivations for the establishment of free trade between the countries, regions started to play a key role (Conklin 1997). Similarly, it was observed that the regions that were located along the national borders tended to enjoy greater economic growth (Conklin 1997) than those further away, which could be explained by the distance decay effects (Krugman 1999). However, regionalism has gone much further than acknowledgement, and noticeable decentralisation of governmental powers has spread across the globe (Fulop 1997; Hendriks 1997; Jouve 1997), with some of this decentralisation being an effect of greater centralisation of some of those powers, e.g. the European Union (EU) (Balme 1997; Wannop 1997).

Thus the role of regions in economic development is further supported by explanations developing Krugman's observation that the geography of economics is not a homogenous picture. Storper (1997) appears to have a rather logically appealing one: interactions between economic actors tend to be localised, adding further to that the localisation of knowledge

production and exchange (Storper 1992, 1995a, b; Wonn Sonn and Storper 2008). The literature then leads to recognition of two key aspects in economic development: 1) networks, 2) knowledge; both, however, quite interrelated.

Knowledge networks

Ever since knowledge, and particularly inventions or innovation, has been given more attention in economic growth (Kaldor 1957; Romer 1986; Lucas 1988; Jaffe 1989; Adams 1990), it invariably became a key ingredient in the literature on economic development, particularly regional (Malecki 1981; Storper 1993; Florida 1995; Storper 1995a; Asheim 1996; Morgan 1997; Rodriguez-Pose 1999; Cooke 2001), although unfortunately it was left out of Krugman's original deliberations (Krugman 1991b), but acknowledged in the NEG's starting point (Krugman 1991a). Knowledge appears to have many propensities discussed by economic geographers, which, beyond pure economic terms, reveal interesting 'behaviour' at a more qualitative level. For example, Storper (1997) neatly states that knowledge is an outcome of localised (i.e. geographically proximate) interactions between social actors. He then geographically limits knowledge, as it is meant to stay in the vicinity in which it was first formed, arguing that it is difficult to export knowledge. This suggests that knowledge networks are spatially constrained constructs.

Nevertheless, knowledge spillovers are unavoidable, as found in Romer (1986, p. 1003), because *knowledge cannot be perfectly patented or kept secret*. Indeed, knowledge spillovers do occur, although they are subject to a decay effect with the increase in distance from the knowledge-production source (Rodríguez-Pose and Crescenzi 2008). In other words, the reach of knowledge networks is limited by physical positions of actors forming such networks, indicating spatial concentrations (Krugman 1991a) of actors to be best placed to benefit from knowledge. Although this would suggest that knowledge appears to be localised in character, more qualitative insight suggests otherwise.

Knowledge is too often treated as an intangible good; however it could be categorised into different phases of development, i.e. when first created it is not yet transmissible and remains tacit; once it becomes codified, transmissibility increases (Nonaka 1991; Kogut and Zander 1992; Nonaka 1994; Cowan and Foray 1997; Storper 2009; Storper 2010), allowing for diffusion. Scholars (Wernerfelt 1984; Kogut and Zander 1992; Storper 1997; Kogut 2000) point out that the advantage of market leaders (e.g. firms) remains until it becomes copied (or 'imitated') by others, but for this to occur the complexity of knowledge has to become absorbed/understood by those others (Cohen and Levinthal 1990), ending in a never-ending race between knowledge-creation and knowledge-imitation (Kogut and Zander 1992). A slightly reorganised categorisation of knowledge is offered by Asheim (2012): 1) synthetic, based on engineering, 2) symbolic, based on the arts (or less technical); and 3) analytical, science-based. The first two categories are less exportable, whilst the last is more diffusible. Noticeably, Asheim's (2012) categorisation appears to be less fluid in changing from tacit to explicit, and from constrained to transmissible.

The core focus in empirical works on endogenous growth theory was placed on universities as key knowledge-producing entities (Jaffe 1989; Anselin et al. 1997; Zucker et al. 1998a; Zucker et al. 1998b; Agrawal and Cockburn 2003; Laursen and Salter 2004; Rondé and Hussler 2005; Agrawal et al. 2006; Fritsch and Slavtchev 2011), evidencing the positive effects of publicly-funded research on economic growth. Given the tendency for private underinvestment in knowledge-generating activities, it is argued that universities and public funding for research play a major role in regional economies (Antonelli et al. 2008), where private firms can act on such produced knowledge through innovation to extract its economic value; innovation being an activity that deals with the implementation of the new knowledge (OECD and European Communities 2005). The concept was originally introduced by Schumpeter (1934), who stressed that 'new combinations' (i.e. innovations) need to be a continuous process in economic development. In his writing about economic development and the important role of innovation,

Schumpeter also focused on entrepreneurs as the main deliverers of innovation, something that nowadays is clearly observable (e.g. Audretsch and Keilbach 2008).

Innovation, however, is a very wide concept, and Schumpeter (1934) himself distinguished five types of innovation, apart from the binary classification between radical (completely new; revolutionary) and incremental (built on previous knowledge; improvement): 1) product, 2) method of production, 3) market, 4) source of supply, and 5) organisational. Scholars find that innovation is a path-dependent process (Roper and Hewitt-Dundas 2008), with a spatially-varying character that depends on the characteristics of the enterprises sourcing innovation (Huggins et al. 2010; Hewitt-Dundas 2013; Roper and Hewitt-Dundas 2015), including business lifecycle (Huggins et al. 2015a). Others report that such collaborative innovation arrangements are non-spatial in character with the network position of actors playing a critical role in determining innovation activity (Huggins et al. 2015b). As a result, nowadays, the key debate about economic development is focused around innovation, and knowledge is treated as an input into the innovation process, or by extrapolation, into economic growth (Romer 1986).

As the role of the networks, knowledge and innovation is clearly essential to the economic development of a region (Huggins and Prokop 2016) and it seems critical to put those factors together in some conceptualised form/model of some functional character. From the literature of the 1990s (mostly), one can learn of three major concepts, which appear to be both complementary to and competing with each other: 1) innovation systems: (a) national (Lundvall 1992), and (b) regional (Cooke 1992); 2) learning region (LR) (Storper 1993; Florida 1995; Asheim 1996; Morgan 1997); 3) triple helix (TH) (Etzkowitz and Leydesdorff 2000). All these conceptualisations have two common features: they present a working model of the networks of firms, universities, and public institutions, in other words: knowledge utilisation, knowledge production, knowledge production and utilisation stimulation.

Innovation systems

The innovation systems literature is to some extent split into two camps, differing in their treatment of geography. One, which coined the terminology and concept, is focused on the nation-state, and refers to National Systems of Innovation (NSI) (Lundvall 1992), whilst the other is at the heart of the economic geography and regionalism: Regional Innovation Systems (RIS) (Cooke 1992). The NSI scholars are motivated by the fact that in order to have a working system, there needs to be cultural homogeneity among social actors, which allows for smoother transfer of information and knowledge; and common institutions for those social actors (Lundvall 1992). Lundvall (1992, p. 2) portrays this further:

> *A central activity in the system of innovation is learning, and learning is a social activity, which involves interaction between people. It is also a dynamic system, characterised both by positive feedback and by reproduction. ... Cumulative causation, and virtuous and vicious circles, are characteristics of systems and sub-systems of innovation.*

Those networks and knowledge encompass a number of organisations, of which NSI stresses four in particular: 1) firms, 2) government, 3) financial institutions, and 4) R&D institutions (Lundvall 1992). Very much in the Schumpeterian notion, firms are responsible for innovation, R&D institutions for knowledge, financial institutions for supporting both knowledge creation and exploitation, whilst the government regulates these processes actively in collaboration with private industry, to stimulate and achieve mutual long-term benefits.

The RIS's primary point is to recognise that innovation set-ups are not national, but more controlled and differentiated among regions (Cooke 1992), given the diversity of core actors fundamental to these systems (Rondé and Hussler 2005; Charles 2006). Although his initial identification of RIS was very much based on nations (i.e. Japan, Germany and France), Cooke (1992) used countries that were more decentralised with clear, strong regions. From his observations three models emerged: 1) grassroots: low control, focused on applied knowledge with little specialisation; 2) network: fairly high control, both basic and applied knowledge

produced, flexible specialisation; and 3) dirigiste: strong control, focused on basic knowledge, highly specialised. In Cooke's (1992) RIS the components are still: firms, public institutions and universities. Again, mutual understanding of needs and goals with the cooperation between all parties is essential.

Learning region

The concept of a LR is focused on knowledge and innovation (also referred to as technology) and networks of social actors that enable these two elements to emerge, diffuse and add to regional growth (Storper 1993; Florida 1995; Asheim 1996; Morgan 1997). Since these processes cannot exist in a vacuum, social actors and institutions play key roles. Clearly firms, universities and public institutions are crucial (Storper 1993; Florida 1995; Asheim 1996; Morgan 1997), but also, as in NSI (Lundvall 1992), financial institutions (Florida 1995) have their own distinct role. LR is highly focused on social interactions that are culturally embedded in the region (i.e. conventions, as in Storper 1993), which ensure the density and co-operability of the networks. This is further enhanced by the regionally-based infrastructure of firms, labour, transport and communication (Florida 1995), whilst the LR's interactions should not be just limited to either a human level or organisational level, but instead should account for both (Asheim 1996). Lastly, the importance of public institutions' understanding and active engagement in these networks cannot be marginalised, as they can have a beneficial effect (Morgan 1997).

Triple helix

Although the TH concept stresses the importance of three elements: academia, industry and government, it emphasises the importance of academia as the leading force for innovation (Etzkowitz and Leydesdorff 2000), as its main unique selling point. The premise behind TH is that the role of the universities has changed from the traditions of teaching and research, and now more heavily involves the so-called Third Mission, engaging in the diffusion of knowledge produced. Etzkowitz and Leydesdorff (2000) present TH as a non-static model, which

recognised the evolutionary aspects of changing and adapting environments. Although knowledge and innovation are crucial in the TH model, collaboration is equally important, thus leading to an interlinked networked environment of academia, industry and government (Etzkowitz and Leydesdorff 2000). The concept, nevertheless, geographically alludes more to a national context, although one could easily find it applicable in a region, as close collaboration between TH stakeholders might suggest.

Spinout companies

Local context plays a crucial role in university spinout support (Klofsten and Jones-Evans 2000; Rasmussen 2008; Fini et al. 2009; Fini et al. 2011; Berbegal-Mirabent et al. 2013; Gonzalez-Pernia et al. 2013), as universities are immobile entities (Grimaldi et al. 2011; Berbegal-Mirabent et al. 2013) and thus need to utilise the available regional resources and capabilities to their best advantage. Consequently, it is difficult for all regions and their innovation systems' (Cooke 1992) actors to perform at a similar level, not to mention learn from each other. Whilst reproducing similar resources in each regional and national context is dependent only on the level of finance devoted to RIS, elements that cannot be easily imitated remain. This is well described by Braunerhjelm (2007, p. 627):

> *Differences in attitudes towards entrepreneurship and commercialization across countries and regions have been formed through culture, economic incentives and traditions, which feed back into social norms that capture the value and desirability of starting new ventures and becoming an entrepreneur.*

Good evidence of such evolutionary forces at work is portrayed in the case of Cambridge's high-technology cluster (Garnsey and Heffernan 2005), which makes a hopeful contribution that each region could transform itself into a competitive and attractive place for entrepreneurship, subject to the willingness and cooperation of the local actors. Indeed, the clustering of core regional actors is also crucial to the development of the university spinout companies. Bekkers et al. (2006, p. 554) suggest that *proximity of a PRO [*or university*], venture capitalists, and*

possible technical facilities and incubation parks form key-ingredients of such a cluster. These could be facilitated by active policy-making of the regional/local authorities engaged in their RIS (Benneworth and Charles 2005). In fact Bekkers et al. (2006) indicate that the national policies, laws and sectoral characteristics define whether spinouts would ever be formed.

In his study of the role of the Canadian policy-makers in facilitating the commercialisation of university knowledge, Rasmussen (2008) notes that actively engaged policy-makers do not just ease the financial burden for such activities, but also stimulate skills development among the TTO staff as well as encourage universities to *experiment with new approaches and initiatives* (p. 515). This bottom-up perspective clearly recognises different local/regional contexts and needs. For example, Ramaciotti and Rizzo (2014) found that spinout formation is greater in Italian regions that have less innovative activity (similar to the findings of Fini et al. 2017), suggesting a knowledge spillover role for these firms; yet spinouts of higher quality (Fini et al. 2017) and characterised by greater performance (Iacobucci and Micozzi 2015) are found in more developed regions, reflecting the complexity involved in spatial aspects of academic entrepreneurship.

Furthermore, Benneworth and Charles (2005), although identifying the small scale of direct effects of academic spinouts, point at a derivative set of benefits of these firms, where these ventures are used regionally as a symbolic tool to shape local/regional entrepreneurship support. This, however, questions the original purpose of academics spinouts, as a mode of diffusing university knowledge, as academic entrepreneurship becomes merely a mythical/prestige argument for policymakers.

Nevertheless, it is important not to lose sight of support available to avoid duplicating initiatives at a cost to the taxpayer. When studying regional entrepreneurship support and university-based entrepreneurship support initiatives in Italy, Fini et al. (2011) suggested that duplication could be avoided if careful attention is paid to the regional contexts: in places where regional policies

stimulate entrepreneurship through a certain set of initiatives, e.g. provision of finance or tax incentives, universities focused on academic spinout companies should ideally invest their time in developing support initiatives not available at a regional level. This is particularly important in light of what Bekkers et al. (2006) indicated, that the institutional-level initiatives are rather responsible for ensuring academic spinouts' success. As a result, regional-based policies have a clear link to the university-based support for academic spinouts.

Firm survival

Where a firm is based plays a crucial role in its ability to survive (e.g. Littunen, 2000), especially if location of a firm is considered endogenous (Stephan 2011), i.e. firms may select their location specifically to exploit place-bounded advantages such as public subsidies. As such, the regulatory environment has been found to be positively related to survival of franchise businesses in the US (Shane and Foo 1999). Furthermore, Renski (2008), who studied new US firms for their first seven years in 1994-1995 found that businesses that were located in rural metropolitan areas (in particular high-tech firms), small cities and suburbs had better chances of survival than those located in urban core areas, perhaps reflecting the costs of doing business in cities. A similar effect was observed in a cohort of Greek manufacturing firms whose urban location contributed positively to their survival (Fotopoulos and Louri 2000), signifying positive agglomeration (or urbanisation) effects similarly reported in a study of Dutch new firms (Burger et al. 2011), or US firms (Renski 2011, although the effect is industry-specific).

Although agglomeration externalities are also reported to be positively related to Italian firm survival, urbanisation measured by population density is not (Basile et al. 2016), perhaps indicating common diseconomies related to inflated property prices. In another US study (Stearns et al. 1995) it was found that firm's location in particular urbanisation area (rural, metro, urban), industry and strategy have an interactive effect on firm survival, signifying that firm characteristics are moderated by geography (Pe'er et al. 2016). The differences in survival of firms, although not found to vary greatly among different countries, were found to be clearer

when firm's growth was considered. US firms, started up with fewer employees compared to their European counterparts, but after the first seven years they grew much faster and achieved a greater average employment size (Bartelsman et al. 2005). Finally, where an entrepreneur locates a business has an effect on firm's survival, with those who found businesses in a region they were familiar with enjoying a greater probability of survival (Dahl and Sorenson 2012). This regional embeddedness can be explained by greater accumulation of social capital (Dahl and Sorenson 2012), also linked to firm's survival.

Industry

A firm's industry characteristics, although hardly influenced by its decisions, play a crucial role in its success. For example, cluster embeddedness (Litzel 2016), cluster diversity (i.e. a cluster composed of firms from complementary industries) that a firm is a part of (Staber 2001) and that cluster's concentration (Wennberg and Lindqvist 2010) contribute positively to firm survival. Also, new firms co-located with their buyers in such a way that their sales revenue comes from only a few large buyers tend to have a lower risk of failure (Bruderl et al. 1992). Furthermore, a more competitive climate is generally found to have a negative effect on a firm's chances of success (Kalleberg and Leicht 1991, female sample only; Jensen et al. 2008), for example, high foreign firms' penetration of an industry (Mudambi and Zahra 2007), industry characterised by scale economies (Audretsch 1991), or industry concentration (Baggs et al. 2009), which could be related to the industry maturity (Jovanovic 1982). Although industry diversity is associated with firm's survival, the effect is unevenly distributed across industries (Renski 2011). Finally, firms located in an industry with a higher growth rate (Mudambi and Zahra 2007; Baggs et al. 2009; Holmes et al. 2010), possibly suggesting effects observed in new industries (Gimmon and Levie 2010) and, specifically, new firms operating in an industry characterised by greater levels of innovation (Jensen et al. 2008) enjoy a greater probability of success.

Macroeconomics

A firm's macro-environment exerts a significant effect on its survival prospects as illuminated by Storey and Wynarczyk (1996), who compared the same survival model across two time periods finding different results, or in Pennings et al.'s (1998) study controlling for major macroeconomic events (war, policy changes). Measures of regional human capital such as population growth or high school dropouts are negatively related to firm survival, whilst greater regional levels of a college-educated population improve firm's success chances (Acs et al. 2007), signifying a clear need for regional investment and policy focus on education. It is also difficult for firms to escape the effects of greater business failure rates (Van Praag 2003), unemployment (Audretsch and Mahmood 1995; Taylor 1999), domestic currency exchange rates (Baggs et al. 2009) or the negative impact of trade tariffs (Baggs 2005; Baggs et al. 2009). The success of a firm is, however, influenced by many other reported macroeconomic indicators, e.g. GDP growth rate (Gimeno et al. 1997; Jensen et al. 2008; Baggs et al. 2009), density of firms (a ratio of number of businesses to population), average size of firms, per capita income growth (Acs et al. 2007), industry average wages (Audretsch and Mahmood 1995), the index of a stock exchange (Jensen et al. 2008), or interest rates (Audretsch and Mahmood 1995, only for SMEs, as micro-firms are negatively affected by higher interest rates; Holmes et al. 2010), emphasizing the need for a strong economic environment.

3.5 Conclusions

This chapter discussed spinout company success by looking at the actors forming university networks. In particular, these actors are on a network distance spectrum with two distinct core categories: a) university network, and b) broader network environment. When combining these actors with discussions developed in Chapter 2, there is a clear corresponding conceptual model studied here, which includes university, firm, and region, as depicted in Figure 3.1.

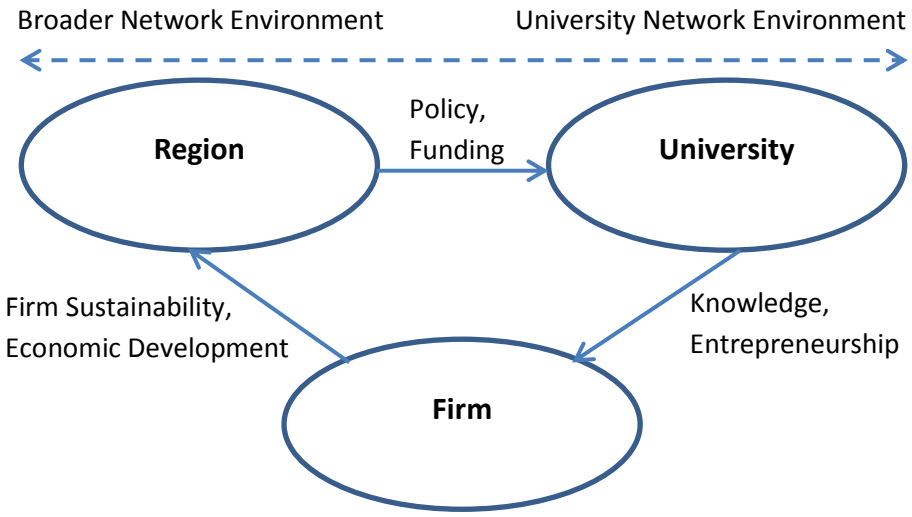


Figure 3.1 Conceptual framework of university spinout company literature

Universities as creators and repositories of knowledge create conditions for academic entrepreneurship, specifically the formation of spinout companies. These firms provide a vital linkage between the university and the wider region by contributing towards regional economic development in conditions when spinout companies enjoy sustainable operations. As such, the loop between the region and university is completed with further policy stimulation and funding. This conceptual structure is rooted in knowledge networks discussed under innovation systems (Cooke 1992; Lundvall 1992), learning region (Storper 1993; Florida 1995; Asheim 1996; Morgan 1997), or triple helix (Etzkowitz and Leydesdorff 2000) paradigms, all stressing collaboration between universities, firms and other actors in the broader regional environment.

From the literature discussed in this chapter, the conceptual model above can be disaggregated to reveal core actors of the university network situated within a broader network environment, as presented in Figure 3.2 in a stylised form. This detailed perspective relates to spinout company support discussions that identified core actors in spinout's development (Degroof and Roberts 2004; Clarysse et al. 2005; Moray and Clarysse 2005; Fini et al. 2011; Bourelos et al. 2012), namely: region, university, TTO, investors, business incubators, management team, and other actors.

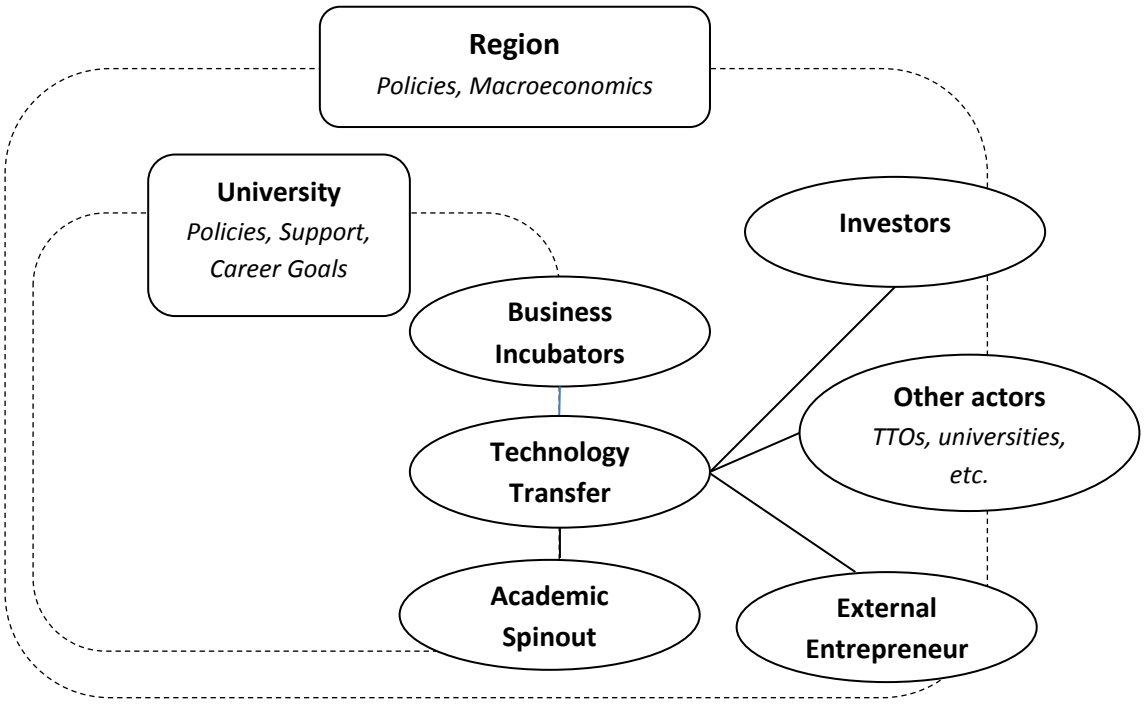


Figure 3.2 University network

An academic spinout receives support primarily through the TTO, but being based in a wider university environment, its development is dependent on university policies, initiatives and funding. Since business incubators are typically university-owned, but can be regionally provided by external organisations, it is a choice made by a TTO as to which ones to access. As much of the literature indicated that business incubators operated in a similar way to TTOs in terms of resource provision, these two elements may have their own links to crucial support ingredients: investors, external entrepreneurs, and other actors deemed necessary. Although most of this activity takes place within a region, some connections might cross geographical boundaries. It is important to note that university networks may differ in their architectures, functionalities, and outcomes, given their geographic contexts that would entail a set of idiosyncratic localised characteristics. Finally, each element present in this university network is an actor in a network of resources necessary for the creation and survival of academic spinouts, and as such network rules apply.

3.5.1 Understanding spinout company success

Although it appears that there is a wealth of empirical evidence on factors influencing firm survival or failure, saturation has yet to be reached. There are some major issues with the evidence reported in this chapter, as with any empirical findings, which require addressing. First and foremost, the evidence on survival factors is limited and there appears to be an important role played by geography. Many of the studies are based on small samples, and even in the case of studies using large samples, it is still unsound to expect those factors to behave the same across all firms without accounting for time, geography, and sector; and hence some of the measures were found to be both positive and negative in relation to survival (for example, industry density: Agarwal et al. 2002; Bayus and Agarwal 2007).

Whilst this chapter attempted to learn from firm survival literature, university spinout companies are unique, raising important questions with regards to applicability of prior knowledge to understanding their success. In particular, it is critical to consider university network actors and their individual contributions to spinout success. As some of these actors have been previously studied in the spinout formation context, their roles in formation and survival remain unknown, especially from a comprehensive perspective.

University characteristics such as institutional policy (e.g. Siegel et al. 2004; Patzelt and Shepherd 2009) and support (e.g. Degroof and Roberts 2004; Clarysse et al. 2005) have a critical role in stimulating entrepreneurial activity. These environmental endowments are clearly linked to resources available to the university. However, there is a limited understanding of the role these resources play in spinout formation and survival. Furthermore, it is unknown whether the same types of resources have different effects on formation and survival.

TTOs, business incubators and networks that represent connectedness, play divergent roles at spinout company formation and in the early stages. In particular, whilst there is a dearth of evidence on spinout company characteristics in predicting survival, firm survival literature

identifies a venture's demographic information to potentially play a key role in spinout's success (e.g. Cressy 1996; Holmes et al. 2010). However, given the unique nature of university spinouts, there is a need for empirical evidence to confirm or disprove this relationship. Furthermore, the role of TTOs, previously assumed to be focused on spinout company formation, is questionable (e.g. Bourelos et al. 2012; Fini et al. 2017), and based on empirical studies of small samples. It remains to be seen whether this effect can be observed in a larger sample, and if confirmed, whether TTO's role is actually critical to a spinout's survival.

Similarly, extant research on business incubators suggests their role in early stage survival of firms (Carayannis and von Zedtwitz 2005; Grimaldi and Grandi 2005), but this does not necessarily extend to spinout companies, as they are rarely incubated (Salvador and Rolfo 2011; Hewitt-Dundas 2015). These ambiguities lead to calls for clarity in the role of business incubation of a spinout company at start-up stage and its survival. Finally, as networks are considered important for spinout company survival (Mustar 1997), and links with industry influence spinouts' productivity (Bourelos et al. 2012), little is understood on the position of spinout companies in networks. Specifically, spinout companies exist in university networks, yet the structural network position of spinout companies that pertains to the use of opportunities, such as investors and management talent, measured through structural holes (Burt 1992), has not been studied in relation to firm survival.

Investors offer further complexity to understanding spinout company success. Whilst investors possess capital necessary for spinout development, extant studies only engaged with the influence of such finance on university firm formation (Brooksbank and Thomas 2001; Bradley et al. 2013) and growth (Clarysse et al. 2011b), omitting a more pertinent question of spinout survival. Firm survival literature identifies the importance of financial endowments, especially those that originate from internal or external private/corporate sources (Cressy 1996; Saridakis et al. 2008), suggesting the critical role to be played of seed funding and VC in spinout survival.

Nevertheless, a lack of empirical evidence offers no confirmation for such assumptions in case of academic spinout companies, given their unique character.

From firm survival literature it is found that characteristics of the entrepreneur, such as demographics (e.g. Wennberg et al. 2010; Wiklund et al. 2010) or human capital (e.g. Rauch and Rijsdijk 2013; Criaco et al. 2014), are important to a firm's success. Studies in the field of academic entrepreneurship observe a requirement for spinout companies to be led by experienced entrepreneur(s) (Franklin et al. 2001; Vohora et al. 2004; Politis et al. 2012), who would form the necessary management team of the firm. However, research into survival outcomes of spinout companies with experienced management teams is non-existent, with the latest study only observing management team diversity in relation to its performance (Visintin and Pittino 2014).

Finally, there is a pronounced role for geography in spinout company success. It constitutes the broader network environment in which the firm operates: an innovation milieu (e.g. Cooke 1992; Morgan 1997; Etzkowitz and Leydesdorff 2000), which could be rich in actors stimulating entrepreneurship, or policies favourable to firm creation and survival. Firm survival literature finds strong relationships between space and firm, especially when observing industry (e.g. Renski 2011; Litzel 2016) or macroeconomic (e.g. Fritsch et al. 2006; Baggs et al. 2009) indicators. Nevertheless, it remains unknown if academic spinout success is affected by spatial differences, and in particular whether university networks differ across regions. This is especially important as prior research on spinout companies largely ignored the role of space, which may influence the development of university networks (e.g. Scott and Storper 2003; Huggins et al. 2010) and the success of spinouts.

The following chapter outlines the methodology applied in this thesis, in particular introducing core research questions, explaining the research approach, and offering a detailed account of steps undertaken to investigate spinout company success.

Chapter 4

Methodology

It is necessary to match the outline of the relevant literature provided in the previous chapters with a pertinent methodology to address the research questions posed below. In this chapter an overview of the core research paradigms is presented, which explains the chosen research design and methods to undertake this inquiry. The study of the success of academic spinouts undertaken here is rooted in the post-positivistic paradigm and correspondingly it employs an explanatory sequential mixed methods approach to answer the research questions rigorously. Data collection for this research has been conducted in two stages: quantitative, and qualitative. The quantitative data has been explored using statistical analyses, namely bivariate tests of independence and multivariate techniques, whilst the qualitative part provides an explanation for the obtained results and exemplifies four distinct university networks illustrating diversity of approaches and outcomes in relation to spinout company success. The sample studied in the quantitative part consists of 81 universities in a study focused on spinout company formation, and 870 spinout companies to explore spinout company survival. In the qualitative part, the sample of 15 actors representing four distinct university network contexts is used to explain both aspects of spinout company success. This chapter also outlines the variables constructed and used in the analyses presented in Chapters 5 and 6.

The chapter is structured as follows: Section 4.1 outlines the research questions pursued in this thesis; Section 4.2 explains the research paradigm this study is set within; the research design is described in Section 4.3; Sections 4.4-4.7 outline data collection, sampling, analytical approach and limitations of quantitative and qualitative parts of this study; Section 4.8 states the core limitations of methods employed; Section 4.9 discusses issues of validity, reliability and generalisability; Section 4.10 states ethical considerations; and the chapter concludes in Section 4.11.

4.1 Research questions

From the literature review presented in the previous chapters a number of gaps emerge as presented in Table 4.1. The key missing elements in understanding the academic spinout phenomenon are the role of university network in the success of spinout companies and whether this role differs across the two success stages considered in the thesis. In particular, the examination of roles of university network actors concerns university TTOs (Shane 2004a), business incubators (Clarysse et al. 2005), management teams (Franklin et al. 2001), investors (Di Gregorio and Shane 2003), and other actors (Lockett et al. 2003). Furthermore, these aspects have been studied only in a limited and fragmented way, overlooking the role of networks (Burt 1992) and other actors of university networks. These lead to the main research question:

What are the key elements contributing to the success of academic spinouts?

'Success' is understood in two contexts, which are interrelated: a) university spinout formation (i.e. births of firms); and b) academic spinout survival. Since the most important development phases for a firm are the early years (as evidenced in the academic entrepreneurship literature, e.g. Vohora et al. 2004), success being sought among the actors of university network is essential.

Given the role played by geography in economic development, and, at a micro level, successful entrepreneurship, where economic activity is not homogenously distributed across space (Krugman 1991b), it is crucial for this research not to be ignorant of major influences/issues, especially relating to university networks (e.g. Cooke 1992; Morgan 1997). Therefore, the next research questions explore the research gaps related to the lack of understanding of the role of broader network environment in the context of academic spinout success and whether this role differs across formation and survival:

a) What are the factors influencing university spinout formation rates and differences across the UK regions?

b) What are the factors conditioning survival rates of academic spinouts and differences across the UK regions?

c) What are the characteristics of UK regional university networks, and do differences across regions enable or inhibit formation and survival of academic spinouts?

Table 4.1 Key literature and research questions

Key works	Literature focus/network elements	Research gaps	Research questions
Shane 2004a; Bourelos et al. 2012; Alexander and Martin 2013; Fini et al. 2017	Technology transfer offices	The role played in formation and survival of spinout companies, and whether these roles differ across the two success stages.	Main research question: What are the key elements contributing to the success of academic spinouts? Sub-questions: a) What are the factors influencing university spinout formation rates and differences across the UK regions? b) What are the factors conditioning survival rates of academic spinouts and differences across the UK regions? c) What are the characteristics of UK regional university networks, and do differences across regions enable or inhibit formation and survival of academic spinouts?
Carayannis and von Zedtwitz 2005; Grimaldi and Grandi 2005; Salvador and Rolfo 2011; Hewitt-Dundas 2015	Business incubators, science parks		
Burt 1992; Mustar 1997; Huggins 2010a; Bourelos et al. 2012	Networks, links with industry		
Di Gregorio and Shane 2003; Mosey and Wright 2007; Huggins 2008b; Bradley et al. 2013	Investors, seed funds, venture capital		
Franklin et al. 2001; Vohora et al. 2004; Politis et al. 2012; Visintin and Pittino 2014	Management team, experienced (surrogate/external) entrepreneurs		
Krugman 1991b; Cooke 1992; Morgan 1997; Fritsch et al. 2006; Baggs et al. 2009	Regional innovation systems, geographic characteristics		

What follows explains how the answers to these questions were pursued, looking at the research philosophy and methodology employed here.

4.2 Research philosophy

There is a clear necessity to outline the research philosophy underlying the inquiry undertaken in this thesis. This, in consequence, is a matter of consistency and discipline to achieve congruent findings that answer the contemplated research questions, as depicted by Little (2009, p. 155):

> *A social science research community will be most successful when it has a wide variety of methods and theories at its disposal, and is thereby able to match its inquiry and explanatory strategies to the particular features of the domain of phenomena to be understood.*

Thus, a number of existing research paradigms require consideration in order to make an informed choice of one that best fits the field of economic geography, and the type of inquiry pursued here. The core paradigms explored below are: positivism, critical theory, constructivism, and post-positivism, which consist of a blend of epistemological and ontological assumptions about knowledge and reality, with epistemology being 'the theory of knowledge' (Crotty 1998, p. 3), whilst ontology refers to the nature of what is known (Guba 1990).

Positivism is a theoretical perspective, assuming an objectivist epistemology that it is possible to pursue an inquiry without any human interference, values and biases, which would lead to discovering reality (Guba 1990; Crotty 1998; Guba and Lincoln 2005). Hence, the ontological perspective of positivism is that of realism: that there exists a 'final' reality that can be uncovered and described, often through rules, laws, or better-known axioms (Little 2009) that govern it (Guba 1990). The use of quantitative methods only is justified as a means to achieve these goals (Guba and Lincoln 2005). Positivism, however, is not free of serious weaknesses, and as a paradigm, it is no longer in dominant use, especially not in the social sciences, where social phenomena cannot easily be separated from the human actors (Little 2009).

Often considered in opposition to positivism (Guba and Lincoln 2005) is critical theory (Guba 1990) or critical social science (Fay 1987). This paradigm has given rise to many theoretical perspectives (also referred to as ideological), such as Marxism, feminism, or materialism (Guba 1990). Critical theory follows a subjectivist epistemological stance, which assumes that the meaning is not objective from the mind, but rather *is imposed on the object by the subject* (Crotty 1998, p. 9). Ontologically, critical theory assumes a critical reality; that the existence of a reality cannot be rejected, but finding it cannot be reached unless people realise they live in a 'false reality' (Guba 1990). Critical theory is about human oppression, and only once the freedom from this oppression can be won, a new 'real' reality can be revealed (Fay 1987). In other words, the oppression can be regarded as an illusion, in which human actors are subjected to suffering, unhappiness, and unfulfilment. Once they learn the truth and take a conscious action to change their reality, they can transform their lives into ones of joy, happiness and fulfilment (Fay 1987; Guba 1990). Although critical theory brings the human actor back into the inquiry, Guba (1990) argues that its epistemological and ontological perspectives give it a weak theorising capacity, especially due to an ontology shared with post-positivism.

Another major paradigm, also treated separately as an epistemology by Crotty (1998), is constructivism (Guba 1990; Guba and Lincoln 2005) or constructionism (Crotty 1998), in which reality is a human construct, are therefore it is neither value-free nor objective (Guba 1990). Thus, epistemologically constructivism sits within subjectivism. Although Guba (1990) argues that constructivism has no clear separation between its epistemology and ontology, he points to its ontological perspective towards relativism (also Guba and Lincoln 2005), since each human actor creates their own reality. Crotty (1998, p. 9) expands on constructivism, in which

> *Meaning is not discovered, but constructed… different people may construct meaning in different ways, even in relation to the same phenomenon.*

Therefore, theory is indeterminable, as each theory is only based within its own theoretical framework (Guba 1990). Guba (1990) adds that the main point of constructivism is to find a common theory (i.e. 'construction') from the many that coexist. Although this paradigm is very

appealing in its taste for complexity, it offers a line of inquiry that is difficult to theorise and transmit to policymakers.

Since positivism was too parsimonious in its original concept, a new paradigm emerged that stays within the objectivist epistemology: post-positivism. Within a post-positivistic paradigm, the major departure point from positivism is in the ontological perspective, where critical realism takes the stand (Guba 1990; Guba and Lincoln 2005). This means that post-positivism acknowledges the existence of reality, but at the same time is aware of the inquirer's limitations, both sensory and intellectual (Guba 1990). Therefore, there is no certainty of uncovering the 'true' reality, and it can only be achieved at a level as close to objectivity as is allowed by the level of inquirer's neutrality (Guba 1990). This neutrality and proximity to objectivity make post-positivistic research open to peer critique (Guba 1990), where theories are evaluated and refuted on the basis of sufficient evidence, making it a more complex and attractive paradigm (Phillips 1990), especially in social sciences (Little 2009). Furthermore, as Guba (1990) suggests, post-positivism, in its aim to achieve the most objective understanding of the reality, often undertakes triangulation of methods (p. 21):

> *... if objectivity can never be entirely attained, relying on many different sources makes it less likely that distorted interpretations will be made.*

Although none of the research paradigms should ever be treated as 'truer' or better (Guba 1990; Morgan 1990), nor as closed systems of strict rules (Firestone 1990; Guba and Lincoln 2005), from previous research (as seen in the literature review), it is clear that the post-positivistic paradigm applied in this thesis not only allows closer engagement with previous studies, but also satisfies the researcher's personal perspective on epistemology (i.e. objectivist) and ontology (i.e. critical realist). Furthermore, it offers the rationale for using a mixed method approach as undertaken in this research and is best placed to answer the research questions pursued here – requiring a specific and close to definitive answer, albeit consciously only a certain degree of realism can be uncovered limited by sample size and timeframe. Nevertheless,

it is important to note that post-positivism has its limitations: for example, deconstructing a power struggle between spinout companies and universities would be better served by critical theory, which offers tools to deal with a complexity of perspectives and meanings. What follows describes the methodologies used in this research.

4.3 Research design

The study utilises a sequential mixed methods approach (Tashakori and Teddlie 2003) with the core part being quantitative, exploring the relationship between academic spinouts' formation rates and success across different university networks, whilst the qualitative side provides an understanding and explanation of the discovered quantitative patterns/results. Creswell et al. (2008) refer to this as explanatory sequential design, as the quantitative research leads to qualitative explanation, whilst the reverse order of methods employed (i.e. qualitative leading to quantitative study) is classified as exploratory sequential design. The use of this approach is dictated by the complexity of the investigated processes, and the researcher's interest in gaining a good understanding of the function and structure of effective academic entrepreneurship.

The quantitative part is based on a unique sample frame of 1,331 university spinout companies registered with Companies House between 1959 and 2013, collected from multiple online sources. This data is enriched with databases that contain information on firm characteristics, university financial indicators, and regional economic performance. Consequently, to maintain consistency of data quality from such a multiple source approach, the analysis is performed on a final sample of 870 spinout companies formed between 2002 and 2013. The analysis employs several methods: social network analysis, descriptive statistics, bivariate tests and regression analysis.

Conversely, the qualitative part is based on interviews with 15 actors across four university networks which were selected using purposeful extreme case sampling applied to the sample frame of 1,331 spinout companies (87 universities). The core criteria for selection were based

on lowest and highest performance of university networks on spinout company formation and survival. At each extreme case, at least two semi-structured interviews were performed to capture the perspective of the university TTO and spinout companies. Where possible, data was also collected from business incubators. Additionally, two investors who focused their activities on spinout companies were interviewed. Qualitative data was examined using content analysis.

Although mixed methods design is relatively new, it offers a more robust and credible approach to understanding the studied matter, avoiding the idiosyncratic fallibilities of using quantitative or qualitative methods alone (Johnson et al. 2007). This is especially important, as the first part of this study is quantitative and adding the qualitative dimension avoids 'context stripping', i.e. limitations to the depth of research imposed by available variables to examine (Guba and Lincoln 1998). Furthermore, such an approach allows for a broader view that examines multiple perspectives, in turn limiting the influence (or improving the neutrality) of the researcher on the studied matter (Guba 1990). Additionally, as the nature of economic geography is a marriage of parsimony and complexity, it appears natural to employ a parallel research design.

It is acknowledged here that with the superior outcomes of using mixed research (Johnson et al. 2007) comes the cost of increased difficulty, especially expressed in time commitment and a broader research skillset required (Flick 2014). Consequently, the research process requires a clear demarcation between the two parts of this study, each with a number of stages in data collection and analysis. Finally, since the core issue in mixed research is the integration of the different methods (Tashakkori and Creswell 2007; Guest 2012), the approach undertaken here is that the results of quantitative part are strengthened with evidence and explanation from the qualitative research.

The study has a cross-sectional character, as long-term observations are costly and impossible to implement during a PhD timeframe, although they could lead to better outcomes in understanding spinout company success, especially in the qualitative part of the research.

4.4 Part I quantitative study

This section outlines how the data was collected for the quantitative part of the study, including the process of arriving at the final sample, and offers consideration of limitations of the data. Furthermore, analytical approaches towards the data collected are described. The section also provides a description and construct of variables used in the analyses in subsequent chapters.

4.4.1 Data collection

The university spinout data was collected from an internet service dedicated to UK academic spinouts (www.spinoutsuk.co.uk) on 12th January 2014, which covered the company name and its parent university(/ies) for 1,303 companies founded from the year 2000 onwards. Additionally, the names of spinout companies were obtained from all UK university websites (Appendix 1), as having spinout companies is typically considered good public relations activity for universities. This helped ensure that the pre-2000 companies would be captured for the following analysis and that partial triangulation was achieved, ensuring robustness of the dataset. A similar approach was employed in a study conducted around the same time, generating an initial sample frame of 1,056 active UK spinout companies (Hewitt-Dundas 2015).

This process resulted in 889 academic spinout companies' names collected, with their respective university affiliations. After merging both lists and removing duplicates, the list comprised 1,530 spinout companies, of which 1,452 had a single respective parent university, whilst the remaining 78 had either two or three parent universities.

As virtually all UK spinout companies take the legal form of a limited company at the start-up stage, due to the number and type of stakeholders involved and associated transaction costs, the list of company names was further enriched with detailed information on the academic spinouts from a Bureau van Dijk's FAME (Financial Analysis Made Easy) database, which holds detailed financial data on registered UK companies obtained from Companies House, as used in similar research (e.g. Lawton Smith et al. 2008; Siegel et al. 2003a). The database holds

information on both live and inactive companies. For each company, a detailed report in a spreadsheet format was downloaded. This data search provided information on the spinout's demographics: 1) status (live/ceased trading; with exact dates of incorporation and dissolution); 2) size (small, medium, large – where available); 3) sector classification (according to Standard Industrial Classification 2007 coding (Office for National Statistics 2009)); 4) address; 5) a list of directors and their respective time spent at the company (including the start and end dates for their roles); and 6) shareholders. From the list of shareholders, investors, such as VC companies and business angel networks, were identified, together with the mode of university ownership engagement (either direct or through a medium of a private limited company formed for such purposes i.e. TTO). The list of shareholders was used to construct a network of UK academic spinouts and their connections, and has an exploratory character, as this has not been attempted before.

The final sample frame for which data was found consists of 1,331 companies, with the remaining 199 firms removed for any of the following reasons: a) not found in the FAME database as either unincorporated or incorporated overseas (for which no extra information was obtainable due to information access limitations); b) found on FAME, however there was no certainty from director or shareholder information that could be triangulated by extra online search to confirm the university affiliation (this is especially crucial as the database holds information on both live and inactive firms, and company names are changed rather frequently, whilst a firm incorporated recently might have the same name as one dissolved some time before, with no actual relationship. Consequently, confirmatory triangulation was an essential step in ensuring the analysis was not distorted by companies that remain outside of the interests of this study); c) any other aspect of the company found during this process that brought into question the academic spinout character of the company (e.g. firms found to be staff start-ups or student start-ups during extra web searches, typically the company website); d) any form of complex incorporation, dissolution and reincorporation dynamics that made it difficult to trace the company's affiliation and existence; e) companies listed multiple times at university

websites (e.g. under both the original spinout name and post-acquisition name); and finally f) any listed under the University Campus Suffolk and Royal Agricultural College, as university-level data described below was not available for all variables of interest for those institutions. Spinouts found to be incorporated overseas were typically registered private companies in the US or Canada, but also in Singapore or Belgium, and in many such cases additional information was found (in most cases a company website) to indicate that these firms were typically a collaboration between UK universities and the country they operated in, suggesting an extra international dimension to such activity.

