University Entrepreneurial Ecosystems and Spinoff Companies: Configurations, Developments and Outcomes

In : Technovation

Daniel Prokop

School of Geography and Planning, Cardiff University, CF10 3WA, Cardiff, UK

Contact details: prokopd@cardiff.ac.uk, +442920879422

This paper seeks to explain the variable outcomes from university entrepreneurial ecosystems by observing their structural and spatial configurations in relation to spinoff company development. Four UK university entrepreneurial ecosystems are examined with data collected through interviews with the core actors of university entrepreneurial ecosystems: technology transfer officers, academic founders, external entrepreneurs, investors, and business incubators. It is found that university entrepreneurial ecosystem outcomes are dependent on the processes of connectedness and filtration, underpinned by geography. The effectiveness of these processes is dependent on university entrepreneurial ecosystem calibration, leading to different outcomes in terms of spinoff company formation and survival across the spectrum of universities. Successful university entrepreneurial ecosystems are characterised by strong connectedness and effective filtration, having a strong local and interregional character.

Keywords: networks, university spinoffs, entrepreneurial ecosystems, survival, firm development, entrepreneurship

Subject classification codes: D85, L26, O18, R12

1. Introduction

This paper seeks to explain why development of spinoff companies is different across universities by examining their ecosystems. Universities play a key role in innovation systems or ecosystems (Benneworth et al. 2017; Cooke 1992; Hayter et al. 2018; Morgan 1997; Pugh et al. 2018; Storper 1993) where, as part of their Third Mission (Zawdie 2010) interwoven with local and regional economic development strategies (e.g. local industrial strategies in the UK),

they engage in knowledge transmission and translation, actively responding to regional skill shortages to improve knowledge receipt, involved in strong networks with firms, stimulated by institutionalised support mechanisms. However, there is a limited understanding of the functioning of parts of these systems devoted to university technology transfer via spinoff company and resultant outcomes in terms of spinoff formation and survival. This is particularly visible in London's regional innovation system (Lawton Smith et al. 2014), where outcomes are varied, despite the presence of strong knowledge-generating institutions. This mixed performance in London is attributed to agglomeration diseconomies and poorly developed institutional support.

As in many studies devoted to academic spinoff companies, only the exemplary cases are studied, for example MIT (Nerkar and Shane 2003), Cambridgeshire (Garnsey and Heffernan 2005), Oxfordshire (Lawton Smith et al. 2008), Emilia Romagna (Fini et al. 2009), Catalonia (Criaco et al. 2014) limiting the understanding of a broader distribution of outcomes, in particular given the emerging evidence on the variable intensity and spatiality of knowledge transfer activities (Zhang et al. 2016). Such studies of regions neglect the heterogeneity and autonomous character of universities within any broader territory and their varied approach to Third Mission, its embeddedness, and outcomes (Nelles and Vorley 2010). Instead, the focus, as pursued in this paper, needs to be on the university as an independent knowledge generating institution, which develops its own idiosyncratic entrepreneurial environment, or *university entrepreneurial ecosystem*. It is argued here that university entrepreneurial ecosystem (UEE) constitutes a unique set of ties with local, regional, and national actors that a university builds and utilises for its commercialization activities, in particular, forming spinoffs and ensuring their success. These UEEs are primarily composed of: technology transfer offices (TTOs) (Fitzgerald and Cunningham 2016), academic founders (Shane 2004a), investors (Huggins 2008; Fini et al. 2017), experienced entrepreneurs (Franklin et al. 2001; Visintin and Pittino

2014), and business incubators (Bourelos et al. 2012; McAdam et al. 2016), and vary on a spatial dimension (Huggins and Prokop 2017), with a particular geographical location and reach.

Networks are important to understanding the successful outcomes of spinoff companies (Hayter 2016a) as they encapsulate the otherwise uncaptured relationships between human and organizational actors, as well as what is being transferred through such ties. In particular, strong cohesive networks tend to be locally embedded (Westlund 1999), yet such structures may suffer from inertial problems (Lin 2001; Zaheer and Soda 2009) by strengthening own constraint (Burt 1992) through limiting the development of new connections to heterogeneous actors. In other words, such cohesive groups that are more internally interlinked than connected to a wider network (Borgatti et al. 1990; Seidman 1983) may limit their performance, for example in innovation (Capaldo 2007). This is especially important, given that network homophily tends to result from spatial proximity (Westlund 1999), as interactions between economic actors tend to have a localised character (Storper 1997). Therefore, the development of networks that wish to exploit new opportunities may involve building non-local and spatially increasingly distant ties (Huggins et al. 2010). For university entrepreneurial ecosystems studied in this paper this suggests that the differential outcomes of spinoff company success are related to the structure, function, and spatiality of these network configurations.