The sample frame so constructed is the closest reflection of the population of such firms ever studied, details of which are largely unknown and unreported in the literature, with only one recent report published by Hewitt-Dundas (2015), which focused on a sample of 350 active spinout companies, representative of a sample frame of 1,044 spinouts, adding to the originality and importance of this research's findings. The consequent and unfortunate limitation of this is the restricted comparability of the sample's characteristics to those of the population of academic spinout companies to assess its representativeness.

The data was complemented with university-specific information obtained from HEFCE's HE-BCIS, which provided both financial data on universities related to their Third Mission activity as well as binary variables for the university network elements. Additionally, university data was collected from HESA (Higher Education Statistics Agency) with regards to university size, operations, and finances.

Furthermore, based on the firms' and universities' addresses, respective regional data from Office for National Statistics (ONS) was added to the database, forming a group of control variables describing the socio-economic structure of regions in which those firms and universities were/are based. The geographical unit utilised in this study is based on the European Union's NUTS (Nomenclature of Territorial Units for Statistics) 1 level, which covers

12 regions: a) 3 devolved nation-regions: Wales, Northern Ireland, Scotland, and b) 9 English regions: South East, South West, London, East of England, East Midlands, West Midlands, North East, North West, Yorkshire and the Humber.

4.4.2 Sample

As the data on spinout companies needs to be matched across a number of other datasets, there is a natural limitation on the availability of such data across time. Whilst the sample frame captured spinout companies formed between 1959 and 2013, with survival event recorded on 1st May 2014, the official HESA statistics (primarily HEBCIS data) are only available for 2002-2014 at university level. ONS data (as used below to control for regional effects) is slightly less restricted in time and as historical regional data for economic output can be found. Nevertheless, the analysis presented from the next section onwards focuses on spinout companies formed between 2002 and 2013, whilst the data itself covers the period 2002-2014. This limitation reduces the number of original spinout companies studied from 1,331 to 870 (or 963 if each university's spinouts were considered, including multiple counts related to spinouts jointly founded by more than one institution), whilst the number of universities is reduced from 87 to 81, clearly not a substantial sacrifice. These changes, although reflected in the descriptive statistics presented in Table 4.2 – especially seen through reduced mean and standard deviation values of spinouts formed (an expected consequence), do not impose any further major changes to the characteristics of the final sample, with both skewness and kurtosis values only slightly reduced.

Table 4.2 Number of spinouts generated: descriptive statistics of sample frame (1959-2013) and sample (2002-2013)

		Sample frame	Sample
Mean		17.01	11.89
Std. Deviation		22.68	14.01
Skewness		2.28	2.15
Kurtosis		5.71	5.33
Minimum		1	1
Maximum		106	67
Quartiles	Low	2.00	2.00
	Median	7.00	6.00
	Top	24.00	17.50
N		87	81

4.4.3 Data collection issues

As the data was collected from university websites, it is expected to correspond with the official HESA's HEBCIS dataset. Nevertheless, it is crucial to elucidate any potential differences between the official statistics (as covered by HEBCIS) and the sample collected in this study. The sample of spinout companies was triangulated with Companies House records, which means that the year recorded for the creation of the company is that of its incorporation. Unfortunately, similar precision cannot be found in how the official HEBCIS collects the data, i.e. in HEBCIS,[1] the question directed to universities does not specify company registration with Companies House, and therefore it remains ambiguous how university administrators interpret creating a new company (i.e. whether they submit a pre-incorporated potential business case or incorporated entity. This distinction is especially visible from the evidence provided by TTO representatives interviewed, who indicated that typically the incorporation of spinouts would be delayed until there is certainty of securing initial investment to ease the administrative burden of registering the company and dividing equity stakes). Furthermore, registered businesses can have complex legal structures, e.g. Spinout X could have more than one legal entity registered to it, and thus precisely which one is the actual spinout company to be considered for the study

[1] https://www.hesa.ac.uk/intros/hebcidefs1011

introduces data problems in which the researcher's careful judgement and evaluation are crucial. Therefore, a level of data inconsistency is expected, regardless of the number of spinout companies in the sample.

4.4.4 Social network analysis

Part of the data collected was utilised in social network analysis (henceforth SNA) to specify the characteristics of the actors. This analysis reveals the full extent of the UK spinout company network, and helps identify the network properties (in particular, structural holes). Moreover, the SNA allows for identification of key actors in the university network, specifically (but not limited to): universities, academic entrepreneurs, external ('surrogate' as in Franklin et al. 2001) entrepreneurs (i.e. management team), and investors. This UK network allowed identification of regional characteristics of academic entrepreneurship activity. Finally, the SNA resulted in a creation of an independent variable (based on network characteristics) used in statistical analysis (university spinout's *structural holes*). The use of such measure has an exploratory character as network structure and characteristics were never studied before in relation to academic spinout companies. The analysis was conducted using Pajek (version 4.05) software.

4.4.5 Statistical analysis

This stage utilises data collected and partially analysed through SNA. Success in this study is assumed to have a dual meaning (spinout formation rates and spinout survival), so two dependent variables are explored. The analysis appears in two chapters: the first examines the university network and broader network environment characteristics through statistical tests that explore the significance of binary relationships in the dataset, and this leads to a multivariate regression analysis presented in the second chapter, which determines the percentage of variance in spinout success explained by university network characteristics.

When exploring university spinout formation rates, the chosen unit of analysis is a university. In bivariate tests, the dependent variable takes a categorical dummy form, as outlined below,

which distinguishes between universities that generate low numbers of spinout companies and those that generate large numbers. Furthermore, in regression analysis the dependent variable is of counts data type expressing the number of spinout companies formed, and hence an appropriate multivariate statistical model is employed, namely a negative binomial model. In the case of academic spinout survival, the unit of analysis is a company. The dependent variable is of a binary nature (i.e. trading status: live or ceased operations), and as such is used in both bivariate tests analysis and regression analysis, where it is fitted to a logistic regression model. The analysis was performed using SPSS (version 22.0.0.1) statistical software.

The following section outlines the variables built from the data collected used in the analyses presented in subsequent chapters.

4.5 Description of variables used in analyses of spinout formation

Although two statistical approaches are used to analyse the data, they share the same variables. This dual analytical nature is important to the greater understanding of the relationships in the data, as the bivariate statistical tests depict isolated probabilities of significant difference of these relationships between two variables of concern only, whilst the multivariate method controls for the effects exerted by other variables considered, offering a more complex image of university spinout company success. The variables described here employ a university as unit of analysis to explain spinout company formation.

4.5.1 Dependent variables

Spinout generation (bivariate analysis only)

As the first statistical analysis performed in this thesis involves bivariate tests of independence, a binomial type dependent variable is required, and in order to gain a greater understanding of the differences between successful universities that generate high numbers of spinout companies (e.g. Oxford University, Imperial College London) and those that generate low numbers (e.g. Birmingham City University, University of Bolton), a top quartile (75th percentile) is used as a

cut-off point (i.e. 17.5 spinout companies). This means that universities that generated a number of spinout companies above the value of the top quartile are in group A (henceforth high spinout generation), whilst the remaining universities that created a number of spinout companies at a rate lower in value to the top quartile constitute group B (henceforth low spinout generation).

Such data split has a distinct quality: 20 institutions (approximately 25% of the sample) in the high spinout generation group formed nearly 65% (625 out of 963) of spinout companies between 2002 and 2013. When using a median to depict the characteristics of the sample, universities that produced more spinout companies than the median point of 6 are responsible for nearly 90% (854 out of 963) of all spinouts formed between 2002 and 2013. This is only an increase of around 24% of all spinouts in the sample over the additional 20 institutions considered, clearly pointing to the top quartile value capturing a unique grouping of universities of different character in relation to spinout company generation. In fact, a similar grouping drawn from the sample frame would include the same institutions (except Herriot-Watt University) classed in the high spinout generation group. As a result, this categorisation is used in all bivariate tests related to spinout formation.

Spinouts formed (multivariate analysis only)

The measure used here refers to all spinout companies generated by 81 UK universities from the sample. It covers firms created between 2002 and 2013, with all of the 81 universities having created at least one spinout in that period. The number of original spinout companies formed by universities in the sample is 870, but after including the jointly-created firms in order to avoid fractions in such counts, the number of spinouts is 963. This includes firms regardless of their trading status (live/dissolved) and university ownership (i.e. not all spinouts have universities as shareholders, although there is a more complex corporate structure story, discussed in subsection 4.4.3). The use of counts of spinout companies, often referred to as spinout rates, is quite common in the literature (Franklin et al. 2001; Di Gregorio and Shane 2003; Lockett and Wright 2005; O'Shea et al. 2005; Powers and McDougall 2005; Fini et al. 2011; Hayter 2013;

Gonzales Pernia et al. 2013) that attempts to explain what contributes to greater numbers of such firms.

4.5.2 Independent variables

Variables used here describe the following university network elements: TTO (*commercialisation experience*), business incubator (*on-campus incubator*, *off-campus incubator*, and *science park*), network (*Δ university industry research income*), investors (*seed fund* and *venture capital*), *management team*, and other actors (*joint spinouts*).

Commercialisation experience

The role of TTO is measured through its age at 1st May 2014. The data for this was collected from HEBCIS. Interestingly, Bristol University has never reported having a TTO to HESA through HEBCIS. An online search, however, found Bristol Innovations Ltd and its start date (in 1996) in Companies House records. Further inconsistencies identified in the HEBCIS dataset are indicative of a complex data collection process. The age of TTO is not an ideal measure, as resources (e.g. employees) available to TTO could perhaps better define its purpose and productivity. Unfortunately, such data is not collected by HEBCIS, nor is it easily accessible from university websites.

Business incubators

There are three business incubation measures explored here: *on-campus incubator*, *off-campus incubator*, and *science park*. Business incubators and science parks have a very similar role in the spinout's lifetime (Clarysse et al. 2005; Tamasy 2007), therefore science parks are treated here as another form of incubation. All measures were obtained from HEBCIS and represent a proportion of a 12-year period between 2002/3 and 2013/14 when particular incubation services were available at the university. The reason for this variable construct is in the changing nature of access to incubation services at many universities, especially in cases where access was reinstated after one or more years with no incubation offered. This could be attributed to the

nature of decisions (funding, provision, need) or changes in personnel responsible for HEBCIS, who could have interpreted incubation differently. For example, in all interviews with TTO representatives, when asked about business incubation, they indicated that spinouts do not incubate in any formal space, but within university departments.

Change in university industry research income

In order to explore the effect of industry networks on spinout company formation, a proxy for such links is used in the form of change in university's industry research income over 2002/3-2013/14. The data was obtained from HESA. The variable built here measures the university's orientation towards development of networks with industry, where greater development is depicted with a higher growth rate of industry research income, whilst lower or negative growth represents divestment from or reduced focus on such network investment.

Investors

University spinout companies are often associated with receipt of external investment from institutional investors, resulting in two measures incorporated here: *seed fund*, and *venture capital*. Both variables were constructed from HEBCIS and indicate a proportion of a 12-year period between 2002/3 and 2013/14, when a particular type of finance was accessible at the university, whether provided by university itself, a partner organisation, or both. It is important to note that seed funding was available at all universities at some point within the timeframe considered in this study.

Management team

It is very difficult to measure the presence of management teams in spinouts, and even more challenging to identify which universities have access to, or networks of, such individuals. As a result, the measure used here is an ex-post type variable, which shows an average of university spinouts' directors' average numbers of directorship positions held at 1st May 2014 or at spinout's deregistration date (i.e. last available date). The data was collected from Companies

House through the FAME database by looking at company information on its directors. It is expected that the measure will take the lowest value if the directors are academics with no previous entrepreneurial experience, and highest for spinouts with directors with the greatest entrepreneurial experience.

Joint spinouts

Universities that are more open to other parties being involved in spinout formation were found to be responsible for greater numbers of spinouts in the UK (Franklin et al. 2001). It is clear that such a collective is better positioned to form spinout companies considering greater resources available to them. The measure was composed from three sources: university websites listing spinout companies, www.spinouts.co.uk, and shareholders' data collected from Companies House through FAME. The variable expresses counts of spinout companies formed jointly with one or more institutions between 2002 and 2013. It is important to add that certain spinouts were founded collaboratively with overseas institutions and UK PROs, whose data on available resources would not be captured by any other measure used in control variables in multivariate analysis.

4.5.3 Control variables

This group of variables defines the university (*university size*, *disclosures*, and *science orientation*), and broader network environment (*Δ regional GVA per capita* and *2002 regional GVA per capita*).

University size

To control for the size effect a sum of total university income over 2002/3-2013/14 is used. The data is produced by HESA annually. It is an imperfect measure among the variables utilised, as employment is more commonly used; however, employment data was not available for the year 2002/3, in effect reducing the sample by 101 observations. The variable is expressed in billions of pound sterling.

Disclosures

This variable captures university-generated knowledge of commercial potential as published in HEBCIS. It is constructed as a sum of annual disclosures between 2002/3 and 2013/14 and is used in two forms: untransformed in bivariate statistical tests, and expressed in natural logarithms to correct positive skew for regression analysis. In case of multiple university parents, the disclosures of all institutions are expressed as a sum. A disclosure is knowledge identified by a university TTO to have commercial potential (or recognised by faculty as having commercial potential and brought to TTO's attention, as in Bercovitz and Feldman 2008) and has been used in similar studies of spinout company formation (Di Gregorio and Shane 2003; Hayter 2013), or academics' entrepreneurial intentions (Fini et al. 2009; Goktepe-Hulten and Mahagaonkar 2010). It is important to note that not all commercialisable knowledge is captured by disclosures, as academics might not be inclined to disclose any invention at all (Chrisman et al. 1995). Another limitation to note is the imperfect nature of this measure of commercialisable knowledge, as some universities might require disclosures to actually be patentable inventions (Di Gregorio and Shane 2003) disregarding other inventions where monopoly market power could not be obtained.

Science orientation

University high-end research capability, which expresses university standing (Di Gregorio and Shane 2003; O'Shea et al. 2005; Powers and McDougall 2005; Lawton Smith et al. 2008), is used here to control for a bias towards science-oriented disciplines being more prone to knowledge commercialisation through spinout companies (Shane, 2004b). Shane (2004b) devoted a whole chapter in his book on spinout companies to discuss the industry or discipline bias predominantly towards spinouts from biomedical sciences, software, electronics, and industrial machinery. The key reason for the bias is in the numbers of spinout companies originating from these university departments. Shane (2004b) explains that the importance of such academic fields corresponds to a number of characteristics of such industries related to

greater levels of IP protection, lower levels of complementarity of assets, an earlier stage of industry development, or smaller average firm size in the industry.

Furthermore, such bias is present in the literature itself (never acknowledged or discussed), with numerous studies depicting either traditional science-based universities (128 companies from MIT were studied by Nerkar and Shane (2003); Delft University of Technology depicted in van Geenhuizen and Soetanto (2009)), science departments (researchers from Natural Sciences and Engineering Research Council of Canada studied in Landry et al. (2006); nanotechnology researchers studied at Chalmers University of Technology in Fogelberg and Lundqvist (2013)), or science spinouts' sectors (Lawton Smith and Ho (2006) profiled Oxfordshire's spinout companies to be primarily in biotechnology, IT, pharmaceuticals, measuring instruments, and optoelectronics sectors; out of 149 spinouts studied in Walter et al. (2006) 69% were in technical services and technical manufacturing sectors). There are exceptions: for example, medicine and science and engineering schools were found to be more supportive of entrepreneurial university paradigm compared to arts and humanities, and business and law schools (Philpott et al. 2011), but the bias is clearly evident in the results of such non-discriminate studies.

Based on the Research Assessment Exercise (RAE) 2008 and the Research Excellence Framework (REF) 2014, a simple measure is composed that reflects university's focus on high-quality scientific research. RAE 2008 measured outputs from 2001 to 2007 (www.rae.ac.uk), whilst REF 2014 covered outputs produced from 2008 to 2013 (www.ref.ac.uk), and so both assessments are well aligned with the sample's timeframe of 2002-2013. The variable first measures research quality and quantity derived either from RAE 2008 or REF 2014, where research outputs receive quality ratings from 1*-4* (unrated output is considered as well): 4* outputs are deemed world-leading. The REF (the successor to the RAE) was used to measure research quality in D'Este et al.'s (2012) study; however, they focused on academic journal

submissions and used citations data as a measure of research quality (citations are also used in O'Shea et al. 2005; Powers and McDougall 2005).

The metric used in this study focuses on the traditional science fields that typically generate more spinout companies, due to their more tangible IP protection method of patenting (Shane 2004b), and therefore the focus is on REF's (and respective fields in RAE 2008) Panels A (clinical medicine; public health, health services and primary care; allied health professions, dentistry, nursing and pharmacy; psychology, psychiatry and neuroscience; biological sciences; agriculture, veterinary and food science) and B (earth systems and environmental sciences; chemistry; physics; mathematical sciences; computer science and informatics; aeronautical, mechanical, chemical and manufacturing engineering; electrical and electronic engineering, metallurgy and materials; civil and construction engineering, general engineering). The approach taken here is to focus on the overall quality profile, which incorporates output, impact and environmental assessments of submissions. The end result simply transforms proportion-expressed RAE and REF scores (in percentage terms) into total submission numbers for every i^{th} university (separately for RAE and REF):

$$HERCM_i = \sum_j RO_{ij} \times NOS_{ij}$$

where:

HERCM – high-end research critical mass (i.e. submission numbers of 4* quality)

RO – sum of percentage of research outputs with overall quality score of 4*

NOS – number of submissions

i – notation for university

j – notation for research field, Panels A and B only.

In order to transform this measure into a more comparable variable it is simply divided by the total 4* research submission numbers in all panels (A-D):

$$UNI\%SCIE = \frac{HERCM_{AB}}{HERCM_{ABCD}}$$

where:

UNI%SCIE – university science orientation (expressed as a proportion of all research fields)

$HERCM_{AB}$ – high-end research critical mass in Panels A and B (i.e. submission numbers of 4* quality)

$HERCM_{ABCD}$ – high-end research critical mass in Panels A-D (i.e. submission numbers of 4* quality)

The variable composed here uses an average of UNI%SCIE measure for RAE 2008 and REF 2014. As a result, the variable covers a timeline from 2001 to 2013.

Change in regional GVA per capita and *2002 regional GVA per capita*

In order to control for regional economic development, two simple weighted measures of GVA (Gross Value Added) per capita are used: 1) capturing change from 2002 to 2014, and 2) controlling for the value of economic activities in 2002. Clearly, a region with greater economic output translates into a larger market, an industrial structure of the region with high-value (typically high technology) activities, whilst level of growth of the region's output indicates spinouts' performance potential in that location. Thus far, only exemplary regions were studied in terms of their spinout activity performance, such as Oxfordshire in Lawton Smith and Ho (2006); or were only used as dummy controls for such performance, such as California and Massachusetts in Toole and Czarnitzki (2007). The data for the variable was obtained from Office for National Statistics and is based on income-based regional GVA per capita (at current prices) measure.

Next, the variables used in survival analyses of university spinout companies are described.

4.6 Description of variables used in analyses of spinout survival

This section outlines the constructs of variables used in the analyses of spinout company survival. These variables undergo both bivariate statistical and regression examinations. The unit of analysis employed to explain spinout survival is the spinout company.

4.6.1 Dependent variable

Spinout survival

Survival of spinout companies is treated here in binomial terms, with an event on 1st May 2014 marking the collection of information on spinouts' trading status. 870 firms were formed between 2002 and 2013 among 81 UK universities. As virtually all studies of university spinout companies focused on the creation of such firms, whilst a smaller proportion that focused on performance or survival typically utilised qualitative methods (e.g. Shane 2004b) or studied firms of one parent, e.g. MIT (Nerkar and Shane 2003), or employed a small sample only (Criaco et al. 2014), the typical use of such a dependent variable can be more broadly related to firm survival studies.

4.6.2 Independent variables

Variables used here describe the following university network elements: TTO (*commercialisation experience*), business incubator (*on-campus incubator*, *off-campus incubator*, and *science park*), networks (*structural holes*), investors (*investment*), *management team*, and other actors (*joint spinout*).

Commercialisation experience

Although the presence of a TTO allows for little differentiation between potential support received by spinout companies, a more valuable insight could be gained by looking at how experienced these commercialisation support departments or companies are, despite their insignificance in terms of spinout company formation (Chrisman et al. 1995; Markman et al. 2005; Clarysse et al. 2011a; Farnstrand Damsgaard and Thursby 2013). The measure used here

estimates the age of a TTO since or until its creation at spinout's birth, and was obtained from HESA's HEBCIS, covering the period of 2002/3-2013/14. In cases with multiple university parents, the age of the oldest parent is used, because combined experience would misrepresent the cumulative nature of experience, i.e. 1 TTO with 10 years of experience does not equal a sum of 1 year experiences of 10 TTOs. It is important to note that for a minority of firms, the variable takes negative values, as the firm was formed prior to the foundation of a TTO.

Business incubation

As the information on spinout companies' use of business incubators is unavailable, less satisfactory measures are used instead that convey similar information. From HESA's HEBCIS data collected for years 2002/3-2013/14 on university's provision of access to on-campus, off-campus business incubators and science parks is used. The information allows the construction of dummy variables describing access to each type of incubator: *on-campus incubator*, *off-campus incubator*, *science park*, at spinouts' birth. In each incubator type, the reference case in multivariate analysis is when a spinout company has been formed by a university with no access to any incubation. 753 spinout companies originated from institutions with access to on-campus incubation; 723 firms from those with access to off-campus type incubation services; and 636 from universities with access to science parks. In case of spinout companies formed by multiple parents, access was assumed as long as one of the institutions offered it.

Structural holes

Spinout companies, given the network composition used here, already hold more central positions in their networks. However, as developing businesses, especially in the context of firm survival, they need to utilise opportunities to increase their chances of success. The data necessary for the construction of the variable was obtained from spinouts' shareholder information available from the FAME database. The variable was calculated using Pajek software for SNA.

Structural holes measure the power of an actor that depends on the extent to which his/her network is unconnected (non-redundant) (Burt 1992), with that actor enjoying greater benefits when the network is more unconnected, leaving the actor the main connecting node. The premise behind structural holes is that actor *i* benefits most if *i* can negotiate between *j* and *k*, when *j* and *k* cannot negotiate directly. Once *j* and *k* develop a relation/link, *i*'s relations become redundant and structural hole advantage is diminished. Structural holes depend on the strength of ties; hence if *i* is connected strongly to *j* and *k*, whilst *j* has a weak relation with *k*, *i* still maintains advantage in the network. Structural holes are measured as a constraint *C* of *j* on *i*, where *i* is more constrained in a network with more redundant ties, as it has few or no structural holes to benefit from (Burt 1992). Therefore, the aggregate constraint *AG* of actor *i* is defined as:

$$AG_i = \sum_j C_{ij}$$

where:

$$C_{ij} = \left(p_{ij} + \sum_{k, i \neq k \neq j} p_{ik}\, p_{kj} \right)^2$$

and:

$$p_{ij} = \frac{a_{ij} + a_{ji}}{\sum_k (a_{ik} + a_{ki})}$$

with p_{ij} being the proportion of relation values *a* from actors *i* to *j*, and *j* to *i*, out of the sum of all relation values $\sum_k (a_{ik} + a_{ki})$ of actor *i* (Burt 1992). AG_i takes a value of 1 for unconnected actors (with degree centrality of 0) in Pajek. For actors with 1 connection (i.e. degree centrality of 1) the aggregate constraint also takes value of 1, as the term $\sum_{k, i \neq k \neq j} p_{ik}\, p_{kj}$ would be equal to 0 reducing C_{ij} to $(p_{ij})^2$.

Due to resource limitations, the university network studied here has undefined values for relationships, which by default take value of 1 (i.e. $a = 1$), consequently excluding the theoretical considerations of the strengths of ties. As a result the C_{ij} depends on degree centrality *DC* of network actors:

$$C_{ij} = \left(\frac{1}{DC_i} + \frac{1}{DC_j}\right)^2$$

as:

$$p_{ij} = \frac{a_{ij} + a_{ji}}{\sum_k (a_{ik} + a_{ki})} = \frac{1+1}{DC_i(1+1)} = \frac{1}{DC_i}$$

therefore:

$$C_{ij} = \left(p_{ij} + \sum_{k, i \neq k \neq j} p_{ik}\, p_{kj}\right)^2 = \left(\frac{1}{DC_i} + DC_i \frac{1}{DC_i DC_j}\right)^2 = \left(\frac{1}{DC_i} + \frac{1}{DC_j}\right)^2 = \left(p_{ij} + p_{kj}\right)^2$$

where the aggregate constraint is a product of degree centrality of *i* and *j*.

The variable is calculated for all network actors (i.e. universities, spinout companies, and their shareholders); however, the values used here are only those that describe the network position of spinout companies. Given that the construct of the variable measures the aggregate constraint, the interpretation of the variable follows an inverse logic: firms with the greatest structural holes have the lowest values of the variable (as being the least constrained in their networks), whilst those with the fewest structural holes achieve the highest values of the measure (being the most constrained in the network).

Investment

The investment received by university spinout companies is measured through the number of original institutional investors, whether seed funds, business angels, or venture capitalists, that became shareholders (exchanging their funding for company equity). The data was obtained from FAME by looking at company's shareholder details. Although a more preferable predictor would measure the value of actual investments received, such data was not available. There is some availability of data on equity stakes, but it is inconsistent, and therefore offers little in terms of robust measurement. The picture of the investors is highly diversified, as filtering such information from the shareholders of 870 firms was an uneasy task. Although all investors are institutional, with the majority being private firms, some are firms set up with public funds, by universities or regional authorities. Furthermore, despite the majority of the investors being domestic firms, a proportion was from overseas: mainly continental Europe and US.

Management team

The role of a management team, first mentioned by Franklin et al. (2001) as external or 'surrogate' entrepreneurs, has not been measured beyond qualitative research, due to difficulty in identifying such individuals in larger quantitative studies, especially in the scarcely produced survival/performance-oriented research. In order to capture the presence of external entrepreneurs, an average of the number of directorships held by spinout company directors is being used. The variable is available, along with other company director information, in the FAME database, with its previously stated limitations. The use of such a proxy is justified by the fact that academic entrepreneurs are typically expected to have limited entrepreneurial involvement (typically having fulltime academic careers). Furthermore, the continuous nature of the measure also helps assist in finding out whether experience of the entrepreneurs is related to firm survival. The variable could alternatively be expressed as a dummy around a value of 1, a lower quartile or a measure of average of directorships. In the sample of 870 firms, there were 869 observations for the variable, as one data point was excluded as a true outlier (representing unreasonable directorship commitments (over 1000) held by a corporate structure, rather than a

person), while 16 missing cases were filled using a mean average value (3.43) for the variable, a standard method of dealing with missing data. This maximised the number of observations without listwise deletion of cases where information (expressed in other variables) was otherwise available.

Joint spinout

Little effort has been devoted to university joint spinout formation thus far (Lockett et al. 2003). The effect of joint spinout company formation is tested here with a variable based on original university website information, enriched with data extracted from the FAME database regarding shareholders. The joint creation data comprises of UK and overseas institutions, as well as PROs, domestic or not. The variable is continuous and measures the counts of parent institutions involved in the formation of a firm, with 93 spinout companies having more than ne parent.

4.6.3 Control variables

This group of variables defines university network elements: university (*university size*, *patents*, and *science orientation*), spinout company (*small firm*, *manufacturing sector*, *information & communication*, *professional, scientific & technical sector*, and *human health & social care sector*, *successful exit*, *number of directors*); and broader network environment (*Δ regional GVA per capita* and *Regional GVA per capita at birth*)

University size

The university size variable captures information on total university income at 81 institutions for the academic year that corresponds to spinout birth between 2002/3 and 2013/14. Such a design allows controlling for resources available at a parent institution to support a new start-up. The data was obtained from HESA. For spinout companies with multiple university parents, a sum of total incomes is used. The variable is expressed in billions of pound sterling.

Patents

In order to control for the effects of patents or monopolised knowledge, as generally used in studies of academic spinout companies (Di Gregorio and Shane 2003; O'Shea et al. 2005; Fini et al. 2011; Gonzales-Pernia et al. 2013), the university granted patents at spinouts' birth are used over the period 2002/3-2013/14. The data was obtained from HESA's HEBCIS. This continuous variable represents codified knowledge, typically considered an integral part of a spinout company (i.e. an IP-based firm) and important to their success (Nerkar and Shane 2003). As these patents are typically obtained by university TTOs, it is reasonable to measure the annual rates of such patents from a university rather than a spinout perspective. It is crucial to add that where spinout companies had more than one UK parent institution, the values of the patents were added together. The number of patents is expressed in thousands.

Science orientation

Based on RAE 2008 and REF 2014, a simple measure (UNI&SCIE) is composed that reflects university's focus on high-quality scientific research (see the previous subsection for details of the variable construct). As much of the qualitative research on academic spinouts focused on science departments or science-based firms (e.g. Haeussler and Colyvas 2011; Bourelos et al. 2012; D'Este et al. 2012), controlling for potential research field bias is important. The variable is used in the following way: for spinout companies formed between 2002 and 2007 UNI&SCIE values based only on RAE 2008 are used, whilst for spinouts formed between 2008 and 2013 UNI&SCIE values are based on REF 2014. In cases when a spinout company was formed by more than one university, HERCM data was added together, and the UNI%SCIE value obtained.

Small firm

Although the size of the firm can be captured by a number of measures, here, due to data restrictions, a categorical dummy variable is used to maximise the number of observations, as exact data on turnover, assets or employment is rare and inconsistent. The variable was constructed using Companies House data accessed through FAME. As a first highest-quality

size indication, employment levels were used, whilst in remaining cases data on the type of reported accounts was utilised to assign size categories. The size classes used refer to small (0-49 staff), medium (50-249 staff), and large (250 or more staff). Where the type of accounts was ambiguous or unavailable, the firm was treated as small, given the greater legal obligations on medium and larger firms to report more details. In the analysis the dummy for small firms is used, with medium and large firms remaining a reference case.

Firm sector

Information on a firm's sector was primarily derived from the FAME database where primary sector data was collected as a firm's main description of its activities. Where such data was missing (fewer than 50 cases), an online search for the company information was performed to classify its sectoral activity. The sector data is based on 2007 Standard Industrial Classification (SIC) (Office for National Statistics 2009). The sample is composed of 144 manufacturing companies, 147 information and communication firms, 451 companies in professional, scientific, and technical activities, 30 human health and social work firms, 50 administrative and support service firms, and 48 firms broadly classed as other sectors. The classification of SIC 2007 codes is available in Table A2 (Appendix 2). The data is used in a multivariate analysis in a dummy form, with four sectors selected as covariates best depicting high-technology sectors: *Manufacturing sector*, *Information & communication*, *Professional, scientific & technical sector*, and *Human health & social care sector*. The reference case are administrative and support and other services.

Successful exit

As academic spinout literature is very concerned with VC investments which greatly inflate business growth, there is an inevitable effect of such capital leading to so-called 'investment exit'. Such exit takes a successful form of IPO or M&A, with acquisition being more common than mergers. The main exit mode studied or commented on in the literature is IPO (Shane 2004b; Lawton Smith and Ho 2006; Lawton Smith et al. 2008; Bonardo et al. 2011), classified

as the point at which a spinout company starts significantly contributing to economic development (Shane 2004b; Lawton Smith and Ho 2006; Lawton Smith et al. 2008). However, Nerkar and Shane (2003) point to acquisitions as a preferred route for spinouts, as can be observed from the structure of this variable. Data on both forms were available from the FAME database, where IPO was identified from a company's legal form (public quoted or Alternative Investment Market (AIM)), and M&A from shareholder data, where ownership by another company is identified when such a firm owns 50.01% or more of a spinout company. As a result the dataset captured 74 M&A exits and 7 IPOs among 870 firms studied here. Due to low IPO numbers, the firm's exit is coded into one dummy variable that expresses any form of successful exit. The reference case for the dummy is when a firm does not exit through either of these means.

Number of directors

As the number of company directors could be a measure of an attempt at executive team-building to incorporate experienced individuals (Vohora et al. 2004), or to enhance a firm's network position (through key network actors), it is crucial to control for such effects. The data on directors is derived from the FAME database, which lists names and other biographical information on company directors. The variable is entered in a continuous form.

Change in regional GVA per capita and *Regional GVA per capita at birth*

Since survival of spinout companies across the UK regions is not uniform, it is important to control for such effects. Studies of firm survival do so by typically measuring change in output (Fritsch et al. 2006; Jensen et al. 2008; Baggs et al. 2009) or controlling for change and the value of output (Santarelli et al. 2009). In order to do so, a variable was constructed that measures a spinout's region's economic performance from a company's birth until deregistration or 2014 (i.e. event time) through change in GVA per capita over that period. Provided that change in economic output is normally expected to decrease with the value of that output, it is reasonable to also control for the size of weighted output at a spinout company's birth. The data

was obtained from the ONS and covers annual income-based regional GVA per capita from 2002 until 2014.

The next section presents the methodology applied in the qualitative part of this research.

4.7 Part II qualitative study

This section outlines the approach undertaken to construct the qualitative part of the study. It presents sampling strategy, how the data was collected, and any associated research problems.

4.7.1 Sampling

The qualitative part of this thesis provides more detailed evidence to the quantitative results, allowing for enhanced understanding of academic spinout company success measured as the births of companies and survival. In order to comply with the conceptual framework developed in the literature review, it is important to understand a range of perspectives from elements of university networks: TTOs, spinout company founders, investors, management teams and business incubators. To achieve such a complex goal, a purposeful sampling method is necessary, in order to maximise variation in the sample by including cases according to important research criteria (Gobo 2007). Purposeful or purposive, alongside quota, emblematic case and snowball sampling, is one of four core qualitative research sampling methods (Gobo 2007), where probability sampling is hard to justify given the objectives of the analysis. As the primary aim of the qualitative research here is to strengthen the quantitative evidence by achieving completeness and explanation (Bryman 2008), a purposeful extreme case sampling was utilised (Patton 2002; Teddlie and Yu 2007) as the primary sampling technique, in order to better reflect the research questions of firm formation and firm survival in the sample selection process. Patton (2002, p. 231) stresses that this sampling method is *information-rich*, but it offers no generalisability.

As extreme case sampling focuses on outliers (Teddlie and Yu 2007), which would not have been otherwise studied in quantitative methods that focus on average results (Patton 2002), it appears to be the best fitting sampling for the employed research design. Teddlie and Yu (2007) indicate that purposeful extreme case sampling is characterised by representativeness and allows for comparability given the contrasting data collected. Furthermore, a secondary technique utilised in the study is snowball sampling, which is applied after the first set of interviews with TTO and business incubator representatives to identify the remaining interviewees. Snowball sampling is used to identify key research participants who could provide a rich insight into the material of interest (Patton 2002) and ensures credibility in selecting the right candidates for interview (Gobo 2007). These representatives act as central agents in university networks or 'stars', as depicted by Berg (1998) in ethnographic research, which can be easily extended to this study as it also investigates social networks. Due to the network position of these 'stars', Berg (1998) suggests that (p. 145):

> *Sometimes a single gesture or word from a star will open more doors than weeks and weeks of attempts to gain access to these portals.*

The truthfulness of this statement could be observed each time a TTO representative introduced the researcher to other actors, who were very difficult to contact otherwise.

The criteria used to construct the sample are two-dimensional and begin with selecting universities that: 1a) generate a low number of spinout companies (below top quartile of 24 spinouts formed by universities in the sample frame, with a minimum of 10 [2] spinout companies); 1b) generate a high number of spinout companies (24 or more spinouts formed by universities in the sample frame); 2a) are characterised by lowest survival of their spinout companies; and 2b) are characterised by highest survival of their spinout companies. These criteria allow to the research to focus on university networks of the following institutions, as classified in Table 4.3: Scottish University (low spinout generation, low survival rate), London

[2] It is acknowledged here that the minimum level of spinout companies is set non-scientifically/conveniently. This was in order to have a selection of companies to contact for interviews by accepting the reality that not every potential research participant will agree to be involved in the study.

University (low spinout generation, high survival rate), Midlands University (high spinout generation, low survival rate), and East Midlands University (high spinout generation, high survival rate).

Additionally, two institutions were studied as pilots (Welsh University: high spinout generation, high survival rate, and Yorkshire University: micro spinout generation, high survival rate) sampled conveniently, although with an underlying intent to represent different institutional contexts. Nevertheless, the pilot nature of Welsh University transformed into that of the main data, given the difficulty accessing research participants at East Midlands University (as can be seen in the uneven distribution of interviewees within each institutional context, and the dates on which interviews were conducted).

Pilot questionnaires they were tested on an experienced qualitative researcher prior to the first interviews, which is a vital step in interview training (Brinkmann and Kvale 2015, p. 75):

> *The craft of research interviewing is learned by practicing interviewing, preferably within a community of experienced interviewers.*

This step allowed the researcher to time the questionnaires and receive comments useful for editing the questionnaires, to avoid repeating similarly-sounding questions and maintaining their qualitative character (for questionnaires see Appendix 3), as well as receiving specific comments on interview technique. Due to the potential sensitivity of the studied firms, anonymity of the interviewees is maintained, and each research participant has received a regional-representative name, used consistently throughout the thesis.

Table 4.3 Classification of selected cases according to sampling criteria

		Spinout generation	
		Low (below 24 firms)	High (24 or more firms)
Spinouts' survival	Lowest	1. Scottish University	1. Midlands University
	Highest	1. London University 2. Yorkshire University	1. East Midlands University 2. Welsh University

Notes: Lowest/highest survival of spinout companies means that the universities selected for the case studies achieved either the lowest/highest survival rate within their criteria quadrant or had one of the lowest/highest rates.

4.7.2 Data collection

The data collection method selected for this part of the study was interviewing, as it allows the researcher to explore perspectives and original stories (Arksey and Knight 1999), which are difficult to capture with other research methods. This is especially important, given the first part quantitative study uncovered broader patterns without allowing for understanding the processes behind these patterns.

All interviews were conducted between November 2015 and February 2016, which was a difficult time period due to Christmas celebrations and increased time commitments of research participants. This was evident in the number of approaches made to arrange each interview and, once arranged, in frequent rescheduling of interviews.

The first step in data collection was to contact TTO representatives as they played the most central roles in university networks. These and subsequent contacts were established over email exchanges, and in each case the invitation email contained a consent form (Appendix 4), which included an overview of the research project, information on participation in the study, and researcher's contact details. Prior to each interview two copies of the consent form were signed. After initial interviews at the six institutions with TTO representatives and business incubator representatives (where possible), interviews at spinout companies were conducted. Although the initial strategy was to study at least one spinout company in each institutional context, this

proved very difficult (for example at East Midlands University and Yorkshire University, this was not possible). The main requirement for the firm was to be an active enterprise, i.e. still active on May 1st 2014, as it is difficult to trace companies that are inactive. In order to identify a company a representative of the TTO was asked to indicate an academic founder and/or management team representative for an interview, as independent attempts to directly approach these individuals (even with the same companies) typically produced no response. Furthermore, representatives from the investment community were approached through recommendations from TTO representatives and management teams, as direct contact was difficult to establish.

In total 18 interviews were conducted, covering the most important actors in each individual institutional context: a technology transfer representative, and a representative of a spinout company. Six technology transfer officers were interviewed, providing a balanced view of how each of the offices approaches formation and support of spinout companies. As not all universities have formal business incubators (or science parks), it was not possible to interview a representative in every context. Nevertheless, the interviewed individuals were responsible for three completely different business incubation facilities (fourth non-existent complements the extreme cases), confirming the distinct character of the institutional contexts and effectiveness of the sampling method employed here.

Altogether six spinout companies were studied through seven actors: either management team representatives or academic founders. Although every attempt was made to speak to both types of actors, this was possible only once, when the academic founder and entrepreneur were based in the same building. It is crucial to state that individuals involved in spinout companies have very busy schedules. For example, academics typically did their already time-consuming full-time jobs and worked part-time in the spinout companies, whilst the management team representatives interviewed were in full-time charge of fast-growing finance-starved businesses. It is observable that academic founders and management team representatives played distinct roles in the spinout companies (technology-oriented and commercially-oriented respectively),

yet each was well aware of the business side of the spinout company and both actors typically held significant equity stakes in the spinout.

Finally, two investors were interviewed, each representing an institutional investment business that had extensive engagement with spinout companies, either at regional or national level. This intensity of working with spinouts translated into unique perspectives, given their wide-ranging experience. It is important to stress that there is only a limited number of UK investors that focus only or largely on spinout companies, and thus studying their insights offers the highest quality data for this thesis.

The interviews lasted from 19 to 73 minutes depending on the type of actor. All interviews were recorded using Zoom H1 digital voice recorder and transcribed, with one exception as outlined in the next section. Table 4.4 outlines the interviews conducted with date and coding and adopted interview names to ensure anonymity.

Table 4.4 Interviewing record

	Actor	Description	Date
Scottish University	SU TTO (Sean)	Low spinout generation and low spinout survival context. Internal university unit. Research-intensive university. The institution has no access to business incubators or established networks with investors.	18/12/2015
	Scottish Systems MT (Sholto)	A CEO who first worked on developing company 1, and then moved to work on building company 2 - Scottish Systems. Scottish Systems is a medical sciences business and currently prepares for attracting investment. Sholto is involved in a number of firms in the region.	16/02/2016
London University	LU TTO (Loxley)	Low spinout generation and high spinout survival context. Wholly-owned university firm. Research-intensive university. It has access to a business incubator located on-campus and established links with investors.	01/12/2015
	LU BI (Lowell)	Wholly-owned university firm. High commercial focus on established firms that pay rent and require custom-made office space (including sophisticated laboratory set-ups). Houses local firms and university spinouts.	20/11/2015
	London Tech. AF (Prof Louie)	Academic founder of a medical sciences company - London Technologies. The spinout has received a number of VC investments and recently underwent an IPO. Prof Louie used to work part-time in the business, now has left the business, but remains a shareholder.	16/02/2016
Midlands University	MU TTO (Milton)	High spinout generation and low spinout survival context. Wholly-owned university firm. Research-intensive university. It has access to science park (business incubator) and established network of investors.	30/11/2015
	MU BI (Millard)	Wholly-owned university firm. Commercial focus (i.e. on rent paying tenants) with a number of sites in locality. Houses local firms and university spinouts. Runs accelerator type programmes for local firms.	30/11/2015
	Midlands Engineering AF (Prof Miller)	Academic founder of a physical sciences company - Midlands Engineering. The company is focused on organic growth with no external investments and acts more as a commercial extension of departmental activities of Prof Miller. The academic works part-time at the business and maintains a fulltime position at the university.	11/12/2015

Table 4.4 *Continued*

Actor	Description	Date	Actor
East Midlands University	EMU TTO	High spinout generation and high spinout survival context. Internal university unit. Research-intensive university. It has access to an on-campus business incubator and established links with investors.	16/11/2015
	EMU BI	Wholly-owned university firm. Commercial focus. Houses local firms, student start-ups and university spinouts.	06/11/2015
Welsh University	WU TTO (Wynn)	High spinout generation and high spinout survival context. Internal university unit. Research-intensive university. It has access (link) to a business incubator and established relations with investors.	13/11/2015
	Welsh Sciences MT (Wil)	External entrepreneur of a medical company: Welsh Sciences. The company focuses on high growth and is VC-funded. Wil has a VC background and works full time as a CEO of the business.	04/01/2016
	Welsh Therap. MT (Waljan)	CEO of a medical devices company - Welsh Therapeutics. The company focuses on high growth and is VC-funded. Waljan has a VC background and works full time as a CEO of the business.	04/01/2016
	Welsh Therap. AF (Prof Wmffre)	Academic founder of a medical devices company - Welsh Therapeutics. The company is focused on high growth. Prof Wmffre works part-time in the business and maintains a full-time position at university.	04/01/2016
	Welsh Nano AF (Prof Wren)	Academic founder of an engineering company: Welsh Nano. The company is in receipt of major VC funding and is currently preparing to undergo testing of its prototype product. Prof Wren maintains a full-time academic position and has a part-time engagement at Welsh Nano.	19/01/2016
Yorkshire University	YU TTO	Micro spinout generation and high spinout survival context. Internal university unit. Post-1992 university with a moderate level of research. It has no access to business incubator but has links with investors.	25/11/2015
Investors			
London Investments	Irving	Nationwide VC investor specialising in academic spinout companies. Invests in all stages of spinout companies and offers comprehensive support to develop the business to investment exit. It has links with a number of institutions in the country. Irving is part of executive team at London Investments.	11/01/2016
Yorkshire Fund	Ingram	Regional pre-seed investor with public backing, engaging with a number of regional venture capitalists and universities. Funding open to all start-ups within a region. Ingram was part of executive team at Yorkshire Fund.	04/12/2015

Notes: TTO=Technology Transfer Office; BI=Business Incubator; AF=Academic Founder; MT=Management Team.

All but one of the interviews were conducted face to face at interviewees' workplaces (the exception was a telephone interview due to interviewee's preference), which allowed the researcher to build credibility (especially with the TTO representatives) or be introduced to other interviewees (once, to two other entrepreneurs on the same day). This had a negative aspect of inflated research costs (time and financial) related to travel as many interviewees were so difficult to access that in most cases it was not possible to schedule them on the same day at each location.

The interviews had a semi-structured character, whilst the questionnaire was designed with open-ended questions to unpack broader aspects behind university spinout success. There were five questionnaires used for interviewing, each tailored to a different actor (see Appendix 3): TTO representatives, business incubator representatives, academic founders, management team representatives, and investors. However, the questionnaires maintained a similar structure and asked questions that addressed all elements of university networks and the broader network environment, and their role in the success of academic spinout companies, allowing observation of both the individual perspectives and comparative views on the studied matter.

Due to the quantitative research design with universities and spinout companies as units of analysis, a similar approach was sought for the qualitative part of this thesis to obtain a two-sided perspective. Unfortunately, in two university contexts it was impossible to interview any spinout company (East Midlands University and Yorkshire University). Consequently, in order to maintain the robustness in the studied examples of university networks, the three interviews that were conducted at East Midlands and Yorkshire Universities are dropped from the explanatory chapter built on in-depth qualitative data. This results in 15 interviews being used, depicting four original university network contexts. It is critical to emphasise that even though such a decision constitutes data loss, the remaining four university networks still fall within the original criteria of purposeful extreme cases sampling.

4.7.3 Data collection issues

The virtues of snowball sampling could be clearly observed through initial informal conversations with TTO and business incubator representatives. Many of the interviewees indicated having been 'overstudied' by Masters-level students, therefore declining to participate in this research. Another major obstacle was the timing of fieldwork, much of it undertaken in November and December. This period is known for increased work and non-work demands. In order to overcome these problems academic CV was attached in interview invitation emails in order to assure prospective interviewees of the researcher's credibility, which proved to be a very effective approach to win research interest.

One interview was not recorded nor transcribed due to technical issues with the voice recorder's battery life (which stopped working after 3 seconds of recording; it was impossible to observe its status due to equipment positioning during the meeting). This interview is in note form, taken immediately after the meeting, therefore minimising any information loss. After that incident spare batteries were carried to all subsequent interviews and the voice recorder was carefully observed during meetings.

4.7.4 Analytical approach

The interviews conducted have been grouped thematically to provide in-depth evidence of the relationships uncovered through quantitative analyses. They are used to improve understanding of these analyses as part of the employed explanatory sequential mixed methods design, especially given the fact that studies on university spinout companies have largely ignored the success aspects of these businesses, focusing in principle on formation instead. Consequently, this allows little comparison to be made of survival results to previous studies. Instead, this research offers a novel insight into the university spinout companies with a careful and robust methodology to understand and explain their success.

Additionally, interview material is used to build examples of institutional contexts, depicting four distinct university networks: a) Scottish University Network (low formation, low survival); b) Midlands University Network (high formation, low survival); c) London University Network (low formation, high survival); d) Welsh University Network (high formation, high survival). Each example provides an opportunity to observe and understand how spinout companies are formed and supported, offering a unique insight into UK academic entrepreneurship. The structure for each example attempts to reflect the two aspects studied in this thesis: spinout company formation and survival. This is done in an integrated way, framed as a transformation process of knowledge into commercial success across network elements.

Given the semi-structured character of the interview questionnaires, the university network elements and broader network environment are used to identify themes within each aspect that relate to the success of spinout companies, much in the line of content analysis (Silverman 2011). The themes are counted at network element level rather than interviewee, to reflect the four illustrative examples as coherent contexts. This approach enables the analysis to ascribe individual-type success characteristics that each contributory network element brings to the spinout company. Finally, the themes identified across different network elements are merged across their commonalities of meanings into broader categories that enable identifications of core spinout company success factors or dimensions.

4.8 Limitations

The research has a cross-sectional character due to the time limitations of a PhD study, and financial constraints, with the data collection time frame of four months in total. The geographical focus of the study is limited to the UK. Although the sample frame of 1,331 academic spinout companies provides a very good coverage of this phenomenon, it is neither equal to the census of such firms nor representative of it, as the full population characteristics are yet unknown. It also needs to be stressed that companies do not file all possible information to Companies House (later obtained through FAME); certain opt-outs are available to firms of

different sizes, and the information they provide is subject to delays on the entrepreneur's side, affecting the quality of information analysed here. Furthermore, the information held in FAME has a time limit, therefore not all activity of the shareholders can be captured there (e.g. original ownership share at the moment of company incorporation).

4.9 Issues of generalisability, validity and reliability

Using a mixed method design allows this study to overcome many threats to validity and reliability of the study, as triangulation aimed at answering the same research questions removes inconsistencies from research design. Nevertheless, it also imposes a great difficulty in addressing issues of validity and reliability (Tashakkori and Teddlie 2008), as these aspects are treated differently in quantitative and qualitative research. Although Tashakkori and Teddlie (2008) suggest using an integrative framework to assess the quality of research, they recommend considering each part separately, as validity and reliability concerns in quantitative and qualitative research differ.

Each part of the research, quantitative and qualitative, was constructed to ensure the highest validity and reliability. In the quantitative part this is related to the large sample size studied and comparing the distribution of active spinout companies across studied institutions to official HESA statistics, as depicted in Table A5.1 (Appendix 5), confirming the representativeness of the sample, and therefore external validity. The table compares the number of active spinout companies officially recorded (N=1231, Mdn=8) and independently in the studied sample (N=1182, Mdn=5) per each university, based on 87 observations. The reason why numbers of active firms are used in the comparison is that HEBCIS does not record all spinout companies created, which would be a more desirable measure to compare. Instead, HEBCIS records data for spinout companies formed since 2002 at university level. A Wilcoxon Signed-Rank test was performed, indicating no significant differences between the two samples ($Z=-1.156$, $p=0.248$, $r=-0.124$). Additionally, a Spearman's correlation was performed, which indicates that both samples have a strong positive and significant relationship ($rho=0.824$, $p<0.001$, $N=87$). These

results suggest that the data collection method (albeit imperfect) produced a dataset that strongly resembles the distribution of active spinout companies recorded by HESA.

Furthermore, as some of the variables used corresponded with previous studies and generated the same results as in the established literature, it is safe to assume that the design is reliable. This in turn ensured validity of measures used, which were largely derived from the literature on academic spinout companies and firm survival. In the qualitative part, strict sampling (i.e. extreme cases purposive sampling) was used, as it is praised in methodology literature as the most reliable and valid, especially in terms of external validity or typically transferability (Teddlie and Yu 2007). Although snowball sampling was also utilised, it was merely a secondary sampling method that did not undermine the extreme cases examined. It is important to clarify that convenience sampling would have increased the speed of data collection, given the fact that qualitative data collection extended into the fourth year of this PhD. It is admitted that against the extra pressure and stress this caused, the 'less convenient' sampling approach was continued to ensure superior validity and reliability of the research design.

Although the results of the quantitative research are generalisable to the population of live spinout companies, the qualitative insight offers no generalisable inferences, but rather a range of perspectives with potential explanations of generalisable quantitative results.

4.10 Ethics

Prior to the commencement of the fieldwork, Ethical Approval was obtained in May 2014 from Cardiff University's School of Planning and Geography's Ethical Committee, certifying that this research project complies with Cardiff University's ethical code of research conduct. This study did not perform research on any vulnerable individuals and was not in a clinical setting. However, it made an assumption that granting anonymity and ensuring participants' confidentiality would reduce any arising ethical issues related to commercial sensitivities and any problems arising from internal organisational politics.

4.11 Conclusion

This chapter has outlined the theoretical approach of this research, which is based in a post-positivistic paradigm. Corresponding methodology is applied, namely explanatory sequential mixed methods, which ensures a link between breadth and depth of data through quantitative and qualitative inquiries. The quantitative part focuses on a sample of 81 universities and 870 spinout companies and, through statistical analyses presented in the next chapters, explains spinout company generation and success. The qualitative part in turn gathered in-depth data from 15 individuals representing four distinct university contexts; extreme cases, providing evidence to explain uncovered quantitative relationships.

The following chapters present the empirical results of the methodology outlined here, indicating a distinction between university network and broader network environment characteristics that explain university spinout formation and spinout company survival.

Chapter 5

Bivariate analysis of university spinout success: university network and broader network environment characteristics

This chapter focuses on the characteristics of university networks and the broader network environment that explain university spinout company formation and success, analysed here using bivariate statistical tests. The analyses of university network elements are based on 81 institutions in the sample that were found to have generated at least one spinout company between 2002 and 2013, and a sample of 870 UK spinouts formed between 2002 and 2013.

The results present a number of interesting associations of university network elements and broader network environment in relation to spinout company formation and survival. First, three variables describing university characteristics are found to be significant across both success forms: university size (expressed in university total income), stocks of commercialisable knowledge (disclosures in spinout generation and patents in spinout survival), and science orientation (representing the scientific bias of universities), together with management teams. Furthermore, whilst access to venture capital investment and networks with other actors (in particular other universities) are found to be significantly related to university spinout company generation, commercialisation experience, business incubation (in a form of on-campus incubation), successful exit, numbers of directors and networks (expressed through structural holes) are only significantly related to spinout company survival. Finally, the broader network environment measured by regional GVA per capita is only significant to spinout company survival. This result suggests a form of break-up post- spinout formation. Such break-up leads to spinout companies developing their success-oriented operations towards a wider set of actors.

Section 5.1 describes the dataset descriptively. In Section 5.2 bivariate statistical tests are used to report results that explore spinout company formation and survival dependent on elements of

university networks. Section 5.3 examines broader network environment. The chapter concludes in Section 5.4 with summarised findings reported from the bivariate tests.

5.1 UK university spinout company generation and survival

The dataset used in the analysis of the elements of university networks is based on a sample frame of 87 universities that created 1,331 original spinout companies between 1959 and 2013. Table 5.1 depicts the sample's spinout rates for every decade, whilst Figure 5.1 presents a period of time in which spinout formation became an annual phenomenon.

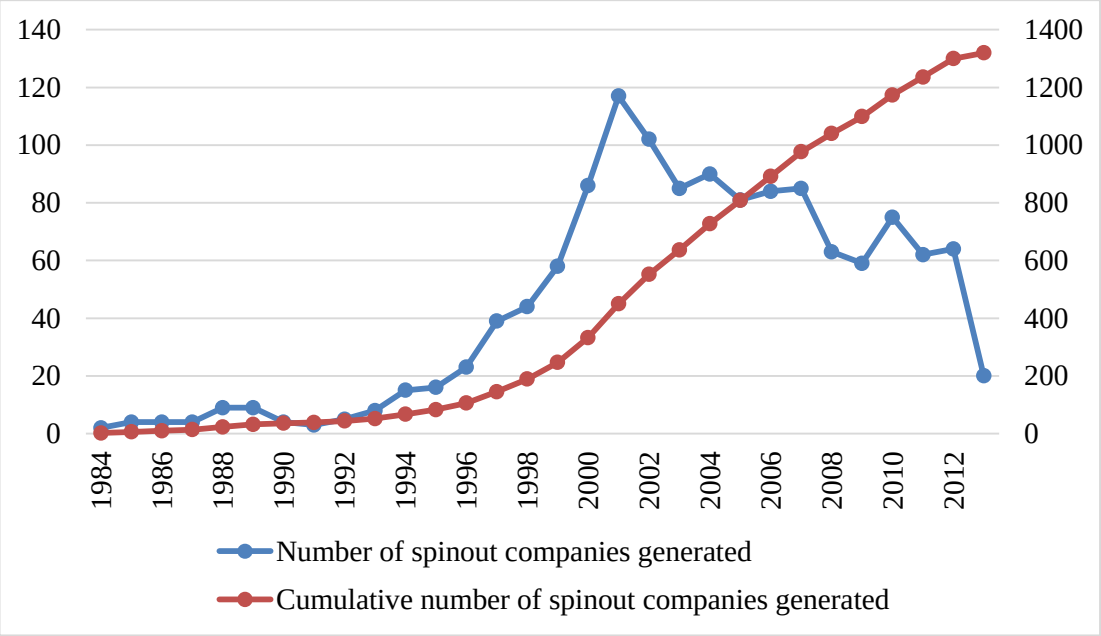
Table 5.1 Spinout companies by registration year

Year of Registration	Number of spinout companies
1959-1969	4
1970-1979	4
1980-1989	35
1990-1999	215
2000-2009	852
2010-2013	221
Total	1331

The moment the spinout company generation stabilised in the UK appears to be related to the US Bayh-Dole Act 1980 responsible for a global 'outbreak' of spinout company formation (Shane 2004b; Kenney & Patton 2009; Grimaldi et al. 2011; Fogelberg and Lundqvist 2013). UK spinout companies creation peaked in 2001 at 117 registrations (Figure 5.1) and appears to be in a falling trend ever since. Interestingly, when the Lambert Review (2003) stressed the need for UK universities to focus on the 'quality' of academic spinout companies rather than pure volume, it merely reflected a trend that had already started, perhaps providing substance and clearer direction to it. Alternatively, the falling tendency could be related to reduced funding for universities that is translated into cuts of non-core operations, such as commercialisation (Chrisman et al. 1995). Notwithstanding this, it remains difficult to ignore the fact that these are very low numbers of spinout companies out of the whole population of

UK businesses, which is close to 3.6 million active firms at the end of 2016 (Companies House 2017). Whilst some argue that spinout companies are irrelevant to economic development (e.g. Harrison and Leitch 2010), given their numbers, it is apparent that knowledge commercialisation in the form of university spinout companies illustrates the complexity of the process. Additionally, such low aggregate numbers may suggest that spinout formation, even after a number of decades, is still in its infancy.

Figure 5.1 Spinout company registrations by year of 'birth' (1959-2014)



With spatially fixed universities it is interesting to consider regional differences, as presented in Table 5.2. The 87 universities forming the sample frame are distributed across all 12 UK regions. Although the largest number of spinout company deregistrations is recorded for firms based in Scotland, due to its universities' high spinout company productivity, (as Geroski (1995) observed - the number of firm births is reflected in the number of firm deaths) it only achieves the third-lowest survival rate (72.50%) for all spinouts generated. The other two regions with greater proportions of firm 'deaths' are the North East (33.33%) and West Midlands (33.78%). Noticeably, the substantial geographical variation of survival rates of spinout companies is made more distinct given results for firms in Wales (87.50%) and the East

Midlands (87.88%), in particular when observing the number of spinouts located in both regions: 48 and 66 respectively.

Finally, when Greater South East regions (i.e. London, the South East and the East of England) are considered, none of the regions are responsible for either the highest spinout formation or survival rates, which is a puzzling finding given the concentration of financial industries and their activities in the area (BVCA and PWC 2008; BVCA 2015, and any report in between). These results indicate a very complex and heterogeneous picture of spinout company creation and survival emerging from such simple cross-tabulation with no obvious patterns or trends from a geographic perspective. This suggests a more complex approach is necessary to examine spatial effects.

Table 5.2 Spinout companies formed between 1959 and 2013 and their status by region

Region/Status	Live/Total	Live	Deregistered	Total	Number of universities
East Midlands	87.88%	58	8	66	5
East of England	81.98%	91	20	111	5
London	77.95%	152	43	195	12
North East	66.67%	38	19	57	5
Northern Ireland	80.70%	46	11	57	2
North West	79.61%	82	21	103	8
Scotland	72.50%	203	77	280	15
South East	82.01%	155	34	189	9
South West	73.77%	45	16	61	5
Wales	87.50%	42	6	48	6
West Midlands	66.22%	49	25	74	8
Yorkshire and the Humber	80.00%	72	18	90	7
Total	77.61%	1033	298	1331	87

Table A6 (Appendix 6) captures survival rates of all spinout 'waves' (i.e. annual cohorts of registered firms) until 2011, with the exception of years 2012-2013 as the 84 firms registered in

that period were all still live on 01/05/2014. Until the 1998 wave, the 3-year survival (and until the 1996 wave the 5-year survival) remained at 100%, perhaps largely due to low numbers of such firms being formed every year, albeit this explanation seems rather unsatisfactory. Although a perfect 3-year survival rate also occurred for 2003 and 2004 spinout waves, this stopped being a feature for other cohorts of firms. Out of the first five spinout companies created, only one (from 1967) deregistered, after 44 years of trading. These high survival rates, especially the 5-year rates, to a limited extent confirm Doutriaux's (1987) study of 38 Canadian university enterprises between 1980-1985 (including spinouts), with a survival rate of 82%. A similar high survival rate (89.3%) over a 10-year period, was reported in a broad-definition study of 25 Welsh university firms between 1990-1999 by Brooksbank and Thomas (2001). Clearly, UK spinout companies from similar periods of time performed much better, although this could be a result of biased reporting of spinout companies generated by the universities, who perhaps only reported the successful companies formed before 1995, rather than all firms generated (it is acknowledged that data used here is not free from imperfections). To establish this would require studying a full population of spinout companies in the UK, yet such data does not appear to exist, given the merits of this study being the largest thus far.

One of the clear trends in survival rates is the fall in percentage terms as the numbers of registered firms increased. This suggests that when there were fewer spinout companies around it was easier to maintain trading. As the population of these firms grew, their propensity to fail increased, rather unsurprisingly (Geroski 1995). The second and most important observation from this table is the sudden survival drop for the year 2014 (at 30-year rate 0%, N=2; 25-year rate 44.44%, N=9; 20-year rate 26.67%, N=15; 15-year rate 27.59%, N=56; 10-year rate 27.78%, N=90; 5-year rate 33.90%, N=53; 3-year rate 46.77%, N=60), which could have a number of explanations. The two most plausible explanations are the delayed effect of the 2008 recession, and/or 2010-2012 government-imposed austerity against established macroeconomic knowledge. As firms typically strive to continue operations until future returns are completely diminished (and often beyond), the delay effect appears more convincing.

The geography of spinout company survival rates provides an interesting decomposition of regional unevenness of such aspect of entrepreneurial activity, as depicted in Table 5.3. The figures represent a spinout company's last location of a registered office, therefore the regional distribution of spinout companies was separately compared to the distribution of spinouts based on their parent university's region using a Chi-square test, finding no statistically significant difference ($\chi^2(11, N=1740)=8.10$, $p=0.70$, $V=0.068$), indicating a co-location effect of spinouts and their parent institutions. Clearly, spinout companies in the sample located in Northern Ireland and Wales have greater 3-year survival rates (100%) than elsewhere in the UK, with only East of England-based firms achieving the second highest 3-year survival rate of 96.92%.

Overall, only four regions achieve survival rates higher than the average of 94.62%, with Scotland being the fourth region at 94.94% survival rate. The lowest 3-year survival rates are achieved by spinouts in South West (91.89%) and London (92.45%), both below the UK regional average of 94.62%. As the average total survival rate for the 12 regions stands at 83.16% (for the full sample of 870 firms born between 2002 and 2013), it signifies a large drop from the average 3-year survival rate for the UK (94.62%). This in turn suggests the observation of a 'honeymoon' period (Hudson 1987; Murray 1988) that benefits UK spinout companies in their first few years.

Table 5.3 Spinout's location and survival rates: 1959-2011 and 2002-2011 waves

Region/Period	3-year (sample frame)*	3-year	3-year (sample)**	3-year
East Midlands	61	95.08%	41	92.68%
East of England	107	98.13%	65	96.92%
London	182	95.60%	106	92.45%
North East	56	94.64%	41	92.68%
Northern Ireland	52	100.00%	27	100.00%
North West	93	95.70%	64	93.75%
Scotland	266	96.24%	158	94.94%
South East	178	95.51%	108	92.59%
South West	58	94.83%	37	91.89%
Wales	39	97.44%	27	100.00%
West Midlands	70	95.71%	55	94.55%
Yorkshire and the Humber	85	94.12%	57	92.98%
Average		96.08%		94.62%
Total	1247		786	

* 1959-2011; ** 2002-2011

UK spinout companies are not very differentiated when considering conventional size categories (Table 5.4), with the vast majority (98.51%) being small firms. As medium and large size indicate a certain level of business success, it is interesting to observe that there are only small firms in Wales. Furthermore, given the quantity of spinout companies registered in Scotland, it has no spinouts employing more than 49 personnel. The greatest numbers of medium and large firms are in the Greater South East, which could be indicative of proximity to finance, whether public exchanges or VC. It is surprising to observe no large spinout company in London, which is an unexpected finding, given the location of public exchanges.

Table 5.4 Spinout companies by latest size and region (2002-2013)

Region/Size	Small	Medium	Large	Total
East Midlands	46	0	0	46
East of England	67	2	0	69
London	117	2	0	119
North East	42	0	0	42
Northern Ireland	31	1	0	32
North West	74	0	0	74
Scotland	172	0	0	172
South East	115	4	0	119
South West	40	0	0	40
Wales	36	0	0	36
West Midlands	58	0	1	59
Yorkshire and the Humber	59	3	0	62
Total	857	12	1	870

Note: Firm size refers to employment bands: small (0-49 staff), medium (50-249) and large (250 or more staff). The regional distribution reported in the table is based on the firm's registered office's location.

In terms of sector categories, based on the primary sector information (SIC 2007; Office for National Statistics 2009) registered, the spinout companies are largely concentrated in the professional, scientific and technical sectors (451 firms) (Table 5.5). A substantial number of firms also classify themselves as manufacturing enterprises (144 firms) and operate in information and communication services (147 firms). Interestingly, the largest proportion of Northern Irish spinout companies are registered as manufacturing entities (34.38%), whilst firms in all other regions tend to be in professional, scientific and technical service sectors (UK average of 51.84% of all spinouts). Proportionately, there are more Northern Irish spinout companies engaged in information and communication sectors than in any other UK region (over 28% of region’s spinouts), with the lowest proportion in the East of England (less than 8% of the region’s firms). Welsh spinout companies are primarily registered in professional, scientific and technical sectors (over 61% of region’s firms), clearly presenting a different sectoral composition of spinout companies, given Welsh and Northern Irish spinouts' 3-year survival rates.

The largest number (also proportionately) of spinout companies in administrative and support services sectors is in Scotland (13.37% of the region's spinouts), whilst only about 5% of Yorkshire and the Humber's spinout companies are in manufacturing sectors. Although the sector categories are distinct, it is important to note that for accounting purposes firms might register as manufacturing enterprises whilst actually being biotechnology firms, and vice-versa. As the choice of a sector is used to describe the primary economic activities of the registered entity, spinout companies that have a more complex corporate structure (for example, operating through several connected but separately registered limited businesses) could have each business registered in a different sector. Therefore, caution is advisable when interpreting these results.

Table 5.5 Spinout companies by sector and region (2002-2013)

Region/ Sector	Manufa-cturing	Information &commu-nication	Prof., scientific & technical	Admin. & support services	Human health & social work	Other	Total
East Midlands	8	5	30	0	1	2	46
East of Eng.	13	5	46	3	0	2	69
London	12	17	73	6	5	6	119
North East	6	7	26	0	2	1	42
N. Ireland	11	9	8	2	2	0	32
North West	13	16	40	1	2	2	74
Scotland	23	37	66	23	7	16	172
South East	26	19	58	8	2	6	119
South West	12	5	16	2	1	4	40
Wales	7	5	22	1	1	0	36
West Midl.	10	9	30	0	3	7	59
Yorkshire & the Humber	3	13	36	4	4	2	62
Total	144	147	451	50	30	48	870

Note: The regional distribution reported in the table is based on the firm's registered office's location. The sectors used are based on broad sector categories used in Standard Industry Classification 2007.

Table A7 (Appendix 7) provides a breakdown of spinout births and survival rates per 87 universities separately for the sample and sample frame. Although it is difficult to judge survival rates when an institution generated only a few spinout companies, it is nevertheless an interesting picture of the success of these firms in the UK. Among the universities in the sample that generated in excess of ten spinout companies, two stand out clearly when it comes to their spinouts' survival record: Aston University (54.55%) and the University of Birmingham (100%), both located in West Midlands. These findings point out large intraregional disparities in terms of the survival of spinout companies associated with particular parent universities, whilst in other regions such intraregional disparities are difficult to find, for example Wales: Cardiff University (90.48%) and University of South Wales (90.91%).

The data presented above portrays a very complex picture of UK spinout companies' success, which appears to have little to do with the numbers of firms generated, as well as where these firms are located. Although there is some variation in the sectoral composition of the sample, UK spinouts are mostly small firms. This substantial sample provides little evidence to focus any policy on the 'high-growth' merits, unlike some evidence presented in Shane (2004b) on (mostly) US companies.[3] Instead, the nature of the innovativeness of such firms could perhaps be a more congruent and palatable explanation for the importance of such businesses. As the data decompositions provided thus far offer very few insights, given the complexity of factors that determine the survival of spinout companies, the following section focuses on bivariate tests in order to elucidate some of the important variables determining spinout company success.

5.2 Bivariate tests of university network elements

This section focuses on university networks. What follows examines its elements: university, TTO, business incubator, spinout companies, networks, investors, management team, and other actors. Each aspect is subjected to bivariate tests of independence.

[3] It is important to note that Shane (2004b) defines university spinoffs as firms based on IP created at university by staff and students. This study utilises a much narrower definition, focusing only on academics.

5.2.1 University

University size

University size describes the organisational capabilities and availability of resources to produce knowledge and administer knowledge production and commercialisation. The sum of total revenue over 2002-2013 is clearly different among institutions characterised by low and high spinout generation (Table 5.6), with larger institutions being responsible for greater numbers of spinouts (Mdn=£4.63bn), whilst smaller ones have lower numbers of academic ventures (Mdn=£1.75bn). The relationship is found statistically significant (U=43, Z=-6.21, p<0.001, r=0.69), indicating a strong role of university endowments in spinout creation. Although previous UK studies employing regression techniques found that the formation of spinout companies is independent of lab (Haeussler and Colyvas 2011) or department size (D'Este et al. 2012), they used slightly different measures and studied periods of time earlier and shorter than presented here.

Table 5.6 Sum of annual university income (£bn) over 2002-2013 and spinout generation

	Low spinout generation	High spinout generation	Total
Median	£ 1.75	£ 4.63	
N	61	20	81

Note: (U=43, Z=-6.21, p<0.001, r=0.69)

Another interesting dimension of university size is in understanding its relationship with spinout survival, as depicted in Table 5.7. In this case the endowment of a university at the time (i.e. year) a spinout company started (in case of multiple parent spinouts, the university size is the sum of parents' incomes) is greater among spinout companies that survive (Mdn=£346.85m) than at institutions of spinout companies that have ceased operations (Mdn=£234.29m). The difference is found to be statistically significant (U=39141, Z=-5.219, p<0.001, r=0.177), suggesting that the resources available to the institution continue to have a relationship with spinout company success, specifically survival. This could be interpreted as a form of university

involvement at post-start-up stages of spinout companies, whether passive (e.g. reputation) or active (e.g. financial or administrative support).

Table 5.7 University's total income (£bn) at spinout's birth and spinout survival

	Dead	Live	Total
Median	£ 0.23	£ 0.35	
N	149	721	870

Note: (U=39141, Z=-5.22, p<0.001, r=0.18)

The results presented above for the variables describing university types paint a very clear picture of the importance of an institution's character on both the formation of spinout companies and their survival. Clearly, larger universities not only are associated with greater numbers of spinout companies, but are also related to more surviving spinouts. Previous research indicated that laboratory size (Haeussler and Colyvas 2011) or department size (D'Este et al. 2012) were not related to spinout formation; however, this study, being larger in scope and covering a greater time-span, reveals a clearer role of university endowments of organisations rather than within-university units, potentially signifying that knowledge commercialisation in a form of spinout companies is a university-level activity involving resources that span university departments/organisation units. Grandi and Grimaldi (2003) found that Italian spinouts gained legitimacy from the reputation of their parent institutions. In the UK 24 research-intensive universities associated as Russell Group (www.russellgroup.ac.uk) reported a total of income of circa £14.22bn in the 2013/14 academic year (HESA), compared to 63 other institutions in the sample framework, with total incomes at £10.53bn for the same year. Furthermore, no previous research indicated survival of spinout companies to be linked to the size of the university the venture originated from, providing an interesting and novel finding.

Disclosures

A spinout's underlying reason for existence is the knowledge it is based on, so it is important to investigate whether this has any association with spinout formation rates. Table 5.8 shows that universities generating higher numbers of spinouts report a greater volume of disclosures (Mdn=985.50) compared to other universities (Mdn=238.00), a statistically significant result (U=70, Z=-5.91, p<0.001, r=0.66). The finding clearly confirms previous studies where invention disclosures were important to spinout company formation (e.g. Di Gregorio and Shane 2003; Fini et al. 2009).

Table 5.8 Sum of annual disclosures over 2002-2013 and spinout generation

	Low spinout generation	High spinout generation	Total
Median	238.00	985.50	
N	61	20	81

Note: (U=70, Z=-5.91, p<0.001, r=0.66)

Whilst knowledge in the form of disclosure is important to spinout companies at a start-up stage, spinout company survival is more reliant on such knowledge being monopolised (through patents) by the spinout, lending it improved market position to facilitate growth and attract investment. It is found that spinout companies that survive tend to originate from institutions with greater stocks of codified knowledge (Mdn=165.00) than spinouts that fail (Mdn=86.00) (Table 5.9). The difference is statistically significant (U=41300, Z=-4.45, p<0.001, r=0.15), confirming that survivors among spinouts originate from institutions that monopolise more knowledge.

Table 5.9 University's cumulative portfolio of patents at spinout's birth and spinout survival

	Dead	Live	Total
Median	86.00	165.00	
N	149	721	870

Note: (U=41300, Z=-4.45, p<0.001, r=0.15)

Universities characterised by greater knowledge production are associated with larger numbers of spinouts companies (Di Gregorio and Shane 2003), a rather unsurprising finding given that spinout companies are based on IP. Furthermore, surviving spinout companies are found to have originated from universities with greater stocks of monopolised knowledge, confirming the advantage spinout companies gain from patents. The result clearly lends evidence to Shane's (2004b) argument that patents constitute the main competitive advantage of a spinout company, shielding it from the threat of established firms copying or reverse-engineering its products or services. Moreover, as patent-based firms survive longer (Fini et al. 2010) it is expected that IP protection may signify a form of sunk cost to spinout companies, translating into increased effort to succeed (Hudson 1987; Murray 1988; Duchesneau and Gartner 1990; Bruderl et al. 1992; Gimeno et al. 1997; Fotopoulos and Louri 2000; Oberschachtsiek 2010). Additionally, Hewitt-Dundas (2015) recently profiled UK spinout companies and found that over 68% of spinouts relied on patents to protect their knowledge base.

Science orientation

Table 5.10 depicts the association between the university focus on excellence in traditional science fields and spinout formation rates. High spinout generation institutions have a greater focus on excelling in science with a mean of science orientation of 58.29% than low spinout generation universities, with a mean of science orientation of 42.79%. The difference is statistically significant (t=-4.32, DF=60.21, p<0.001, r=0.49), indicating that science-orientation of universities is related to formation of spinout companies.

Table 5.10 Science orientation (average of RAE 2008 and REF 2014) and spinout generation

	Low spinout generation	High spinout generation	Total
Mean	42.79%	58.29%	
N	61	20	81

Note: (t=-4.32, DF=60.21, p<0.001, r=0.49)

In terms of spinout survival, the science orientation measure shows (Table 5.11) that surviving spinout companies originated from universities with a higher focus on excelling in science (Mdn=55.64%) unlike non-active spinouts (Mdn=51.07%). With the result being statistically significant (U=45848, Z=-2.82, p<0.01, r=0.10) it is clear that not only does a university strength in science matter to its ability to produce spinout companies: it is also important to the survival of those spinouts.

Table 5.11 Science orientation (RAE 2008 based for 2002-2008 spinouts, REF 2014 for 2008-2013 spinouts) and spinout survival

	Dead	Live	Total
Median	51.07%	55.64%	
N	149	721	870

Note: (U=45848, Z=-2.82, p<0.01, r=0.10)

Larger universities would typically have more traditional science departments given their capital requirements (laboratory and equipment) and thus traditional science disciplines would typically produce more knowledge of a patentable form. This science orientation or bias is clearly related to greater numbers of spinout companies and spinout companies' survival. Shane (2004b) is clear that certain university departments (i.e. science-based) are more advantageous in generating spinout companies, as their disciplines are better aligned with best forms of knowledge protection. This result also suggests that there could be a greater population of

traditional-science based spinouts than ventures based on knowledge from other academic fields, providing a better understanding of survival of such spinout companies.

5.2.2 TTO

Commercialisation experience

TTO's commercialisation experience, as presented in Table 5.12, reveals a difference between the two groups of universities with regards to the formation of spinout companies, with the better performing ones having more commercialisation experience (Mdn=24.54 years) than universities less engaged in spinout company generation (Mdn=16.33 years). The relationship, however, is not statistically significant at a conventional level (U=452, Z=-1.73, p=0.08, r=0.19).

Table 5.12 Commercialisation experience of university TTO (age until 01/05/2014) and spinout generation

	Low spinout generation	High spinout generation	Total
Median	16.33	24.54	
N	61	20	81

Note: (U=452, Z=-1.73, p=0.08, r=0.19)

This result is very important, as it contributes to the growing literature that discounts the TTOs' importance for spinout generation activity, whether measured through faculty entrepreneurial intentions (Clarysse et al. 2011a) or represented by their greater focus on licensing activity (Chrisman et al. 1995; Markman et al. 2005; Farnstrand Damsgaard & Thursby 2013) as opposed to company formation. Although the presence of TTO and training level of its staff was found important in the Italian study of spinout company formation (Fini et al. 2011), as did age of TTO and professionalism of its staff in the Spanish research (Gonzales-Pernia et al. 2013), or prior experience measured in spinout companies formed (Fini et al. 2017), the UK experience leans towards a limited relationship of TTO to spinout generation. The role of the office perhaps relates predominantly to administrative duties easing the bureaucracy in identifying (Macho-Stadler et al. 2007) and protecting the IP (Shane 2004b; Bercovitz and Feldman 2008), and

forming a company (Alexander and Martin 2013), pointing to an assisting role at such an early stage, but not one that would relate to spinout company generation levels.

When the association between the age of a TTO is considered on the development of spinout companies in view of their contribution to the region, the results here presented give little support to Saxenian's (1996) study, which suggested this was part of the dynamics of regional development in Silicon Valley, as compared to Route 128, that the technology licensing office at Stanford University was opened at least a decade before the one at MIT. Whilst being insignificant to spinout company formation, UK TTOs' role could have evolved and remains undefined in the literature. Alternatively, there might be something intrinsic about the UK TTOs' operations that make them different to TTOs in other countries.

University commercialisation experience was also tested for its relationship with spinout company survival (Table 5.13). For live spinout companies in the sample, the experience of their commercialisation office at start-up was greater (Mdn=15.79 years) than for spinouts that stopped trading (Mdn=13.85 years). The difference is found to be statistically significant ($U=43129$, $Z=-3.79$, $p<0.001$, $r=0.13$), suggesting a relationship between university's experience in commercialising research and spinout company's success.

Table 5.13 Commercialisation experience of university TTO (age at spinout's birth) and spinout survival

	Dead	Live	Total
Median	13.85	15.79	
N	149	721	870

Note: ($U=43129$, $Z=-3.79$, $p<0.001$, $r=0.13$)

This result clearly rejects the null of constant probability of TTOs' experience having no relationship to spinout companies' survival (Chrisman et al. 1995; Markman et al. 2005; Clarysse et al. 2011a; Farnstrand Damsgaard and Thursby 2013). However, it is important to

note that all of the universities from the sample have a TTO now, and as such an analysis incorporating a different (more recent) period of time might produce a different result. The importance of university commercialisation experience on firm survival indicates that beyond typically assumed function (related to company formation) TTOs have a role to play in spinout company success. As such, over the years the TTO role may have evolved and adapted to the spinout's development path. Perhaps this post-start-up role is quite simple and relates to withdrawal of engagement in the entrepreneurial process, where universities resign from their spinout equity stakes and break the link with the firm, allowing it to be more independent, as found by Doutriaux (1987), where firms that remain linked to their university grew slower than those without them.

University TTOs that are more experienced are able to realise the benefits of this, whilst this may be more difficult for the less experienced commercialisation teams. More recently, Gilsing et al. (2010) in their study of spinout companies in Belgian Leuven and Eindhoven suggested that universities should break their relationship with spinout companies in order to facilitate their stronger market orientation. Another explanation for such independence-seeking action could be in the credibility of business offering, especially in terms of spinout company location (Vohora et al. 2004). Securing independent office space could help spinout companies in justifying higher pricing for their products or services, which could be translated into a better proposition to potential investors as well as breaking even more quickly. Furthermore, breaking such a linkage could send a positive signal to investors of the non-public organisation business culture (Vohora et al. 2004). Perhaps this is the key contribution more experienced UK TTOs can make to spinout company success. However, a longer-term study of spinout company IPOs found that a link with a university improved the valuation of the firm at the IPO stage; nevertheless, it was also found to be associated with worse performance afterwards (Bonardo et al. 2011), painting a rather complex role of TTOs.

5.2.3 Business incubators

On-campus incubator, Off-campus incubator, Science park

The relationship between the university's provision of on-campus, off-campus business incubators, and science parks is explored in relation to spinout company generation and survival. Table 5.14 shows the medians of proportions for universities that generate high and low levels of spinout companies are the same, with 78 out of 81 universities having had some form of access to on-campus business incubation provided by the university, a partner organisation, or both. Nevertheless, the differences in the table (Mdn=100% for both groups) are not statistically significant (U=504, Z=-1.30, p=0.20, r=0.14), indicating the same type of access to on-campus business incubation across universities that generate differing levels of spinout companies.

Table 5.14 Proportion of years between 2002 and 2013 when on-campus incubator was available at university and spinout generation

	Low spinout generation	High spinout generation	Total
Median	1.00	1.00	
N	61	20	81

Note: (U=504, Z=-1.30, p=0.20, r=0.14)

The proportion of years when universities provide access to off-campus business incubation is no different in terms of the levels of spinout company formation intensity (Mdn=100% for both groups; Table 5.15), with 76 out of 81 universities having had some form of access to off-campus business incubation provided by the university, a partner organisation, or both. The result is statistically insignificant (U=532, Z=-0.94, p=0.35, r=0.10), again portraying the same level of access to business incubation at all 81 universities in the sample.

Table 5.15 Proportion of years between 2002 and 2013 when off-campus incubator was available at university and spinout generation

	Low spinout generation	High spinout generation	Total
Median	1.00	1.00	
N	61	20	81

Note: (U=532, Z=-0.94, p=0.35, r=0.10)

In general, science parks are less accessible to spinout companies, with 65 out of 81 universities in the sample providing some form of access themselves, through a partner organisation, or both. Although the proportion of years when science park access was provided by high spinout generation universities is greater (Mdn=100%) than other universities (Mdn=83%), the result is statistically insignificant (U=480, Z=-1.5, p=0.13, r=0.17), suggesting that the differences in provision are merely coincidental (Table 5.16).

Table 5.16 Proportion of years between 2002 and 2013 when science park was available at university and spinout generation

	Low spinout generation	High spinout generation	Total
Median	0.83	1.00	
N	61	20	81

Note: (U=480, Z=-1.5, p=0.13, r=0.17)

The results presented above confirm much of the literature on business incubators (Di Gregorio and Shane 2003; Fini et al. 2011; Gonzales-Pernia et al. 2013) and science parks (Lockett and Wright 2005; Salvador and Rolfo 2011) having no relationship with spinout company generation, regardless of the type of incubator or science park. Only Bourelos et al.'s (2012) study found a positive effect of business incubators on spinout creation, but this only represents a Swedish context, which is unique. Perhaps these results do not reflect the effects these services have on regional economic development (Grimaldi and Grandi 2005; Wynarczyk and Raine 2005), if non-spinout firms are also users of these facilities (Benneworth and Charles

2005). However, the results suggest that business incubators and science parks have a role to play in spinout company survival, protecting it against initial market risks (Carayannis and von Zedtwitz 2005). In such a case, the role of off-campus business incubator provision could be more important, focusing on business growth (Grimaldi and Grandi 2005). Failure to find such relationships may support Tamasy's (2007) view that such facilities may have a merely political role to inflate local electorate's support.

In order to distil such associations, the provision of any type of access to business incubation by university, partner organisation, or both, is tested in relation to spinout company survival. Table 5.17 presents a distribution of spinout company access to on-campus business incubators. The difference between the distribution of the sample's live and non-surviving firms is statistically significant ($\chi^2(1, N=870)=4.41$, $p=0.04$, $V=0.07$), indicating that a greater proportion of surviving spinouts enjoyed access to on-campus business incubator services than non-surviving spinouts.

Table 5.17 Access to on-campus incubator at spinout's birth and spinout survival

	Dead	Live	Total
No	28	89	117
Yes	121	632	753
N	149	721	870

Note: $\chi^2(1, N=870)=4.41$, $p=0.04$, $V=0.07$

In the case of access to off-campus business incubators (Table 5.18), no difference is found between live and dead spinouts ($\chi^2(1, N=870)=2.69$, $p=0.10$, $V=0.06$), indicating that off-campus incubation matters little to spinout company survival, suggesting instead the importance of 'parental' proximity (i.e. on-campus) in nurturing the company.

Table 5.18 Access to off-campus incubator at spinout's birth and spinout survival

	Dead	Live	Total
No	32	115	147
Yes	117	606	723
N	149	721	870

Note: $\chi^2(1, N=870)=2.69$, $p=0.10$, $V=0.06$

The availability of access to science parks (Table 5.19) is found to be indifferent among the live and dead spinout companies at their birth ($\chi^2(1, N=870)<0.01$, $p=0.99$, $V=0.001$), suggesting the same level access provision at spinout companies' parent institutions.

Table 5.19 Access to science park at spinout's birth and spinout survival

	Dead	Live	Total
No	40	194	234
Yes	109	527	636
N	149	721	870

Note: $\chi^2(1, N=870)=0.0002$, $p=0.99$, $V=0.001$

Spinout companies' access to facilities such as business incubators and science parks, as presented above, reveals a number of interesting findings. The results for the sample indicate a relationship between survival and on-campus business incubation only. Off-campus incubation is not related to spinout company survival, pointing to the spatial link firms have to their parent institutions (Bruneel et al. 2012). Perhaps the role of off-campus incubators has more to do with supporting local businesses that are non-spinouts, aiding regional economic development (Benneworth and Charles 2005). The importance of on-campus business incubation is an indication of 'early years nurturing' spinout companies require, albeit in proximity to the parent university. This creates appropriate conditions in which to grow by decreasing risk of failure (Carayannis and von Zedtwitz 2005; Grimaldi and Grandi 2005).

Although Bruneel et al. (2012) suggested a distinct role played by science parks from typical business incubators, as later stage incubation facilities, the above analysis did not find any evidence for that. The typical tenants of science parks are subsidiaries of multinational corporations (Tamasy 2007), therefore it is perhaps difficult to capture their relevance to spinout company survival. Furthermore, as UK science parks are typically strongly linked to universities and often located on campuses (Siegel et al. 2003a, b), the results found here provide an interesting insight, especially in comparison to on-campus business incubation. These results are especially important given the focus of the literature on relating spinout formation to business incubation (Di Gregorio and Shane 2003; Lockett and Wright 2005; Fini et al. 2011; Bourelos et al. 2012; Gonzales-Pernia et al. 2013), rather than (more appropriately) spinout survival or performance.

5.2.4 Spinout company

Successful exit, Number of directors

A spinout company is examined here by looking at its successful exit and the number of directors at the company. From Table 5.20 it can be observed that the vast majority of spinout companies (80 out of 81) that reported a form of investment exit are also live firms. The difference in distribution between live and dead spinout companies and their successful exit is statistically significant ($\chi^2(1, N=870)=15.89$, $p<0.001$, $V=0.14$), indicating that a successful exit is important to a spinout company's success strategy.

Table 5.20 Successful exit and spinout survival

	Dead	Live	Total
No	148	641	789
Yes	1	80	81
N	149	721	870

Note: $\chi^2(1, N=870)=15.89$, $p<0.001$, $V=0.14$

As found by Nerkar and Shane (2003) acquisition is a preferred exit mode for spinout companies, although as important to spinout's success as IPO (Shane 2004b; Lawton Smith and Ho 2006; Lawton Smith et al. 2008). When a firm is acquired or trades on public exchange, it gets access to greater capital than it could previously gather from investors. This in effect allows spinout companies to improve their survival chances, as they can focus their resources on building the business, rather than finding investment or generating early sales to develop the company. Bonardo et al. (2011) in their study of 131 'floated' spinouts from Germany, the UK, France, and Italy, found that these companies achieve higher valuations at IPO stage. However, this is reduced after the IPO, suggesting large information asymmetries with regards to spinout companies' real performance and their reputation among investors, in favour of spinouts.

In order to understand the experience of spinouts' directors it is important to look at the numbers of directors at live and dead spinout companies. This may provide information on the size of board of directors and whether a greater number of directors is related to success-oriented decisions at spinout companies. Table 5.21 shows that live spinout companies have fewer directors (Mdn=4) than spinouts that failed (Mdn=6), a statistically significant difference (U=31166, Z=-8.16, p<0.001, r=0.28).