As such, this paper pursues the following research question: why do university entrepreneurial ecosystem outcomes differ across universities? The outcomes considered here are related to spinoff formation and survival. To answer this question four UK-based UEEs are examined. The key contribution of this paper is in recognising that the variable outcomes from university entrepreneurial ecosystems are explained by geography, connectedness and filtration, reflecting different configurations of these ecosystems.

The paper is structured as follows: section 2 introduces UEEs and their key actors, section 3 outlines the methodology and data collection employed; section 4 presents the findings; section 5 offers a discussion; whilst section 6 concludes the paper with implications for policy and future research.

2. University Entrepreneurial Ecosystems

2.1. University Entrepreneurial Ecosystems and Academic Entrepreneurship

Whilst universities are part of larger regional and national innovation systems (Lawton Smith et al. 2014) or networks (Huggins and Prokop 2017), they typically hold central positions in such architectures (Benneworth and Charles 2005), and are able to define and shape their network structure and reach through a broad set of engagements (Pugh et al. 2018). In particular, regional innovation systems (RIS) (Cooke 1992) describe an idiosyncratic functioning of a set of actors which encompass universities, private industry and government at a regional level. Their individual and collaborative effectiveness contributes to the regional economic development. As such the entrepreneurial ecosystem (EE) concept offers a departure from the university-centric depiction of local and regional development by placing the entrepreneurs in the centre (Stam 2015). Hayter et al. (2018) specifically identify that EEs related to academic entrepreneurship are composed of a set of key actors: universities, TTOs, entrepreneurs, management teams, and investors. Technology transfer ecosystem concept, which focuses on university knowledge commercialisation stresses that its composition involves TTOs, science parks, incubators, and investors in the form of university venture funds (Good et al. 2019).

However, this presents a rather closed system, suggesting limited or no role for actors non-affiliated with universities, especially those mentioned in Hayter et al. (2018). This

difficulty in defining the boundary whether spatial or relational is one of the critiques of the concept (Audretsch et al. 2019).

Instead, an approach focused on social attributes of the ecosystem that pertain to network benefits (Spigel 2017) offers a framework that departs from such stringent restrictions on the actors involved and enables an exploration of variable configurations of these university entrepreneurial ecosystems giving rise to these issues. In particular, Spigel (2017) and Feldman et al. (2019) highlight the need to better understand these configurations that lead to existence of different types of ecosystems. This is especially important, as the variable configurations of EEs may result in a variety of outcomes (Vedula and Kim 2019), however how these are produced at a granular level remains unknown (Guerrero et al. 2016).

As such, the approach employed focuses on the relational space of the UEEs rather than one defined by the typical geographical boundaries of the local or predominantly urban EEs (Ghio et al. 2019; Vedule and Kim 2019), recognising that spinoff companies may be formed and operate in networks that span outside of their immediate entrepreneurial ecosystems (Fuster et al. 2019; Feldman et al. 2019).

Whilst previous studies found a whole range of actors involved in the process of forming and supporting spinoffs (Hayter 2016a) through different arrangements of knowledge intermediaries (Hayter 2016b), this paper connects the above mentioned literatures with spinoff outcomes in line with Hayter et al.'s (2018) critique of a lack of holistic treatment of ecosystem elements in academic entrepreneurship literature, developing the links between the micro, meso, and macro level components.

It is important to observe that university entrepreneurial outcomes such as spinoff formation and survival are related to a specific set of ecosystem elements (Hayter et al. 2018), which can be captured in the framework of dimensions offered by Vedula and Kim (2019): a) supportive entrepreneurial culture – with reference to availability and character of social capital,

b) access to entrepreneurial finance, whether early or later stage, c) human capital captured by the academic founders and management team (or external entrepreneurs), d) innovation capacity represented by the locational conditions, e) formal support organisations represented by business incubators and science parks. To explore these dimensions this paper focuses on a group of key UEE actors: TTOs, academic founders, external entrepreneurs, investors, and business incubators (inclusive of science parks). Whilst not confined to specific geographical boundaries of a place or locality as often captured in EEs literature (e.g. Vedula and Kim 2019), these networks are not aspatial constructs, therefore vital to their understanding is their broader geography.

TTOs focus on early stages of opportunity identification (Macho-Stadler et al. 2007), IP protection (Bercovitz and Feldman 2008) and contribute their networks of investors and external entrepreneurs (Lockett et al. 2003). However, their role is found to have a mixed effect on spinoff formation rates, whether by mere presence or staff count, as evidenced in UK-based (Clarysse et al. 2011), Italian (Fini et al. 2011), US (Aldridge and Audretsch 2011), Spanish (Gonzales-Pernia et al. 2013), and Swedish (Bourelos et al. 2012) or multi-country (Fini et al. 2017) studies. There is a growing evidence that whilst TTOs may have a less influential role in spinoff formation, these units are related to investment generation for spinoff ventures (Fini et al. 2017) or their survival (Prokop et al. 2019). As such, the role of the TTOs appears more complex than originally ascribed to them (e.g. Shane 2004a).

Academic founders, whilst responsible for knowledge generation and their networks with the industry (Goethner et al. 2012), are primarily recognised for early stage technology development (Hayter 2016a). Their characteristics, such as prior industry funding or scientific excellence, are related to higher levels of disclosures (D'Este et al. 2012), whilst prior industry collaboration or invention experience play a role in academic entrepreneurship (D'Este et al. 2012; Hewitt-Dundas 2015). Furthermore, it is important to note that academic entrepreneurs

(i.e. the spinoff founders) are individuals with experience in operating in public or non-profit sectors (Colombo and Piva 2012) transitioning to a profit-driven market. Such a change suggests their potential struggle to run typically for-profit firms, especially given their non-financial motivations (Fini et al. 2009) or lack of entrepreneurial training (Neves and Franco 2018), indicating a need to involve industry-experienced individuals to enhance success chances of such ventures (Bekkers et al. 2006).

These are regarded as external (and experienced) entrepreneurs, who focus on the business development (Vohora et al. 2004), consequently building spinoff's credibility that is vital to searching for external funding (Wright et al. 2006). Given their business experience (Franklin et al. 2001), external entrepreneurs also tap into their networks with investors (Vohora et al. 2004), explaining why such firms have high-growth characteristics compared to inventor-led spinoffs (Politis et al. 2012; Lundqvist 2014). Furthermore, involving external entrepreneurs is related to higher rates of spinoffs (Lockett et al., 2003). However, it is important to observe that relying on external entrepreneurs to the exclusion of the academic founders may lead to suboptimal firm performance, as found by Visintin and Pittino (2014), who stress the need for a diverse management team.

Investors could be depicted in the form of business angels (Mosey and Wright 2007), public funds (Huggins 2008), university venture funds (Fini et al. 2011; Good et al. 2019) or venture capital industry (Wright et al. 2006), and offer the much needed finance to otherwise cash-starved spinoff companies, increasing their survival chances (Prokop et al. 2019). Their engagement focuses on all stages of the company development, although it is most pronounced in the early years of the new ventures. However, there is a mismatch in how investors and spinoffs understand each other's role as characterised by Wright et al. (2006), where spinoffs seek out their first investment from the venture capitalists, and venture capitalists expect to invest in spinoffs once they secure proof-of-concept or seed funding. This has led many

universities to provide the initial financing to their spinoff firms (Shane 2004b; Wright et al. 2006) and a development of proof of concept centres (Bradley et al. 2013) to bridge such funding issues. Furthermore, spinoff formation may not necessarily be related to the co-location of the venture capital industry or their investment activity (Di Gregorio and Shane 2003), suggesting the difficulty in conceptually capturing academic spinoff activity with locally-bounded frameworks.

The role of business incubators is most pronounced at the early stages of spinoff company development (Bourelos et al. 2012). These facilities offer a list of business support services: office space, administration, training, investment, consultancy and professional business management support (Bruneel et al. 2012; Grimaldi and Grandi 2005). Whilst early studies suggested that business incubators support spinoff generation (e.g. Tornatzky et al. 1995) and development, especially the privately-owned types (Grimaldi and Grandi 2005), more recent evidence indicates their importance to spinoffs is questionable (Fini et al. 2011; Salvador and Rolfo 2011; Gonzales-Pernia et al. 2013) as they tend to incubate in university departments (Hewitt-Dundas 2015). A similar set of findings is reported for the science parks (Siegel et al. 2003; Lockett and Wright 2005), which are typically considered to offer a similar type of support to firms, whilst having clearer links with universities (Tamasy 2007).

Although previous research has drawn attention to these actors, little connection has been made between them and their spatial settings. For example, Salvador and Rolfo (2011) report that there are more spinoff companies in Italian regions with more business incubators and science parks, but when deconstructing their data they find that the majority of spinoffs are not based in these facilities. Furthermore, Lawton Smith et al. (2014) studied London universities, which not only achieve different outcomes in terms of formation of spinoffs, but also form networks of variable structure and spatial distribution. Nevertheless, it remains unknown why they differ beyond their varied institutional capabilities to generate knowledge

and spinoff companies. In view of these unexplored complexities, individual university entrepreneurial ecosystems could offer an insight when considering their outcomes in terms of spinoff company generation and survival.