Table 5.21 Number of directors at spinout company and spinout survival

	Dead	Live	Total
Median	6.00	4.00	
N	149	721	870

Note: (U=31166, Z=-8.16, p<0.001, r=0.28)

This could partially be related to the diseconomies of management (Kaldor 1934; Robinson 1934), where larger boards of directors are negatively associated with a spinout company's survival. An explanation for this could be sought from the transaction costs perspective, in which the costs of reaching a decision increase with the number of parties involved in the

process. As spinout companies are young, dynamic businesses, this process may require less time, as directors expend a large portion of their commitments on securing investment funding (Vohora et al. 2004), given their experience and strong networks, to maintain business operations, in particular technology development.

5.2.5 Networks

Change in university industry research income, Structural holes

Table 5.22 captures the difference between the directions of university industry research incomes of the two groups of universities studied here. Clearly, high spinout generation institutions are more focused on developing networks with industries (Mdn=24.16%) than low spinout generation institutions (Mdn=10.53%). However, the difference observed is not statistically significant (U=501, Z=-1.19, p=0.23, r=0.13), suggesting that spinout company generation is unrelated to industry-focused university network development, when no other effects are considered.

Table 5.22 Change in university industry research income over 2002-2013 and spinout generation

	Low spinout generation	High spinout generation	Total
Median	10.53%	24.16%	
N	61	20	81

Note: (U=501, Z=-1.19, p=0.23, r=0.13)

Although the variable used here is not free from imperfections – as it does not measure the industry networks of academics more directly (for example, through degree centrality, time invested in such relations), it does not offer a confirmation of literature findings, where the presence of such relations was found to be important to German faculty entrepreneurial intentions (Krabel and Mueller 2009; Goethner et al. 2012), or in case of Swedish academics where time spent with managers of private companies was related to the number of spinouts formed (Bourelos et al. 2012). Although this network dynamism is not reported to be significant

to spinout company formation, it could indicate that other actors play an important role in spinout formation instead.

Whilst university network links are important to spinout company generation, it is crucial to establish how spinout company position in these networks relates to its survival. As presented in Table 5.23, surviving spinout companies have a lower aggregate constraint (or more structural holes) (Mdn=0.14) compared to non-surviving spinouts (Mdn=0.20). The result is statistically significant (U=40507, Z=-4.73, p<0.001, r=0.16), indicating the importance of network position to spinout companies' success.

Table 5.23 Spinout's structural holes and spinout survival

	Dead	Live	Total
Median	0.20	0.14	
N	149	721	870

Note: (U=40507, Z=-4.73, p<0.001, r=0.16)

These results confirm how essential networks are to survival of spinout companies (Mustar 1997; Grandi and Grimaldi 2003; Pérez Pérez and Mártinez Sanchez 2003; Vohora et al. 2004; Walter et al. 2006; Politis et al. 2012). Being better positioned in a network allows spinout companies to improve their performance (Scholten et al. 2015). Building stronger networks allows spinout companies to develop their credibility (Bower 2003; Grandi and Grimaldi 2003; Bruneel et al. 2012) and increase their pool of investment and growth opportunities (Grandi and Grimaldi 2003; Chan et al. 2010; Bruneel et al. 2012), ensuring their survival prospects. Some of these networks could be a result of recruiting experienced or external entrepreneurs (Franklin et al. 2001), who have the capability to shift the spinout company's position in the network. It is important to stress that spinout company networks are subject to a high degree of dynamism (Rasmussen et al. 2015), leaving the management team of the company responsible for strategic development of its structural holes, or lowering aggregate constraints.

Networks are very complex and dynamic, and regardless of those responsible for developing them, whether TTOs (Lockett et al. 2003; Shane 2004b; Farnstrand Damsgaard and Thursby 2013) or the faculty (Bourelos et al. 2012), building connections is crucial, even when it comes at a cost (Patzelt and Shepherd 2009). These networks can be then accessed by future academic entrepreneurs (Mosey and Wright 2007), leading to increased spinout company formation.

5.2.6 Investment

Seed fund, Venture capital, Investment

Financial capital is crucial to new businesses and spinout companies can access it at most universities, whether early stage seed-corn funding (Table 5.24) or VC (Table 5.25). The proportion of years seed funding access was available to spinout companies at low or high spinout generation universities was found to be largely the same (Mdn=100% for both groups), with any differences being purely coincidental (U=515, Z=-1.46, p=0.14, r=0.16). This is unsurprising, as at certain points within the timeframe considered (2002-2013) all universities provided access to some form of seed funding.

Table 5.24 Proportion of years between 2002 and 2013 when seed funding was available at university and spinout generation

	Low spinout generation	High spinout generation	Total
Median	1.00	1.00	
N	61	20	81

Note: (U=515, Z=-1.46, p=0.14, r=0.16)

The proportion of years when access to VC was available is greater at universities generating higher spinout numbers (Mdn=100%) compared to institutions generating lower levels of spinouts (Mdn=92%). The difference between the two groups of universities is statistically significant (U=300, Z=-3.77, p<0.001, r=0.42), suggesting that access to VC is important to spinout company generation, especially when oriented towards a model where universities provide wider access to such funding.

Table 5.25 Proportion of years between 2002 and 2013 when venture capital was available at university and spinout generation

	Low spinout generation	High spinout generation	Total
Median	0.92	1.00	
N	61	20	81

Note: (U=300, Z=-3.77, p<0.001, r=0.42)

Although the literature suggests that early stage capital should be provided by university internal funds (Degroof and Roberts 2004; Grimaldi et al. 2011), due to lower interest from the private industry (Huggins 2008), with some evidence for that presented here (in that most of the universities offer access to such capital), there is no relationship of such funding with spinout generation, or at least it does not offer any explanation for the differences between the two groups of universities. Therefore, generating greater numbers of spinout companies is not associated university's provision of access to seed funding, the importance of which was suggested by Brooksbank and Thomas (2001). Rather, university access to VC funding is crucial to spinout generation (Hayter 2013), as alluded to in Fini et al. (2017), who call such spinouts 'quality' firms due to their technology having undergone external examination. As VC is typically a larger investment than seed funding, the significance is clear, especially as it becomes available to spinout companies at post-proof-of-concept stage (Wright et al. 2006). Such a result could also be due to the expectations of venture capitalists who often prefer to limit their risk by co-investing with other funds – in this case, universities.

As investment capital is necessary for companies, the actual receipt of such funding is tested in Table 5.26. There is no statistically significant difference given the median values (all at 0) between survivors and non-survivors[4] (U=49077, Z=-1.83, p=0.07, r=0.06), although the result

[4] Mann Whitney U-test compares ranks of variables in order to deparametrise the variable, and therefore the test is still valid. Reporting of medians is merely a convention with regards to non-parametric statistical methods, given poor reflection of the true average point in non-normally distributed data depicted with a mean. In essence, positively skewed data typically has greater mean value than median due to the influence of a few observations at the right-end of the distribution's tail.

is only marginally insignificant (p=0.067). This suggests that there is no relationship between the number of investors and the survival prospects of spinout companies.

Table 5.26 Investment received and spinout survival

	Dead	Live	Total
Median	0	0	
N	149	721	870

Note: (U=49077, Z=-1.83, p=0.07, r=0.06)

As financial constraint, such as unavailability of external finance, is a determinant of business failure (Bayus and Agarwal 2007), and in particular, seed funding (Clarysse et al. 2011b) and VC (Vohora et al. 2004; Clarysse et al. 2005; Wright et al. 2006; Clarysse et al. 2007; Fini et al. 2011; Politis et al. 2012) allow new firms early operating capital to facilitate growth, the findings reported here offer no clear confirmation of a link between spinout's success and its financial position. Although the number of investors is an imperfect measure in place of the more desirable actual investments, it has an added advantage signifying risk-aversion of investors. Nevertheless, due to variables used, the result needs to be interpreted with caution.

5.2.7 Management team

Management team

Table 5.27 depicts university spinouts' (formed between 2002 and 2013) average number of directorships held by spinout company directors, as the closest measure indicative of the presence of external entrepreneurial talent (expected to have held more directorship positions). Universities that generate more spinouts employ directors with greater experience (Mdn=3.26 years) than universities that form fewer spinout companies (Mdn=2.33 years). The result is statistically significant (U=325, Z=-3.12, p=0.002, r=0.35), confirming the importance of experienced management teams or surrogate entrepreneurs to spinout formation.

Table 5.27 Management team's experience and spinout generation

	Low spinout generation	High spinout generation	Total
Median	2.33	3.26	
N	61	20	81

Note: (U=325, Z=-3.12, p=0.002, r=0.35)

The role of a management team is expected to be also important in securing a spinout company's success. From Table 5.28 it is found that live spinout companies have more experienced teams of directors (Mdn=2.40 years) than spinouts that deregistered (Mdn=1.62 years). The difference between the two groups is statistically significant (U=38026, Z=-5.61, p<0.001, r=0.19), indicating the importance of an experienced management team to a spinout company's success.

Table 5.28 Management team's experience and spinout survival

	Dead	Live	Total
Median	1.62	2.40	
N	149	720	869

Note: (U=38026, Z=-5.61, p<0.001, r=0.19)

The results confirm the importance of a management team (i.e. external entrepreneurs) to both spinout company formation (Franklin et al. 2001; Lockett et al. 2003; Vohora et al. 2004; Hayter 2013) and its growth (Vohora et al. 2004; Walter et al. 2006; Djokovic and Souitaris 2008; Lundqvist 2014), or more precisely here, the survival of spinout companies. Moreover, the clear message from these findings stresses the role of management team in spinout company success, more broadly confirming Taylor's (1999) observations about UK firms. The two core aspects brought by external entrepreneurs are business experience and networks (Franklin et al. 2001), which are crucial to any company's survival, especially at the early development stages. Further commercial (Wennberg et al. 2011) and management skills (Grandi and Grimaldi 2003) are also important, as academic founders can focus on the development of the invention rather

than running the business, even though the benefit of managerial experience only lasts until a certain stage of firm development, given its non-linear character (Holmes and Schmitz 1996).

Furthermore, these somewhat contradictory results confirm the importance of management team diversity being critical to spinout's performance (Visintin and Pittino 2014). Nevertheless, it is critical to indicate that some of the experience accounted for in the surviving firms is down to ‘repeat commercialisers’ (Hoye and Pries 2009) i.e. previous self-employment (Taylor 1999). The results, given the focus on the number of directorships held, disprove the negative effect of over-commitment, as found by Kalleberg and Leicht (1991), although the studied firm samples are different as the results are related here to UK spinout companies only. Perhaps, two decades of progress in communication methods inverted the negative effect of over-commitment, allowing company directors to run more than one business successfully. Furthermore, as external entrepreneurial talent is not readily available in great supply, some universities might opt to upskill the academic founders to prepare them for the role (Moray and Clarysse 2005), but the effects of such training commitment are yet to be captured in future studies.

5.2.8 Other actors

Joint spinout

The focus in this sub-section is on how involving other actors, in particular other universities as parent institutions, relates to spinout formation and survival. The university collaborative effort in creating spinout companies is explored in Table 5.29. There were 186 spinout companies among 49 universities that had more than one parent university (responsible for 93 original firms), with 32 institutions that did not collaborate with any university to form a spinout company. As can be observed, the universities that generate more spinout companies also form more joint spinouts with other institutions (Mdn=4), suggesting their greater use of networks and superior connectedness to that of low spinout generation universities (Mdn=0). The difference between the two groups is statistically significant ($U=97$, $Z=-5.87$, $p<0.001$, $r=0.65$), providing evidence for the role of networks. Universities that are better at utilising their

networks and building new relations are associated with greater numbers of spinout companies (Lockett et al. 2003).

Table 5.29 Number of spinouts with multiple parents over 2002-2013 and spinout generation

	Low spinout generation	High spinout generation	Total
Median	0	4.00	
N	61	20	81

Note: (U=97, Z=-5.87, p<0.001, r=0.65)

The results presented above do not just emphasise the importance of the networks, as stressed in the literature (e.g. Franklin et al. 2001; Vohora et al. 2004; Mosey and Wright 2007; Grimaldi et al. 2011; Bourelos et al. 2012; Fogelberg and Lundqvist 2013): they clearly point to the strong performance of universities that engage in collaboration to found spinout companies. The main advantage of such organisation is in greater availability of resources to these new firms. Previous studies on UK universities indicated a similar effect (Franklin et al. 2001; Lockett et al. 2003) largely due to a more open nature of high spinout generation universities. Given the sample studied here refers to 2002-2013 compared to those previously studied (1994-1998) (Franklin et al. 2001; Lockett et al. 2003), the effect clearly holds over time and for different (i.e. larger) cohorts of spinouts and universities.

In the case of spinout company survival, its association with having multiple parent institutions is unknown. As can be observed from Table 5.30 there is no statistically significant difference (U=51153, Z=-1.71, p=0.09, r=0.06) observable among the surviving and non-surviving spinout companies in relation to the number of parent universities (Mdn=1 for both groups). Although the result is only marginally insignificant, it suggests that a greater number of parents is not related to improved survival chances, even though pure university size is (as previously established).

Table 5.30 Number of parent institutions for spinouts formed between 2002 and 2013 and spinout survival

	Dead	Live	Total
Median	1.00	1.00	
N	149	721	870

Note: (U=51153, Z=-1.71, p=0.09, r=0.06)

As spinout companies initially 'inherit' networks from their universities (Grandi and Grimaldi 2003), it is expected that there would be an increased benefit to co-created firms, as they develop their network positions to more commercially oriented (Pérez Pérez and Mártinez Sanchez 2003), consequently strengthening their success prospects. This could signify 'parental' withdrawal from spinout company development, with higher transaction costs of increased numbers of parents collaborating over extended period of time.

In the following section the broader network environment is examined with regards to spinout company formation and survival.

5.3 Bivariate tests of characteristics of broader network environment

This section focuses on the broader network environment by examining characteristics of geography. In particular, it engages with measures that describe the regional economic environment of spinout companies.

5.3.1 Geography

Change in regional GVA per capita, 2002 regional GVA per capita

The geography of spinout company success provides an interesting decomposition of regional unevenness of entrepreneurial activity, as depicted in Table 5.31. High spinout generation universities are located in regions with economic growth (Mdn=46.93%) not very different from those where low spinout generation universities are (Mdn=46.79%), a result not statistically

significant (U=601, Z=-0.10, p=0.92, r=0.01). This suggests that spinout generation is independent of regional economic performance.

Table 5.31 Change in regional GVA per capita over 2002-2014 and spinout generation

	Low spinout generation	High spinout generation	Total
Median	46.79%	46.93%	
N	61	20	81

Note: (U=601, Z=-0.10, p=0.92, r=0.01)

Changes in output provides limited indication of the value of output itself, which can reflect market size or competition level (for example, high-value economic activities) in a region that spinout generation can be subjected to. Table 5.32 confirms the insignificance of economic development (i.e. the state of it) to spinout company generation (U=610, Z=-0.00, p=1.00, r=0), with universities generating lower numbers of spinouts being located in regions of similar output level (Mdn=£15,208) as those of high spinout generation universities (Mdn=£15,270).

Table 5.32 Regional GVA per capita in 2002 and spinout generation

	Low spinout generation	High spinout generation	Total
Median	£ 15,208.00	£ 15,270.00	
N	61	20	81

Note: (U=610, Z=-0.00, p=1.00, r=0)

A similar approach is utilised to test the effect of regional economic performance on spinout survival. As presented in Table 5.33, more live spinout companies are in regions with lower economic output growth (Mdn=15.91%) than dead spinouts (Mdn=18.49%), but the result is not statistically significant (U=49592, Z=-1.48, p=0.14, r=0.05). This indicates that spinout company's survival is relatively undisturbed by economic performance of its region.

Table 5.33 Change in regional GVA per capita from spinout birth (from 2002 to 2013) to company deregistration or 2014 and spinout survival

	Dead	Live	Total
Median	18.49%	15.91%	
N	149	721	870

Note: (U=49592, Z=-1.48, p=0.14, r=0.05)

As in spinout formation, it is important to test if, regardless of output changes, the pure value of the output could be related to spinouts' success. In Table 5.34 there is a statistically significant difference found (U=43153, Z=-3.78, p<0.001, r=0.13) between the higher regional economic output of survivors (Mdn=£19,087) and regional economic output of non-survivors (Mdn=£17,936). The difference clearly indicates that being in a region characterised by greater economic output per capita is related to spinout company survival.

Table 5.34 Regional GVA per capita at spinout birth and spinout survival

	Dead	Live	Total
Median	£ 17,936.00	£ 19,087.00	
N	149	721	870

Note: (U=43153, Z=-3.78, p<0.001, r=0.13)

The results present an interesting insight into the geography of the success of spinout companies. Clearly, there is no difference between regional spinout formation performance of universities and economic development. The main reason behind this is that such institutions could have adapted to their immobility and regional economic environment (Nelson and Winter 1982). Consequently, aggregate regional formation of spinouts from universities is reasonably uniform, suggesting regional innovation system (Cooke 1992) developments oriented towards spinout volumes. Conversely, the path of a region's economic development or magnitude of change over spinout's lifetime is also unrelated to its success, which could be indicative of how decoupled university spinouts are from typical businesses, not least by achieving generally high survival rates. As successful spinout companies are located in regions with greater levels of GVA per

capita, it is clear that spinouts are more successful in specific geographical conditions, particularly better developed regions (Iacobucci and Micozzi 2015). This could signify a limited number of regional innovation systems (Cooke 1992) have adapted to achieving entrepreneurial success, working to support spinout companies' development. Therefore, only some regional innovation systems accommodate a dual design that generates strong outcomes in both spinout formation and survival.

5.4 Conclusion

The bivariate analysis used in this chapter uncovered a number of interesting relationships between university networks, the broader network environment and university spinout company success. In particular, spinout company formation is dependent on university network elements only. Conversely, spinout company success is conditioned by broader network environment as well. Therefore, broader network environment appears to have a role in distinguishing the functionality or outcomes of university networks: formation and survival.

University network elements that describe university characteristics were found to play a significant role in both the formation and survival of spinout companies. University size, expressed here through its total income, is positively related to spinout company formation and survival. In other words, larger UK universities are associated with greater number of spinout ventures. Similarly, spinout companies from these institutions have a higher rate of survival, suggesting that university endowments and related reputation - stemming from university's research intensity and excellence, are critical to spinout companies.

Furthermore, spinout company generation and survival are clearly dependent on knowledge production and protection (Di Gregorio and Shane 2003; Hewitt-Dundas 2015). Specifically, UK universities that report a greater number of disclosures generate more spinout companies, clearly signifying that the most important ingredient for a spinout is knowledge. However, a spinout company's survival relies on monopolising it, limiting unintended knowledge leakage.

UK spinout companies are associated with a bias towards traditional fields of science (Shane 2004b), as the findings indicate. This is partially implied by two related aspects: university size and stock of knowledge production. Traditional science fields, such as physics, engineering or biosciences require capital-intensive infrastructure, which requires greater university income for maintenance. At the same time, patenting knowledge from such science domains is easier (Shane 2004b), which translates into greater numbers of firms formed and improved survival outcomes.

Neither TTOs nor business incubators were found significant to spinout generation. This result is both confirmatory (in terms of TTOs, e.g. Clarysse et al. 2011a) and controversial (in terms of business incubation, e.g. Salvador and Rolfo 2011). Nevertheless, spinout company survival is positively related to TTOs and business incubators, as well as spinout company characteristics, such as successful exit or smaller boards of directors, and its network position.

Specifically, a greater proportion of surviving spinout companies originated from universities with more experienced TTOs. This indicates that the role of TTO might be different than originally defined - as pure knowledge transfer. In turn, these actors appear to ensure successful outcomes of spinout companies, pointing to previously suggested network-oriented connection function (Siegel et al. 2004).

Whilst business incubators are infrastructural and functional solutions aimed at new businesses, they appear to have a more prominent role in spinout company survival, i.e. instead of being associated with the births of firms, incubation is related to their longevity, much in the line of intended mission (Carayannis and von Zedtwitz 2005; Grimaldi and Grandi 2005). This effect, however, is only observed for spinout companies that originated from universities with on-campus business incubation access. Consequently, other forms of business incubation, such as off-campus and science parks, have no particular effects on spinout companies.

Spinout company characteristics, such as successful exit through acquisition or IPO and number of directors, are related to its survival. In particular, all spinouts that were acquired by another established firm or underwent IPO survived, except one, meaning that the success of spinout companies is clearly related to the financial stability that stems from greater access to capital. This is especially important, as Nerkar and Shane (2003) previously observed that US spinout companies preferred to exit through acquisition. Additionally, spinouts with larger boards of directors are associated with failure, suggesting that there are diminishing returns to management (Kaldor 1934; Robinson 1934).

Networks constitute the connections between actors and, with the use of the structural holes measure (Burt 1992), define a spinout company's position. Clearly, the opportunities available in the immediate vicinity of spinout companies are related to their survival outcomes. This result corroborates the extant literature that observed this effect in less sophisticated terms (e.g. Mustar 1997). However, at the spinout formation stage, networks with industry are found to have no significance, contrary to previous findings reported in Germany (Krabel and Mueller 2009; Goethner et al. 2012).

Management teams are crucial to both spinout company formation and survival, confirming Franklin et al.'s (2001) observation that external entrepreneurs contribute business experience and networks, in turn stimulating firm's development. These findings add empirical evidence that attempted to measure the presence of such entrepreneurial talent in spinout companies through the number of directorships held by spinout directors.

Although finance has been described as essential to a spinout company's creation and success (e.g. Fini et al. 2011; Politis et al. 2012; Gonzalez-Pernia et al. 2013; Hayter 2013), the results reported from bivariate tests indicate that access to VC is only related to spinout company formation. This is especially important as access to seed funding is found insignificant to spinout formation, lending some support to previous discussions on spinout companies' early

stage funding gap (Huggins 2008b). Interestingly, the number of investors a spinout company has had is not associated with its survival, suggesting that finance plays the most critical role at the earliest stages of the spinout development.

Finally, university networks necessitate broader network environment contextualisation. Specifically, spinout company survival is found to be related to the characteristics of the region it is based in. Spinout companies born in regions with higher output per capita are associated with greater survival. This improved performance outcome dependent on the geography confirms recent findings reported by Iacobucci and Micozzi (2015), contributing further empirical evidence on spatial effects and spinout company outcomes. However, no regional effects are observed in relation to formation of spinout companies, suggesting a complex mechanism at work.

The following chapter explores the variables used here through multivariate analysis, taking a much broader approach to explain spinout company success, by controlling for multiple parameters. It presents two analytical approaches: modelling: 1) spinout company generation through negative binomial regression; and 2) spinout survival using logistic regression. As a result, the next chapter combines university network and broader network environment characteristics.

Chapter 6

Characteristics of university networks and broader network environment: multivariate analysis

The previous chapter explored the characteristics of university networks and broader network environment, using bivariate statistical tests. In this chapter a multivariate approach is applied to examine if the same results occur when other aspects of university networks are also considered. As a result, this chapter takes on a different structure by combining all actor characteristics to undertake two separate lines of inquiry related to university spinout success: formation and survival.

It is found that spinout company generation and spinout survival are explained by different combinations of characteristics of university networks and broader network environment. In particular, universities with higher spinout rates have access to venture capital investment (whether internal or external), business incubation in the form of a science park, other actors expressed by collaborating with further universities in spinout foundation, as well as access to experienced management teams (i.e. entrepreneurs/managerial talent) and networks, specifically with industry. Once created these spinout companies have greater success chances when in receipt of investment, especially from a larger number of investors, if they employ experienced management teams, and enjoy favourable network positions with maximised structural holes. These results are strengthened by the support surviving spinouts receive from their parents' experienced TTO. Finally, it is important to report that spinout company success is not free from broader network environment effects. Specifically spinout company formation is more prevalent in regions that achieve higher output growth, but started at a lower base value of the output. In contrast, survival of spinout companies is improved if spinouts are based in regions with both higher output growth and higher level of output at their birth.

The chapter has the following structure: Section 6.1 applies a negative binomial regression model to 81 UK universities to explore spinout company formation between 2002 and 2013; Section 6.2 uses a logistic regression on 869 spinout companies to better understand the survival of these high technology firms; and in Section 6.3 summary of this chapter's results and concluding remarks are offered.

6.1 University spinout generation and university network characteristics

This section identifies the elements of university networks and broader network environment that affect university spinout formation. In particular, it looks at university commercialisation experience, access to business incubation services and investment, the experience of management teams, the presence of other actors, network types, and regional effects. As the dependent variable measures the numbers of spinout companies formed, it is a counts type indicator and requires appropriate statistical models, and therefore a negative binomial regression is fitted to the data, as similarly applied (with variants of the general model) in previous studies of spinout company generation (Lockett and Wright 2005; Gonzales-Pernia et al. 2013; Ramaciotti and Rizzo 2014; Fini et al. 2017). The model is structured in a cross-sectional character, although it covers spinout formation between 2002 and 2013, given different challenges presented by the data.

6.1.1 Description of variables

The descriptive statistics for the variables depicted below are available in Table 6.1. Each variable's design is explained in detail in Chapter 4.

Table 6.1 Descriptive statistics of variables (N=81)

Variable	Mean	Standard deviation	Minimum	Maximum
Spinouts Formed	11.89	14.01	1	67
University Size	£ 2.69	£ 2.17	£ 0.37	£ 12.57
Disclosures	5.56	1.54	0.00	8.14
Science Orientation	0.47	0.20	0.03	1.00
Δ Regional GVA per capita	0.47	0.06	0.39	0.60
2002 Regional GVA per capita	£ 16.18	£ 4.14	£ 11.74	£ 26.70
Commercialisation Experience	20.62	8.51	6.28	45.33
On-Campus Incubator	0.80	0.29	0.00	1.00
Off-Campus Incubator	0.78	0.33	0.00	1.00
Science Park	0.65	0.42	0.00	1.00
Seed Fund	0.95	0.13	0.33	1.00
Venture Capital	0.82	0.29	0.00	1.00
Management Team	3.14	1.67	0.60	8.48
Joint Spinouts	2.30	4.02	0	20
Δ University Industry Research Income	0.64	1.70	-0.76	10.44

6.1.2 Results

The relationships between variables are depicted in Table 6.2 through Pearson's correlations. All independent variables except *Δ University Industry Research Income* have positive relationships with the dependent variable. However, only three of these relationships are statistically significant and include the following predictors: *Commercialisation Experience*, *Venture Capital*, and *Joint Spinouts*. Some of the very strong correlations between explanatory variables are a cause for multicollinearity concerns, specifically: *University Size* and *Disclosures* (r=0.61), *Δ regional GVA per capita* and *2002 regional GVA per capita* (r=0.60), and *University Size* and *Joint Spinouts* (r=0.75). To test this, the models were first fitted using OLS regressions to compute collinearity diagnostic tests, with a particular interest in VIF (variance inflation factor) measures (reported in Table 6.4), where levels of 10 are still acceptable (Hair et al. 1998). In all instances the variables used here do not go beyond a VIF value of 3.3, and in most cases the variables are below 2.0. Furthermore, no inflated coefficients

or high standard errors of parameters were observed in the regressions, suggesting few if any mutlicollinearity problems in the dataset.

Table 6.2 Correlations between variables (N=81)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Spinouts Formed	1.00													
2 University Size	**0.86**	1.00												
3 Disclosures	**0.56**	**0.61**	1.00											
4 Science Orientation	**0.37**	**0.29**	0.19	1.00										
5 Δ R. GVA/capita	0.05	-0.01	-0.10	**0.39**	1.00									
6 2002 R. GVA/capita	0.10	0.17	0.07	**0.40**	**0.60**	1.00								
7 Comm. Experience	*0.24*	**0.30**	*0.24*	0.04	-0.11	-0.04	1.00							
8 On-Campus Incubator	0.16	0.15	0.08	0.07	-0.12	-0.17	0.12	1.00						
9 Off-Campus Incubator	0.12	0.10	0.18	*0.23*	-0.05	-0.14	-0.10	0.03	1.00					
10 Science Park	0.16	0.14	0.17	0.10	**-0.37**	*-0.22*	-0.04	0.12	0.20	1.00				
11 Seed Fund	0.16	0.20	**0.32**	-0.08	-0.11	-0.13	0.17	0.00	0.14	0.19	1.00			
12 Venture Capital	**0.33**	**0.31**	**0.35**	0.13	-0.06	-0.04	0.13	0.12	0.05	0.10	**0.58**	1.00		
13 Management Team	0.17	0.19	0.15	0.19	0.12	0.03	0.15	0.08	-0.13	**-0.32**	-0.02	0.16	1.00	
14 Joint Spinouts	**0.84**	**0.75**	**0.40**	**0.34**	0.12	0.22	*0.24*	0.09	0.06	0.07	0.13	*0.26*	0.17	1.00
15 Δ University Industry Research Income	-0.02	-0.08	-0.13	0.13	0.14	-0.04	-0.12	*-0.28*	0.19	-0.16	0.07	-0.16	-0.14	-0.11

Note: Correlations in bold are significant at 1% level (2-tailed); correlations in italics are significant at 5% level (2-tailed).

As the dependent variable is of a counts type – i.e. it represents the numbers of spinout companies generated by each of the 81 universities, with each observation taking a positive value between 1 and 67, this implies the use of counts-type regression models, primarily a Poisson-based distribution model. Nevertheless, the assumptions of Poisson distribution are not met by the dependent variable, where the mean (11.89) is not equal (or near equal) to its variance (196.40). Instead the variance being greater than the mean indicates a need for models that deal with overdispersion (Cameron and Trivedi 2013), suggesting the use of a negative binomial model. Cameron and Trivedi (2013) suggest that in cases where dependent variable's variance is less than twice as large as its mean, overdispersion can be dealt with by addition of parameters; otherwise the overdispersion requires a different model. Finally, as both models use an alpha (α) parameter which takes a strict value of 0 in Poisson specification (given strict

criteria with regards to dependent variable), whilst it is estimable in negative binomial models[5] (strictly as a correction for overdispersion), comparing such models allows to test for fit to the data.

In order to remain cautious (even though the dependent variable's variance is approximately 16.5 times larger than its mean), a dispersion parameter (also known as θ) is explored by fitting a regression to the Poisson model and subsequently to a negative binomial model with estimable alpha (Cameron and Trivedi 2013). The ideal value of θ should be 1 (or close to): any sign of θ<1 is indicative of underdispersion, whilst θ >1 indicates overdispersion. As the dispersion parameter is greater than 13 for the Poisson (intercept only) model, and 1.12 for the negative binomial (intercept only) model (alpha=1.06), a regression with a base set of control parameters (5 in this case) is fitted again, to discount the possibility that residual deviance could be reduced enough to overcome overdispersion by the addition of covariates. Although the overdispersion parameter for the Poisson model fell to 3.64, for the negative binomial model it remained nearly the same (i.e. 1.14, with alpha=0.27). This confirms Cameron and Trivedi's (2013) proposition and clearly suggests a negative binomial model as most appropriate for the data.

The model employed is of the following notation:

$$\log(\mu_i) = \alpha + \beta X_i + \gamma Z_i + \varepsilon_i$$

where μ_i represents the counts of spinout companies generated by university i, X_i corresponds to a vector of control variables describing university i, Z_i represents the vector of remaining independent variables that describe network characteristics of university i, whilst ε_i is an error term. The identity link function in the model is logarithmic.

Table 6.3 presents two models of regressions fitted to explain university spinout company formation, whilst additional VIF values for each model are presented in Table 6.4. Furthermore, both models are an improvement over an intercept-only model (so-called Omnibus test)

[5] In fact, if alpha=0 in a negative binomial model, the over-dispersion parameter theta would equal that of the Poisson specification.

significant at a 1% level, whilst model 2 is an improvement over the base model 1 as indicated by Akaike's information criterion (AIC) and pseudo-R^2 measure.

Table 6.3 Negative binomial regressions of spinout formation between 2002-2013

	Model 1	S. E.	Model 2	S. E.
University Size	0.214***	0.046	0.080	0.051
Disclosures	0.289***	0.081	0.321***	0.079
Science Orientation	1.492***	0.486	0.700	0.497
Δ Regional GVA per capita	3.014*	1.601	2.903*	1.516
2002 Regional GVA per capita	-0.085***	0.024	-0.056**	0.023
Commercialisation Experience			0.003	0.008
On-Campus Incubator			0.269	0.259
Off-Campus Incubator			-0.326	0.212
Science Park			0.546**	0.219
Seed Fund			-0.699	0.711
Venture Capital			0.860**	0.353
Management Team			0.087*	0.046
Joint Spinouts			0.065***	0.022
Δ Uni. Ind. Res.Income			0.147***	0.050
Intercept	-0.847	0.748	-1.726	1.007
Alpha	0.271		0.166	
N	81		81	
DF	6		15	
AIC	492.584		487.102	
Deviance/DF	1.143		1.289	
Pseudo-R^2	0.047		0.055	

Note: The significance levels: *** p<0.01, ** p<0.05, * p<0.1. Pseudo-R^2 measure used is equal to $1 - (Deviance_{fitted\ model} / Deviance_{intercept\ model})$ (Cameron and Windmeijer 1996, 1997; Cameron and Trivedi 2013).

Table 6.4 Variance Inflation Factors

	Model 1	Model 2
University Size	1.7	3.3
Disclosures	1.6	1.8
Science Orientation	1.4	2.0
Δ Regional GVA per capita	1.7	2.0
2002 Regional GVA per capita	1.7	2.1
Commercialisation Experience		1.2
On-Campus Incubator		1.2
Off-Campus Incubator		1.3
Science Park		1.7
Seed Fund		1.9
Venture Capital		1.8
Management Team		1.4
Joint Spinouts		2.5
Δ University Industry Research Income		1.5

Model 1 is the base model with control variables only. All controls enter the equation significantly at conventional levels (although *Δ regional GVA per capita* only marginally) and with positive coefficients, except *2002 regional GVA per capita,* which does so with a negative coefficient. Clearly, in absence of other covariates, university size, its stock of commercialisable knowledge, greater orientation of research towards scientific disciplines, and the level of regional economic output (as well as change in the output) explain spinout formation between 2002 and 2013.

When independent variables are regressed on spinout company formation (model 2), a number of interesting results are observed. First, two control variables become insignificant: *University Size* and *Science Orientation*; instead, other university-related variables better explain spinout company generation. Only *Disclosures* remains significant, suggesting a very strong link between the stock of commercialisable knowledge and the numbers of spinouts formed by a university. Furthermore, regional output measures remain significant, with *2002 regional GVA per capita* reduced to 5% level, indicating the strong role of geography in spinout company

formation. From the independent variables, it is important to note that *Management Team*, *Δ University Industry Research Income*, *Science Park*, *Venture Capital*, and *Joint Spinouts*, were found to be positively and significantly related to spinout company formation. Clearly, there are two important aspects to be observed here: 1) the openness of university networks is related to forming greater numbers of spinout companies; and 2) the main ingredients for spinout companies are knowledge, greater finance, incubation facilities and management.

Although literature finds the TTOs critical in the process of disclosure identification (Macho-Stadler et al. 2007) and more importantly creation of spinout companies (Alexander and Martin 2013), no support for this was found here in relation to the levels of experience of TTOs. In fact, TTOs' impact on faculty's intentions to disclose knowledge of commercial potential is very limited (Clarysse et al. 2011a), and therefore the role of TTOs' experience could be related to facilitation of spinout foundation, which has no association with the numbers of spinouts formed. The result, however, could also be related to how the experience is measured, as Fini et al. (2017) expressed it by cumulative number of spinout companies and found a significant and positive relation to spinout formations.

Although business incubators are important to a new firm's chances of success (Carayannis and von Zedtwitz 2005; Grimaldi and Grandi 2005) by shielding it from market risks (Carayannis and von Zedtwitz 2005), as found in a Swedish study of spinout rates (Bourelos et al. 2012), only partial confirmation of this association can be found here. Whilst on- or off-campus incubators were found insignificant to spinout formation, as in previous studies of spinout generation (Di Gregorio and Shane 2003; Gonzalez-Pernia et al. 2013; Hewitt-Dundas 2015), university access to science parks is related to greater numbers of spinouts. This is a surprising finding given previous research suggesting no such effect (Lockett and Wright 2005). However, an explanation of this result could be found in Tamasy's (2007) research, which suggested that these are prestige-oriented facilities housing subsidiaries of multinational corporations, which

might attract other companies to the science park and draw the attention of investors towards such services.

The analysis offers an interesting perspective on access to investment. In particular, it finds no association between access to seed funding and spinout formation. In a study by Huggins (2008b), an early stage funding gap was indicated, due to limited interest from private investors, yet large finance (VC) is found to be significantly related to spinout generation in much of the literature (e.g. Bonardo et al. 2011; Fini et al. 2011; Politis et al. 2012; Gonzalez-Pernia et al. 2013; Hayter 2013). This could be explained by the capital requirements of spinout companies, which may be higher than seed funding could satisfy. Spinouts are typically technology-based firms and seed funding might not suffice to sustain immediate post-foundation activities of the company, which could be resource-intensive, especially in continuing high-value activity such as R&D.

University spinout generation is further explained by spinouts' ex-post measured access to management teams, confirming previous studies that identified and suggested such link (Franklin et al. 2001; Lockett et al. 2003; Vohora et al. 2004; Hayter 2013; Visintin and Pittino 2014). Moreover, the significant relation between the number of joint spinout companies formed and spinout formation confirms Locket et al.'s (2003) finding that UK universities that generate more spinout companies were associated with greater openness to collaborate with external entrepreneurs or other universities. This effect is especially visible when inspecting particular cases of such collaborative propensity: for example, Imperial College London and University of Cambridge are each responsible for 20 spinouts; University of Oxford 16; and University College London 11.

Finally, university networks that are developed to foster greater industry engagement are positively related to spinout company formation, confirming studies on entrepreneurial intentions (Krabel and Mueller 2009; Goethner et al. 2012). Such networks offer academics a

better understanding of commercial realities, equipping them with the commercial acumen to become entrepreneurial. In addition to that, these networks might also result in the development of more knowledge of applied character, which could be easier translated into a business proposal.

The total income universities receive (i.e. university size) is not related to spinout formation rates, confirming previous studies measuring size of lab (Haeussler and Colyvas 2011) and department (D'Este et al. 2012). Furthermore, the bias that universities that generate more research in traditional science are associated with creating more spinout companies (Shane 2004b) is unsubstantiated in the evidence presented here.

A spinout's region and this geography's economic performance is found to be important to a university's propensity to generate spinout companies, suggesting that their immobility (Grimaldi et al. 2011; Berbegal-Mirabent et al. 2013) or regional-boundedness is associated with how universities pursue such entrepreneurial activities, clearly pointing to the importance of innovation systems or setups (Cooke 1992; Lundvall 1992; Storper 1993; Florida 1995; Asheim 1996; Morgan 1997; Etzkowitz and Leydesdorff 2000). However, universities located in less developed regions are positively related to spinout formation, perhaps playing a central economic role in their regions (Morgan 1997). The results confirm the importance of university resource inputs into spinout company generation, in particular the accumulated knowledge of commercial potential (Di Gregorio and Shane 2003; Shane 2004b; Fini et al. 2009; Hayter 2013).

The following section explores the survival aspect of spinout company success by exploring a similarly structured model of university networks and broader network environment.

6.2 University spinout survival and university network characteristics

Whilst the previous chapter uncovered interesting bivariate relationships between spinout company survival and a number of independent variables representing university networks and the broader network environment, this section focuses on testing the ceteris paribus effects of these variables present in the same regression model. Given the binomial nature of the dependent variable, a logistic regression model is selected for the analysis, with similar design found in Criaco et al. (2014) in their study of Catalonian spinouts. Out of 870 observations, the analysis in the full model focuses on 869 spinout companies, given the presence of an outlier in a predictor. The section first outlines the variables utilised in the analysis, explores binary linear relationships between the variables, and explores the survival of spinout companies by fitting a regression model.

6.2.1 Description of variables

The descriptive statistics for the variables are presented in Tables 6.5 for continuous variables and 6.6 for categorical variables. The construct of each variable is presented in Chapter 4.

Table 6.5 Descriptive statistics of continuous variable (N=870)

Variable	Mean	Std. Deviation	Minimum	Maximum
Number of Directors	4.48	2.41	1	18
University Size	£ 0.42	£ 0.33	£ 0.02	£ 2.26
Science Orientation	0.54	0.17	0	1
Patents	0.39	0.62	0	3.69
Δ R. GVA per capita	0.21	0.13	-0.01	0.60
R. GVA per capita at birth	£ 20.44	£ 6.00	£ 12.21	£ 40.52
Investment	1.20	1.96	0	14
Joint Spinout	1.13	0.39	1	4
Management Team*	3.41	3.87	0	50
Comm. Experience	16.19	10.08	-2.77	44.32
Structural Holes	0.21	0.21	0.01	1.00

Note: * N=869.

Table 6.6 Properties of categorical variables (N=870)

Variable	Yes	No
Spinout Survival	721	149
Small Firm	857	13
Manufacturing Sector	144	726
Information & Communication Sector	147	723
Professional, Scientific & Technical Sector	451	419
Human Health & Social Work Sector	30	840
Successful Exit	81	789
On-Campus Incubator	753	117
Off-Campus Incubator	723	147
Science Park	636	234

6.2.2 Results

Table 6.7 presents correlations of all variables, with a number of interesting relationships with dependent variable uncovered. Specifically, *Professional, Scientific and Technical Sector*, and *Successful Exit* show positive relationships with spinout company survival, whilst *Number of Directors* is negatively related. All three university controls are also positively related to spinout company survival, whilst only the level of regional output per capita is positively associated with spinout survival. Five of the eight independent variables have significant correlations with the dependent variable, notably *Investment*, *Management Team*, *Commercialisation Experience*, *On-Campus Incubator*, and *Structural Holes*, all of expected coefficient signs. Despite the sample size (N=870) there is one pair of variables that could indicate presence of multicollinearity: *University Size* and *Patents* (r=0.76). As none of the parameters in the regressions have abnormally inflated standard errors or coefficients, and models with one of the suspected variables removed were tested with minimal effect on the results, any presence of multicollinearity is considered to be of small effect. Nevertheless, to further test for multicollinearity VIFs were obtained by fitting an OLS regression (results reported in Table 6.9), with the highest values reached only by *Professional, Scientific and Technical Sector* (VIF=2.9), *Patents* (VIF=3.1), and *University Size* (VIF=3.4), all well below conventional VIF threshold

value of 10, that is typically interpreted as indicative of modelling problems, suggesting no cause for concern.

Table 6.7 Correlations between variables (1-9) (N=870)

		1	2	3	4	5	6	7	8	9	10
1	Spinout Survival	1.00									
2	Small Firm	-0.01	1.00								
3	Manufacturing Sec	0.02	0.00	1.00							
4	Info & Comm Sec	0.00	0.00	**-0.20**	1.00						
5	Prof, Scie & Tech Sec	*0.07*	-0.02	**-0.46**	**-0.47**	1.00					
6	Health & Soc Work Sec	0.00	0.02	*-0.08*	*-0.09*	**-0.20**	1.00				
7	Successful Exit	**0.14**	**-0.09**	0.00	-0.05	0.02	0.03	1.00			
8	Number of Directors	**-0.35**	**-0.19**	0.04	**-0.09**	0.02	-0.01	-0.03	1.00		
9	University Size	**0.16**	*-0.08*	-0.02	-0.06	**0.11**	-0.03	0.06	*0.07*	1.00	
10	Science Orientation	*0.08*	-0.03	-0.02	-0.02	0.02	-0.02	0.05	0.06	**0.36**	1.00
11	Patents	**0.11**	-0.01	-0.03	*-0.08*	**0.09**	0.02	0.06	*0.08*	**0.76**	**0.44**
12	Δ R. GVA/capita	0.05	**-0.10**	*0.07*	-0.02	0.00	-0.03	*0.08*	**0.10**	**-0.18**	-0.02
13	R. GVA/capita at birth	**0.10**	0.02	*-0.08*	-0.02	*0.07*	0.00	0.03	0.01	**0.33**	**0.38**
14	Investment	*0.07*	**-0.17**	0.04	-0.05	**0.10**	-0.06	0.01	**0.40**	**0.12**	*0.07*
15	Joint Spinout	0.05	**-0.11**	0.01	-0.04	0.03	-0.05	-0.02	**0.17**	**0.40**	*0.07*
16	Management Team	**0.10**	-0.02	-0.06	**-0.10**	**0.10**	0.00	0.04	0.02	0.00	0.01
17	Comm. Experience	**0.13**	*-0.07*	-0.04	-0.06	**0.09**	-0.04	*0.08*	0.03	**0.45**	**0.21**
18	On-Campus Incubator	*0.07*	0.01	-0.05	0.04	0.01	0.00	0.01	-0.07	**0.18**	**0.11**
19	Off-Campus Incubator	0.06	0.00	0.03	0.00	0.06	-0.05	-0.02	0.01	**0.15**	**0.14**
20	Science Park	0.00	0.01	-0.03	0.02	0.00	-0.01	-0.01	0.01	**0.16**	-0.05
21	Structural Holes	**-0.15**	**0.09**	**-0.10**	0.02	*-0.08*	**0.11**	-0.07	**-0.26**	**-0.16**	**-0.13**

Note: Correlations of Management Team are available for 869 observations only. Correlations in italics significant at 5% level (2-tailed); correlations in bold significant at 1% level (2-tailed). Correlations between continuous variables are Pearson's, correlations between continuous and categorical dummy variables are point-biserial, correlations between categorical dummies are phi coefficients.