2.2. The Variations in University Spinoff Activity

Much of the literature on spinoffs focuses on the formation of these firms (e.g. Fini et al. 2017; Krabel and Mueller 2009), yet as suggested in Lambert Review (2003), this is a very one-sided and limited early-stage perspective, when other outcome measures such as survival should be considered (Ulrichsen 2019). This is especially important if considering outcomes from a UEE and policy implications with regards to arranging its structure, distribution of resources and definition of functions. For example, a UEE focused on spinoff formation may require a completely different architecture than one pursuing firm development, for example – prioritising actors that play intensive early stage roles; and potentially even more so than one encapsulating both goals, especially when considering the complexity of connecting two rather disparate aims – short-term early-stage with a definite end in registering a company, and undefined long-term late-stage. More recent focus in the literature on the post-formation parts of lifecycle of spinoff companies examining performance through either financial (Jelfs 2016; Barbosa and Faria 2020) or survival measures (Wennberg et al. 2011; Criaco et al. 2014) reveals some findings that contradict formation studies, for example pertaining to TTOs (Prokop et al. 2019). Whilst these deliberations only consider the construct of UEEs, they are devoid of the rooting such architectures have in spatial complexity, which could consider network's reach, availability of actors, and distance between them.

These two outcomes depict spinoff activity from two perspectives: one related to the birth or registration of the company, the other the spinoff's ability to persevere. Whilst forming a spinoff company requires a disclosure and university's TTO's decision to select a particular

commercialisation path for the university-generated intellectual property, the survival depicts spinoff's time in building the business or just staying "alive". Jelfs (2016) points at the importance of recognising that some spinoff companies stay dormant, not trading but still registered as "live" firms, therefore potentially skewing the picture of surviving firms as not all being actively growing companies. However, as reported in Prokop et al. (2019), this does not significantly interfere with the measurement of spinoff survival, as such firms are low in numbers and are notably younger than non-dormant spinoffs.

In accounting for the university variations in spinoff company outcomes previous studies considered geography to be important (Fini et al. 2009; Lawton Smith et al. 2008; Shane 2004a), albeit typically at the local level. This has been related to the entrepreneurial ecosystem partly fuelled by the university's activities in enhancing the absorptive capacity and entrepreneurial landscape of the locale. However, the wider regional economic environment is important in understanding the spinoff outcomes from spatially-anchored universities. Prencipe et al. (2020) found that spinoff growth is more pronounced in certain regions than others (similar results were reported by Rodriguez-Gulias et al., 2017), however, they only observed this effect for Spanish firms, but not Italian ones, indicating the importance of national institutional settings. Prokop et al. (2019) reported that spinoff survival in the UK is related to the industrial specialisation of a region, pointing to cluster effects. Salvador and Rolfo (2011) inspected whether the numbers of spinoffs in Italy are related to the presence of business incubators and science parks in their regions, finding that there are indeed more spinoffs in regions with more of such facilities, although not necessarily using their services. Further studies inspected the level of innovation activity within a region and spinoff formation (Ramaciotti and Rizzo 2014), as well as regional concentration of technology firms and spinoff performance (Iacobucci and Micozzi 2015), or controlled for regional socio-economic indicators (Meoli and Vismara 2016; Fini et al. 2017).

Whilst these intra-regional perspectives are very valuable, there is some limited evidence of inter-regional aspects related to spinoff outcomes. This is especially important, as Lawton Smith et al. (2014) noted that many spinoff firms from London universities had their registered offices based outside of London. As such, this suggests that spinoff firms operate in complex networks characterised by inter-regionality, as particular resources or knowledge may not be available locally (Hayter 2016a), conversely to established notions pertaining to the entrepreneurial ecosystems concept. However, there is a limited understanding of how such networks look like and why, at least some of them, are not locally-bounded.

A further determinant are networks (Harrison and Leitch 2010; Lawton Smith et al. 2008), which are largely expressed by the collaborative works with the industry or TTOs' connections to the wider investment community and pools of external entrepreneurs (Shane 2004a). For example, spinoffs with links to industry benefit through improved knowledge conversion capability (Sousa-Ginel et al. 2017), indicating an important function of network development. For spinoff companies building networks is a response to information asymmetry problems (Shane 2004a) and resource starvation (Hayter 2016a). The more connected firms may radiate credibility and legitimacy required for newly formed firms to secure first sales or investments (Bower 2003; Grandi and Grimaldi 2003; Chan et al. 2010; Bruneel et al. 2012). Bourelos et al. (2012) report that spinoff numbers are explained by the frequency or length of interactions between academics and industry (and entrepreneurs), suggesting a potential for opportunity recognition.

Furthermore, such networks have a cumulative character in terms of the effects on future academic entrepreneurs (Berggren and Dahlstrand 2009), as successful academic founders tend to remain in their university employments (Hewitt-Dundas 2015). This enables a pool of entrepreneurial experience and contacts with industry and investors to be accessible within universities, contributing to a more effective environment in terms of guidance and

support in founding and growing academic spinoffs. Such effects could be observed in the increased post-formation role of TTOs, as measured through their accumulated experience (Fini et al. 2017). Additionally, this evolutionary accumulation of social capital could lead to cluster formation (Garnsey and Heffernan 2005), contributing to local economic development.

The network position of a spinoff company is related to its early growth and survival, particularly its degree centrality constraint (Prokop et al. 2019) and bridging ties (Scholten et al. 2015), pointing towards the importance of structural holes (Burt 1992) to its successful development. Drawing on network capability (Walter et al. 2006), spinoff companies that are able to exercise their structural position in a network and accumulate network capital (Huggins 2010), whilst mediating between their non-redundant connections, increase their likelihood of success. In fact, their success in resource acquisition is related to a greater diversity of actors and strength of such ties (Zane and DeCarolis 2016). This is a dynamic process, where networks spinoff companies form at their incorporation adapt and transform with their growth (Rasmussen et al. 2015). Such networks could evolve into either more calculative (Huggins 2010) or affective (Jack et al. 2010).

The gaps in understanding how the networks contribute to UEE outcomes, whether formation or spinoff development, are especially pronounced in the limited attention devoted to conceptual involvement of networks as part of academic entrepreneurship determinants (Djokovic and Souitaris 2008). In particular, there is a limited understanding how the networks of UEEs differ, and how these variations are related to spinoff outcomes.

Another key factor explaining the diversity of university spinoff outcomes is in selectivity (Degroof and Roberts 2004), with universities reflecting a range of strategies on this dimension. The key decision for universities is whether a particular intellectual property should be commercialised through a vehicle of a company or as a license to an established firm (Shane 2004a), which is often the case in the US (Damsgaard and Thursby 2013), as it bears lower risk

and requirements for resources to support the technology transfer. As such university-generated IP undergoes evaluation of commercial potential (Thomas et al. 2020), followed by the mode of technology transfer, indicating spinoff formation as a unique and difficult decision. Macho Stadler et al. (2007) also refer to this work by the TTO as filtration of technologies, which can only be effective if the university generates a larger pool of IPs.

On the background of this, Degroof and Roberts (2004) specify two key types of university-based entrepreneurial infrastructures: a) low selectivity and low support, and b) high selectivity and high support. This dichotomy highlights the university approaches to identification of disclosures, starting-up a spinoff company, and supporting it during that process. The selectivity is important at the identification of the disclosure stage, either as a bottom-up activity performed by the academics (in low selectivity environments) or top-down approach with the leading role performed by the TTOs (in high selectivity contexts). The support is recognised as resources enabling the potential spinoff venture to develop the underlying technology and grow the firm. Much of the responsibility for the support is placed on the TTOs. Whilst very insightful, the study does not recognise a possibility for mixed entrepreneurial infrastructures, that is: low selectivity and high support, or high selectivity and low support, leaving a theoretical gap in understanding how UEEs approach knowledge commercialisation through spinoff companies. A similar linear set of findings were reported by Clarysse et al. (2005), who observed three types of selectivity and support: low, supportive, and incubator model. The selectivity is also recognised as a process related to disclosure identification, whilst support pertains to developing the disclosure into a growing company.

Given the spinoff company selectivity is theorised as an early-stage, disclosure-based process, there is a clear lack of understanding whether further selectivity takes places, or how the selectivity looks like in the unobserved UEEs. Furthermore, whilst particular support mechanisms observed in the above studies indicate resource commitments, more insight could

be gained from measuring an outcome such as spinoff survival. The scale of resources may not always translate into expected outcomes, suggesting measurement bias in such theorisations.

2.3. *The UK Context*

In the UK there were over 1200 active spinoff companies reported in 2013 (Table 1) with Scotland accounting for 16.6%, Wales for 10.1%, West Midlands for 7.6%, and London 13.8% of the firms. Whilst there is a clear divergence in outcomes at regional level, a number of interesting insights can be observed. First, there is an expectation that regions that are typically known for high-technology entrepreneurship would have greater numbers of spinoffs (Shane 2004a), yet in the UK Scotland outperforms London and South East in absolute numbers. Second, within any particular region there is a high rate of variation in terms of spinoff outcomes at the UEE level, with the lowest variation recorded in South West (15) and highest in London (72). For example, in West Midlands Aston University had 6 active spinoff companies, yet at the same time University of Birmingham was responsible for 26 active spinoffs (Higher Education Statistics Agency 2012/13). Even more confusingly, both universities are based in the same city and are research intensive, clearly suggesting that each UEE is subject to a unique set of conditions. As such, taking a regional view of academic spinoff activity requires caution to avoid misrepresenting inherent heterogeneity across universities. Third, typical explanations of regional differences pertaining to economic peripherality (e.g. measured through GVA per capita) are not very helpful in the context of spinoff companies, as indicated by the case of Scotland (highest formation rate) and Wales (third highest formation rate). Fourth, the more inclusive regional environment associated with entrepreneurship activity (Mason and Brown 2014) measured in net international migration further confirms that academic spinoff outcomes do not follow typical macro socio-economic patterns, with London and Scotland responsible for the highest numbers of spinoffs experiencing highly diverse rates of migration. This is especially important considering that