Table 6.7 *Continued*

		11	12	13	14	15	16	17	18	19	20
11	Patents	1.00									
12	Δ R. GVA/capita	**-0.20**	1.00								
13	R. GVA/capita at birth	**0.45**	**-0.15**	1.00							
14	Investment	0.03	**0.23**	-0.04	1.00						
15	Joint Spinout	**0.25**	**0.13**	0.02	**0.25**	1.00					
16	Management Team	-0.02	0.03	0.01	**0.14**	0.04	1.00				
17	Comm. Experience	**0.33**	**-0.17**	**0.24**	0.03	**0.14**	0.06	1.00			
18	On-Campus Incubator	**0.17**	**-0.18**	0.06	0.04	*0.08*	0.05	**0.16**	1.00		
19	Off-Campus Incubator	**0.16**	0.00	0.05	**0.09**	**0.11**	-0.04	0.01	**0.10**	1.00	
20	Science Park	-0.06	-0.07	*-0.08*	-0.01	**0.10**	**-0.12**	-0.02	-0.02	*0.09*	1.00
21	Structural Holes	**-0.12**	**-0.25**	-0.02	**-0.42**	**-0.19**	-0.04	-0.05	-0.02	**-0.14**	-0.03

Note: Correlations of Management Team are available for 869 observations only. Correlations in italics significant at 5% level (2-tailed); correlations in bold significant at 1% level (2-tailed). Correlations between continuous variables are Pearson's, correlations between continuous and categorical dummy variables are point-biserial, correlations between categorical dummies are phi coefficients.

The dependent variable is of binomial distribution, taking a value of 0 for spinout companies that were dissolved, and a value of 1 for firms that were still live on 01/05/2014, with a mean clearly falling between these two values (Hosmer et al. 2013), suggesting a logistic regression model. The use of other binomial family models (probit, log-log, or complementary log-log), is typically applicable in special cases, especially when estimating the probability is of the main concern, or poor fit of logistic regression is achieved (Hosmer et al. 2013); therefore, as none of the situations is particularly apparent in the case of subsequent analysis, logit is employed.

The model fitted to explain university spinout company survival takes the following logit form:

$$\mathrm{g}(x_i) = \ln\left(\frac{\pi(x_i)}{1-\pi(x_i)}\right) = \alpha + \beta x_i + \varepsilon_i$$

where:

x_i – vector of covariates defining firm i

α – model constant

β – coefficients of parameters

ε_i – error term capturing variance unaccounted for by the model.

The regressed models explaining university spinout company survival are presented in Table 6.8, whilst complementary VIF values are available in Table 6.9 for the respective models. The two models presented are an improvement over an intercept-only model (as given by Omnibus test) significant at 1% level, with model 2 being a better fit than control model 1 as observed from AIC (and BIC) or pseudo R^2 measures. According to Nagelkerke, R^2 model 1 explains 33% of variance, whilst model 2 explains 42%. Classification plots indicate that both models estimate predicted probabilities correctly for more than 85% of fitted values, in particular, the sensitivity tests present that in excess of 96% of surviving spinout companies were correctly predicted by the models. Furthermore, in all three models the null hypothesis cannot be rejected under Hosmer and Lemeshow tests, suggesting no significant difference between fitted and predicted values.

Table 6.8 Logistic regressions of spinout survival between 2002 and 2013

	Model 1	S. E.	Model 2	S. E.
Small Firm	-1.531	1.139	-2.166	1.404
Manufacturing Sector	1.094***	0.370	1.043**	0.408
Information & Communication Sector	0.816**	0.359	0.853**	0.395
Professional, Scientific & Technical Sector	0.987***	0.302	0.796**	0.330
Human Health & Social Work Sector	0.867	0.600	1.355**	0.686
Successful Exit	3.272***	1.119	3.421***	1.098
Number of Directors	-0.462***	0.048	-0.645***	0.063
University Size	2.353***	0.610	1.389**	0.681
Science Orientation	0.159	0.726	-0.496	0.776
Patents	-0.120	0.352	-0.021	0.380
Δ Regional GVA per capita	3.238***	0.909	2.046**	0.970
Regional GVA per capita at birth	0.043*	0.024	0.052**	0.026
Investment			0.288***	0.082
Joint Spinout			0.127	0.373
Management Team			0.152***	0.048
Commercialisation Experience			0.027**	0.013
On-Campus Incubator			0.032	0.316
Off-Campus Incubator			-0.010	0.299
Science Park			0.143	0.264
Structural Holes			-2.102***	0.545
Intercept	2.095	1.344	3.490*	1.809
DF	13		21	
N	870		869	
Nagelkerke R^2	0.330		0.424	
McFadden R^2	0.241		0.321	
Percentage Correct	85.52%		87.57%	
Sensitivity	97.36%		96.94%	
Specificity	28.19%		42.28%	
-2LL	604.609		541.107	
AIC	629.223		583.107	
BIC	691.213		683.221	
Hosmer & Lemeshow Test	4.369		9.111	
Hosmer & Lemeshow Test's p	0.822		0.333	

Note: *** denotes significance at 1% level; ** 5% level; * 10% level.

Table 6.9 Variance Inflation Factors

	Model 1	Model 2
Small Firm	1.1	1.1
Manufacturing Sector	2.1	2.2
Information & Communication Sector	2.1	2.2
Professional, Scientific & Technical Sector	2.7	2.9
Human Health & Social Work Sector	1.3	1.3
Successful Exit	1.0	1.0
Number of Directors	1.1	1.3
University Size	2.4	3.4
Science Orientation	1.3	1.4
Patents	2.8	3.1
Δ Regional GVA per capita	1.1	1.3
Regional GVA per capita at birth	1.3	1.4
Investment		1.5
Joint Spinout		1.3
Management Team		1.1
Commercialisation Experience		1.3
On-Campus Incubator		1.1
Off-Campus Incubator		1.1
Science Park		1.2
Structural Holes		1.4

The regression fitted in model 1 describes the environment of university networks that is composed of control variables for a spinout, its university and geography. Only four parameters have insignificant coefficients: *Small Firm*, *Human Health & Social Work Sector*, *Science Orientation*, and *Patents*, with the last two specifically indicating a lack of science bias in spinout survival, with no importance of monopolised knowledge. Only one significant variable is negatively associated with spinout company survival, which is *Number of Directors*, strengthening the bivariate analysis results on diseconomies of management. The remaining variables confirm that university spinouts are typically based in high technology sectors, in well developed and developing regions, and their survival is related to their successful sale or IPO

generating increased capital for growth, and in the absence of other predictors detailing university networks, university endowment is positively related to spinout success.

Model 2 introduces independent variables that define university networks. Although most of the control variables remain significant, there are three major changes. *Human Health & Social Work Sector* becomes significant; *Manufacturing Sector*, *Professional, Scientific & Technical Sector*, *University Size*, and *Δ regional GVA per capita* change significance levels from 1% to 5%; whilst *Regional GVA per capita at birth* increases its significance in presence of other predictors to conventional levels. Among the independent covariates, only four are significant in explaining spinout company survival: *Investment*, *Management Team*, *Commercialisation Experience* and *Structural Holes*. Receiving equity type investment from a greater number of investors and having a more experienced management team are associated with survival; experienced TTO professionals are critical for a growing venture; and a spinout's position in the university networks plays an important role in explaining its chances of success. Spinout companies that have lower aggregate constraint are associated with higher probability of survival. The remaining university network elements expressed with *Joint Spinout* and three incubation types (on-campus, off-campus, and science park) are unrelated to spinout survival.

The number of investors being positively related to spinout company survival confirms a wide array of literature praising the role of VC (e.g. Bonardo et al. 2011; Fini et al. 2011; Politis et al. 2012; Gonzalez-Pernia et al. 2013; Hayter 2013; Fini et al. 2017), but also seed capital and public funds (Huggins 2008b), and business angels (Mosey and Wright 2007; Huggins 2008b). Holding other things equal, an additional investor improves spinout's survival by 33%. Clearly, the survival of university spinout companies is related to external capital to maintain and accelerate their development. Given the importance of firm size (as discussed above), such non-organic forms of growth promote quicker transition from a small company to a more established one, improving spinout's credibility. However, spinouts also face challenges in attracting external capital, not least due to an inability to present an investment opportunity (Vohora et al.

2004). Furthermore, the findings could indicate the viability of universities holding their own VC funds (beyond current seed capital or challenge funds) to reduce risks to potential external entrepreneurs through matched/joint funding.

Other actors forming the university networks tested here are additional parent institutions. Whilst such forms of collaboration were found to be significantly related to spinout company formation, the effect does not stretch to company survival. Joint spinout formation has only been studied in relation to company formation (Lockett et al. 2003), where it is a characteristic of universities that are better at forming spinout companies, due to their openness and network orientation. This access to a greater pool of resources and support indicates that universities play a limited role in spinouts' post-start-up activities.

Although the engagement of the management team in a university spinout company has been widely discussed (Franklin et al. 2001; Lockett et al. 2003; Vohora et al. 2004; Walter et al. 2006; Djokovic and Souitaris 2008; Hayter 2013), little empirical effort has been put into confirming the relevance of management teams to spinout company survival. Only a select number of scholars linked the role of management team to spinout company performance (Vohora et al. 2004; Walter et al. 2006; Djokovic and Souitaris 2008; Visintin and Pittino 2014), evidence of which is present in the analysis, where one additional year in the average experience of a management team improves the probability of spinout's success by approximately 16%. The important role of such entrepreneurs clearly stems from experience, commercial (Wennberg et al. 2011) and management skills (Grandi and Grimaldi 2003) and developed networks (Franklin et al. 2001). More generally, entrepreneurs' experience is a vital asset to a firm's survival, whether accumulated in previous employment (Bruderl et al. 1992; Cressy 1996; Gimeno et al. 1997; Taylor 1999; Van Praag 2003) or self-employment (albeit only in the UK – Taylor 1999). Finally, management teams could also act as facilitators of investment-driven growth as suggested by Vohora et al. (2004), as their introduction at spinout companies could relieve the academic founders' time from searching for capital to technology development.

The significance of the experience of the TTOs contributes a fresh insight into the role of such teams, lack of which is especially pronounced among spinout creation studies (Di Gregorio and Shane 2003; Vohora et al. 2004; Lockett and Wright 2005; Fini et al. 2009; Aldridge and Audretsch 2011; Clarysse et al. 2011a; Bourelos et al. 2012), also confirmed in the previous section, except Fini et al. (2017). Some scholars argue that TTOs could improve if better resourced and able to employ experienced professionals (O'Shea et al. 2005; Powers and McDougall 2005; Wright et al. 2006; Macho-Stadler et al. 2007; Mosey and Wright 2007; Farnstrand Damsgaard and Thursby 2013; Gonzales-Pernia et al. 2013), whilst Degroof and Roberts (2004) suggest that TTOs could collaborate with other TTOs for resource access, or as pointed out by Leitch and Harrison (2005), concentrate efforts on research of commercial potential only. However, those studies have not inspected the role of TTO beyond the scope of identifying disclosures and founding spinout companies. Experienced TTOs could develop networks that can be utilised for spinouts' advantage.

Business incubators have a very prominent place in the literature on academic spinout companies (e.g. Bekkers et al. 2006; Djokovic and Souitaris 2008; Gilsing et al. 2010; Grimaldi et al. 2011; Bourelos et al. 2012; Lundqvist 2014), yet no evidence has been found of any positive or significant relationship to their survival, much against their purpose of shielding firms from failure (Carayannis and von Zedtwitz 2005; Grimaldi and Grandi 2005). Yet the result may transpire as rather unsurprising, given prior studies which found business incubators to be of limited importance to academic entrepreneurs (Doutriaux 1987), outlining difficulties in graduating from business incubators (Rothaermel and Thursby 2005), or indicating negligible utility of science parks to spinout companies (Siegel et al. 2003b). Although the panacea for incubator problems has been suggested to be in the number of different types of incubators (Siegel et al. 2007) to suit the heterogeneity of university spinouts, the analysis refutes its effectiveness.

The significance of spinouts' structural holes lends evidence to the well advanced debate in the literature on the importance of networks (e.g. Mosey and Wright 2007; Aldridge and Audretsch 2011; Grimaldi et al. 2011; Bourelos et al. 2012; Fogelberg and Lundqvist 2013; Rasmussen et al. 2015; Scholten et al. 2015), contributing a specific context of spinout company survival and an actual network measure. The network position a spinout company finds itself in, defining and redefining it through contact with other actors and over time (Rasmussen et al. 2015), is crucial to its activities as a network actor (Granovetter 1985; Burt 1992; Lin 1999, 2001; Granovetter 2005). As structural holes posit that there are opportunities in the immediate relationships in the network of an actor (Burt 1992), it is important for spinout companies to learn to recognise their network positions, and transform this knowledge into a practical approach, where spinouts can be more calculative and strategic (Huggins 2010a, b) in using their contacts to pursue competitive advantage. This clearly produces observable results in terms of reduced probability of failure for spinout companies.

With time and capital, firms expand, which is associated with a lower risk of failure (e.g. Bridges and Guariglia 2008; Jensen et al. 2008; Musso and Schiavo 2008; Baggs et al. 2009; Holmes et al. 2010) as confirmed in the results reported here. Even though most of the spinout companies in the sample are small, medium or large spinouts are 25.4 times more likely to survive than small spinouts, clearly indicating the importance of firm size. Whilst spinout companies are not the typical ‘gazelles’, there is a clear benefit of achieving a larger size in reducing success risk. As a result, spinout companies might be more inclined towards non-organic forms of growth, as independent variables discussed above indicate.

Spinout company sectoral classification offers a rather unsurprising finding: as long as spinout companies are not operating in administrative and social services, and other sectors their industrial sector classification has no negative association with their existence. In other words, IP-based firms have good success chances in nearly all typical high technology sectors. This confirms the wide literature on innovation and firm survival (Cefis and Marsili 2006; Mudambi

and Zahra 2007; Jensen et al. 2008), where what a firm does and how it does it is more important than the exact market it operates in.

Investment exit clearly improves the chances of success for spinout companies (over 30 times) compared to those that have not been acquired or listed on a public exchange yet. This confirms the importance of exits to spinout's success (Nerkar and Shane 2003; Shane 2004b; Lawton Smith and Ho 2006; Lawton Smith et al. 2008; Bonardo et al. 2011). The clear advantage of such an event is in greater availability of capital (IPO especially) and other strategic resources, such as developed supply chains, managerial talent and distribution systems (acquisition) for the spinout company to support its growth.

Although the number of company founders at start-up stage is positively related to firm survival (Cressy 1996), only evidence for an inverse relationship is found in case of spinout companies. This could suggest diseconomies of management (Kaldor 1934; Robinson 1934) represented in inflated boards of directors, similarly observed in Visintin and Pittino (2014) in relation to spinout performance. The result poses a clear challenge to the aspect of executive team building (Vohora et al. 2004), where careful selection is necessary.

Regional output per capita performance over the measured lifetime of each spinout company is related to spinout's survival. However, it remains debatable whether the result can be explained by the fact that regions with lower output value would typically report higher growth or whether these spinouts are based in genuinely higher growing regions. Once *Regional GVA per capita at birth* results are considered, it becomes clear that spinout companies also benefit from being located in better developed regions, lending further evidence to results reported by Iacobucci and Micozzi (2015). The findings indicate that high technology entrepreneurship, and especially development of successful regional innovation systems with greater levels of such entrepreneurial activity, is positively related to regional economic performance as often

conceptualised in the literature (Cooke 1992; Storper 1993; Florida 1995; Storper 1995a, b; Asheim 1996).

6.3 Conclusion

This chapter presents a two-fold approach in studying university spinout company success, namely by exploring the generation of spinout companies and their survival. Spinout company formation is analysed with negative binomial regressions, whilst spinout survival utilises a logistic regression model. There are a number of unique findings reported here. Across the university network and broader network environment there are clear variations observed in the elements that play key roles in spinout company success. The results reported here advance bivariate findings from Chapter 5 to reflect the complexity of university network setups, where particular configurations generate formation- or survival-oriented outcomes.

University networks that aim to generate more spinout companies are reliant on their university's knowledge productivity (Di Gregorio and Shane 2003), especially that of commercial potential. However, this knowledge pre-requisite is insignificant to a spinout's survival. This means that spinout company formation requires the most basic ingredient - i.e. knowledge, without which the firm cannot be founded. Once established, university support becomes more important. In particular, university size is observed to be critical to spinout's survival outcome, but not to its formation. This indicates that universities generating higher incomes have a potential to offer more support to spinout companies, whether through networks or finance-based resources. Importantly, the bias towards traditional science fields is found to play no significant role in either formation or survival of UK spinouts, providing evidence that other factors being more important thwart the previously assumed (Shane 2004b) advantage of such spinouts.

Networks are critical to both the formation and survival of spinout companies. In particular, universities with greater links with industry generate more spinout companies, emphasising the

need for well-operating connections. Similarly, spinout companies that have more structural holes in their network positions' vicinity enjoy a greater probability of survival. Clearly, networks are positively related with both formation and survival outcomes.

University networks that aim to focus on the formation of spinout companies require access to business incubation in the form of science parks. Whilst prior UK research discounted the role of science parks (Lockett and Wright 2005), this thesis offers more robust evidence based on the largest sample studied thus far, of 870 spinout firms. Given Tamasy's (2007) research, the finding could imply that spinout companies benefit from positive externalities of science park operations. These could be related to co-location of non-spinout firms, closer association with university (e.g. reputation effects), or other effects.

Conversely, university networks that achieve greater spinout company survival outcomes rely on the roles of the TTO and the characteristics of the spinout company. Whilst TTOs play no role in spinout formation, confirming the discussions advanced in the literature (Clarysse et al. 2011a), these actors are important to spinout survival, offering a novel finding. Crucially, the role played by TTOs requires redefinition to avoid premature dismissal of a university network actor that enhances such vital outcome. These results suggest that more experienced UK TTOs underwent evolutionary adaptive processes (Nelson and Winter 1982), recognising the needs of spinout companies and responding with their redesigned functionality.

The characteristics of the spinout company are clearly important to its survival. Whilst the size of the spinout is neutral to its survival outcomes, sector of activity, successful exit, and the number of directors are not. In particular, spinout companies from high technology sectors enjoy improved survival, as previously established (e.g. Jensen et al. 2008). Furthermore, spinouts that are acquired or undergo IPO achieve improved access to capital - with financial health being a vital survival predictor (e.g. Musso and Schiavo 2008; Helmers and Rogers 2010;

Wennberg et al. 2016). Finally, it is important that spinout companies have dedicated boards of directors, as there are clear diminishing returns to management (Kaldor 1934; Robinson 1934).

Investment plays a major role in both spinout companies' formation and survival. Whilst there is no significant effect observed for university networks with access to seed funding, VC is critical to generating spinouts. Furthermore, investors are further found significantly related to spinout companies' survival, confirming the key role played by this university network actor. Crucially, the findings presented here offer confirmation of the existence of an early stage funding gap for such high technology companies (Huggins 2008b). At the same time, these results provide strong evidence that finance is important to the success of a spinout company (e.g. Fini et al. 2011; Politis et al. 2012; Hayter 2013) throughout its development.

The findings reported in this chapter emphasise the role of management teams consisting of experienced entrepreneurs to spinout company formation and survival. This confirms prior research suggesting the important skills contributed by such individuals to a spinout company's development (e.g. Franklin et al. 2001; Grandi and Grimaldi 2003). Clearly, spinout companies are primarily endowed with academic founders that provide the strong knowledge background with which the company could seek commercial opportunities. The management team contributes the connection to transform and externalise this knowledge in university networks.

The engagement of other actors, in particular universities, is only important to spinout company formation (Franklin et al. 2001; Lockett et al. 2003). In essence, this could improve a spinout company's early stage network position, but the benefits of such connectedness diminish with a spinout company's development. This means that spinout companies with multiple university parents have no more advantage to achieve survival than ventures with single university parents. This signifies two effects: a) the most intensive development period is at the formation stage of the company; and b) the spinout's network orientation evolves from academically-based to commercially-oriented (Pérez Pérez and Mártinez Sanchez 2003).

Finally, the broader network environment offers further insight into the functionality of university networks. First, the regional economic environment plays a critical role in spinout company formation and survival. Regions characterised by greater growth in economic output are associated with generating more spinout companies and their enhanced survival prospects. However, a static measure of the value of economic output provides a different picture. The survival of spinout companies is positively associated with their location in regions with higher output per capita, but the formation of spinout companies is related to being in areas with lower output per capita. This paradoxical finding reveals how some regions evolve to be dependent on universities as major economic actors (Brown 2016).

It is important to note that a number of findings reported here depart from those observed in Chapter 5. These are identified as follows: a) formation-based variables: university size, science orientation, science park, change in university industry research income, change in regional GVA per capita, 2002 regional GVA per capita; and b) survival-based variables: patents, science orientation, on-campus business incubator, change in regional GVA per capita, investment. The reason for these differences could be explained by the complex relation of these variables with the dependent variable, where the presence of other factors clearly affects their importance.

The following chapter presents four examples of university network contexts, displaying how university spinout success is achieved in UK institutions' different environments. In particular, it examines the regional settings of these networks to identify place-based conditions of spinout success.

Chapter 7

Survival of academic spinouts: examining success factors of four unique university networks

In the previous two chapters the success of academic spinout companies was explored using a quantitative approach. The results that highlight the role of networks and finance, in particular, provide a novel understanding of spinout success. Nevertheless, the detailed dynamics behind the results require in-depth investigation to validate results exploring detailed university network (depicted in Chapter 3) and offer an insight into these processes. Therefore, this chapter aims to offer an explanation for the dynamics of university networks that lead to the success of academic spinouts, providing a broader network environment perspective to understand how university networks differ across regions.

First, it illustrates four distinct examples of university networks, each achieving a different level of performance across two dimensions: spinout company formation and survival. The Scottish University Network is characterised by low spinout company formation and low survival. The Midlands University Network generates high numbers of spinout companies, but these firms achieve low survival. The London University Network creates low numbers of spinout companies, but these firms' survival is high. Finally, the Welsh University Network forms high number of spinout companies and its spinouts are characterised by high survival rates.

Second, the chapter then continues to explore the success characteristics identified from the four university networks, identifying three dimensions of spinout company success: filtration, connectedness, and time. Filtration is observed here as a dimension representing a level of selectivity over time, with the most successful university networks being progressively less selective across subsequent stages of a spinout company's path towards survival, as information asymmetry problems are partially resolved. In other words, the original spinout company opportunities have to pass through new, finer filters as they grow towards successful outcomes.

On the other hand, connectedness expresses the level of network capital development, which is required in decreasing intensity over time. This means that spinout companies rely the most on strong university networks at their earliest phases of growth in order to access resources they cannot afford. Once spinout companies develop and accumulate resources, the reliance on network capital decreases in intensity. The most successful university networks are found to be those that have the ability to align all three dimensions: filtration, connectedness, and time.

It is found that the Scottish University Network is characterised by remote location and poor access to networks with management teams, investors and other actors. This is coupled with the fact that the network's selectivity of spinout company opportunities is very porous and produces low outcomes in terms of spinout formation and success. Conversely, the Midlands University Network is strongly connected with local and regional networks, benefitting from an urban location. However, its approach is rigid and results in poor selectivity of commercial opportunities, consequently over-generating spinout companies with humble success outcomes. Finally, the London and Welsh University Networks are well-connected and located in urban settings, collaborating with specialist VCs that strengthen their filtration of spinout company opportunities, resulting in highly successful outcomes. These networks differ, however, on spinout company formation, with the London University Network creating fewer spinouts than the Welsh.

The chapter begins with an introduction to the university networks studied here, in Section 7.1. It outlines their location characteristics and distinguishing features of elements within each university network: TTOs, academic founders, management teams, investors, business incubators, and networks. This background information utilises interview material and secondary data collected for statistical analysis. Section 7.2 reports findings from qualitative data analysis structured into a sub-section on each unique university network. Its composition follows the conceptualised university network and broader network environment elements, by depicting their original role in particular university networks. The aim of this section is to

present in-depth results of interviews with university network actors by exploring their functioning. This insight allows understanding of how unique network architectures achieve outcomes in generating spinout companies and ensuring their survival. Success characteristics are discussed in Section 7.3, derived from themes identified in the findings section. It offers a discussion of each university network element in relation to these themes. Finally, Section 7.4 ends with recognition of three dimensions that explain spinout company formation and success. This framing of university network success factors contributes to understanding of how such networks approach knowledge commercialisation through the vehicle of a spinout company. The chapter concludes in Section 7.5, recalling core findings reported here.

7.1 Outline of university networks

The background information on the university networks considered here is presented in Table 7.1. It is a reflection of the conceptual framework and stylised model built from the literature review which identified broader network environment i.e. geography, and the following elements of university networks: university (represented by TTO), academic founder, management team, investor, business incubator, networks. The table also provides names for all interviewees and organisations.[6]

[6] For anonymity, the names of all actors were changed to reflect the geography of the networks.

Table 7.1 Background of four university networks (and interviewees)

	Scottish University Network	Midlands University Network	London University Network	Welsh University Network
Geography	• based in Scotland • remote small urban location	• based in West Midlands • urban location	• based in London • large urban location	• based in Wales • urban location
University (TTO)	• university department • 2 FTEs • 10 disclosures/FTE per year // 1 spinout per year • **Scottish University TTO** (SU TTO) • **Sean** (SU TTO representative)	• wholly owned subsidiary, previously university department • 7 FTEs • 1 disc/FTE per year // 2.5 spinouts per year • **Midlands University TTO** (MU TTO) • **Milton** (MU TTO representative)	• wholly owned subsidiary • 10 FTEs, and growing (3 more planned) • 4.5 disclosures/FTE per year // 1 spinout per year • **London University TTO** (LU TTO) • **Loxley** (LU TTO representative)	• university department • 7 FTEs • 11 disclosures/FTE per year // 1.6 spinout per year • **Welsh University TTO** (WU TTO) • **Wynn** (WU TTO representative)
Academic Founder	• key role in early stages	• key role in early stages • **Prof Miller** (Midlands Engineering academic founder)	• key role in early stages, but also continual role in spinout to ensure success • **Prof Louie** (London Technologies academic founder)	• key role in early stages, after that typically some limited engagement • **Prof Wmffre** (Welsh Therapeutics academic founder) • **Prof Wren** (Welsh Nano academic founder)
Management Team	• recruited from region or beyond • **Sholto** (Scottish Systems management team representative)	• recruited from locality or region	• recruited from locality or region	• recruited from region or beyond (mostly) • **Wil** (Welsh Sciences management team representative) • **Waljan** (Welsh Therapeutics management team representative),
Investor	• no formal or informal relations	• informal relations with VC and BA community	• formal relations with a specialist VC • informal relations with VC community	• formal relations with a specialist VC and VC in locality
	• **London Investments** (investor specialised in spinout companies), **Irving** (London Investments' representative) • **Yorkshire Fund** (proof of concept investor), **Ingram** (Yorkshire Fund's representative)			

Table 7.1 *Continued*

Business Incubator	• no business incubator at university or in locality • plans to build an incubator	• wholly owned subsidiary • manages a number of sites in locality • at university campus • **Midlands Business Incubator** (MBI) • **Millard** (MBI representative)	• wholly owned subsidiary of TTO • late stage incubator • in vicinity of university campus • **London Business Incubator** (LBI) • **Lowell** (LBI representative)	• no own business incubator at university, but university is a joint partner to a local incubator • in vicinity of university campus
Networks	• regional (mostly) and national, but not local	• local and regional (mostly), national	• local and regional (mostly), national	• regional and national (mostly), local
Other Actors/ Interviewees	**Scottish University** (SU), **Scottish Systems** (spinout company)	**Midlands University** (MU), **Midlands Engineering** (spinout company)	**London University** (LU), **London Technologies** (spinout company)	**Welsh University** (WU), **Welsh Sciences** (spinout company), **Welsh Therapeutics** (spinout company), **Welsh Nano** (spinout company)

Scottish University Network

The university network represented here is based in Scotland, with SU based in a remote small urban location. The university is research intensive, but it generates low numbers of spinout companies (below the top quartile of 24 in the sample frame) and their survival rate is one of the lowest in the study (below 60% over 1959-2013). The network suffers from poor centrality degree, especially given a lack of investors and business incubators. Its access to a management team is indirect, recruited mostly from the region or other parts of the UK. It has a TTO, which is its internal department and employs two professionals. Scottish University Network is mostly regional in nature.

Midlands University Network

Midlands University Network is based in the West Midlands, with its university (MU) in a major urban area. It is a research intensive institution characterised by high-level spinout

company generation (above the top quartile of 24 over 1959-2013), but poor survival (less than 70% over 1959-2013). It is composed of all elements of the conceptualised university network, with its own on-campus business incubator (MBI), TTO which is its wholly-owned subsidiary staffed with seven employees, informal relations with investors, and a pool of management team talent within the locality and region. Midlands University Network has a primarily local and regional character.

London University Network

The university network presented here illustrates an institutional example of LU. It is a research intensive institution with its own business incubator (LBI) based in London. London University Network operates within mechanisms focused on the long-term success of its spinout companies. LU has generated low spinout company numbers (below the top quartile of 24 in 1959-2013) whilst achieving high survival rates (over 90% between 1959 and 2013). London University Network resembles a full conceptualised university network model, with its own off-campus business incubator, TTO - a wholly-owned university's subsidiary employing ten professionals, good access to local and regional management team talent, and strong links with investors. London University Network has a local and regional focus.

Welsh University Network

The network depicted here is based around WU, a research intensive university based in Wales. The university generated high levels of spinout companies (above the top quartile of 24 over the period of 1959-2013) and its spinouts achieved some of the highest survival rates (of approximately 90% over the period of 1959-2013) in the study. Whilst it has no wholly-owned business incubator, it is a joint venture owner (with local public bodies) of an off-campus incubator. As a result Welsh University Network has all conceptualised university network elements, but its access to some is mediated by other network elements. For example, whilst it has direct investor links, it typically sources its management teams through the investors, from

the region or other parts of the UK. Its TTO is the university's internal department, with seven employees. Welsh University Network has a particularly strong regional and national character.

The following section outlines four distinct university networks across the elements described here. It offers findings from interviews, with multiple network actors identifying idiosyncrasies of each network architecture.

7.2 University networks - outline of four unique approaches to spinout company success

This study seeks to better understand the success of academic spinouts by examining university networks. Whilst much of the empirical evidence has been outlined in the previous two chapters, the underlying processes and dynamics of achieving spinout company success are captured in the qualitative data. The four examples of university networks presented below depict success as spinout formation and survival.

7.2.1 Scottish University Network

Geography

The university's location is a challenging factor in forming and supporting spinout companies. Being unable to enjoy the benefits of agglomeration economies, due to the small local population limiting networks and opportunities, the SU TTO needs to rely on regional support programmes mainly run by Scottish Enterprise (regional development agency) and other support programmes to form and build its spinout companies, as indicated by its representative Sean. This affects three key aspects of spinouts: a) access to management talent (or management teams); b) access to investors; and c) access to business incubation.

The managerial talent for high technology companies is not easily available in the locality nor the region, as stressed by Sean. He explained that the geographical constraints imposed by their remote location mean that SU TTO has to recruit management talent from other regions, especially the Greater South East, which Sean notes has a higher concentration of entrepreneurial activity. However, Sholto, CEO of Scottish Systems (SU's spinout company),

revealed a more complex dynamic in place, where the negative implication of large distances from entrepreneurial clusters is somewhat mitigated by the fact that these experienced entrepreneurs, once recruited, typically stay with spinout companies. Sholto explained that this complex situation is also partly resolved by the possibility of running a company from a virtual office. Whilst it is a spatial problem, the Scottish University Network is clearly not at a complete disadvantage, especially in terms of retention of talent; also, thanks to technological progress, such companies can run in a less structured or geographically-centralised way:

> *It's much easier to run virtual organisations now than it used to be, so I'm quite used to having a start-up located in one area for a central office, but most of the team are spread out through the country. [Sholto]*

Although seed funding is important for spinout companies to progress in their development (Clarysse et al. 2011b), access to such early stage finance remains problematic in Scotland, as reported by Sholto. Whilst the public support programmes are typically intended to resolve market failure, their regional design appears to exacerbate constraints on spinouts' development in this particular case. The CEO of Scottish Systems explains that to benefit from regional support programmes, spinout companies are required to already have received seed investment. There is an evident disconnection between regional policy-making and reality, contributing to the understanding of low survival rate of spinouts in Scottish University Network:

> *The problem is a lot of these companies need to be up and running and have matched funding to access a lot of regional support, so we're at the stage, because we're not yet funded, there's a lot of grants we can't access yet. ... That's actually a general problem in Scotland, and I think it's probably across the whole UK: there's very little grant support available without matched funding for getting companies investor-ready. ... To get them investor-ready they need a lot more support, but nobody is able to pay for that support, so it's a bit of a catch-22 in there. [Sholto]*

According to Sholto, the location of the university limits its ability to access business incubation. Whilst the university itself has no business incubator facility nor there is one in the locality (given their non-urban location), the university can only access business incubators from other places in Scotland, which essentially requires the spinout company to relocate away from its parent university. The CEO of Scottish Systems stresses that there are not many business incubators within the region. These aspects clearly emphasise geographically-induced limitations on SU and its spinout companies in forming them and their survival:

> *First of all, there aren't too many of them around in the geographic location, so [Scottish Systems] hasn't used one because [SU] doesn't have one. ... Glasgow has a small one, but it's pretty full; Strathclyde's got a medium[-sized] one ... I think Edinburgh's probably got one of the better incubator space-type programmes. [Sholto]*

University (TTO)

The backgrounds of the SU TTO are complementary in skills and areas of expertise, with one individual being a life scientist and academic, whilst the other is physical scientist and has commercial experience. The team's role is mostly focused on the early stages of a spinout company, typically until the company is formed, as described by Sean, SU TTO's representative. Furthermore, Sean stresses that it is open to bringing in an external company to help in the commercialisation process or to license the technology. However, he clearly demarcates the boundaries of SU TTO's engagement, where post-formation of a spinout the management of the company becomes the responsibility of the management team, with Sean's office having a more passive-supportive role. This approach to spinout companies concurs with Scottish Systems' CEO's expectations, as Sholto emphasises that university TTOs in general have little experience of running later-stage companies:

> *The whole idea of the commercialisation process is that the company becomes active and becomes run by commercially knowledgeable people (that's the management of the company and their board), so as a university we are hanging onto their coat-tails. It is not our role as a university to run the companies. [Sean]*

Academic Founder

The role of academic founder in the spinout companies at SU is well articulated, starting with the awareness of the process and expectations of future engagement in the company, as outlined by Sean. This adaptive and sympathetic arrangement is further stressed by the SU TTO representative, who describes the function of academic founders more broadly, that *their role in the spinout process is to be comfortable and happy with the process that they're going through*. This accommodating treatment is very important, as there are at least two critical aspects of academic's involvement that could be affected: a) departmental role at the university, b) transfer of tacit knowledge from the academic to the spinout company. Sean adds, however, that academic founders need *to learn and be educated and not to block the right commercial decisions happening*.

Sean clearly explains that the role of the academic founder in the spinout company reduces over time, especially with the equity becoming diluted during subsequent investment rounds. The consequence of this is that academic founders typically resume their university roles. Whilst literature on academic founders portrays them as entrepreneurial (Chrisman et al. 1995; Fini et al. 2010), in Scottish University Network they seem to select a risk-averse source of income; however, it does not preclude other researchers from leaving academia:

> *I have no instances of this university where they [academic founders] have left the university to be 100% employed by the company, but that doesn't necessarily mean that the postdoctoral researchers or the people in the lab don't jump into the company and become 100% employed by that. [Sean]*

Management Team

SU TTO is only able to install a management team if appropriate funding from a regional support programme run by Scottish Enterprise can be obtained, pointing to the clear resource limitation of the TTO to offer more comprehensive support to its spinout companies. Once such funding is secured, Sean's office attempts to recruit a management team - *a sympathetic*

commercial champion, prior to company registration in order to bring the unincorporated spinout to a point of investor-readiness. This, according to Sean, aims to develop the underlying technology to satisfy investors' commercial expectations:

> *They're [spinouts] never mature enough before coming out of the university to get properly invested, and therefore you end up with inadequate investing at the early stage, which leads to poorer success in the longer term. [Sean]*

It is observable that there are two crucial factors in forming the spinout company that influence its success outcome: a) the stage of technology development at spinout formation, and b) attracting initial investment. The CEO of Scottish Systems outlines his development plans for the spinout as a two-stage fund-raising process, with the first priority being the seed investment to build up the spinout company for VC-type investment:

> *My aim is to get it seed funded, enough seed funding in to get its first milestones and value proposition up large enough to do an A-round of funding in about two years' time. [Sholto]*

However, this sense of structured planning is riddled with challenges beyond the control of the management team, as illustrated by Sholto: he described a situation in which Scottish Systems' investors withdrew from funding the company, which nearly led to the firm's liquidation. The situation was remediated by Sholto's business management experience, exposing the role and importance of experienced entrepreneurs to spinout companies:

> *We had funding at the table and then we didn't close it because the investors fell out with each other. We have managed to bootstrap things keeping going on the commercial development side of things and the technical side of things, so we've kept the company alive by keeping working away at it to get it to the point where it's more investor-ready for a different type of investor. [Sholto]*

Investor

Although the investment for a spinout company in Scottish University Network is the responsibility of the management team, over the past few years the initial funding to attract a management team has come from SU TTO's applications for financial support from the Scottish Enterprise, under the High Growth Spinout Programme. The programme allows a Scottish spinout to fund personnel, consumables, market research, patents, equipment, and other expenses (Scottish Enterprise, 2016). While not all applications are successful, once the *commercial champion* [Sean] is recruited thanks to the regional support, the roles are very distinct:

> *Their job is to go out and raise the funding. Our job is to support that. So, we'll work the back room, they're the front: they do the presenting, they find the investors, they go to the meetings, because what we're trying to do is portray a company setup before there is actually a company to raise the investment. [Sean]*

For Irving, the London Investments representative, the management team is the most important ingredient in building spinout companies, as experienced entrepreneurs are the drivers of a venture's development. He notes that it is critical for the management team to take over responsibility for the spinout company, to ensure it is on the right path for growth:

> *You need to have evangelisers to keep completely concentrated, believe it, live and breathe it, wake up in the morning thinking 'company', go to bed thinking 'company', so that is the single most important role … of the founding management team. [Irving]*

Apart from commercial credibility, the management team's task is further evaluated by the SU TTO with respect to success in fund-raising by assigning a level of start-up equity in the spinout company. Although this performance pay might motivate the management team, the final outcome is very difficult to achieve given the above-described failed co-investment. Therefore, the management team requires a clear strategy to attract such 'difficult' investment. Sholto's approach is to first have a business plan and then to focus on the most relevant investors. He

stresses the importance of identifying the sector focus of venture capitalists, to only approach those with enough interest:

> *I tend to take the approach of ... developing the business plan and then specifically targeting the right type of VC for that type of company to invest. [Sholto]*

Business Incubator

At SU, spinout incubation typically takes place in the departments of academic founders: *We have several companies beavering away in biology and chemistry and physics [departments]* [Sean]. Other than departmental requirements, it is only if a need arises for the spinout to move to its own premises that the company leaves the departmental space and relocates to other areas in Scotland. According to Sean, such a need is typically dictated by the spinout company's investor, which is never local:

> *It's not a question of that they've been incubated in the university and they've either got too big or we've kind of bored of them; it's a question of their investors are not from [here], their investors might be from Edinburgh or from Glasgow or somewhere else and they ... are quite insistent that ... the best place is going to be somewhere else, not in [here]. [Sean]*

It is important to note that SU is moving towards building a business incubator: it has purchased land outside the university town. The main reason, according to Sean, is to better manage the use of departmental space, as pressure for space increases alongside the number of spinout companies.

Networks

Given the limited resources of SU TTO, the development of networks remains another major task for the management team. Furthermore, SU TTO relies on the networks spinout companies can access through Scottish Enterprise, whilst itself not organising any events that could help

the companies build them. This is largely confirmed by CEO of Scottish Systems, who stresses that one of his key tasks is to develop connections:

> *A large part of my function is to build new networks for the right type of the organisation. [Sholto]*

7.2.2 Midlands University Network

Geography

Although MU's location is advantageous, given agglomeration economies it can tap into, there remain spatial issues affecting spinout companies in Midlands University Network. These could be categorised as follows: local, national, and international. Firstly, it is important that spinout companies maintain physical distance from the university, as expressed by Millard, MBI representative, in order to demonstrate commercial readiness. In this case, MBI assists spinout companies to achieve a compromise location that is halfway between the commercial and academic environments. Secondly, from the perspective of Milton, MU TTO representative, the investor networks developed by the MU TTO are broader than just regional. Whilst the core investors the university works with are based in West Midlands, others are located in Oxford and London, stressing that Midlands University Network is not entirely focused on spatial proximity; rather, particular resources are more important to it. Finally, as Midlands Engineering, MU's spinout company, is located within MBI, it benefits from its relatively central location, with good links to London and proximity to an international airport. Furthermore, geography plays a role in the complexity of supply chain processes of Prof Miller's Midlands Engineering, where path-dependent industry concentration in West Midlands has not delivered expected services/outcomes to the spinout company:

> *We initially thought [that] it'll be quite good being based in the Midlands because there's historically a lot of manufacturing industry here. We started putting jobs out, sub-contracts out to local industry. Bizarrely enough, we found that we could get the same stuff made in Holland cheaper, and get it delivered quicker, and get a higher quality job done. [Prof Miller]*

University (TTO)

MU TTO's recent change in legal status to a wholly-owned subsidiary allows it more flexibility and shields it from internal university's managerial politics. All MU TTO staff have experience in both commercial and academic environments. Milton stresses that there are two core skills in the office: contracts and negotiation. Nevertheless, being able to work with academics is also critical, as he points out: *they've got to have technical knowledge and empathy that they can get on with the academics*. The MU TTO's primary role is to identify the commercial potential of the disclosure they proactively seek from academics and decide which commercialisation route to follow, if any. In the process of evaluating the disclosures, MU TTO describes itself as selective, outlining that early stage disclosures require further development before being considered for commercialisation:

> *We are very selective. Disclosures can be very early and one of the options, when we do the Next Actions section on a disclosure, we say, 'actually this is still in the research mode, go and get another research grant and try and achieve this'; or, 'it's too narrow, there's no commercial traction'. [Milton]*

Once the spinout company option is selected MU TTO takes responsibility for the concept, designing a business model and business plan, raising funding, attracting a management team, and securing grants for the proof of concept. It is important to emphasise that whilst the support offered by MU TTO is comparatively extensive, its spinout formation is limited by the number of disclosures it can process. Milton's TTO has an established procedural approach to founding spinout companies. After it secures proof-of-concept funds it would typically manage the spinout project or company (depending on the stage of development) until it can find a suitable management team with whom it can approach the investors in its network to search for first major funding. This process was established after learning from previous unstructured experiences:

We've evolved this process over the past few years. Historically the academic was just left to have a go which didn't really work and most of those legacy companies have gone. [Milton]

The supportive role of MU TTO at formation stage is confirmed by Prof Miller, praising the assistance received, especially at the early stages of the company formation without which Midlands Engineering would not be incorporated. MU TTO maintains its supportive role post-start-up, even though this is not one of its core functions. Prof Miller sees this support as a source of objective advice that contributes to the future direction of the company, which includes a business strategy overview and applying for publicly-funded support programmes, whether regional, national or EU-level:

My team … they should be more proactive in support of the spinouts… Because we always want to be highly regarded, as a professional service to the spinouts. [Milton]

The remit of MU TTO activities is clearly broader, given its supportive role focuses on the first two years of a spinout company, and extends to funding patents for their newly formed spinout companies. However, Milton stresses that due to quickly escalating costs MU TTO is unable to maintain support for spinouts beyond the first two years, especially if the company does not develop in that period. Such dormant spinout companies are liquidated. Therefore, patents become more critical to a spinout company after MU TTO withdraws its support, where a lack of patenting could lead to IP copying or force a spinout to incorporate the costs of R&D in its pricing, reducing its competitiveness, return on investment, and survival. Milton stresses that, in general, technology commercialisation is underfunded, leading to difficulties in achieving high quality outcomes, as can be observed from the time constraint on spinout companies' development. Furthermore, the factors underlying the success of spinout companies from MU may be sought in the function of MU TTO leadership issues, as noted by Prof Miller, who experienced knowledge commercialisation personnel changes:

Most of them have been pretty good. Some of them, and the one we've got at the minute, is excellent. Occasionally, you get somebody that you don't feel really gets what you're trying to do, but that's the minority of cases. [Prof Miller]

Academic Founder

Prior to spinout company formation, MU TTO is accountable for the executive decision as to whether to create a spinout company beyond the commercial feasibility of the underlying disclosure. According to Milton, this responsibility is necessary in order to manage academic founders' expectations and impacts on the university's faculty, including conflict between teaching, research and private business. MU TTO would typically identify a less time-demanding role for the academic founder, such as Chief Scientific Officer (CSO), in order to facilitate a balance between the academic's work and commercial commitments, and to maximise the academic founder's contribution to the spinout company within such constraints. Milton further explains that academic founders typically stay engaged with spinout companies over the long term, although frequently their role would have an unpaid part-time character, especially as CSO. Occasionally, spinout companies employ academic founders on a consultancy basis and pay for their time; however Milton stresses that this is a very expensive option, which does not occur frequently at MU. Prof Miller explains that his core motivation is research, whilst a spinout company comes second to it, confirming why MU TTO's role in managing academic founder's engagement is so crucial:

The reason I get up for work on a Monday and look forward to coming into work is the research element, and if I can actually end up making something useful for people, that in my lifetime I can see actually being used, that floats my boat. [Prof Miller]

Milton stresses that academics are great science communicators and that this skill needs to be exploited, rather than expecting academics to engage in highly applied activities such as product development. According to Milton, this makes academic founders crucial to the management team, especially during investment pitches where they can explain the technical side of the

technology and bring their university's reputation to every deal and agreement. Although Milton states that the university name cannot be explicitly used in commercial engagements of the spinout company, the university reputation remains implicit with the academic founder:

> *They have a role in securing investment in a way that the CEO alone often does not have, because he or she may not have the core technology. The other thing, of course, that the CEO won't have is the associated brand value of the university, which the academic has. [Milton]*

Whilst spinout allows the academic founder to transfer university technology to the outside world, it also helps the academic founder to obtain research grants, having a positive reciprocal role, as explained by Prof Miller. This is accomplished thanks to the revised criteria of research grant funding programmes, which require evidence of future application of the outcomes of funded research. Midlands Engineering provides Prof Miller with unquestionable evidence to use in grant applications, proving his ability to produce research with impact. According to Prof Miller, the knowledge transfer itself becomes lubricated by a spinout company, as other modes such as collaborative research or consultancy are more expensive, given the full economic cost charged by MU and its finance office's risk-averse nature, coupled with a highly bureaucratic approach to such interactions. Prof Miller admits that such internal arrangements of university and industry interactions have already resulted in millions of pounds of blocked income from the private industry. Midlands Engineering allows Prof Miller to overcome internal barriers to collaborating with industry by becoming a connecting actor to the commercial world. In addition, it sends a credibility signal to the businesses that they would be dealing with a commercially-oriented entity:

> *Probably about 80-90% of the business that the company has obtained is because people know about the work that the research group's done, and that there's a company out there that's licensed to exploit the intellectual property. [Prof Miller]*

Management Team

According to Milton, the management team has become more important in the roles of MU's spinout companies over the past five years, given the less structured approach adhered to previously when the academic founder managed the spinout company. MU TTO is focused on recruiting the right type of individual for each spinout from its own networks or networks of its investors. However, an important role here is played by MBI, which is one of the main sources of experienced entrepreneurs. Some of the recruited management team talent take on a more involved role in the spinouts, such as investor-managers, as explained by Milton. Once these avenues are exploited, MU TTO might turn to professional head-hunters; however Milton admits that due to inadequate funding it cannot pay for such services itself:

> *If we don't have anyone in our network, then we will go out and search for them. Quite often we will go by the investors … and sometimes we'll use head-hunters, but usually that's only when they [the spinout company] have investment. [Milton]*

Once recruited, the management team becomes the main driving force in building the spinout company, with time-limited support from MU TTO. The recruited individual takes on a role of CEO in the spinout company, as pointed by Milton. It is noticeable that previous lack of focus on installing an experienced individual to manage the spinout company could be an explanatory factor behind low survival of spinouts at Midlands University Network.

Investor

MU TTO has its own network of investors with whom it meets on regular basis to discuss the disclosures that have the potential to become spinout companies. This allows MU TTO to attract investors earlier and provides an opportunity to have a conversation about potential business models that more experienced investors could suggest or advise on. This approach is especially important given the account of the representative from Yorkshire Fund, Ingram, who stressed that spinout companies overestimate their investment readiness:

Investors are extremely reluctant to put any money in, unless they can see a return for it. And academics, and universities, consistently underestimate how much development there is to do of the R&D bit. There's a lot of development to do, and it often takes years. [Ingram]

Once the management team is recruited to the spinout company, MU TTO continues to make its network of investors available to the spinout, and is active in raising funding until the first major VC investment is secured. However, it is important to observe that investment is not prioritised for all spinout companies, as some might not require it due to operating in a niche market, where they could either be run as small firms or would require extensive investments in fixed assets, more in line with what IPO could offer, to start operating in certain markets:

One of the things that we've never done is sought to get external investment. Part of the reason for that is the area we operate in is quite specialised ... whilst it's valuable, there's a limit to the size of the market ... The only instances where we've thought that there's something bigger, the leap, the distance has been too big. [Prof Miller]

MBI maintains a separate network of investors available to MU TTO, which concentrates on business angels. The reason behind such distinct focus is the incubation programme at the facility aims at preparing companies for the VC investment. This is particularly important, as VC community views business angel funding very favourably, as admitted by Millard, MBI representative.

Business Incubator

MBI's main aim is to provide commercial and physical space for firms in the region, with no particular focus on spinout companies. However, whilst not part of a formal path for spinouts from MU, MBI has housed 16 spinouts, with four of them currently using the services of the incubator. This is confirmed by Milton: *for spinouts ... there is no formal incubation*. The majority of the firms at MBI reflect the sector composition of the region. Although the

incubator's facilities are very generic, it can accommodate specialist firms that require laboratories, such as spinout companies. For firms located at MBI's university campus, there is a prerequisite that they are expected to engage in collaborative work with MU. In general, MU's spinout companies tend to be 'incubated' in their departments. Midlands Engineering, as explained by Prof Miller, has a virtual office with a registered address at MBI, whilst still using the university's department's space to access specialised equipment:

> *The company has a legal office based in [MBI] that is nothing more than a post box really. ... A lot of the stuff is sub-contracted out ... and that person sometimes works from home, sometimes comes in and uses equipment here, and works closely with people in the research lab. [Prof Miller]*

Apart from a typical office space, MBI offers a specially designed incubation programme for early stage firms from the region, including spinout companies. As explained by Millard, the programme lasts for twelve months and offers extensive support, including mentoring, coaching, investment and office space. In order to join the programme, firms are strictly assessed on their growth focus and potential. Millard further points out that a requirement of the programme is that the core team of the company has to be committed full-time to working in the business only. Although it is a highly supportive programme, its demands mean that only a third of the companies succeed, as admitted by Millard.

Networks

Although MU TTO has own extensive networks with investors and a list of potential candidates for management team roles, it does not organise network-building events. Such events are only organised by MBI and focus on business angels. However, MU TTO recognises the need for developing networks for its spinout companies. In addition, Milton explains plans to better connect with university alumni and engage them more actively than as merely a source of donations. Milton further stresses that a long-term view is necessary in developing such

relationships, which could bring non-financial benefits to the university and spinouts in particular:

> *You must accept that they may never give you money because they don't believe in it, but they may want to come to your events, they may want to talk to your students, they may want to talk to your PIs [principal investigators/academics], they may get a buzz out of seeing science in the raw. [Milton]*

Whilst Midlands Engineering is clearly in reach of existent parent-developed networks, it also has own organically built networks brought in by every individual working in the company. The networks are critical to the success of Midlands Engineering, what is particularly stressed by Prof Miller, indicating that many customers of the company came from these networks:

> *We had all these contacts of companies that we'd worked with on various research projects. We had networks from people that we meet at conferences and that were involved in organisations and associations that we were already involved in. [Prof Miller]*

7.2.3 London University Network

Geography

Being based in London, LU benefits from agglomeration economies. This translates into good contact with local investors, who are mostly concentrated in the capital. The LU TTO maintains further networks with the business angel community from Cambridge and Oxford, emphasising the connectedness of the LU. The TTO is focused on clusters of high-technology entrepreneurship activity. The importance of geography at London University Network goes beyond the more static major linkage locations of LU and focuses on the spinout companies. Although typically spinout companies would tend to stay close to the university, especially in highly urban areas such as London, Loxley, LU TTO representative, outlines that some LU spinouts have moved to other regions in the UK:

They stayed within the university for ... twelve months or so before they moved out across to South London and now they're based in [the South-West]. [Loxley]

Location plays a crucial role in the operations of LBI, whose representative, Lowell, stressed that all incubators in London are positioned close to tube stations in central zones. LBI, in particular, benefits from access to fibre optic used by the financial district in London, and access to major international airports:

You need to be in a good area for superfast [broadband]. We don't have any superfast in the UK yet, in comparison to Kansas City and Austin ... Luckily we have a compensatory factor in being close to Canary Wharf which has great points of provision. [Lowell]

University (TTO)

LU TTO is split into three specialist teams by broad science fields that work closely with respective university departments. The background of the LU TTO team is highly varied and reflects a focus on complementary skills, with academic, VC, commercial, and legal the core experience sets in the group. This enables LU TTO to act on a broad range of business issues, offering a high level of support and expertise to spinout companies. Additionally, as stressed by Loxley, such a diverse team brings highly specialised and far-reaching networks into the university's knowledge commercialisation activity, greatly improving the survival chances of spinout firms. The three specialised teams of LU TTO actively seek out disclosures, which are regularly evaluated by all its professionals on monthly basis:

We have a number of criteria that we use to measure our interest and that's around, usually, patentability, commercialisation potential: can we take it from where it is now to get it to market or to investment, and we use a fairly standard procedure to evaluate that. [Loxley]

LU TTO has an agreement with London Investments that specialises in spinout companies and has a preferential right to evaluate the disclosures from the university. If London Investments selects a particular disclosure, it supports it fully until its own investment exit. The remaining disclosures undergo the internal assessment of LU TTO team described above. According to Loxley, the selected disclosures of commercial potential become 'spinout projects', which are not yet incorporated at that stage. LU TTO's evaluation includes identifying the stage of technology development, which is of critical importance to gauge whether the project is ready to seek out investors or help the academic founders to progress the IP to investment-readiness. In such cases LU TTO has internal seed funds sufficient to independently, or through matched-funding, help the project develop the concept:

> *We have funds that we can use for consultancy, so we can bring externals in to do a bit of business planning … to help us form what the company might look like or … to act … [as] an interim mentor or management role. [Loxley]*

LU TTO prioritises installing a management team in a spinout company early, so long as it has the necessary funds to do so; alternatively it might offer equity to a prospective CEO or take a temporary management role itself until the right individual can be recruited. The spinout is typically registered as a company once the first major investment is secured (usually VC-type funding), as explained by Loxley. In instances when the company is registered without investment, LU TTO supports the spinout in obtaining grants or other types of small-scale funding, including internal funds until the company is ready for the major growth capital injection. It is crucial to note that LU TTO has a very flexible approach to its spinout companies, recognising the highly heterogeneous nature of these firms:

> *So the types of opportunity we see are very varied and require different amounts of resource, different type[s] of resource, and different leaving times, to the point where it can operate under its own management; so there's no set formula. [Loxley]*

Once the major investment is secured, LU TTO expects to have a reduced role, or that the spinout company will become self-sufficient. Loxley further states that LU's spinout companies that survive at least five years typically generate revenue or are in receipt of major investment, confirming the positive outcomes of its supportive commercialisation approach.

Academic Founder

Loxley explains that academics typically lack entrepreneurial skills, although there are cases within LU's companies where the academic founder has become the CEO of the spinout. This, however, has largely been due to highly entrepreneurial character of the individuals, and hence the majority of the spinout companies from LU have management teams recruited to run them, as outlined by Loxley. This is partially confirmed by Prof Louie, academic founder of London Technologies, who, whilst not interested in nor knowledgeable about commercial matters had an entrepreneurial character organising trips to the US for students as an undergraduate when it was very costly to travel:

> *At that stage I didn't know anything about companies, I was a typical academic. I wasn't interested in companies. I didn't understand the structure. I didn't understand the shareholding. I didn't understand anything about them. I was just happy to have little project going. And I kind of viewed it almost like a research grant. [Prof Louie]*

The task of LU TTO is often in finding a non-conflicting role for the academic founder in the spinout company, specifically one that would not have adverse effects on the academic's teaching and research commitments. According to Loxley, such roles would normally be of a consultancy or advisory nature, for which some spinout companies might buy the academic's time from the university. Prof Louie stresses that involvement in spinout might interfere with academic work, especially if the company struggles financially. Nevertheless, Loxley emphasises that engagement in a spinout company is frequently about managing the expectations of academics:

The issue might arise when you have entrepreneurial academics … where they have a big influence in the running of the company and if an investor comes in that doesn't want that to continue. So it's at that point when you manage their expectation and your relationship with the academic. [Loxley]

Loxley further stresses that venture capitalists invest in people and not technologies, and therefore the success of spinout companies is crucially linked to resolving such internal challenges. However, this is not to say that academic founders are dispensable, as at later stages they might become crucial:

I'd been doing it for 25 years … I had kind of had enough basically. And I thought, right, I'm going to step aside. Now that was a bit of a problem because I had my shareholding. … What you don't realise and I didn't realise [is that] the share price of a small company … is very emotional. And if anyone who's invested in it sees the person who's well known, leaving the company and selling some shares, the shares … could become zero pounds per share. [Prof Louie]

Management Team

The management team is a key part of building the spinout company at LU, largely to enable the spinout to attract VC-type investment. When the partner VC specialising in spinout companies, London Investments, selects a disclosure to build a company around, responsibility for recruiting the management team is with that VC. In all other instances, it is LU TTO recruiting experienced individuals to direct spinouts. LU TTO has its own network of individuals who could play such roles or alternatively it might use the academic founder's network to find the right individual:

For Spinout Company X, we identified the CEO through contacts that the academic had - so the … industry is a very small industry. Everyone knows each other. [Loxley]

It worked well with the people they [the university] chose. One was … a chief executive of [a bank], and the other used to be a chairman of [a firm], which was a massive

company. So both of them knew about companies, and the one who was a chairman … was keen on small companies. [Prof Louie]

In all instances the management team is recruited at an early stage, typically as interim part-time CEO or consultant, as outlined by Loxley. However, he points out that the original management team might change as the company grows, due to differing requirements to achieve growth and expectations from, or vision of, the spinout. Prof Louie explains that whilst the university installed a good management team, it was focused only on organic growth. In order to receive VC-type investment, the London Technologies management team had to change, which led to appointing a highly success-oriented CEO, who proved critical to company's success, steering it through its growth amid challenging situations:

And they got one, a serious business person. … Whenever she looked at you, you could see dollar notes running around her eyes … And so with her in charge, she raked the company out of its impasse, persuaded … the [VC] to put yet more money in. … She transformed the company. [Prof Louie]

Investor

LU has an agreement to work with London Investments and allows it early access to LU's disclosures. London Investments, whilst very selective, offers extensive support to the spinout companies it develops, ensuring the success of those companies. When LU first signed an agreement with London Investments, London Technologies had already been operating for several years, growing organically. This established nature convinced London Investments to make its first investment in a non-early stage London Technologies, even though it was not part of the agreement with LU. The VC subsequently installed their own individual on the spinout's board of directors and *began to have more influence on the company*, according to Prof Louie. A few years later when the London Technologies contract for a commercial project went wrong due to a technical omission, London Investments stepped in. As the VC was success-oriented

and invested on long-term basis, London Investments was ready to support the spinout when action was required:

> *We're the ultimate patient capital … we can easily stay with companies for fifteen years and longer. … I guess how that's different from traditional VC, they wouldn't get involved in identifying ideas … found the company … build the company. They would come in at some stage, depending on what kind of VC they are, normally … the fifth, sixth, seventh year … staying an average of seven years. [Irving]*

However, not all LU's spinout companies are built through London Investments. According to Loxley, the remaining disclosures are evaluated and selected by LU TTO and would receive financial support from it. At first LU TTO would typically use own internal funds to assist with proof-of-concept and subsequently utilise its own network of mostly London-based investment community to seek out initial major funding:

> *We have spinouts where London Investments declined an investment and we're free to go elsewhere. … where the technology is fairly well developed, we can go out quite quickly and talk to other potential investors and try to take that through to the point where we can receive investment. [Loxley]*

Business Incubator

LBI is run as a commercial company and remains outside any predefined path for spinout companies from LU. According to Lowell, such legal arrangements shield the university's reputation from any threat of LBI's future insolvency. The facility is a late-stage incubator with limited competition in the region. According to Lowell, the incubator's support focuses on office needs which might be very capital-demanding in terms of technical arrangements:

> *We are … a purpose-built incubator from the basement up. That means … complicated air conditioning systems to accommodate a wide diversity of science companies, from light biotech to heavy duty medicinal chemistry, advanced computer systems to control it all. [Lowell]*

As a commercial entity LBI remains operative thanks to the rent it charges to the tenant companies. According to Lowell, even though it is associated with LU, its prices are affiliation-neutral. This arrangement makes it natural for LBI to prefer long-term tenancies. Whilst it currently houses two spinout companies from LU, being an independent commercial entity LBI is open to all high technology companies from the region, including spinout companies of other London universities. Being a late stage incubator, its companies achieve high growth, largely due to prior VC investment, which enabled the companies to be based at LBI in the first place. Lowell stresses that such a business model allows LBI to focus on broader economic impacts:

> *Stable companies, long lease policies, we have no churn policy, because we are talking about jobs created and safeguarded … It's not just a matter of creating jobs, but making them stay. [Lowell]*

Networks

Spinout companies from LU have access to a wide range of networks. The networks of academic founders could be extensive, especially if the individual is a 'star scientist', as Prof Louie's were, thanks to frequent television appearances. Prof Louie stresses that the majority of his networks are based within the scientific community, whilst the industry and commercial networks were brought to London Technologies by the management team:

> *When anything went wrong or scientific we couldn't get things right, I knew people to phone up and to help me out. [Prof Louie]*

Apart from the management team, LU TTO contributed extensive networks thanks to the highly varied backgrounds of the office's personnel. However, Loxley warns that maintenance of these networks is highly reliant on minimising staff turnover, as VC industry finds it difficult to navigate through changing TTO teams. In order to build and maintain networks LU TTO organises networking events and uses networking events hosted by its business incubator, LBI, which allow spinout companies to improve their connectedness. Although investor networks are

critical to spinout company success, LU TTO finds it challenging to maintain such networks due to the dynamism of VC professionals:

> *You can have relationships with people within [the] VC community, but it's not until you have an opportunity that comes along that you can really take forward and pitch it. And in a particular sector that might only happen once every four or five years and, of course, your contacts may have gone or that VC might not be investing in that area any more. [Loxley]*

7.2.4 Welsh University Network

Geography

Welsh University Network enjoys the benefits of agglomeration economies. Whilst at a regional level it has an advantageous location, Wales itself is a peripheral UK region, placing Welsh University Network at a disadvantage in terms of access to majorly London-based entrepreneurial capital funding, as admitted by Waljan, CEO of Welsh Therapeutics. Waljan stresses that VC investors have a particular perception which is spatially-bounded and affects access to investment for non-London firms. Although Waljan disagrees with the investors' London-oriented concentration, the commercial reality remains different:

> *I've heard some anecdotes of some investors [who] won't even get on a train to go and visit their companies. They'll go on a tube but if they can't get there by tube they're not going to invest in it, because they think that the talent is around London and, okay now they're expanding out to Oxford and Cambridge. I think that's wrong, but it doesn't matter what I think, it's what they think. [Waljan]*

Geography also affects access to the management talent, with the two interviewed CEOs of WU's spinouts, Wil (Welsh Sciences) and Waljan (Welsh Therapeutics) having moved to or closer to the university's city after engaging with their respective spinout companies. This is particularly clear in the case of Wil, who moved to a city in the South West in order to be close to the offices of his previous employer, based in Wales and Yorkshire, and the VC community

in London. Prof Wren, the academic founder of Welsh Nano, outlines that whilst the geography plays no specific role in his company, Welsh Nano is spatially very flexible, with its management team based in different regions: Wales, West Midlands, North, and East of England. Although this spatial distribution allows Welsh Nano to access experienced individuals, it necessitates a central point for company's board meetings to minimise travel costs. Welsh Nano's approach applied to the management team extends to product-building, illuminating the complex geography of innovation:

> *It was built at a lot of different places actually. So some parts were built in West Midlands … Some … in Essex, but most of the assembly work in [Wales]. [Prof Wren]*

At a local level geography was important to the development of Welsh Sciences and Welsh Therapeutics, both based in the same business incubator that allowed them good access to a hospital. Despite the high cost of space in the incubator, both spinouts benefit from this location:

> *From our perspective the location here has worked brilliantly because … we need to scan patients and we need to get advice from experts. [Wil]*

University (TTO)

WU has an agreement with London Investments, allowing it access to its portfolio of disclosures. As a result WU has an equity stake in London Investments, which takes whole ownership of the spinout companies from the university. The main reason for the agreement, as presented by Wynn, WU TTO's representative, is the recognition that university has only one out of three critical components to generate successful spinout companies, namely a strong knowledge base and the ability to produce world-class research. The remaining two ingredients are investment and management talent, which WU improved its access to by partnering with London Investments:

> *We entered into an arrangement with them that said: OK, anything that comes out of the university that we think we can build a company around, and provided everybody*

wants to do that, including the academic founders, etc., we'll let you guys do it and in return, they had to raise a pot of money for us. [Wynn]

The background of WU TTO's team is predominantly academic, with each individual educated to PhD level. As stressed by Wynn, within the team some have industrial experience, but it is the ability to communicate and understand academics and their research that are the key tasks of WU TTO. This is well exemplified by the experience of Prof Wmffre, the academic founder of Welsh Therapeutics, describing an informal disclosure identification, where a WU TTO professional filtered and identified the foundations of his spinout company:

She [WU TTO professional] came up and said: 'Look, you're always coming up with mad ideas, have you got anything that could be patentable?' So I said: 'Well, I've got this and I've got this; and there are all these ideas that I've either made or had'. So … she went, 'Well, that's pretty much a company in itself'. [Prof Wmffre]

There are two clear routes that spinout companies from WU can develop through. First, as mentioned, specialist VC; and second through the WU TTO itself. Whilst the first route is more commercially-oriented, where success is expected to be expressed in financial terms, as explained by Wynn, the second route is closer to the original concept of knowledge commercialisation: translating academic research, where WU aims to have a social impact. This allows WU TTO flexibility to support a wider range of companies, beyond *blockbuster* type firms:

Occasionally, a technology or an opportunity comes along and we think: 'you know what, maybe we can grow a business around that and create a high value, high growth company.' [Wynn]

Crucially, WU TTO identifies and develops the IP. To do so, it attracts external investment and provides its own seed funding for selected disclosures, as explained by Prof Wren. Furthermore, WU TTO provides IP advice, assists with patent application, does important documentation

work when forming the company, recruits a management team and secures initial major investment, enabling the spinout company to operate more independently. According to Prof Wmffre, WU TTO also cares for its academic founders, recognising it as part of the process leading to successful outcomes. As the key role of WU TTO is primarily focused on the pre-incorporation stage, it gradually withdraws when the management team becomes more involved. It is important to observe that WU TTO still offers support to spinout companies in later stages, as explained by Wil, where WU TTO assisted Welsh Sciences in obtaining external public funding:

> *It'll just help. If it can help with getting grants or anything like that it will do that. If it can help with commercial agreements within the university for resources or royalty or anything like that it will help, but it is stepping back and saying: 'You run that business'. [Wil]*

Finally, Wynn clearly underlines that WU TTO is resource-limited and unable to translate a larger volume of research. Even though Welsh University Network appears well placed to develop spinout companies, its good performance is only a function of maximising outcomes from a highly-constrained environment. This is further evidenced by Prof Wmffre, who had first-hand experience of the resultant selectivity of WU TTO:

> *A couple of them [disclosures] went by the wayside for financial reasons more than anything else, because we couldn't afford to invest in all of them. So we went with the main idea. [Prof Wmffre]*

Academic Founder

At WU it is not usual that academics become CEOs of their spinout companies. Moreover, Wynn stresses that WU TTO would not encourage academics to assume such roles, even though examples could be found among their spinout portfolio. The core reason behind this, according to Wynn, is utilising the strengths of academics, who are great scientists, and avoiding a 'brain drain'. Nevertheless, WU TTO recognises that it is critical that the academic founder is involved

in the process from a very early stage in order to facilitate the transfer of tacit knowledge to the spinout company to enable it to become independent from university; and in particular, to avoid problems at WU that could affect the spinout company at later stages:

> *We want to be able to quickly and efficiently transfer as much knowledge as we can from the academic into the company, because if something happens to that individual or that research group the company could find itself high and dry. [Wynn]*

The academic founder typically takes on a part-time position, usually unpaid, unless the spinout company has attracted investment to afford to buy out the academic's time to work in the company on a consultancy basis, as is the case of Professors Wmffre and Wren. Both founders prioritise academic positions over their spinout engagements, largely due to the stable nature of such an income source. Waljan points out that he offered a full-time position to Prof Wmffre at Welsh Therapeutics, but he refused, instead maintaining the part-time advisory role. However, according to Wynn, those academics who want to be more engaged might invest relatively large sums of their own money, specifically to strengthen their positions in the companies:

> *I put some of my own money into it because I believe in the idea. [Prof Wmffre]*

Finally, Professors Wmffre and Wren also brought their industrial experience and connections to their spinout companies. These were derived from prior extensive work with private industry on consultancy and collaborative research projects. Good contact with the industry strongly influenced the original ideas for the technologies of Welsh Therapeutics and Welsh Nano:

> *They [industry clients] had a piece of technology and they wanted us to check if this device would work, and we did that work and we gave them the results. And after that, a colleague and I carried on, we had a look at thinking about how we could make this particular piece of technology better and we came up with some ideas of doing that. So the prompt initially was from industry and then just as an unfunded project, we carried on running it, and that sparked the interest then of [London Investments] engaged by*

[WU TTO] because we'd come up with a much more efficient way of doing something we hadn't seen before. [Prof Wren]

Management Team

The management team is typically provided by London Investments; otherwise WU TTO would search for the right individuals for the majority of its spinout companies. According to Wynn, it is a critical component of the university's spinout formation procedure to install the management team, since investors are typically guided by the quality of business management. It is also important that the management team is recruited early, as explained by Prof Wmffre, to allow for greater understanding of the business. Furthermore, Wynn outlines that the management team's composition needs to adapt to the dynamics of the spinout company:

Sometimes by the time you exit, the management team won't be the same as we had at day one, because … as these entities grow you've got different issues if you're managing twenty people compared [to] if you're managing five people. [Wynn]

Business development is clearly a complex undertaking, which requires comprehensive knowledge of the processes involved in stimulating a venture's growth. The CEOs of Welsh Sciences, Welsh Therapeutics and Welsh Nano gained this understanding through careers in business development and VC investment. All three entrepreneurs were first employed by London Investments and engaged in the early spinout formation processes until becoming more involved:

About six years ago … London Investments said part of my job should be to run the business because it was looking to take a product that had been blue-skied, developed and now needed to be sold. So how are we going to … actually generate revenue, make it into a business that employs people and sells products? So I then took over being CEO on a part-time basis and then became full-time. [Wil]

Prof Wren notes that the management team in his spinout was very supportive, bringing senior industry experience vital to company development. It is also crucial that London Investments has a very flexible approach towards its management talent being involved in spinout companies:

> *I think initially he was given a year's sabbatical to get this off the ground and if it didn't work out then he could always go back. ... He's just jumped in with both feet ... and he's MD of the company. [Prof Wmffre]*

Investor

Spinout companies from WU typically receive their first investments from the university in the form of proof-of-concept funding. This funding is increasingly important, as it helps the underlying IP become validated, sending a strong signal to the VC community that there is serious commercial potential in a spinout company built around this IP. Whilst unusual, given the agreement between WU and London Investments, Prof Wmffre noted that London Investments only invested once the university committed to seed funding, stressing the extent of support of WU TTO:

> *We ... got some money from the university ... for proof-of-concept work. ... We got some funding then from London Investments who Waljan used to work for. [Prof Wmffre]*

London Investments is not the only investor that WU works with, as it cooperates with regionally-based Finance Wales, which is a more traditional VC-type firm. This generates more funding for WU's spinouts at lower risk exposure for the two VCs. Such an arrangement is particularly advantageous given the business-building know-how of London Investments, enabling spinout companies to become attractive for investors. The downside of this success-oriented partnership is the high level of selectivity applied by London Investments, filtering disclosures under very strict criteria:

The university has this arrangement with the venture capital, they show them all of these ideas and then they pick the ones they want to look at, the sweetest ones. [Prof Wren]

Our job was to look at all the ideas, all the nuggets as they came up and say, 'actually that is a nugget of gold and we can do something with it'. So our job was to cherry-pick, but to then work really hard on those ones once we had done [so]. [Wil]

However, this process of choosing the right type of disclosure with high commercial potential is clearly related to the resources that London Investments can direct into building the venture, as once it selects a particular IP the VC is very supportive. For Welsh Nano this support meant funding for early market research, and matched funding for two further publicly-sponsored grants, which were crucial to the company and its VCs:

Those sorts of grants, even if they're not fully funded grants, they're absolute gold dust to companies like us, because it, let's say, provides 50% funding, it means our investors get £2 for every £1 they put in in terms of R&D which is great for them and for us. [Waljan]

You want access to friendly money; you want to know that the person that's put some money in will be there for the next round and the round after that, because you can't spend your whole time running out of money and looking for money, because you can never focus on doing your job. [Wil]

When London Investments identifies disclosures together with TTO teams, the disclosures undergo another evaluation internally at the VC. The selectiveness is clearly very thorough, emphasising the investor's focus on success, as explained by Irving. The spinout companies so identified are built fully by London Investments, as such a process requires large doses of funding unavailable to WU. However, the process is far from simple and undergoes further filtration that minimises London Investment's risk exposure:

So when we first have an idea … we put in a, sort of, what we call 'grab money'. It's probably between £50,000 and £250,000 and you're actually trying to make them fail. … You want them to fail, if they're a bad idea: fail early, fail cheaply, fail professionally. … When you're starting these companies, you're probably on a fifteen-year journey … so you don't want to spend a lot of time on one that's not going to work. [Irving]

Business Incubator

Welsh Sciences and Welsh Therapeutics are both based at a business incubator, praised for the flexibility it grants to the spinout companies. Although this comes at a cost (as noted by Waljan), Wil stresses that the particular business incubator provides life sciences spinout companies with access to clinicians from a nearby hospital, which outweighs the tenancy costs. It is important to add that the business incubator used by these two spinouts offers no services related to typical 'accelerators' that engage in assisting in tenant business development; merely flexible office space:

It's great, because on the downside you only have to have your one month's notice so you don't have to sign up for a five-year lease, and if god forbid the technology doesn't work out you don't end up owing someone four years of rent: you can give one month's notice and be out of here. [Waljan]

Not all spinout companies from WU experienced such positive externalities of being based at a business incubator. Prof Wren describes one of two incubators his spinout was based at in a rather negative light, indicating little support was received from these facilities. Prof Wren noted that the best incubation his spinout received was from WU TTO at the university department, indicating how important and extensive WU TTO support is for its spinout companies.

Networks

Whilst networks are recognised as important by WU TTO, it relies on the networks of London Investments, who have extensive national-level contacts critical to building businesses. Spinout companies from WU typically access the networks of their academic founders, management teams and investors. Professors Wmffre and Wren have own industry networks developed through previous academic work. However, as outlined by Prof Wren, the links of Welsh Nano's management team were critical to the feasibility of the technology and product, market potential and customer needs. Furthermore, Waljan explains that early stage spinout companies benefit from good networks by being able to develop without recruiting critical professionals. In this case, networks allow the companies access to resources they otherwise cannot afford:

> *For the first two to three years of our existence, we were a virtual company. So we were absolutely relying on networks to bring in appropriate external people to help actually do the work. Then it was only when we got towards having our CE mark, which allows us to go and sell the product around Europe, that we started to bring people on as employees. [Waljan]*

At later stages of spinout company development, networks could be used to identify potential buyers for the company. Prof Wmffre explained how their networks in the sector attracted the interest of major companies, which currently observe the spinout company's performance as a potential acquisition target. However, as stressed by Wil, building networks is costly in terms of time commitment, in particular when using networking events. There is a pronounced need for network development to have a more structured and strategic approach:

> *I've done less of those [events], but it's more been the networks that people, from a business perspective, where we've gone specifically to them because they've been identified rather than all standing in a room saying: 'Hello, I'm from X'. [Wil]*

7.3 Success factors

The illustrative examples of four university networks depicted in the preceding section allow an insight into the highly challenging and complex environment of dynamics that lead to spinout company formation and survival. Table 7.2 presents a summary of key characteristics of each university network element across the four networks.

Table 7.2 Spinout success analytical framework - summary of network characteristics

	Scottish University Network	Midlands University Network	London University Network	Welsh University Network
Geography	• reliance on regional government support • location affects connectedness given no benefits of agglomeration economies • necessary to form national networks	• benefitting from agglomeration economies • good (central) location to benefit from international supply chains	• most advantageous position in terms of access to investors, broadband etc. • benefitting from the best agglomeration economies in the UK	• benefits from agglomeration economies • location limits access to investors • at a local level, spinouts exploit locational advantages of business incubator
University (TTO)	• under-resourced • processing high numbers of disclosures • improving survival outcomes in recent years • support until formation only, post hands-off - MT's role to build the spinout	• good resource endowment, but still insufficient to deal with all disclosures • selective at disclosure evaluation stage • procedural approach to formation • supportive (for two years only) • improving survival outcomes in recent years	• highly diverse and broad networks, well-connected • TTO very selective • well-resourced & funded TTO, very supportive • spinouts are all different, hence flexible approach	• focused on disclosures and pre-incorporate stages - knows its limitations: it is only good at identifying disclosures; VC partner brings in MT and funding • VC-backed spinouts: commercial goals only • non-VC-backed spinouts: social and other goals • highly supportive, even past formation
Academic Founder	• adaptive & sympathetic approach to AF in terms of involvement in spinout	• TTO decides on AF's role as university's agent • spinouts important to AF's academic career due to revised grants criteria	• TTO manages AF's expectations to ensure the spinout is successful (TTO's executive role here to allow or deny involvement)	• strong links with industry
Management Team	• recruited at pre-incorporation stage to attract investment and build spinout • only recruited if TTO manages to source funding for MT from government support programmes	• recruited by TTO from own or BI's networks, or by investors • main driving force in building the spinout • previously AF's 'had a go' without MT, hence poor survival	• MT installed early on, but supported by TTO • crucial to attract VC; VC invests in people • TTO has own MTs' network & is mostly responsible for finding the first MT • VCs might change MTs at later stages	• VC provides MT, otherwise TTO (non-VC way) • recruited early has better understanding of the spinout, kept long-term • changed at later stages due to skillset required • first MTs come directly from VC (its own team)

Table 7.2 *Continued*

	Scottish University Network	Midlands University Network	London University Network	Welsh University Network
Investor	• early stage funding obtained from government programme - selection of commercially oriented spinouts • MT's role is to attract funding • highly structured way of approaching investors by MT, no prior networks used	• increasingly contacts VCs to discuss disclosures • TTO proactive in investor finding until first major investment • VCs evaluate BA-invested firms favourably	• specialist VC partner preselecting disclosures to develop • TTO seed funds spinout companies not selected by the VC partner and uses own networks of investors early on to secure funding	• TTO seed-funds spinouts then usually uses specialist VC • specialist VC risk averse, invests after TTO commits seed funds, with another regional VC • highly selective specialist VC • long-term specialist VC engagement, critical to survival of spinout, focusing on business building
Business Incubator	• incubation in departments for as long as needed; typically investors would require spinouts to relocate closer to them	• not part of formal spinout path, but houses some spinouts • used as office space & to access MTs & BAs • incubation in departments, only for two years • BI runs accelerator programme (twelve months)	• not a formal spinout path, but houses spinouts, also from universities in the region • charges commercial rents, also to spinouts from University B • long-term contracts, but office space only	• the local BI has a favourable location to spinouts • allows for flexibility to early stage risky ventures, but is expensive • business incubation typically just office space
Networks	• poor networks of the TTO team • responsibility of MT to build networks • MT becomes a central actor early on in the network	• TTO and BI have good networks with VCs, BAs, MTs • extensive industry networks brought in by AFs	• AF brings scientific network • MT brings industry/commercial network • TTO adds other networks - investors and MTs • TTO finds it difficult to maintain investor networks whilst forming one spinout per year - it is a dynamic market (VC people changing jobs, VC changing sectors)	• MT's bring industry contacts at senior level • networks used to access specialist talent - accessing resources without committing to recruitment/employment costs • networks used to learn about industry needs • collaborative, specialised roles in the university network

These extracts allow identification of a number of core themes within each network element, enabling better understanding of spinout company success, as presented in Table 7.3. The themes searched for had to meet two criteria: a) they should explain the success of university networks; and b) have a frequent occurrence across the university networks. As such, three themes were identified: *connectedness*, *selectivity*, and *time*. *Connectedness* was expressed across a number of references to networks, supply chains, and spatial reach of connections. *Selectivity* was typically articulated in early-stage identification process, the selection of viable spinout projects, and the evaluation of commercial potential. *Time* was captured across a number of expressions that referred to the length of time (e.g. short/long), stage of development (e.g. early), or longevity of engagement.

The themes identified are used in the following subsection to discuss the contribution of each network element to the success of spinout companies. Clearly, success is achieved through factors that are not shared by all university networks. In particular, the lowest-performing Scottish University Network lacks a large number of success factors in its dynamics.

Table 7.3 Identified themes across university network elements

	Scottish University Network	Midlands University Network	London University Network	Welsh University Network
Geography	connectedness			
University (TTO)		selectivity		
			connectedness	
Academic Founder	time			
		connectedness		
Management Team	time connectedness			
Investor	time connectedness selectivity			
			time	
Business Incubator		connectedness		
	time			
Networks	connectedness			

Note: Shaded areas signify that none of the core themes were identified for particular actors in specific university networks.

7.3.1 Success factors in university networks

Geography

Access to networks and the level of linkage in these networks is dependent on the broader network environment. University networks based in small urban locations or peripheral regions are at a disadvantage, unable to access dense local or regional networks. Being unable to enjoy connectedness related to advantages of agglomeration economies (Krugman 1991b), where centralisation and clustering of actors results in broad and dense networks, spinout company formation and success cannot operate at optimal levels. Furthermore, due to constraints of location, university networks (such as Scottish University Network) have to build connections beyond their own locality and across the country's regions. This means that university networks characterised by poor connectedness need to resolve linkage problems by constructing spatially-increasingly distant networks. These mixed networks confirm the distance-modified connections observed by Asheim and Isaksen (2002) and Asheim (2012). Whilst this is helpful, greater network connectedness is typically related to spatial proximity (e.g. Storper 1997; Howells 2002; Scott and Storper 2003), undermining the effects of such 'cures'.

At the same time, urban locations, even in peripheral regions, enable university networks to achieve and maintain strong connectedness. This is not only expressed at the local level, but extends to the regional, national and even global scope of networks. In this case, strong connectedness at local level allows university networks to expand links thanks to solid foundations, in line with previous research stressing this expansionary character (Asheim and Isaksen 2002; Malecki 2010; Asheim 2012). Distance ceases to be a constraining factor in such university networks. This was exemplified in Midlands, London and Welsh university networks, all centred in major urban locations.

University (TTO)

TTO's connectedness is dependent on resources available to it. Low levels of endowments make it difficult to build and maintain networks (Patzelt and Shepherd 2009), as noticeable in Scottish University Network compared to TTOs of other university networks. This translates into limited

support available from the TTO to spinout companies, affecting the probability of success. Whilst some previous studies on the role of TTO dismissed its importance (e.g. Aldridge and Audretsch 2011; Clarysse et al. 2011a; Bourelos et al. 2012; Fini et al. 2017), only some research recognised TTOs as playing boundary-spanning roles (Siegel et al. 2004; Alexander and Martin 2013). It becomes clear that resources devoted to commercialisation activities play a critical role in determining the success outcomes of spinout companies identified in spinout formation-type research (e.g. Mosey and Wright 2007; Farnstrand Damsgaard and Thursby 2013; Gonzalez-Pernia et al. 2013) or spinout quality studies (Fini et al. 2017).

Additionally, TTOs play a significant role in early stage selectivity processes, which have great influence on the future success of spinout companies (Degroof and Roberts 2004). When TTOs evaluate their disclosures, it is imperative that selectivity is effective. One way the London and Welsh university networks achieve this is by using specialist VCs in the disclosure assessment stage, unlike in Vohora et al.'s (2004) study where this role was played by industry and external entrepreneurs. These TTOs learn from such collaboration how to strengthen their selectivity methods to build better filtration models. The effects of these co-operations with specialist VCs have been illustrated in the preceding section. Although the literature recognises the role of VC in formation and success of spinout companies (e.g. Huggins 2008; Politis et al. 2012; Hayter 2013; Fini et al. 2017), its cursory understanding of the role of VC in spinout companies as merely investors dismisses their extensive engagement with selectivity, especially, in contexts where strong selectivity and connectedness could be built through formal partnering with VCs, essentially complementing and strengthening the activities of university TTOs.

These are also dependent on TTOs' approaches to spinout companies, where highly rigid support provision in Midlands University Network meant that spinout companies not achieving growth after two years would be forced to cease operations. Such rigidity is a direct outcome of resource starvation of TTO activities intensifying short-termism, high risk-aversion, and signifies poor utilisation of networks to resolve the problems of information asymmetry. In contrast, a flexible approach to spinout company support, represented by the London University

Network, is related to good resource endowment and resultant utilisation of networks in developing and exploiting strong connectedness. Hence, the combination of resources, selectivity, connectedness and approach to spinout companies at university TTOs determines their success, as partially suggested in previous studies focused on institutional (i.e. university) contexts (Degroof and Roberts 2004; Clarysse et al. 2005; Fogelberg and Lundqvist 2013).

Academic founder

Whilst academic founders rarely manage spinout companies, reflecting more closely the considerations of allocation of time (Becker 1965) and opportunity cost (Geroski 1995), they play two major roles in academic spinout companies. Their importance is most pronounced in the science and industry connections they bring into spinout companies, as expressed by Midlands, London and Welsh university networks. Previous studies identified that academics most likely to become academic entrepreneurs typically have built links with industry (Krabel and Mueller 2009; Bourelos et al. 2012; Goethner et al. 2012). However, the importance of academic networks was never specified. In fact, academic founders become major bridging agents in spinout's access to specialist networks. This in turn indicates that an academic founders' core role, apart from knowledge transfer, is in improving connectedness, greatly enhancing the survival chances of a spinout company. Furthermore, each of the four university networks illustrated in the previous section emphasise that whilst the knowledge transfer role of an academic is concentrated around the early stages of the company (Jensen and Thursby 2001; Farnstrand Damsgaard and Thursby 2013), the academic's involvement remains over the longer term in a reduced capacity. The early stages are critical due to the tacit character of knowledge making it difficult to transmit (e.g. Nonaka 1991; Kogut and Zander 1992; Nonaka 1994) to a spinout company, thus requiring greater involvement of the academic founder. Once knowledge is captured by the spinout company, the unchanged academic founder's role is in ensuring strong connectedness.

Management team

The key entrepreneurial role in a spinout company is that of the management team. Previous studies identified the importance of external or surrogate entrepreneurs (Franklin et al. 2001; Lockett et al. 2003; Vohora et al. 2004; Hayter 2013; Lundqvist 2014; Diánez-González and Camelo-Ordaz 2016), stressing that the specific nature of work undertaken by the management team is very complex. First of all, a management team is the core business-building force at pre- and post-formation phases (Politis et al. 2012), with the early stage being most emphasised. As the experiential learning of Midlands University Network exemplified, success is unpredictable if spinout company development is left to academic founders. Therefore, TTOs and investors focus on installing management teams before registering spinout companies, ensuring stable company development as management teams pursue the security of their own equity stakes and pleasing investors (Monsen and Downs 1965). However, to recruit a management team, the university TTO or academic spinout company requires resources. Although strong connectedness overcomes many of the resource constraints, in order to have strong connectedness in the first place, substantial endowment is necessary (Patzelt and Shepherd 2009). In the Scottish University Network, it was observable that outcomes are difficult to achieve and rely extensively on regional publicly-financed support programmes (Brown 2016), without which attracting a management team, albeit at times from afar, is hardly possible. As Brown (2016) noted, particular Scottish innovation problems lie in policy lock-in, and so the findings regarding the Scottish University Network are unsurprising, with limited entrepreneurial activity in the region.

Whilst the primary role of the management team is business building, the secondary role is to bring in and develop networks (Franklin et al. 2001; Wright et al. 2006), effectively strengthening the connectedness of the spinout company. This undertaking is uneasy and in part reliant on the management team's existing level of connectedness and ability to strategically seek out actors advantageous to the spinout company’s development. Furthermore, it is important for spinout companies to involve academic founders, as the diversity of the company's management team is critical in a spinout's performance (Visintin and Pittino 2014).

This could be observed particularly well in Welsh University Network, where academic founders were engaged post-formation, whilst TTO of Midlands University Network was clear about designating an academic founder's role, including no engagement.

Investors

Poorly connected university networks, as in the case of Scottish University Network, rely on publicly-funded support programmes to recruit management teams and task that team with attracting investors. This increased network distance compromises the quality of success outcomes by switching network centrality position from TTO to management team. The implications of such poor connectedness for TTO are in reduced opportunities of TTO and its highly constrained position to support commercialisation activities, due to nearly non-existent structural holes in its vicinity. Clearly, the struggle to connect with investors is reflected in the low survival of Scottish University Network's spinout companies. In contrast, university networks characterised by strong connectedness, such as in London University Network, maintain the TTO's central position, enabling it to access opportunities advantageous to its spinout companies, in particular financial investment from business angels and venture capitalists (Wright et al. 2006; Siegel et al. 2007; Huggins 2008).