foreign-born academics are more entrepreneurial (Krabel et al. 2012), and that places characterised by higher levels of high technology companies tend to be more diverse (Florida and Gates 2001). Fifth, the entrepreneurial dynamics across the UK regions further add to this perplexing picture with Wales and London being at opposing ends in terms of firm birth and death rates. Finally, although firms in London and East of England have traditionally had a greater access to venture capital funds (Klagge and Martin, 2005), this does not explain the differential spinoff outcomes across UK regions, especially considering Scotland with the highest number of spinoffs and the fourth lowest value of venture capital stage funding per firm. The performance of North West even suggests that the predominantly London-based venture capitalists may no longer be so London-centric with their activity, although no clear explanation or pattern can be observed from the regional data.

Table 1 About here

Whilst extant research has enabled identification of the core actors forming university entrepreneurial ecosystems, the processes behind their functioning, set in diverse geographical contexts, remain unknown. Consequently, this paper sets out to explain how these idiosyncratic UEEs differ in their commercialization outcomes.

3. Method

3.1. Sampling

The first stage in the sampling employed in this paper was to define the populations of universities and their spinoff companies in the UK. This was conducted by extracting the names of spinoff companies and their university affiliations from an online service (www.spinoutsuk.co.uk)[1] collecting such data on firms registered in the year 2000 and onwards.

This step was conducted on 12th January 2014. In order to capture firms founded before 2000, a search of all UK university websites was undertaken, acting as a validation step of post-2000 firms and their affiliations. These initial identifications resulted in 1530 spinoff companies formed across 89 universities.

The dataset was complemented with firm records obtained from a Bureau van Dijk's FAME (Financial Analysis Made Easy) database, which covers data on UK firms registered with Companies House. The key data extracted included the incorporation and dissolution dates, firm characteristics, and shareholder information, which allowed for further validation of the university affiliations with the spinoff companies. The resultant sample frame consisted of 1331 spinoff companies formed between 1959 and 2013 from 87 UK universities. 80.39% of these firms survived until 1st May 2014, when the status of firms was tested. Table 2 depicts annual births of spinoffs from 1990 onwards.

Table 2 About here

In order to understand the underlying processes that lead to successful spinoff company outcomes, it is important to understand a range of perspectives from actors of UEEs. To accomplish such a complex task, a purposeful extreme case sampling was utilised as it enables maximising the variation in the sample by including observations according to important research criteria (Gobo 2007) and achieves completeness and explanation (Patton 2002; Teddlie and Yu 2007). Patton (2002) stresses that this sampling method is 'information-rich' (p. 231), but it offers no generalizability. Instead, Teddlie and Yu (2007) indicate that purposeful extreme case sampling is characterised by representativeness and allows for comparability given the contrasting data collected.

The criteria used to construct the sample are two-dimensional to encapsulate the outcomes from the university entrepreneurial ecosystems and offer a strong fit with the research question (Eisenhardt 1989). The first criterion focuses on the university's formation rate of

spinoff companies, where a top quartile of 24 is applied to maximise variation in the sample. There is a distinct character of the sample frame when applying the top quartile: 24% of institutions are responsible for nearly 70% of spinoff companies generated, suggesting the top quartile to be inclusive of unique universities that would be more indicative of the factors that help them translate research into such high numbers of commercial opportunities. The highest formation rate recorded stands at 106 spinoffs, whilst the lowest at 1. The second criterion considers the survival rate of spinoff companies established by each university where a simple approach looking at the highest and lowest survival rates is applied. Due to limited information offered from universities with very low numbers of spinoff companies and their extreme survival rates, 10 spinoff companies is considered the minimum threshold for survival dimension. The highest survival rate achieved by a university is 96.9%, whilst the lowest is 54.6%.

At first four universities were selected that represented the extreme values on spinoff outcomes, however two had to be dropped (low spinoff generation, low survival rate; and high spinoff generation, high survival rate) as either the TTO representative or spinoff companies could not be interviewed. In their place, two universities were added with the second most extreme values on spinoff outcomes.

Consequently, the paper focuses on university entrepreneurial ecosystems of the following institutions, as classified in Table 3: Scottish University (low spinoff generation, low survival rate), London University (low spinoff generation, high survival rate), Midlands University (high spinoff generation, low survival rate), and Welsh University (high spinoff generation, high survival rate). Due to the sensitivity of the studied organizations, anonymity of the interviewees is maintained and each research participant has received a regional-representative name. The universities and their respective UEE elements have received regional pseudonyms to further ensure anonymity of the interviewees.