Whilst good connectedness allows access to such opportunities, close collaboration has a direct effect on selectivity activities of university TTOs. This is exemplified by London and Welsh university networks, where formal partnership with a specialist VC fine-tuned their filtration models, resulting in highly successful outcomes for identified disclosures. As investors' sustainability relies on an appropriate commitment of funding to investment proposals offering a 'trustworthy' return (BVCA/Library House 2005), they need to apply highly effective filtration models. In order to strengthen their selectivity techniques, investors maintain strong connectedness with actors that assist them in resolving information asymmetry problems as to the future potential of a particular disclosure, technology, or company. This is clear from the different expectations investors have compared to TTOs or spinout companies, who focus on the applicability of the technology and exit, whilst the latter actors focus on recruiting

experienced management teams (BVCA/Library House 2005). Therefore, the selectivity of spinout companies is improved greatly in university networks that build and maintain strong connectedness with investors, whether regional or national in scope, as previously suggested (Wright et al. 2006; Siegel et al. 2007; Huggins 2008). As these roles in Midlands, London and Welsh university networks were clearly played by TTOs, the results offer some confirmation of the importance of TTOs taking on intermediary roles (Siegel et al. 2004; Alexander and Martin 2013).

Furthermore, the temporal dimension plays a critical role in the engagement of investors at spinout companies. All university networks emphasise the need for funding at early stages; however, only London and Welsh university networks partner with a specialist investor to select disclosures of the highest commercial potential, and TTOs of both these university networks offer seed funding to these spinout company prospects, recognised as a critical step prior to VC investment (Wright et al. 2006; Huggins 2008). The example of Scottish University Network specifically, which had no early funding access, could suggest a role for a proof-of-concept centre (Bradley et al. 2013) in the locality or region, to overcome the unavailability of investment. Although crucial at such an early phase to endow a spinout company with resources which kick-start its development, in both networks the investor's long-term engagement is particularly stressed to allow the spinout company to minimise time spent fund-raising and maximise time devoted to business-building. This is confirmed by a specialist VC investor who outlined that their commitment to spinout companies spans at least fifteen years of engagement with continuous funding.

Business incubators

The core role of business incubators is provision of flexible office space, which has a negligible influence on spinout company success, as found in interviews at Midlands, London and Welsh university networks, confirming a number of previous studies (Di Gregorio and Shane 2003; Lockett and Wright 2005; Fini et al. 2011; Gonzales-Pernia et al. 2013; Hewitt-Dundas 2015). This is largely due to the original role of a business incubator in supporting business

development (Carayanis and von Zedtwitz 2005; Grimaldi and Grandi 2005; Wynarczyk and Raine 2005; Bruneel et al. 2012), which is clearly different from their current roles. Whilst at inception they might have been better funded with public programmes, withdrawal of such support transformed business incubators into little more than office rental spaces. In addition to that, in each university network it was stressed that spinout companies are incubated in their respective departments, a crucial aspect given the decay effect of knowledge spillovers (Rodríguez-Pose and Crescenzi 2008), therefore cancelling out the need for business incubators. This is especially clear in the Midlands and London universities' networks' incubators, both open to local population of businesses able to afford their rents, geared towards a wider local and regional economic impact (Benneworth and Charles 2005). Furthermore, as found in Salvador and Rolfo (2011), even though there might be a higher incidence of spinout companies in places with business incubators, this does not mean that spinouts would be based at those facilities - lending some confirmation to their findings.

Although business incubators are found to play an insignificant role in spinout company success, their limited input at certain points on a spinout's development path may be beneficial to its outcomes. Business incubators provide a well-connected network of entrepreneurs and, at times, investors (Bruneel et al. 2012). For example, Midlands University Network improves its connectedness by using links developed by business incubator with business angel investors and management teams. Nevertheless, a similar utility of business incubator has not been observed in case of London University Network, suggesting perhaps a role that is non-essential to spinout company outcomes. Furthermore, this indicates that for TTOs that are expected to play central roles in university networks (Siegel et al. 2004; Alexander and Martin 2013), those which do not fully develop their connectedness attempt to bridge their gaps using business incubators. As with Scottish University Network, this approach increases the distance between the central TTO and other network actors, leading to poorer resource access and inflating the aggregate constraint (Burt 1992) of TTO, affecting its support for spinout companies. In effect, university networks without business incubators should not be affected in their spinout companies' success

outcomes. However, in poorly connected university networks, business incubators improve their linkage functionality.

Networks

It is clear that networks are costly to develop (Patzelt and Shepherd 2009) and represent opportunities and resources that spinout companies cannot access directly from their own parent universities (Grandi and Grimaldi 2003; Fini et al. 2011). In addition, spinout companies utilise extensive networks most intensely in their early stages, as Waljan, CEO of Welsh Therapeutics, explained, offering access to professionals the company was unable to employ for reasons of financial risk and commitment. Furthermore, networks characterised by strong connectedness benefit from closer trust-based relationships (Burt 1992), which improve the transfer of information, opportunities, and resources.

University network's connectedness is a sum of inputs from its elements' network capitals (Huggins 2009, 2010a). Therefore, a critical discerning factor of success here is the recognition that a university network is built up by specialist networks contributed by TTOs (Franklin et al. 2001; Locket et al. 2003; Shane 2004a; Farnstrand Damsgaard and Thursby 2013), academic founders (Bourelos et al. 2012), management teams (Franklin et al. 2001; Lockett et al. 2003; Wright et al. 2006), and investors. Although connections of TTOs vary extensively across university networks explored, especially exemplified by London (a large and highly diverse network) and Welsh university networks (strong collaboration with VC partner), the overall level of connectedness appears to define spinout company outcomes. This is especially crucial as the studied networks are university-centred, given university's more central position in networks (Roper and Hewitt-Dundas 2013). Academic founders typically have strong links within academia, but also with industry, playing a critical role in spinout company development. Management teams bring their own networks within industry, but are also capable of connecting with investors, perhaps playing the most dynamic role in a university network's connectedness. Finally, investors have specialist networks with management teams, other investors, and

consultants that enable them to assess commercial opportunities and inflate their business potential in a short space of time.

7.4 Core success dimensions: filtration, connectedness, and time

From the analysis performed on the data collected from the four distinct university networks a number of themes were identified that represent spinout company success. These themes reflect three dimensions that help explain university spinout company success, based on the frequency of occurrence across all university network actors. These are: connectedness, filtration, and time, as captured in Figure 7.1.

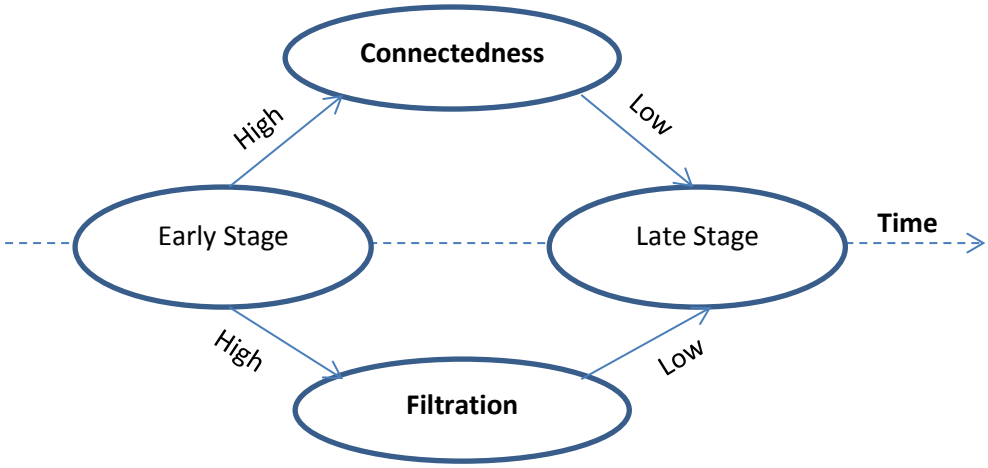


Figure 7.1 Dimensions of spinout company success in university networks

The first dimension - connectedness, represents a crucial feature of any network, and describes the level of network density or centralisation subject to space. In social network theory, it would be concerned with the number of connections between actors in a network (Freeman 1978). Consequently, the size of the network is dependent on the needs of the spinout company and its ability to invest in network capital (Huggins 2010a). Poor connectedness would be expressed by actors in a network being largely disconnected from each other, constraining the size of such network. Consequently, a central actor in a university network such as TTO would have limited access to resources and opportunities with which to support its commercialisation efforts in forming spinout companies and ensuring their success. Conversely, high connectedness is a manifestation of a network that is large and has multiple linkages between actors. This translates

into good access to resources and opportunities to support spinout company generation and survival, representing a high level of network capital (Huggins 2010a).

Furthermore, connectedness is strongly related to the broader network environment, as the geography of university networks clearly defines their reach, and to quality, as the density of connections translates into outcomes for spinout companies. For example, urban-based university networks in core regions benefit from connections to mostly spatially proximate actors, as evidenced in the four illustrative cases. These spatially-concentrated university networks tend to be characterised by dense connections. The elemental part of this is evolutionary processes behind development of place-based university networks, characterised by clustering of core actors relevant to spinout company success (Bekkers et al. 2006), much in the notions of learning region (Storper 1993; Florida 1995; Asheim 1996; Morgan 1997), regional innovation systems (Cooke 1992) or localised/regionalised triple helix models (Etzkowitz and Leydesdorff 2000). However, there is a possibility (unobserved here) that such university networks, whilst proximate, might have poor network size, in effect decreasing the level of connectedness. This could be a result of underinvestment in network-building capabilities (Huggins 2010a), given the high costs of such activities (Patzelt and Shepherd 2009). Conversely, university networks characterised by poor connectedness can be found in less urban and more remote locations. As such, to overcome these spatial issues they would reach out to key actors at a larger physical distance, as suggested by Huggins (2010a) in his deliberations on characteristics of network capital. Although in the four illustrative cases, it was observed that such a network has a low level of connectedness, there could be a university network with such distance-unconstrained focus that is characterised by a high density of connections.

Whilst alternative architectures, in terms of connectedness, are probable, evidence for such organisations has not been captured in this thesis. Furthermore, there is an inherent problem with such alternatives, given extant literature suggesting that the density of networks has a proximate character (Storper 1992, 1995b; Storper and Scott 1995; Storper 1997; Howells 2002;

Scott and Storper 2003). Therefore, it is expected that proximate university networks would be dense in connections as a consequence of social capital (Huggins 2010a), signifying strong connectedness, whilst distant university networks would be characterised by poor quality connections and a consequently low level of connectedness. These architectures would translate into outcomes for spinout companies, with university networks of high level of connectedness related to greater numbers of spinouts formed and improved survival results.

The second dimension relates to decision-making and is identified as filtration, signifying a university network's ability to select disclosures and later spinout companies with the highest probability of successful outcome. Filtration is concerned with the quality aspects of university networks, which consider returns on investments in the relationships (Huggins 2010a). Previous studies of academic entrepreneurship recognised selectivity (Degroof and Roberts 2004; Clarysse et al. 2005) as part of a set of success-oriented dynamics, with Fogelberg and Lundqvist (2013) criticising it as being merely managerialist, suggesting such contexts should evolve into complex network-based systems. Whilst selectivity is a single stage process, filtration may involve numerous stages and types of catalysts, including the TTO's rigid or flexible approach to supporting spinout companies, which is evidently based around decisions about choices to support or withdraw support from spinout companies. What this means for the commercialisation process that results in successful spinout companies is that, from the disclosure stage until spinouts become successful (i.e. sold to a larger established company), the intermediate spinout company project requires constant evaluation and assessment to determine if it is commercially viable and whether it is on the correct path that ensures success.

Effective filtration is characterised by university networks that actively engage their actors in selectivity processes, and is most visible in the number of disclosures translated into spinout companies at early stages, and an overall high survival rate of spinouts later in their development. This reality contrasts with university networks with porous filtration, which incorporate a greater number of spinout companies from their disclosures, and have passive involvement of their actors in assessing the commercial potential of primarily disclosures. Once

spinout companies from such porous university networks reach later stages, when investors and markets evaluate their commercial viability, survival outcomes become distinctly low. Clearly, university network actors, especially spinout companies, need to appropriate returns from their investments in developing connectedness (Huggins 2010a), and strong filtration delivers these outcomes.

It appears clear that university networks characterised by greatest survival rates are both strongly connected and operate effective filtration of knowledge. Whilst numerically London and Welsh university networks' annual disclosures translation into spinout companies is virtually the same (respectively: on average 1.6 spinout companies from 77 disclosures annually between 2002/3 and 2013/2014, and on average 1 spinout company out of 45 disclosures per year between 2002/3 and 2013/2014; approximate early filtration equal to 0.02),[7] the volumes underlying their activities are clearly of different magnitudes. Midlands University Network is strongly connected, given its actors' networks; however, with the Midlands University Network's porous filtration (average of 2.5 spinout companies from 70 disclosures annually between 2002/3 and 2013/2014; achieving circa 0.04 early filtration level), it is unable to achieve success outcomes comparable to those of Welsh University Network. Finally, Scottish University Network suffers from low resource endowment, which is responsible for its poor connectedness and porous filtration (on average 1 spinout company is formed from 20 disclosures per year between 2002/3 and 2013/2014; early filtration level of circa 0.05).

The final dimension - time - recognises that success of spinout companies is not independent of time and that connectedness and filtration change their character over time. Crucially, this dynamism of university networks reflects the evolutionary character of network capital (Huggins 2010a), where with time spinout companies become more strategic and selective in their network investments. This is observable in the attention devoted by all interviewees to the early stages of spinout company development, where connectedness and filtration are most

[7] If the figure is compared to the size of holes in the filtration mesh, the lower the number, the finer the filter. Conversely, the larger the number, the larger the holes in filtration mesh, indicating a more porous filter.

intensely employed to select the correct opportunities and endow them with the resources and networks to increase their chances of survival. It was evident in these accounts that at early stages, spinout companies relied on both social and network capital.

With time, the intensity levels of filtration and connectedness decrease, given that spinout companies have already resolved many information asymmetry problems and become more self-sufficient as increasingly established businesses. These dynamics clearly resemble inducing early sunk cost-type commitments to success as identified in firm survival literature (Hudson 1987; Murray 1988; Duchesneau and Gartner 1990; Bruderl et al. 1992; Gimeno et al. 1997; Oberschachtsiek 2010). Furthermore, these decreased levels of filtration and connectedness represent a transition away from social capital, where more calculative and careful decision-making reveals a spinout's network capital dependence (Huggins 2010a). This was particularly well captured by Wil from Welsh Sciences, who stressed the need to build relationships in a planned approach, according to business needs. Additionally, it is important to note that the role of management team in building a spinout company transforms over time, increasing the team's engagement in the company. It signifies decreased reliance on connectedness for survival and eased (albeit still very effective) filtration, stemming from a greater availability of information on current and past performance of the spinout company.

These three dimensions of success indicate a much greater complexity of a cooperative of different factors determining company success. Whilst building and maintaining networks is recognised as crucial to spinout companies, these networks have scarcely been defined, discounting the interpretation and understanding vital for actors forming university networks to achieve desirable outcomes. Similarly, although the importance of different actors was identified in previous studies of academic spinout companies, their exact role in determining business success remained largely unknown. Connectedness and filtration across time clearly resolve these problems, enhancing understanding of entrepreneurial processes beyond the visible and obvious.

7.5 Conclusion

This chapter's focus was to illustrate academic spinout company success by examining in-depth four distinct university networks, exemplifying the dynamics and complexity of actors and processes involved in achieving entrepreneurial survival. In the Scottish University Network, the success of academic spinouts is difficult to achieve, given constraints placed by the unfavourable geographic location, resource constraints of TTO, and poorly developed connections. As a result, Scottish University Network is characterised by low level of spinout company formation and poor survival. Midlands University Network represents a different environment, which benefits from a more central and urban location, with well-developed networks, but underfunded and undergoing change from a previous unsuccessful approach to commercialising knowledge through spinout companies. The revised procedural approach allows Midlands University Network to create a high number of spinout companies, but due to rigidity arising from financial starvation, it achieves low survival rates.

London University Network benefits from a highly urban location in a core UK region, with extensive networks. In addition, the TTO of London University Network is well resourced to maintain the network and support its spinout companies. Whilst it creates low numbers of spinout companies, they are highly successful. Spinout companies in Welsh University Network are based in urban locations and benefit from high levels of linkage and well-funded TTOs. Welsh University Network generates large numbers of spinout companies with a high success rate, partly due to the long-term character of its partnership with local VC.

The themes identified from interviews at the four university networks help understand spinout company success as three-dimensional dynamics. It is dependent on connectedness, filtration and time factors. At early stages successful university networks utilise most intensive filtration of spinout company opportunities, and connectedness to endow the most promising ventures with the support necessary to start development. The success of spinout companies is achieved when connectedness and filtration become less important in deciding the businesses' future. This happens as late-stage spinout companies generate revenue, profits, and employ a

significant number of personnel, allowing them to gather greater information about their own past and present performance, from which assessment of future success path becomes less complex.

The following chapter provides a synthesis of findings, merging the parsimonious with the complex. It offers policy implications, recommendations for future research on academic spinout companies and university networks, and it outlines the major limitations of this research.

Chapter 8

Conclusions

This thesis set out to answer the following research question: what elements of university networks contribute to the success of academic spinouts? The thesis has attempted to answering this question by employing a mixed methods research design in a sequential explanatory approach. Consequently, the quantitative analysis presented in preceding chapters has an exploratory character, whilst an in-depth explanation is offered by the qualitative part. Such triangulation allows this thesis to overcome shortcomings that might arise from myopia of singular methodological designs.

This research first identified university networks and broader network environment from a systematic analysis of literature on academic spinout companies. University networks are composed of: universities, technology transfer offices, spinout companies, business incubators and science parks, investors, and management teams (i.e. external entrepreneurs). Each of these actors has been found to be critical to spinout companies individually, yet previous research has not attempted such a broad examination of university networks. Additionally, from the methodological point of view, existing studies utilised poor samples, with typically fewer than a hundred observations, limiting the application of their findings to a broader population of spinout companies, or limiting the understanding of their 'true' impact on regional economies. This study overcomes such shortcomings by investigating a large sample of 870 spinout companies; approaching it from both exploratory and explanatory perspectives; and relating it to both formation and survival of spinout companies.

It is found that the success of a spinout company is determined by a different composition of characteristics of university networks. Spinout company generation is dependent on a number of university network elements, namely: business incubation, investors, management teams, networks and other actors. Conversely, spinout company survival is explained by a different configuration of university network characteristics, notably: investors, management team,

networks, and TTO. Furthermore, across both formation and survival of spinout companies an important role is played by the broader network environment, in which rather paradoxical findings are observed: less developed regions offer more fertile ground for the creation of spinout companies, whilst better performing ones contribute to their survival. These findings are captured by three core success factors identified from in-depth interviews: filtration, connectedness, and time. Whilst filtration is responsible for a continuous process of selectivity, crucially represented by investors, connectedness accounts for networks of spinout companies utilised throughout the firm's development, manifested by elements such as management teams and TTOs. Importantly, the geography participates in the mediation of connectedness in spinout company success, and can either restrict or improve linkage with actors, leading to differential outcomes of university networks.

This chapter begins with the synthesis of findings from quantitative and qualitative research in Section 8.1. Section 8.2 outlines how the thesis contributes to theory, methodology and policy. Subsequently, Section 8.3 explains the limitations of the research, including the generalisability of findings. Finally, Section 8.4 offers recommendations to overcome the deficiencies of this study, and to provide directions for future research in the field.

8.1 Synthesis of findings

This section combines findings reported in the quantitative chapters (5 and 6) with those observed in the qualitative Chapter 7. It is structured around the following aspects: geography, universities (TTO), management teams, investors, business incubators, and networks. Following the explanatory sequential mixed-methods approach, each subsection explains the quantitative results with qualitative findings.

8.1.1 Geography

Spinout company formation is found to be more intense in regions characterised by lower levels of economic development, suggesting that university networks centred on such immobile knowledge-creating institutions as universities (Grimaldi et al. 2011; Berbegal-Mirabent et al.

2013) play critical roles in economic development in their regions (Morgan 1997; Brown 2016). Conversely, spinout company survival is greater in regions that are better developed economically, as reported in a performance study by Iacobucci and Micozzi (2015). This paradoxical situation can be explained by the role of the broader network environment in university networks that represent university-centred innovation systems (Cooke 1992; Lundvall 1992; Storper 1993; Florida 1995; Asheim 1996; Etzkowitz and Leydesdorff 2000), in which remote locations require university networks to reach beyond regional boundaries in order to connect with necessary actors, a parallel situation to how innovative and high performing firms build spatially-unconstrained networks to source their knowledge (Huggins et al. 2010). In contrast, this is mitigated by geographically better connected locations, such as larger urban (metropolitan) areas in non-peripheries. Clearly, regions characterised by less peripheral economic development outcomes typically have a more urban character (e.g. London), allowing them to utilise the clustering of various actors of university networks.

The implications of these findings for university networks in peripheral or small urban locations are twofold. First, such locations constrain access to dense networks of diverse actors, impacting on the success of spinout companies (e.g. Scottish University Network), due to reduced access to filtration actors (i.e. investors). Second, in order to mitigate such spatial disadvantages, regional actors need to develop far-reaching linkages (e.g. Welsh University Network) to improve their connectedness. Nevertheless, the key problem of such network reconstructions lies in the availability of resources for universities and spinout companies to acquire capabilities to connect with actors from unfamiliar places. This is an uneasy task, given that firms' networks and resultant survival have a strong localised character (Dahl and Sorenson 2012) due to path-dependent (Nelson and Winter 1982) familiarity development.

8.1.2 University (TTO)

Whilst experienced TTOs have no effect on spinout company formation (Aldridge and Audretsch 2011; Clarysse et al. 2011a; Bourelos et al. 2012), they enhance spinout company survival chances. These findings are novel on two accounts. First, a substantial proportion of the

literature on spinout companies dismissed the importance of TTOs to spinouts (Di Gregorio and Shane 2003; Vohora et al. 2004; Lockett and Wright 2005; Fini et al. 2009), sending rather misleading signals to university administrators and policy-makers. Second, as limited interest in success aspects has been exhibited by academic entrepreneurship scholars (e.g. Di Gregorio and Shane 2003; Fini et al. 2009; Fini et al. 2017), the role of TTOs was perhaps prematurely dismissed. Broadly in line with notions of the TTOs' suggested 'boundary-spanning' role (Siegel et al. 2004; Wright et al. 2006; Siegel et al. 2007; Alexander and Martin 2013), TTOs improve the connectedness of spinout companies and play a critical role in early-stage filtration of spinout company opportunities (e.g. London University Network). However, it is critical to emphasise from the observed results that spinout opportunities emerge from academic staff (Vohora et al. 2004), as such university networks that have TTOs and are characterised by very low or no research activity cannot be expected to generate large numbers of spinout companies, if any.

The responsibility for ensuring a stream of commercial opportunities leading to spinout company formations lies clearly with university administrators managing internal efforts devoted to research activities, and policymakers that decide on the allocation of funding for research. Furthermore, given the role TTOs play in filtration and developing university network connectedness, a revision of the TTO role in the process of knowledge commercialisation could stimulate appropriate top-down responses. This is especially important, as TTOs appear to play a much more important role than just 'boundary-spanners' (Siegel et al. 2004; Wright et al. 2006; Siegel et al. 2007; Alexander and Martin 2013), as they actively participate in the filtration processes of entrepreneurial opportunities (Macho-Stadler et al. 2007) made available to them.

8.1.3 Management team

Both the formation and survival of spinout companies depends on the presence of experienced external entrepreneurs in the founding teams of spinouts, who are primarily responsible for spinouts' connectedness (Franklin et al. 2001), as well as bringing unique dynamic capabilities

(Teece et al. 1997; Eisenhardt and Martin 2000; Teece 2007) through their commercial (Wennberg et al. 2011) and management skills (Grandi and Grimaldi 2003). By ensuring greater connectedness in spinout companies, management teams resolve problems of resource starvation in new high technology ventures (e.g. Welsh Therapeutics), specifically assisting the academic founders to focus on technology development in the early spinout development phases. Furthermore, engagement of external entrepreneurs in spinouts' management teams allows the companies to portray trust (or credibility) in relations with investors (Wright et al. 2006), who explicitly require commercially-experienced individuals to manage their potential investees. In effect, trust lubricates spinout companies' connectedness attracting positive outcomes in filtration processes.

University networks that fail to include management teams in their setups achieve inferior formation and, in particular, success outcomes (e.g. Midlands University Network). While management teams are important actors in architectures of successful university networks, it is critical to emphasise that building such linkages is difficult, as spatial effects may limit proximate access to entrepreneurial talent (e.g. Scottish University Network). Finally, it is critical to observe that spinout companies require a diversity of actors in their founding teams, including both academic founders and external entrepreneurs (Visintin and Pittino 2014) to achieve greater success outcomes. Therefore, university networks that remove academic founders from spinout companies and instead prioritise professional management teams struggle to achieve high success outcomes, because academic founders not only develop underlying technology, but also spinout company's connectedness (e.g. Welsh University Network), especially through industry linkages (Krabel and Mueller 2009; Bourelos et al. 2012; Goethner et al. 2012).

8.1.4 Investors

Generating spinout companies is dependent on university's access to VC-type funding; however, it is not reliant on access to seed corn investment. Furthermore, the success of spinout companies confirms the importance of private equity-type investors. These findings can be

better understood from the process of spinout company formation. When a particular disclosure is identified to have commercial potential, TTOs tend to look for seed funding (e.g. Welsh University Network); however, when such investment cannot be secured, TTOs register spinout companies in order to obtain larger VC investment (e.g. Scottish University Network). This process is well aligned with the reality of an early stage funding gap (Huggins 2008b), forcing spinout companies to search for larger investment.

Whilst obtaining VC funding is regarded as a signal of a spinout company's business quality (Fini et al. 2017), this is a short-sighted understanding of the complex reality of university knowledge spillovers. In particular, university knowledge is often more advanced than the current technological paradigm of consumer markets, beyond purely tacit/explicit considerations (Nonaka 1991; Nonaka 1994), causing a mismatch between what can currently be absorbed by the market and what researchers study. This is increasingly clear from the fact that VC firms often employ professionals with purely financial backgrounds (Wright et al. 2006), making it difficult for them to comprehend the nature of highly complex knowledge generated at universities. Furthermore, even within academia breakthrough, research receives recognition only after a time-lag (e.g. Nobel prizes), suggesting a general lack of ability to identify commercial applications of university-generated knowledge in university networks.

The importance of this finding is in all three aspects of success of university networks: filtration, time, and connectedness. First, investors are core filtration agents in the process of university knowledge commercialisation (Fini et al. 2017). They identify the knowledge with most immediate commercial opportunities (e.g. London Investments), whilst rejecting all other disclosures. In further refining processes of spinout company success, investors are the driving force behind continual filtration of the most successful companies. Second, investors play an ancillary role in improving connectedness of university networks by tapping into their own linkages with management teams and other investors (e.g. Welsh University Network). Third, VC-type funding has the unique characteristics of private equity investors pursue investment

exit goals (BVCA/Library House 2005), consequently building a medium- to long-term relationship with spinout companies.

8.1.5 Business incubators

The importance of business incubation actors in university networks offers a complex picture of spinout company success. Whilst spinout companies are primarily incubated within university departments (e.g. Scottish University Network), having access to science parks is associated with higher formation levels, contrary to previous UK findings (Lockett and Wright 2005). However, there is no relationship between business incubation (on-campus, off-campus or science park), and spinout company survival. These results can be understood from the aspect of connectedness, where science parks improve university networks' links to local populations of entrepreneurs and investors (as observed in Midlands University Network). Consequently, university networks with access to science parks generate more spinout companies, yet the effect is more a result of co-location than interaction (Salvador and Rolfo 2011). Interestingly, such university network designs struggle to support spinout companies post-formation.

The implications of these findings concern university administrators and policymakers. Business incubation in a designated facility is more important for a local stock of businesses, with UK spinout companies rarely using such services (Hewitt-Dundas 2015), contributing to the wider regional economic development role of such structures (Benneworth and Charles 2005). However, in the context of academic spinout companies, business incubators (science parks in particular) serve merely as connectedness-strengthening actors (Wynarczyk and Raine 2005). Such a role is especially critical in poorly developed and peripheral regions, where access to localised entrepreneurial talent is limited (as illuminated in Scottish University Network). Furthermore, such university network structures may result in developing entrepreneurial clusters, although the outcomes are yet to be observed.

8.1.6 Networks

The connectedness of university networks is critical to both spinout company formation and survival. Universities with greater industry links generate more spinout companies, whilst spinouts with advantageous positions in university networks have better survival prospects. The core reason for connectedness playing such a strong role is primarily resource starvation of academic spinout companies (Grandi and Grimaldi 2003; Hayter 2013), which need to develop underlying technology, acquire commercial orientation, obtain capital, and connect with potential customers and suppliers to understand their markets (e.g. Welsh Nano). As networks are very dynamic, spinout companies have to proactively reconstruct their linkages over time to match changing business needs (Rasmussen et al. 2015). In doing so, spinout companies should adopt a calculative approach (Huggins 2010a, b) to maximise derived benefits, such as a greater likelihood of survival (Mustar 1997) or performance (Scholten et al. 2015).

Building networks is a resource-intensive activity (Patzelt and Shepherd 2009), requiring special consideration from all university network elements. Actors that actively contribute to spinout company success (i.e. TTOs, investors, management teams, business incubators) through network construction and reconstruction cycles require support from policymakers to facilitate and lubricate such activity much in the line of original thinking about the stimulant role of government behind triple helix (Etzkowitz and Leydesdorff 2000), innovation systems (Cooke 1992; Lundvall 1992), and learning region (Storper 1993; Florida 1995; Asheim 1996; Morgan 1997) models.

8.2 Contributions

8.2.1 Theory

Spinout companies constitute a unique mode of knowledge spillover, thanks to the direct character of involvement of an academic founder (i.e. knowledge creator) and the ability to transmit both tacit and codified knowledges. Whilst scholars studying academic entrepreneurship contributed immensely to understanding how such firms are formed (e.g. Di Gregorio and Shane 2003; Lockett and Wright 2005; Fini et al. 2011; Bourelos et al. 2012;

Ramaciotti and Rizzo 2014; Berbegal-Mirabent et al. 2015; Meoli and Vismara 2016), they inadvertently placed little importance on the determinants of survival of spinout companies (e.g. Nerkar and Shane 2003; Criaco et al. 2014). Therefore, the major contribution of this thesis is to understanding the success of academic spinout companies. Thus this study focuses on the role of university networks and their particular features across time and space as they contribute to both formation and survival.

The geography of academic entrepreneurship has rarely been considered, with the most prominent work thus far conducted by Iacobucci and Micozzi (2015), as national-level studies often focused on samples too small to examine regional effects of such activity. In this thesis, regional differences in the UK context are clearly illuminated, offering a unique understanding of the conditions necessary for spinout company formation and survival. In particular, regions characterised by poorer economic development are more advantageous for spinout company formation, where universities tend to play a more prominent economic role (Brown 2016). In contrast, spinout companies succeed in regions that are better developed, illuminating a paradox of such direct knowledge spillovers. These findings represent the complexity of regional innovation system set-ups, where such unique types of firms as academic spinout companies might not fit into the previous RIS moulds that offer good support for other forms of entrepreneurship. The challenge this poses for the economic geography literature is to steer towards less parsimonious modelling of regional ecosystems.

The role of university TTOs has been identified as having a limited effect on spinout company formation (e.g. Vohora et al. 2004; Fini et al. 2009; Aldridge and Audretsch 2011; Bourelos et al. 2012; Fini et al. 2017), as confirmed in this study. However, rather than such findings meaning that TTOs should be disbanded or regionally centralised (as alluded to by Degroof and Roberts 2004), this thesis examined the role of TTOs in the survival of spinout companies, contributing a novel insight to the current stage of academic entrepreneurship literature. Specifically, it appears critical to redefine the role played by TTOs in the lifecycle of spinout companies. Academic entrepreneurship literature needs to position TTOs in university networks

as boundary-spanning actors that engage in activities that offer stimulus to the survival of university spinout ventures. TTOs achieve such outcomes by engaging with multiple actors across local, regional and national space.

Whilst previous research identified the important role of management teams to spinout companies (e.g. Franklin et al. 2001; Lockett et al. 2003; Vohora et al. 2004; Hayter 2013), especially at the formation stage, a broader understanding of management teams to survival of these firms was elusive. Clearly, experienced entrepreneurs are critical to spinout companies, especially if they improve the diversity of the company's founding team (Visintin and Pittino 2014). Furthermore, it is important to observe diseconomies of management (Kaldor 1934; Robinson 1934; Visintin and Pittino 2014) in complex high technology ventures such as spinout companies, where quality (not mere quantity) entrepreneurial talent is necessary for their survival. For spinout companies, this means that to achieve survival, they require high quality management teams that include experienced entrepreneurs. The importance of this is in distinguishing the contribution of the academic founder, which is primarily focused on knowledge transfer from university. As such, it is critical to view spinout companies as comprising knowledge translating actors (i.e. the academic founders) and knowledge application or innovation actors (i.e. experienced entrepreneurs). Therefore, academic entrepreneurship literature needs to position the spinout company more closely within knowledge spillover processes to better understand the success of these firms.

Investors enjoy the most prominent position in the literature on academic spinout companies; however, little has been known about the effects of early-stage finance gap (Huggins 2008b) on spinout company formation. It has been illustrated here that spinout companies unable to source seed funding change their orientation towards VC-type investment. Consequently, while the funding gap has remained in place, spinout companies adapted to it by pursuing larger finance. There appears to be a clear dynamic that has not been observed before in the academic entrepreneurship literature, in which spinout companies are typically considered in a static form. In effect, this thesis has captured the evolutionary aspects (Nelson and Winter 1982) of spinout

companies, whose development path reveals adaptation to conditions that would otherwise restrict their growth.

Business incubation traditionally asserts a role that shields companies from failure (Carayannis and von Zedtwitz 2005; Grimaldi and Grandi 2005). Only limited evidence for that role has been found in relation to spinout companies' formation, particularly in science parks. As can be understood from this thesis, spinout companies do not normally locate themselves in designated business incubators (Hewitt-Dundas 2015), but stay within university departments. In turn, the role of science parks is in improving connectivity of university networks that is most critical at early stages of spinout companies. As found by Hewitt-Dundas (2015), since spinout companies rarely locate themselves in business incubators, there is no direct effect on their survival. This has implications for the academic entrepreneurship literature, which presents business incubators in a different light (e.g. Bourelos et al. 2012). Most recent research (Salvador and Rolfo 2011; Hewitt-Dundas 2015) lacked sufficient depth to examine the antecedents of such effects. Additionally, it is critical to incorporate this redefined role into RIS, where business incubators may indeed have a wider economic impact as a side effect of policies stimulating entrepreneurship support infrastructure development (Benneworth and Charles 2005).

Studies of academic entrepreneurship indicated a strong role for networks (e.g. Brooksbank and Thomas 2001; Vohora et al. 2004; Mosey and Wright 2007; Grimaldi et al. 2011; Hayter 2013); however, little evidence beyond qualitative (Rasmussen et al. 2015) or small sample quantitative studies (Scholten et al. 2015) has been provided to confirm that. This thesis not only identifies that spinout companies need to play a highly central position in their networks, but it also quantifies this to provide strong evidence for networks being critical to their formation and survival. Specifically, academic entrepreneurship literature needs to recognise the utility of appropriate social network theories, in particular structural holes (Burt 1992) to advance understanding of spinout companies' development and success. Clearly, sustainable spinouts actively engage in configuring their network positions to maximise opportunities for development.

Through the use of qualitative research, this thesis contributes to understanding of dimensions critical to the success of a spinout company, particularly: connectedness, filtration, and time. These dimensions bring together the literatures of academic entrepreneurship and economic geography, where high technology entrepreneurial survival (Criaco et al. 2014) appears dependent in large part on geographical characteristics, such as networks (Huggins and Prokop 2016) and evolutionary development (Krugman 1990). Critically, university networks characterised by strong connectedness enjoy greater spinout company formation and greater ability to support their future development. Such university networks tend to have a proximate character (e.g. large urban locations) where availability or density of actors allows for the development of links. Over time, connectedness plays a limited role, as established spinout companies achieve sustainability stage, where additional links bring benefits of decreasing value. In other words, there are diminishing returns to connectedness as a spinout company develops. Increasingly mature spinout companies engage in more calculative network-building activities (Huggins 2010a), and therefore they focus their resources on achieving improved network returns.

A similar mechanism is found in filtration dimension, where university networks with effective filtration engage in continuous evaluation of a spinout company, with the most intense filtering activity concentrated in the early stages of the spinout's lifecycle. Filtration allows the selection of spinout companies that have a higher probability of success, offering a return on investment in connectedness-oriented efforts. University networks with porous filtration might enjoy high formation rates of spinout companies, but low survival rates of these firms. Similarly to connectedness, there are diminishing returns to filtration as a spinout company reaches sustainability stage. These findings contribute to the understanding of mechanisms behind successful regional innovation systems (Cooke 1992).

In firm theory considerations, as expounded in Chapter 2, it was noted that spinout companies are unique enterprises that do not fit neatly within currently available explanations of firms' existence. Specifically, there are two core problems with extant firm theories: a)

overtheorisation (Machlup 1967; Hart 1989; Maskell 2001); and b) an inability to capture academic spinout companies adequately. It is suggested here that existing theorisations of the firm could contribute to a single model that is more efficient at dealing with a special category of firms (as depicted in Chapter 2), which spinout companies appear to be. In particular, such a model could engage with aspects that are clearly complex and network-based when considering the eight dimensions of firm's existence in university networks: boundary, efficiency, management, resources, knowledge, capabilities, structure and ownership. Academic spinout companies require a network theory of the firm that takes account of their complexity as entrepreneurial ventures. This theory should posit that firms exist as actors in networks of organisations and individuals across geographical spaces. In this view, firms acquire, absorb, transform and exchange knowledge efficiently and effectively by participating in these multi-actor networks and exploiting the benefits of their own connectedness across time. With this revision, the network theory of the firm is rooted in economic geography, resolving many deliberations arising in Maskell (2001).

8.2.2 Methodology

This study has been difficult to conduct as there is no official public record of spinout companies in the UK. As a result, a novel approach has been adopted in constructing a sample for this research, where a privately-owned website that publishes the names of spinout companies was utilised, together with university websites, to collect the names of spinouts and their affiliations. At the time of data collection (2014), no previous research was known to have adopted such an approach, although a year later a study was published which made use of such triangulation (Hewitt-Dundas 2015). Nevertheless, this research has gone a step further in order to collect data on spinout companies from the FAME database, rather than conducting a survey of such firms. The core motivation for such an approach was to overcome the existent methodological limitations of university spinout company studies, namely small samples. While the vast majority of research focuses on samples of less than a hundred spinout companies, this research examined 870 such firms, providing a strong foundation for the applied analyses.

The use of mixed method design is not unique in spinout company studies, but it is infrequent (Nerkar and Shane 2003, Bekkers et al. 2006; Hoye and Pries 2009; Lam 2011), implicit, and focuses on both a survey and interviews, resulting in small quantitative samples. This thesis employed a different approach, explicitly using an explanatory sequential design, which has not been outlined before in university spinout company research, contributing a novel methodological insight to the field. Furthermore, this study does not utilise a survey method; instead, it asserts its main motive to be that of maximisation of sample size in order to generate more credible, representative and generalisable findings that contribute to knowledge within a post-positivistic paradigm (Guba 1990; Guba and Lincoln 2005). As a result, the triangulation performed here signifies a substantial attempt at pursuing reality (Guba 1990), in particular, that of the success of university spinout companies in the UK.

As the success of university spinout companies has not been extensively studied, this thesis contributes an analytical model of examining university network elements. Previous models of spinout company success were limited to one university - i.e. MIT in the US (Nerkar and Shane 2003), or focused on human capital only (Criaco et al. 2014). As a result, this study combined previous modelling knowledge from firm survival literature and examined a conceptualised university network framework to better understand how survival of spinout companies is achieved within such university-centred innovation systems. Additionally, this thesis studied both formation of spinout companies and their survival using a similar model design, which added a novelty of understanding a time-based context of success for spinout companies, especially through identification of variable outcomes of university network architectures.

Studying network aspects is infrequent in the literature on university spinout companies (e.g. Rasmussen et al. 2015; Scholten et al. 2015), although many studies suggest spinouts benefitting from networks (e.g. Brooksbank and Thomas 2001; Grandi and Grimaldi 2003; Vohora et al. 2004; Mosey and Wright 2007; Grimaldi et al. 2011; Hayter 2013). Moreover, none of the scholars of academic spinout companies attempted to gain understanding of spinouts' position in networks by applying mixed method designs. These clear methodological

shortcomings of the extant literature are overcome in this thesis, which utilises the original sociological measure of structural holes (Burt 1992) quantitatively from a uniquely-built network of spinout company shareholders, and examines in-depth the importance and characteristics of networks qualitatively to enhance understanding of spinout success.

8.2.3 Policy

Given the above discussion, the academic spinout phenomenon is difficult for researchers to interpret, yet remains even more difficult to translate directly into policies either stimulating or regulating this activity. The high politicisation of this phenomenon (Benneworth and Charles 2005) might be an obstacle in itself to improve spinout creation efforts, stimulate venture's success (Brown 2016), and create necessary mechanisms to stop unwanted and unintended counter-effects. This is especially evident in Fini et al.'s (2017) study, where formation and quality of spinout companies were found to be determined by many opposing factors, clearly advocating careful policymaking.

UK policymakers recognise the complex problems associated with university knowledge commercialisation (Science and Technology Committee 2013), specifically academic spinout companies (Lambert 2003). In particular, policymakers are concerned about how research from UK universities can best be delivered to the wider public, given financial limitations (Science and Technology Committee 2013). Extant research has shed some light onto issues of venture funding (e.g. Huggins 2008b), but new venture investment reality has not progressed significantly in recent years. Policymakers should indeed reconsider whether funding of an early stage character, such as proof-of-concept, could not be provided by government-sponsored agencies. There appears to be a clear market failure motive to justify such intervention. Alternatively, government could stimulate the formation of privately- or part-publicly-operated proof-of-concept centres, as becomes a practice in the US context (Bradley et al. 2013).

University TTOs are clearly underfunded to pursue commercialisation of all university-generated knowledge. Policymakers interested in improving outcomes that are quantity-based

and, in particular as observed in this thesis with regards to Welsh and London university networks, quality-oriented (Lambert 2003), have to consider how best to fund TTOs. One possible solution is to create regional funding that interested TTOs could apply for in order to meet their individual commercialisation needs. Alternatively, policymakers should consider restructuring university funding by adding a category of commercialisation-tied financing, to be distributed by Higher Education Funding Councils of the UK. The intent of such funding should be enhancing the operations of university TTOs.

Given the complex contribution of business incubators to spinout company success, policymakers should examine how best to utilise such infrastructural investments to enhance regional economic development goals. In particular, there is a strong case for all universities engaged in spinout company type knowledge commercialisation activities to have access to business incubators located in proximity. This would require both political will and financial commitment to realise such a challenging goal. However, such a resurgence in business incubator interest also requires policymakers to understand that these actors contribute to stronger RIS dynamics, in particular improving connectedness of university networks. These broadly defined goals will result in positive outcomes for spinout companies, albeit indirectly.

Successful spinout companies clearly require high quality human capital to steer the company through the challenges of knowledge transfer and commercialisation. In recognition of such virtues policymakers should bolster spinout companies' access to experienced entrepreneurial talent at regional level. This could be accomplished with specialist programmes that engage with successful entrepreneurs and connect them with academic founders. Where the availability of such entrepreneurial talent is limited, policymakers should support development of cross-regional programmes. In addition to these developments, there is a clear need for policymakers to aim to overcome high levels of high technology entrepreneurship concentrations across the UK, with policies aimed at developing similar clusters in other regions.

It is evident that spinout companies improve their success outcomes by engaging in the development of their own network positions, allowing them to exploit structural holes (Burt 1992) to recognise opportunities for growth. There is, however, a role for policymakers to support spinout companies that are located in poorly connected university networks to stimulate the development of linkages. As such disadvantaged university networks are typically located in non-urban or peripheral regions, policy development should favour redistribution of outcomes by increased funding devoted to initiatives that support high technology enterprises from such areas.

Successful academic spinout companies undergo filtration processes where experienced and skilled university network actors evaluate the commercial potential of such ventures. However, there is a need to stimulate policy developments that support the creation of such functions at poorly performing university networks and further enhance filtration processes at successful university networks. These approaches require policymakers to understand the value of mechanisms underlying successful RIS.

The success of academic spinout companies varies across and within UK regions. These differences in outcomes necessitate interest of policymakers and appropriate policy responses that would promote efforts that overcome such variations. In particular, UK policymakers need to become sensitive to the fact that spinout company formation and survival require different network architectures. In order to maximise the positive economic impact of such commercialisation activity, it is necessary to construct university networks defined by diversity and strong local adaptation, allowing them to develop resilience characteristics (Bristow 2010).

8.3 Recommendations for further research

This thesis has examined the success of academic spinout companies in the context of university networks. Whilst this research has contributed significantly to advancing understanding of spinout company success, it is the first such study in the UK, and one of the very few in the world. There is a need for more research to share interest in understanding of spinout company

success, in particular by considering different determinants across spinout company development phases. Although this thesis attempted to study both 'ends' (i.e. birth and death) of the spinout company lifecycle, understanding the intermediate phases remains nonetheless limited.

Academic spinout companies are the most ideal form of university knowledge transfer, however, excessive attention has been devoted to them, ignoring much richer forms of entrepreneurship, such as student start-ups. First of all, academics are already in employment and their careers are assessed on non-commercial aspects, compared to students who do not have careers whilst completing their university education. Secondly, the population of students is much larger than that of academics, making their entrepreneurial impact on the economy much more pronounced. Consequently, more research effort should be devoted to understanding how to stimulate formation of student enterprises and ensuring their success.

Spinout company success has been found to vary across regions, yet extant studies have largely overlooked regional aspects. There is a clear need to further the understanding of regional effects on spinout company formation, development, and survival. Future studies should focus on how particular university networks should be adapted to regional characteristics to maximise positive outcomes.

This thesis reported a mismatch between what TTOs do to support spinout companies and what has been known, largely by examining the survival aspect of spinouts. As a result, it is necessary to further investigate how TTOs contribute to spinout company success and what resources they require to operate effectively, in order to understand how TTOs add value to knowledge commercialisation. This is especially important, given the dynamic and continuous learning path followed by each university's TTO in adjusting its operations to improve commercialisation outcomes (e.g. Midlands University Network).

Whilst a network approach has been adopted in this thesis, allowing a quantification of the network positions of spinout companies, as well as examining qualitative aspects of connectedness, it remains a novel and unique method of studying academic spinout companies. Further research should focus on understanding the evolutionary dynamics of networks, with particular focus on both qualitative and quantitative studies, and identification of change in the networks from multiple perspectives of university network actors.

Investors are clearly important for spinout companies to achieve commercial success. It has been observed here that spinout companies obtain VC funding when unable to attract seed funding, adding to the difficulties that new technology ventures experience in early phases of development. Nevertheless, it remains unclear how spinout companies make such decisions and how they organise and fund their early operations prior to obtaining VC funding. Researching these areas should improve understanding of selection spinout companies undergo when in resource-starved conditions.

The starting point of the research underlying this thesis was to build a unique database of UK spinout companies, as information regarding their names, existence and operations remains unknown. In order to continue investigating aspects of academic spinout companies, an official public record of such companies could improve the efficiency of numerous research efforts, especially as it becomes increasingly difficult to identify spinout companies after acquisitions or company name changes. Furthermore, this thesis has observed some shortcomings of HEBCIS, which is the main source of university knowledge commercialisation activity in the UK. It is recommended here that attention should be paid to better development of HEBCIS in order to collect more precise data on spinout companies, as well as minimising response bias (for example, Bristol University has a TTO, but respondents from the university have never indicated this in all rounds of HEBCIS utilised here).

Filtration is one of the core success factors identified in this thesis, however the exact contribution of each university network's actor to this process remains unknown. Consequently,

it is recommended that an increased research effort should be devoted to identifying how different filtration actors operate in university networks, what type of filtration requirements they have at particular stages of spinout company development, and how they interact in selecting successful university spinouts.

Whilst this research intended to gather critical perspectives on the functioning of university networks, it has not engaged with university administrators. Crucially, in the knowledge commercialisation domain where TTOs are institutional sub-units, whether departments or separate legal entities, there is a struggle over mission and strategy between the two parties. It remains largely unknown whether the performance outcomes of university networks are down to structure, or whether it is a consequence of decision-makers with variable interests or understandings of university spinout company formation and survival. Hence, there is a clear need for research rooted in critical theory that could tackle such complex problems, specifically examining power struggles between university administrators and TTOs.

This thesis pursued understanding of the UK context of university networks and the success of academic spinout companies. There is a role for UK policymakers to engage in stimulating the development of regional ecosystems that could improve knowledge commercialisation outcomes. However, there is limited research of comparative character across countries to learn from a diversity of policymaking approaches. Therefore, there is a clear need for research that would examine policy progress that contributes to the development of university networks and their outcomes across countries. The resultant perspectives could inform and shape effective national and regional high technology entrepreneurship policymaking.

Regional innovation systems depend on actors that represent universities, private industry and policymakers. University networks studied in this thesis involve all these actors, however, in empirical investigations of illustrative contexts, the role of local policymakers, as representatives of a particular geography, was excluded. Future research should aim to bridge this gap by studying all actors forming university networks, which could contribute perspectives

not explored in this work. In particular, economic geography scholars should seek to uncover how evolution of university networks aligns with local, regional, and national policy developments, and study the direction of future policy debates as well as the involvement of policymakers in shaping performance outcomes of university networks.

Foundation of a university spinout company is one of the modes of knowledge spillovers. Whilst this thesis tasked itself with investigating success of spinout companies that arises from university networks, this limited focus has not tackled the issue of further knowledge transfers. Specifically, there is a need for researchers to study regional knowledge spillovers originating from spinout companies. Understanding such derivative knowledge transfers would assist in identifying the broad economic development contributions of academic spinout companies. This is especially important, as the success of spinout companies could alternatively be defined in terms of knowledge entrepreneurship induced by a particular spinout, even when the spinout company becomes insolvent. In particular, future research might undertake avenues that explore cluster formation, development of absorptive capacity, or evolution of regional ecosystems.

8.4 Limitations

Although this thesis pursued the most objective view of reality in terms of university spinout company success, and in so doing it utilised mixed methods and a large sample of spinouts, it is still not free from imperfections. First, the inability to access official spinout company data, including names of firms, restricted the data collected and used here. Whilst a sample of 870 spinout companies is used, drawn from a sample frame of 1,331 firms, there is no census of spinouts. In order to overcome this, HEBCIS reporting of active spinout companies was used to test for representativeness of the active firms from the sample frame, establishing a good representation across UK universities. However, lack of public data on spinout companies that ceased operations restricts any comparison to a population or previous studies. In essence, this study suffers from problems associated with 'liability of novelty', i.e. studying that which was not examined before.

In the quantitative analyses a combination of datasets was used, which resulted in a smaller sample. Whilst data was collected on spinout companies formed between 1959 and 2013, HEBCIS data was not available for years prior to 2002 at an institutional level. Furthermore, some of the critical variables used in the regression analysis that measured the university networks, namely, management team, investors (survival analysis), and structural holes, were only available in 2014. The direct consequence of this was the restriction on modelling, where panel techniques would typically be more appropriate.

Whilst qualitative data was collected by employing a purposive extreme case sampling method, it is not without imperfections. A better dataset would involve all actors of university network at each institutional context, however, it was difficult to gain access. Some actors, such as business incubators were not present in all university networks. Furthermore, these illustrative contexts did not study the policymakers' perspective as representatives of regions or university administrators, burdening this work with another limitation. In order to maintain stronger integrity of the analysis, two examples of university networks were excluded, as it was not possible to speak to any representatives from the spinout companies. As a result, the in-depth insights obtained do not have a fully 'rounded' character; however, it was asserted that university TTOs and spinout companies were the two core actors without whom the analysis could not be performed.

Success has been considered here in terms of spinout company birth and survival. This start-to-end approach is imperfect in itself, as success is better explained in financial terms. It is perhaps a major weakness of this thesis, stemming from the unavailability of data. As spinout companies are mostly small firms, they are allowed by Companies House not to disclose all information on their operations, specifically performance-related data, such as revenue, profits or employment. Furthermore, it was impossible to collect data on receipt of investment, in particular the value of such investment, which could elucidate some intermediate success of spinout companies. Whilst data on so called 'investment exits' was captured, it appears rather controversial to refer to acquisitions as successes, given extant critique (Brown 2016). Although such data issues could

have been resolved by employing a survey method, extant research on spinout companies suggested a poor response rate was likely.

Social network analysis performed to construct structural holes variable is limited by the actors selected to build it, namely shareholders. The reason why shareholders were used, is that they form strong formal networks, with invested equity or effort. This in turn illuminates a level of trust in such networks. Nevertheless, a better way of examining the networks of spinout companies would be to survey the firms and ask them to simply indicate individuals they know (e.g. Scholten et al. 2015), but this may have led to an excessively large list of actors difficult to process, with little indication of the importance of such actors. As a result, it is acknowledged that structural holes measured here have an imposed network boundary of company shareholders.

This thesis has confirmed an early stage funding gap and identified the evolution of finance needs of spinout companies towards later-stage capital. However, this work has not pursued solutions to these problems, which exhibit a level of complexity that requires separate research question. Whilst this places restrictions on the practical usefulness of reported findings, the mere observation of a problem is cause to stimulate an academic debate and potential policy actions, as outlined above.

Finally, the interest of this research is in uncovering which actors in university networks have causal relationships with successful outcomes of spinout companies. The findings of the thesis identify the complexity of university networks, which cannot ignore spatial aspects in pursuit of positive commercialisation outcomes. As a consequence, it remains in the interest of stakeholders of particular university networks to engineer a structure that best fits their context and expected outcomes. Nevertheless, this work does not engage in generating a best model prescription, which could be a pleasing output for policymakers in particular. Such parsimonious solutions are neither useful nor realistic, given extant literatures invoked in this thesis.

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Appendix 1

University websites visited

Universities	**Date Accessed**
England	
The University of Bath	24/01/2014
http://www.setsquared.co.uk/companies/bath	
The University of Birmingham	13/01/2014
http://www.birmingham.ac.uk/generic/alta-innovations/spin-out-companies/Spinouts/Spinout-Portfolio.aspx	
The University of Bristol	14/01/2014
http://www.bristol.ac.uk/cellmolmed/about/spin-outs.html	
http://www.setsquared.co.uk/companies/bristol	
The University of Cambridge	14/01/2014
http://www.ceb.cam.ac.uk/enterprise/spinouts	
http://www.enterprise.cam.ac.uk/industry/equity-portfolio/	
The Institute of Cancer Research	14/01/2014
http://www.icr.ac.uk/enterprise/Spin_Out_Companies/index.shtml	
http://www.icr.ac.uk/research/new_research_highlights/research_highlights/8729.shtml	
The City University	14/01/2014
http://www.city.ac.uk/for-business/business-services/commercialisation/our-spin-outs	
University of Durham	15/01/2014
https://www.dur.ac.uk/research.commercialisation/spinouts/	
The University of East Anglia	15/01/2014
http://www.uea.ac.uk/business/business-partnerships/companies	
The University of Exeter	15/01/2014
http://www.exeter.ac.uk/careers/enterprise/doit/setsquared/	
Imperial College of Science, Technology and Medicine	15/01/2014
http://www3.imperial.ac.uk/naturalsciences/about/spinout	
http://www3.imperial.ac.uk/engineering/ourresearchhome/spinouts	
http://www3.imperial.ac.uk/bioinspiredtechnology/about/spinouts	
http://www.gla.ac.uk/news/archiveofnews/2002/february/headline_29706_en.html	
http://www.innovation-search.com/companies/search?search=spinout	
The University of Kent	24/01/2014

http://home.eps.hw.ac.uk/~ceeyrp/WWW/seminar_speakers.html

King's College London 15/01/2014

http://www.kcl.ac.uk/innovation/business/how/spinouts.aspx

http://www.kcl.ac.uk/innovation/business/how/spinoutcompanies.aspx

The University of Lancaster 15/01/2014

http://www.lancaster.ac.uk/researchenterprise/spinout.htm

The University of Leeds 24/01/2014

http://www.innovation-search.com/companies/search?search=spinout

The University of Leicester 16/01/2014

http://www2.le.ac.uk/business/tech-transfer/spin-outs

Liverpool John Moores University 16/01/2014

http://www.ljmu.ac.uk/NewsUpdate/index_116482.htm

Loughborough University 16/01/2014

http://www.lboro.ac.uk/enterprise/work-with-us/new-technologies-services/spinoutcompanies/

http://sti.lboro.ac.uk/spinoutcompanies.aspx

The University of Manchester 16/01/2014

http://www.eee.manchester.ac.uk/industry/spinout-companies/

http://www.mib.manchester.ac.uk/business/spinoutcompanies/

http://umip.com/list-of-spin-out-companies/

The University of Newcastle-upon-Tyne 16/01/2014

http://www.ncl.ac.uk/res/enterprise/ventures/spin-out.htm

The University of Nottingham 19/01/2014

http://www.nottingham.ac.uk/chemistry-bpu/spin-outcompanies.aspx

http://www.nottingham.ac.uk/medicine/research/industry/spin-out-companies.aspx

http://www.nottingham.ac.uk/servicesforbusiness/documents1/university-of-nottingham-spin-out-brochure-2012.pdf

The Nottingham Trent University 19/01/2014

http://www.ntu.ac.uk/apps/news/152030-15/Ministry_of_Defence_order_for_university_spin-out.aspx

http://www.innovation-search.com/companies/search?search=spinout

Oxford Brookes University 19/01/2014

http://www.brookes.ac.uk/business-and-employers/spin-outs/

The University of Oxford 19/01/2014

http://www.isis-innovation.com/spinout/index.html

The University of Plymouth 19/01/2014

http://www.tamarsciencepark.com/news/frontier-ip-group-plc-

announces-new-spin-out-company-with-plymouth-university

http://www.frontierip.co.uk/portfolio/porexpert-limited.aspx

Queen Mary and Westfield College 19/01/2014

http://www.qmul.ac.uk/media/downloads/qmmag/25285.pdf

http://www.bci.qmul.ac.uk/news/grants-a-awards/103-bci-spin-out-company-activiomics-receives-over-p05m-new-investment.html

http://www.qmul.ac.uk/qmul/news/newsrelease.php?news_id=237

http://www.qmul.ac.uk/qmul/news/newsrelease.php?news_id=970

http://www.eecs.qmul.ac.uk/news/view/double-success-for-queen-mary-spinout-making-the-internet-better-for-everyo

http://www.qmul.ac.uk/media/news/items/se/77900.html

The University of Reading 19/01/2014

http://www.reading.ac.uk/news-and-events/inthenews/Media204.aspx

http://www.reading.ac.uk/maths-and-stats/OutreachAndEnterprise/maths-industry.aspx

Royal Agricultural College 19/01/2014

http://dk5y2dlrctiai.cloudfront.net/2012/01/16/110937_MWAmbassadorSales.pdf

Royal Holloway and Bedford New College 20/01/2014

http://www.rhul.ac.uk/forbusiness/licensingcommercialisation/home.aspx

http://www.rhul.ac.uk/iquad/services/researchsupport/commercialisation/home.aspx

The Royal Veterinary College 20/01/2014

http://www.rvc.ac.uk/News/PressReleases/pr0702_stemcells.cfm

Sheffield Hallam University 20/01/2014

http://www.shu.ac.uk/research/meri/news/lightweight-ceramic-technology-gets-heavyweight-investment

http://www.shu.ac.uk/business/news/antibodies-made-sheffield

The University of Sheffield 20/01/2014

http://seg.sheffield.ac.uk/AboutUs/CommercialCentres/SpinOutCompanies.aspx

http://www.sheffield.ac.uk/civil/industry/spinouts

http://www.fusionip.co.uk/portfolio/

The University of Southampton 20/01/2014

http://www.southampton.ac.uk/business/business_creation/university_created_companies_directory.html

http://www.southampton.ac.uk/medicine/business_partnership/success

_stories/spinout_companies.page

http://www.setsquared.co.uk/companies/southampton

Staffordshire University 20/01/2014

http://www.staffs.ac.uk/for_business/expertise/ip/spinout/

University Campus Suffolk 20/01/2014

http://www.ucs.ac.uk/About/Visiting%20Professors%20and%20Senior%20Fellows/Visiting-Professors/School-of-Science,-Technology-and-Health/Chris-Winter.aspx

The University of Surrey 20/01/2014

http://www.surrey.ac.uk/business/why/Spinouts/index.htm

http://www.surrey.ac.uk/computing/news/stories/2012/88486_surrey_computing_spinouts_work_tiger_nation_featured_by_bbc.htm

http://www.surrey.ac.uk/computing/research/de/

The University of Sussex 20/01/2014

http://www.sussex.ac.uk/internal/bulletin/staff/2011/021211/tradesift

http://www.sussex.ac.uk/research/review/2012/directorintro

Teesside University 20/01/2014

http://www.tees.ac.uk/sections/news/pressreleases_story.cfm?story_id=3985&this_issue_title=April%202012&this_issue=227

http://www.tees.ac.uk/schools/sse/staff_profile_details.cfm?staffprofileid=U0023133

http://www.tees.ac.uk/sections/news/pressreleases_story.cfm?story_id=4522&this_issue_title=November%202013&this_issue=246

http://www.tees.ac.uk/schools/sse/staff_profile_details.cfm?staffprofileid=U0025697

http://www.tees.ac.uk/sections/research/technology_futures/staff_profile_details.cfm?staffprofileid=U0020301

www.tees.ac.uk/docs/docrepo/publications/enterprise4.pdf

http://www.tees.ac.uk/docs/docrepo/publications/enterprise6.pdf

http://www.tees.ac.uk/docs/docrepo/about/worldwide.pdf

University College London 20/01/2014

http://www.uclb.com/what-we-do/our-companies

http://www.ucl.ac.uk/research/rae-2008/28

The University of Warwick 20/01/2014

http://www2.warwick.ac.uk/services/ventures/spinout-companies/spin-out-companies-a-z/

http://www2.warwick.ac.uk/services/ventures/licensing/licensing-opportunities/?newsItem=094d43d541dba2bd0141e49fd5a8757d

http://www2.warwick.ac.uk/services/ventures/news/warwick_ventures_news_2011

http://www2.warwick.ac.uk/fac/cross_fac/ias/current/ace/resources2/warwick_ventures.pdf

The University of Wolverhampton 20/01/2014

http://www.wlv.ac.uk/default.aspx?page=19806

The University of York 20/01/2014

http://www.york.ac.uk/news-and-events/news/2005/xceleron-ltd/

http://www.york.ac.uk/biology/working-with-business/informationforstaff/spin-outcompanies/

http://www.york.ac.uk/news-and-events/news/2005/solvents/

http://www.york.ac.uk/news-and-events/news/2003/ip2ipo/

http://www.york.ac.uk/news-and-events/news/2003/toxic-testing/

http://www.york.ac.uk/news-and-events/news/2005/company-scientific-analysis/

Wales

Aberystwyth University 22/01/2014

http://www.aber.ac.uk/en/media/departmental/ccs/newsletterpdf/Exchange-April-2013.pdf

Bangor University 22/01/2014

http://www.bangor.ac.uk/research/full.php.en?nid=8221&tnid=8221

http://www.bangor.ac.uk/eng/research.php.en

http://www.bangor.ac.uk/news/VCDPost.php.en

Cardiff University 22/01/2014

http://innovation.engineering.cf.ac.uk/industry-and-community/working-with-industry/spin-out-companies

http://www.cardiff.ac.uk/racdv/latestventures/new-spinout-nanotether-discovery-services.html

http://www.cardiff.ac.uk/racdv/latestventures/asalusinnervisionclinicaltrials.html

http://www.cardiff.ac.uk/news/articles/hwb-enfawr-i-waith-ymchwil-y-brifysgol-7891.html

http://www.cardiff.ac.uk/racdv/latestventures/engineering-spinout-wins-major-decc-funding.html

http://www.cardiff.ac.uk/news/articles/2699.html

http://www.fusionip.co.uk/launch-abcellute-tissue-bank/

http://www.cf.ac.uk/racdv/workwithus/Commercial%20Development@Cardiff%20E.pdf

http://www.cardiff.ac.uk/racdv/latestventures/cardiff%20shingles%20treatment.html

http://www.rae.ac.uk/submissions/ra5a.aspx?id=13&type=uoa&subid=2200

http://www.cardiff.ac.uk/news/articles/early-warning-for-arthritis-2390.html

http://www.cardiff.ac.uk/news/articles/double-success-for-university-spin-outs-10136.html

http://www.cf.ac.uk/racdv/workwithus/resources/2012.pdf

http://www.fusionip.co.uk/portfolio/

Glyndŵr University 22/01/2014

http://www.glyndwr.ac.uk/en/AboutGlyndwrUniversity/PressOffice/Expertsdirectory/Photovoltaics/

Swansea University 22/01/2014

http://www.swansea.ac.uk/media-centre/whats-happening/newapproachtodevelopingmembranetechnologyrecognisedbyicheme.php

http://www.swansea.ac.uk/media-centre/news-archive/2013/springforwardcollaborationtoaidwelshmanufacturingbusinesseslaunches.php

http://www.swansea.ac.uk/medicine/research/a-zofresearchgroups/articularcartilage/

http://www.swansea.ac.uk/engineering/research/impact/economic-benefits-of-finite-element-analysis-applied-to-industrial-problems/

University of South Wales 22/01/2014

http://www.southwales.ac.uk/news/2013/08/28/university-spinout-launches-worlds-toughest-shin-p/

http://business.southwales.ac.uk/news/en/2013/nov/12/usw-spinout-company-geovs-ltd-bought-1m-deal/

http://business.southwales.ac.uk/kt/commercialisation/

<u>Scotland</u>

The University of Aberdeen 23/01/2014

http://www.abdn.ac.uk/business-info/invest-in-technology/2column-page-65-65.php

http://www.abdn.ac.uk/engineering/research/spinout-companies-202.php

http://www.abdn.ac.uk/mediareleases/release.php?id=834

http://www.hw.ac.uk/news-events/news/heriot-watt-hosts-final-

converge-challenge-2013-13875.htm
University of Abertay Dundee 23/01/2014
http://www.abertay.ac.uk/researchandenterprise/researchexpertisebyschool/contemporarysciences/scsstaff/dralanbruce/
http://www.abertay.ac.uk/business/spin-outcompanies/
The University of Dundee 23/01/2014
http://www.dundee.ac.uk/research/spinouts/fact-file/category/view-all/
http://www.dundee.ac.uk/case/industry/spinoutandstartupcompanies/
Edinburgh Napier University 23/01/2014
http://www.napier.ac.uk/about/Pages/about.aspx
http://www.napier.ac.uk/media/Pages/NewsDetails.aspx?NewsID=378
The University of Edinburgh 23/01/2014
http://www.ed.ac.uk/news/all-news/scholarships-010911
http://www.research-innovation.ed.ac.uk/Portals/0/Enterprise-Network-of-companies-to-31st-July-2012.pdf
http://www.research-innovation.ed.ac.uk/Entrepreneurs/Enterpriseshowcase.aspx
http://www.ed.ac.uk/schools-departments/pathway-medicine/news-events/all-news/fios-genomics
http://www.research-innovation.ed.ac.uk/News/Successstories/SpinoutofVLSIVision.aspx
http://www.research-innovation.ed.ac.uk/Portals/0/Documents/Celebrating-40-years-of-innovation-at-the-University-of-Edinburgh-booklet.pdf
http://www.research.ed.ac.uk/portal/en/clippings/university-launches-spinout-company-i2eye-diagnostics(a073b5b2-70bb-4b5a-8658-908fd7970206).html
http://www.research.ed.ac.uk/portal/en/impacts/spinout-company--sofant-ltd(8669a7d8-aac6-47e8-9c13-b1c18ef71379).html
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http://www.gla.ac.uk/news/archiveofnews/2010/august/headline_169229_en.html

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Queen Margaret University, Edinburgh 24/01/2014
http://www.qmu.ac.uk/casl/partners.htm
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http://www4.rgu.ac.uk/cree/general/page.cfm?pge=10750
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The University of St Andrews 24/01/2014
http://www.hw.ac.uk/news-events/news/practical-guide-business-start-up-seminarwebinar-14043.htm
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http://www.stir.ac.uk/news/news-archive/13/02/university-start-up-scoops-award/name-39942-en.html
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http://www.gla.ac.uk/news/archiveofnews/2006/october/headline_28923_en.html
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http://news.ulster.ac.uk/releases/2010/4789.html

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http://oi.ulster.ac.uk/company-portfolio/introduction

Note: Universities where no spinout companies were found are excluded from this list.

Appendix 2

Classification of firm sectors

Table A2 Firm sectors based on 2007 Standard Industrial Classification

Sector categories	Alphabetical SIC sectors	Numerical SIC sectors
Manufacturing	Manufacturing	10821, 10822, 13910, 13990, 14120, 20140, 20411, 20420, 20590, 20600, 21100, 21200, 23110, 23440, 23690, 23990, 24450, 25110, 25210, 25500, 25730, 25990, 26110, 26200, 26301, 26309, 26511, 26512, 26513, 26600, 26701, 26702, 26800, 27110, 27120, 27310, 27320, 27900, 28110, 28132, 28250, 28910, 28960, 28990, 29201, 32200, 32300, 32500, 32990, 33140, 33200
Information and Communication	Information and Communication	58110, 58210, 58290, 59111, 61200, 61900, 62011, 62012, 62020, 62030, 62090, 63110, 63120, 63990
Professional, Scientific and Technical	Professional, Scientific and Technical	70100, 70229, 71111, 71121, 71122, 71129, 71200, 72110, 72190, 72200, 73120, 73200, 74100, 74209, 74300, 74901, 74909
Administrative and Support	Administrative and Support	77310, 81300, 82990
Human Health and Social Work	Human Health and Social Work	86102, 86210, 86220, 86230, 86900
Other	Agriculture, Forestry and Fishing Mining and Quarrying Electricity, Gas, Steam and Air Conditioning Supply Water Supply Sewerage, Waste Management and Remediation Activities Construction Wholesale and Retail Trade Repair of Motor Vehicles and Motorcycles Transportation and Storage Accommodation and Food Service Activities Financial and Insurance Activities Public Administration and Defence Compulsory Social Security Education Arts, Entertainment and Recreation Other Service Activities	1110, 1610, 2400, 3210, 9100, 35110, 36000, 37000, 38210, 38320, 39000, 41100, 43210, 43999, 46170, 46180, 46440, 47190, 47749, 47789, 47890, 47910, 49319, 52290, 55900, 26702, 26800, 27110, 27120, 27310, 27320, 27900, 28110, 28132, 28250, 28910, 28960, 28990, 29201, 32200, 32300, 32500, 32990, 33140, 33200, 64999, 66190, 66210, 84110, 84120, 85310, 85320, 85421, 85590, 85600, 90020, 90030, 93199, 95110, 96090

Appendix 3

Interview questionnaires

TTO Questionnaire

TTO Demographics

1 What is your role?

2 How many TTO employees deal with disclosures and knowledge commercialisation?

3 What background do employees dealing with knowledge commercialisation have?

4 What is the role of TTO in a spinout company? (formation/once formed)

Start-up Experience and Survival Experience: <u>from your perspective:</u>

5 What is the role of external entrepreneur?

6 What is the role of academic founder?

7 What is the role of investors?

8 What is the role of business incubation?

9 What is the role of networks?

10 Should university TTOs be university offices, external university commercial arms, or perhaps external organisations centralised to serve a number of universities in a region/locality?

11 When does the university/TTO exit the spinout's stake?

12 How is the success of spinout formation used?

Business Incubator Questionnaire

Business Incubator Demographics

1 What is your role?

2 What type of businesses do you incubate here?

3 Have the firms in your incubator grown/graduated?

4 What support do you offer to incubated firms?

5 Is the location of the business incubator important?

6 In terms of different types of incubators, how would you define yours?

Start-up Experience and Survival Experience: <u>from your perspective:</u>

6 What is the role of business incubator for spinout company?

7 How many years does it take for a spinout company to graduate from your incubator?

8 What is the role of external entrepreneur?

9 What is the role of academic founder?

10 What is the role of university/TTO?

11 What is the role of investors?

12 What is the role of networks?

Academic Founder Questionnaire

Academic Founder Demographics

1 Brief story on research behind the spinout.

2 Did you have any previous entrepreneurial or private industry experience?

3 At start-up, what type of capital/investment did you use?

4 Where there any non-academic founders?

Spinout Demographics

5 What is the company's relationship with university(ies)?

6 How has location of spinout company changed from startup until now?

Start-up Experience and Survival Experience: <u>from your perspective:</u>

7 What is the role of university/TTO?

8 What is the role of external entrepreneurs?

9 What is the role of investors?

10 What is the role of business incubation?

11 What is the role of networks?

12 What role did location or geography play at the start-up stage?

13 What happened to the original IP?

14 Are there any special regional support programmes you are accessing now that are aimed at spinout companies, high technology companies, in particular?

15 Does your business plan for any exit strategy – by acquisition or IPO?

External Entrepreneur Questionnaire

External Entrepreneur Demographics

1 Tell me about your background prior to the spinout company.

2 Are you from the same region/locality as the university?

Spinout Demographics

3 What is the company's relationship with university(ies)?

4 How has location of spinout company changed from startup until now?

Start-up Experience and Survival Experience: <u>from your perspective:</u>

5 What is the role of university/TTO?

6 What is the role of academic founder?

7 What is the role of investors?

8 What is the role of business incubation?

9 What is the role of networks?

10 What role did location or geography play at the start-up stage?

11 How did you join the spinout company?

12 What was your vision for the spinout?

13 Can you describe how the company developed since you joined?

14 Are there any special regional support programmes you are accessing now that are aimed at spinout companies, high technology companies, in particular?

15 Does your business plan for any exit strategy – by acquisition or IPO?

Investor Questionnaire

Investor Demographics

1 Tell me about your firm, background of your employees?

2 What companies do you invest in (spinouts?)?

3 What growth do firms achieve whilst in receipt of your investment?

4 Does the geography matter in investing in a spinout company? (proximity)

5 What role do networks play in securing investment from your organisation?

Start-up Experience and Survival Experience: <u>from your perspective:</u>

6 What is the role of external entrepreneur/management team?

7 What is the role of academic founder?

8 What is the role of university/TTO?

9 What is the role of business incubators?

10 What is the role of networks?

11 How does your organisation evaluate university spinout company for investment?

12 How does your organisation identify spinout company investment opportunities?

13 What are your organisation's preferred modes of exit for spinout companies?

14 How many years does your organisation expect for a university spinout from initial investment moment to be exit-ready?

15 How many investment rounds does your organisation do with a spinout company?

16 What role does your organisation play in a spinout company post investment?

Appendix 4

Consent form used in recruitment of interview participants

Consent Form

Research Project:

University Networks and the Success of Academic Spinouts.

Researcher:

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Project overview

Given limited research on academic spinout companies, especially devoted to the success of such firms, and restricted sampling used, it is important to understand larger picture of this specific university knowledge commercialisation activity. This research aims to understand two aspects of success in relation to university spinout companies by focusing on university spinout support infrastructure (i.e. university networks). First, university spinout company formation is studied at over 80 UK universities, identifying network elements that contribute to generating greater numbers of such firms. Second, the survival of approximately 1000 spinout companies formed at these institutions is explored to understand university spinout support infrastructure's elements that play a significant role in venture success. Both aspects are studied using quantitative methods to establish non-coincidental explanatory factors.

In order to better understand the quantitatively-derived results, this study involves qualitative research techniques that aim to gather a well-rounded picture from participants of university networks. This step focuses on semi-structured interviews with representatives of technology transfer offices, spinout company founders, external entrepreneurs participating in spinout company development, representatives of business incubators, and investors. It explores broader contexts of spinout company creation and survival, in particular, the complexity of university spinout support infrastructure that cannot be captured through quantitative studies.

It is expected that the results of this research project will improve understanding of university spinout company formation and survival, providing a more complete image of these university knowledge transfer processes. This means that UK universities will learn about initiatives that work, essentially drawing their focus away from counter- or non-productive activities. For policy-makers, this research will provide a guide in understanding the diversity and complexity of issues related to university spinout company success, and indicate what efforts could provide the greatest outcomes. For academic and external entrepreneurs, this research will offer guidance in venture development and success conditions, ensuring they make informed business decisions about firm strategies and objectives with a long-term view. The results of this research will also provide better image of the role played by business incubators, and for managers of these support facilities it will improve understanding of support spinout companies require. Finally, this research aims to explore the role of investors, and offer advice for university spinout companies on securing investment and for investors on selecting the right ventures (i.e. with the greatest success potential).

Consent to participate in interview research

1. I understand the information about the project and how to contact the researcher, provided as part of this consent form.
2. I have been given the opportunity to ask questions relating to the project and my participation. I understand that I can ask further questions during and after my participation in this research.
3. I understand that my participation in this research involves providing answers at a semi-structured interview about my or my organisation's role in university spinout company formation and success, which will last no longer than 1 hour. I understand that during the interview the researcher will take notes and only record it with my consent.
4. I voluntarily agree to take part in this research project.
5. I understand that I can withdraw from this research at any point in time without giving a reason.
6. I understand that my participation in this research will be anonymous by default, unless I request to be named.
7. I understand that the information I provide will be shared with research supervisors and may be used in future publications.
8. I understand that, in accordance with the Data Protection Act, this information may be retained indefinitely.
9. I understand that this research project received approval from Cardiff University's School of Planning and Geography's Ethical Committee.

Participant

Name	Signature	Date

Researcher

Name	Signature	Date

Appendix 5

Sample representativeness

Table A5.1 University Spinout Rates: Spinout companies with or without university ownership

University	Number of active firms (2012/13) HESA	Number of active firms (2014) Own Data	Number of all firms (2014) Own Data
Aberystwyth University	13	1	1
Aston University	6	7	13
Bangor University	5	1	3
Birkbeck College, University of London	1	1	1
Birmingham City University	1	1	1
Bournemouth University	5	1	1
Brunel University	0	2	5
Cardiff University	35	26	29
City University London	9	4	4
Coventry University	13	3	6
Cranfield University	6	4	4
De Montfort University	6	4	7
Durham University	34	14	23
Edinburgh Napier University	6	7	11
Glasgow Caledonian University	2	15	16
Glyndŵr University	8	1	1
Goldsmiths, University of London	1	1	1
Heriot-Watt University	19	25	32
Imperial College London	72	88	106
Keele University	4	3	4
King's College London	14	12	20
Lancaster University	16	13	16
Liverpool John Moores University	9	0	1
London South Bank University	2	1	1
Loughborough University	16	17	19
Manchester Metropolitan University	6	2	2
Newcastle University	28	32	41
Northumbria University	2	1	1
Nottingham Trent University	7	5	5
Oxford Brookes University	3	2	2
Queen Margaret University	0	1	1
Queen Mary University of London	13	17	18
Queen's University Belfast	44	38	47
Robert Gordon University	4	6	10
Royal Holloway, University of London	4	2	4
Royal Veterinary College	1	1	2
Sheffield Hallam University	3	1	1
Staffordshire University	8	4	4
Swansea University	50	6	7
Teesside University	0	5	6
The University of Southampton	16	21	31
The University of Wolverhampton	4	0	1
University College London	50	47	55
University of Aberdeen	23	27	31

University of Abertay Dundee	0	2	5
University of Bath	10	17	19
University of Birmingham	26	27	28
University of Bolton	0	1	1
University of Bradford	8	3	3
University of Bristol	20	29	38
University of Cambridge	60	85	100
University of Central Lancashire	0	1	1
University of Dundee	21	21	26
University of East Anglia	4	7	7
University of Edinburgh	46	55	76
University of Essex	1	2	5
University of Exeter	13	15	20
University of Glasgow	21	24	31
University of Greenwich	3	2	3
University of Hertfordshire	5	0	1
University of Huddersfield	3	1	1
University of Hull	7	7	7
University of Kent	3	3	3
University of Leeds	29	27	33
University of Leicester	14	10	11
University of Liverpool	15	11	17
University of Manchester	39	48	54
University of Nottingham	28	31	32
University of Oxford	58	86	103
University of Plymouth	11	9	9
University of Portsmouth	2	1	1
University of Reading	2	1	2
University of Salford	12	3	3
University of Sheffield	34	29	36
University of St Andrews	24	12	21
University of Stirling	0	3	3
University of Strathclyde	37	44	56
University of Sunderland	0	0	2
University of Surrey	16	15	20
University of Sussex	3	4	4
University of the Highlands and Islands	0	4	5
University of the West of Scotland	1	1	1
University of Ulster	16	13	16
University of Warwick	31	26	40
University of York	22	17	24
Institute of Cancer Research	4	5	6
University of South Wales	13	10	11
Total	1231	1182	1480[8]

[8] There are 1331 original academic spinout companies in the sample framework, however, a number of those firms were jointly created by more than one institution, with other UK universities in the sample framework, UK public research organisations, and overseas universities. When the number of spinout companies is presented at a university level, duplication of counts of some firms is inevitable, hence 1480.

Table A5.2 University spinout rates: Spinout companies with or without university ownership

University	Sample (own data)	HEBCIS data
Aberystwyth University	1	32
Aston University	11	20
Bangor University	1	14
Birmingham City University	1	6
Bournemouth University	1	8
Brunel University	4	35
Cardiff University	21	24
City University London	4	12
Coventry University	6	28
Cranfield University	4	27
De Montfort University	7	21
Durham University	17	23
Edinburgh Napier University	7	14
Glasgow Caledonian University	11	11
Heriot-Watt University	17	39
Imperial College London	66	63
Keele University	4	10
King's College London	8	15
Lancaster University	14	21
Liverpool John Moores University	1	26
Loughborough University	10	25
Manchester Metropolitan University	1	21
Newcastle University	26	23
Northumbria University	1	4
Nottingham Trent University	4	8
Oxford Brookes University	2	30
Queen Margaret University	1	2
Queen Mary University of London	11	16
Queen's University Belfast	25	31
Robert Gordon University	8	15
Royal Holloway, University of London	4	9
Royal Veterinary College	2	12
Sheffield Hallam University	1	6
Staffordshire University	4	90
Swansea University	6	52
Teesside University	6	13
The University of Southampton	18	24
The University of Wolverhampton	1	20
University College London	33	42
University of Aberdeen	20	27
University of Abertay Dundee	2	2
University of Bath	14	5
University of Birmingham	23	37
University of Bolton	1	19
University of Bradford	3	29
University of Bristol	22	17
University of Cambridge	57	37
University of Central Lancashire	1	1
University of Dundee	19	24
University of East Anglia	6	9
University of Edinburgh	44	37

University of Essex	1	9
University of Exeter	15	10
University of Glasgow	21	36
University of Greenwich	3	0
University of Hertfordshire	1	19
University of Hull	6	29
University of Kent	2	8
University of Leeds	22	39
University of Leicester	9	77
University of Liverpool	10	65
University of Manchester	33	57
University of Nottingham	25	20
University of Oxford	67	52
University of Plymouth	4	34
University of Reading	2	8
University of Salford	3	18
University of Sheffield	22	24
University of St Andrews	10	16
University of Stirling	2	1
University of Strathclyde	30	22
University of Sunderland	2	7
University of Surrey	13	12
University of Sussex	4	18
University of the Highlands and Islands	3	2
University of the West of Scotland	1	13
University of Ulster	10	34
University of Warwick	31	36
University of York	16	23
Institute of Cancer Research	2	23
University of South Wales	11	25
Total	963[9]	1873

[9] There are 870 original academic spinout companies in the sample, however, a number of those firms were jointly created by more than one institution, with other UK universities in the sample, UK public research organisations, and overseas universities. When the number of spinout companies is presented at a university level, duplication of counts of some firms is inevitable, hence 963.

Appendix 6

Survival rates of spinout waves

Table A6 Survival rates across spinout waves 1959-2011

Wave/ Period	Births	3-year	5-year	10-year	15-year	20-year	25-year	30-year	44-year
1959	1	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
1963	1	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
1967	1	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	0.00%
1969	1	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
1970	1	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	
1977	3	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	
1982	3	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	66.67%	
1984	2	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	0.00%	
1985	4	100.00%	100.00%	100.00%	100.00%	100.00%	75.00%		
1986	3	100.00%	100.00%	100.00%	100.00%	75.00%	75.00%		
1987	4	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%		
1988	9	100.00%	100.00%	88.89%	88.89%	77.78%	77.78%		
1989	9	100.00%	100.00%	100.00%	100.00%	88.89%	*44.44%*		
1990	4	100.00%	100.00%	100.00%	75.00%	75.00%			
1991	3	100.00%	100.00%	100.00%	100.00%	100.00%			
1992	5	100.00%	100.00%	100.00%	100.00%	100.00%			
1993	8	100.00%	100.00%	100.00%	100.00%	100.00%			
1994	15	100.00%	100.00%	100.00%	100.00%	*26.67%*			
1995	13	100.00%	100.00%	93.75%	68.75%				
1996	23	100.00%	100.00%	95.65%	86.96%				
1997	39	100.00%	97.44%	92.31%	74.36%				
1998	42	100.00%	97.73%	90.91%	72.73%				
1999	56	98.28%	96.55%	81.03%	*27.59%*				
2000	84	98.84%	94.19%	76.74%					
2001	113	98.29%	94.02%	74.36%					
2002	101	99.02%	97.06%	81.37%					
2003	81	100.00%	92.94%	82.35%					
2004	90	100.00%	93.33%	*27.78%*					
2005	78	98.77%	87.65%						
2006	81	98.81%	86.90%						
2007	83	96.47%	89.41%						
2008	61	95.24%	90.48%						
2009	53	94.92%	*33.90%*						
2010	73	98.67%							
2011	60	*46.77%*							

Note: The dotted line separates the sample analysed in further sections of this chapter.

Appendix 7

Survival rate of spinout companies across sample and sample frame

Table A7 Spinout companies survival across sample* (2002-2013) and sample frame (1959-2013) by parent institution

	2002-2013 sample		1959-2013 sample frame	
University	Survival rate	N	Survival rate	N
Aberystwyth University	100.00%	1	100.00%	1
Aston University	54.55%	11	53.85%	13
Bangor University	100.00%	1	33.33%	3
Birkbeck College, University of London	*N/A*	0	100.00%	1
Birmingham City University	100.00%	1	100.00%	1
Bournemouth University	100.00%	1	100.00%	1
Brunel University	0.00%	4	40.00%	5
Cardiff University	90.48%	21	89.66%	29
City University London	100.00%	4	100.00%	4
Coventry University	50.00%	6	50.00%	6
Cranfield University	100.00%	4	100.00%	4
De Montfort University	57.14%	7	57.14%	7
Durham University	64.71%	17	60.87%	23
Edinburgh Napier University	85.71%	7	63.64%	11
Glasgow Caledonian University	72.73%	11	93.75%	16
Glyndŵr University	*N/A*	0	100.00%	1
Goldsmiths, University of London	*N/A*	0	100.00%	1
Heriot-Watt University	82.35%	17	78.13%	32
Imperial College London	84.85%	66	83.02%	106
Keele University	75.00%	4	75.00%	4
King's College London	62.50%	8	60.00%	20
Lancaster University	78.57%	14	81.25%	16
Liverpool John Moores University	0.00%	1	0.00%	1
London South Bank University	*N/A*	0	100.00%	1
Loughborough University	80.00%	10	89.47%	19
Manchester Metropolitan University	100.00%	1	100.00%	2
Newcastle University	80.77%	26	78.05%	41
Northumbria University	100.00%	1	100.00%	1
Nottingham Trent University	100.00%	4	100.00%	5
Oxford Brookes University	100.00%	2	100.00%	2
Queen Margaret University	100.00%	1	100.00%	1
Queen Mary University of London	90.91%	11	94.44%	18
Queen's University Belfast	88.00%	25	80.85%	47
Robert Gordon University	62.50%	8	60.00%	10
Royal Holloway, University of London	50.00%	4	50.00%	4
Royal Veterinary College	50.00%	2	50.00%	2
Sheffield Hallam University	100.00%	1	100.00%	1
Staffordshire University	100.00%	4	100.00%	4
Swansea University	83.33%	6	85.71%	7
Teesside University	83.33%	6	83.33%	6
The University of Southampton	77.78%	18	67.74%	31
The University of Wolverhampton	0.00%	1	0.00%	1
University College London	87.88%	33	85.45%	55
University of Aberdeen	85.00%	20	87.10%	31
University of Abertay Dundee	100.00%	2	40.00%	5
University of Bath	85.71%	14	89.47%	19
University of Birmingham	100.00%	23	96.43%	28
University of Bolton	100.00%	1	100.00%	1
University of Bradford	100.00%	3	100.00%	3
University of Bristol	86.36%	22	76.32%	38
University of Cambridge	89.47%	57	85.00%	100

University of Central Lancashire	100.00%	1	100.00%	1
University of Dundee	89.47%	19	80.77%	26
University of East Anglia	100.00%	6	100.00%	7
University of Edinburgh	84.09%	44	72.37%	76
University of Essex	100.00%	1	40.00%	5
University of Exeter	73.33%	15	75.00%	20
University of Glasgow	80.95%	21	77.42%	31
University of Greenwich	66.67%	3	66.67%	3
University of Hertfordshire	0.00%	1	0.00%	1
University of Huddersfield	*N/A*	0	100.00%	1
University of Hull	100.00%	6	100.00%	7
University of Kent	100.00%	2	100.00%	3
University of Leeds	86.36%	22	81.82%	33
University of Leicester	77.78%	9	90.91%	11
University of Liverpool	80.00%	10	64.71%	17
University of Manchester	93.94%	33	88.89%	54
University of Nottingham	96.00%	25	96.88%	32
University of Oxford	85.07%	67	83.50%	103
University of Plymouth	75.00%	4	100.00%	9
University of Portsmouth	*N/A*	0	100.00%	1
University of Reading	50.00%	2	50.00%	2
University of Salford	100.00%	3	100.00%	3
University of Sheffield	90.91%	22	80.56%	36
University of St Andrews	80.00%	10	57.14%	21
University of Stirling	100.00%	2	100.00%	3
University of Strathclyde	80.00%	30	78.57%	56
University of Sunderland	0.00%	2	0.00%	2
University of Surrey	76.92%	13	75.00%	20
University of Sussex	100.00%	4	100.00%	4
University of the Highlands and Islands	66.67%	3	80.00%	5
University of the West of Scotland	100.00%	1	100.00%	1
University of Ulster	100.00%	10	81.25%	16
University of Warwick	74.19%	31	65.00%	40
University of York	75.00%	16	70.83%	24
Institute of Cancer Research	50.00%	2	83.33%	6
University of South Wales	90.91%	11	90.91%	11
Total		963		1480

Note: The table includes joint spinout companies therefore the full number represented here is greater than the number of original spinouts formed. *The institutions with N/A label are not part of the final sample.