Table 3 About here

3.2. Data Collection

In order to understand the individual university entrepreneurial ecosystems and their outcomes it was important to collect data from the representatives of the TTOs, business incubators, investors, and spinoff companies. Whilst the technology transfer officers were contacted directly, the remaining actors were suggested by the TTO representative. The main requirement for the firm was to be a live enterprise, i.e. still active on May 1st 2014, as it is difficult to trace companies no longer in existence.

In total, 15 interviews were conducted between November 2015 and February 2016 and lasted on average 40 minutes; they were voice-recorded and transcribed, with one exception where notes were taken. The number of interviews complies with the guidelines set by Saunders and Townsend's (2016) review of qualitative research samples. The interviews were typically conducted face to face at interviewee's workplaces, except for one telephone interview. The interviews had a semi-structured character to unpack broader aspects behind university spinoff outcomes, allowing observation of both the individual perspectives and comparative views on the studied matter. Table 4 outlines the summary information on the actors and organizations they represent.

Table 4 About here

3.3. Analytical Approach

The study employs an inductive approach (Strauss and Corbin 1998), whilst the analysis performed learnt from the insights offered by Eisenhardt (1989) and Gioia et al. (2013), in particular in observing the data coding approaches and theorising. At first, the data was summarised in large contingency tables at the university entrepreneurial ecosystem level and across its elements: geography, TTO, academic founder, management team, investor, business

incubator, networks. This step enabled data familiarisation and identification of initial patterns (Eisenhardt 1989) or lower order codes (Gioia et al. 2013). These initial observations were then compared across the university entrepreneurial ecosystems but within each element, leading to identification of higher order codes (Table 5). These were then consulted with the initial constructs identified from the literature reshaping and questioning them, and reexamining the data (Eisenhardt 1989). This activity was followed by going outside of individual elements and comparing the codes identified across UEEs, with another iterative process of inspecting the initial constructs to observe connections between the codes (Eisenhardt 1989). The final step involved iterative reexamination of the themes with the data and the literature to search for explanation and previously untheorised relationships between the themes (Eisenhardt 1989), resulting in the identification of core factors influencing the differential outcomes of UEEs.

Table 5 About here

4. Findings

The four university entrepreneurial ecosystems allow an insight into the highly challenging and complex environment of dynamics that lead to different levels of spinoff company formation and survival. The summary of contextual findings is available in Table 6, whilst Table 7 presents key themes across the four settings.

Table 6 About here

Table 7 About here

These extracts allow identification of three core themes: *connectedness*, *filtration* and *geography*. *Connectedness* was expressed across a number of references to networks, supply chains, and spatial reach of connections. *Filtration* was typically articulated through early-stage identification process, the selection of viable spinoff projects, and the evaluation of commercial

potential. Whilst the *geography* was investigated more explicitly, it has emerged as a complex theme representing locality, agglomeration economies, interregional/national links, and peripherality. The identified themes are used in the following subsection to discuss the contribution of each element to the outcomes from UEEs.

4.1. Differences in University Entrepreneurial Ecosystem Outcomes

Geography

Access to networks and the level of linkage in these university entrepreneurial ecosystems is dependent on the broader network environment. UEEs based in small urban locations or peripheral regions (e.g. Scottish UEE) are at a disadvantage, unable to access dense local or regional networks. Being unable to enjoy connectedness related to advantages of agglomeration economies (Krugman 1991), where centralization and clustering of actors results in broad and dense networks (London UEE), spinoff company formation and success cannot operate at optimal levels. Furthermore, due to constraints of location, university entrepreneurial ecosystems (such as Scottish UEE) have to build connections beyond their own locality and across the country's regions. This means that UEEs characterised by poor connectedness need to resolve linkage problems by constructing spatially-increasingly distant networks.

At the same time, urban locations, even in peripheral regions (Welsh UEE), enable UEEs 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 UEEs to expand links thanks to solid foundations. Distance ceases to be a constraining factor in such UEEs. This was exemplified in Midlands, London and Welsh UEEs, all centred in major urban locations.

University (TTO)

TTO's connectedness is dependent on the availability of resources, as low levels of endowments make it difficult to build and maintain networks (Patzelt and Shepherd 2009), as noticeable in Scottish UEE. This translates into limited support available from the TTO to spinoff companies, affecting the probability of success. It becomes clear that resources devoted to commercialization activities play a critical role in determining the outcomes of spinoff companies as evidenced in London and Welsh UEEs.

Additionally, TTOs play a significant role in early stage selectivity processes (Midlands, London, and Welsh UEEs), which have great influence on the future success of spinoff companies (Degroof and Roberts 2004). When TTOs evaluate their disclosures, it is imperative that selectivity is effective. One way the London and Welsh UEEs 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 how to strengthen their selectivity methods to build better filtration models. The effects of these co-operations with specialist VCs result in the selection of the most promising commercialization opportunities.

These are also dependent on TTOs' approaches to spinoff companies, where highly rigid support provision in Midlands UEE meant that spinoff 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 utilization of networks to resolve the problems of information asymmetry. In contrast, a flexible approach to spinoff company support, represented by the London UEE, is related to good resource endowment and resultant utilization of networks in developing and exploiting strong connectedness. Hence, the combination of resources, selectivity,

connectedness and approach to spinoff companies at university TTOs appears to determine their success.

Academic Founder

Whilst academic founders rarely manage spinoff companies, reflecting more closely the considerations of allocation of time (Becker 1965) and opportunity cost (Geroski 1995), they play two major roles in academic spinoff companies. Their importance is most pronounced in the science and industry connections (Bourelos et al. 2012; Krabel and Mueller,2009) they bring into spinoff companies, as expressed by Midlands, London and Welsh UEEs. In fact, academic founders become major bridging agents in spinoff's access to specialist networks. This in turn indicates that apart from knowledge transfer an academic founders' core role is in improving connectedness, greatly enhancing the survival chances of a spinoff company. Furthermore, each of the four UEEs emphasise that whilst the knowledge transfer role of an academic is concentrated around the early stages of the company, the academic's involvement remains over the longer term, however in a reduced capacity. The early stages are critical due to the tacit character of knowledge making it difficult to transmit (Kogut and Zander 1992; Nonaka 1994) to a spinoff company, thus requiring greater involvement of the academic founder. Once knowledge is captured by the spinoff company, the unchanged academic founder's role is in ensuring strong connectedness.

External Entrepreneur

The key entrepreneurial role in a spinoff company is that of the external or surrogate entrepreneurs (Diánez-González and Camelo-Ordaz 2016; Franklin et al. 2001), stressing that the specific nature of work undertaken by these actors is very complex. First of all, an external entrepreneur is the core business-building force at pre- and post-formation phases (Politis et al. 2012), with the early stage being most emphasised. The experiential learning of Midlands UEE

exemplified that success is unpredictable if spinoff company development is left to academic founders. Therefore, TTOs and investors focus on installing external entrepreneurs – often referred to as management teams, before registering spinoff companies, ensuring stable company development as the external entrepreneurs pursue the security of their own equity stakes and pleasing investors (Monsen and Downs 1965). However, to recruit such actors the university TTO or academic spinoff 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 UEE, it was observable that outcomes are difficult to achieve and rely extensively on regional publicly-financed support programmes (Brown 2016), without which attracting an external entrepreneur, albeit at times from other regions with high technology entrepreneurship clusters, is hardly possible.

The secondary role of the external entrepreneurs is to bring in and develop networks (Franklin et al. 2001; Wright et al. 2006), effectively strengthening the connectedness of the spinoff 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 spinoff company’s development. Furthermore, it is important for spinoff companies to involve academic founders, as the diversity of the company's management team is critical in a spinoff's performance (Visintin and Pittino 2014). This could be observed particularly well in Welsh UEE, where academic founders were engaged post-formation, whilst TTO of Midlands UEE was clear about designating an academic founder's role, including no engagement.

Investors

Poorly connected UEEs (Scottish UEE) rely on publicly-funded support programmes to recruit external entrepreneurs and task them with attracting investors. This increased network distance

compromises the quality of success outcomes by switching network centrality position from TTO to external entrepreneur. The implications of such poor connectedness for TTO are in reduced opportunities of TTO and its highly constrained position to support commercialization activities, due to nearly non-existent structural holes in its vicinity (Burt 1992). Clearly, the struggle to connect with investors is reflected in the low survival of Scottish UEE's spinoff companies. In contrast, UEEs characterised by strong connectedness, such as in London UEE, maintain the TTO's central position, enabling it to access opportunities advantageous to its spinoff companies, in particular financial investment from business angels and venture capitalists (Huggins 2008; Siegel et al. 2007).

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 UEEs, where formal partnership with a specialist investor 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.

Furthermore, all UEEs emphasise the need for funding at early stages; however, only London and Welsh UEEs partner with a specialist investor to select disclosures of the highest commercial potential, and TTOs of both these UEEs offer seed funding to these spinoff company prospects, recognised as a critical step prior to VC investment (Huggins 2008; Wright et al. 2006). The example of Scottish UEE 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. In the London and Welsh UEEs the investor's

long-term engagement is particularly stressed to allow the spinoff 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 spinoff companies spans at least fifteen years of engagement with continuous funding.

Business Incubators

The core role of business incubators is in supporting business development (Bruneel et al. 2012; Grimaldi and Grandi 2005), which has a negligible influence on spinoff company success, as found in interviews at Midlands, London and Welsh UEEs, confirming a number of previous studies (Gonzalez-Pernia et al. 2013; Hewitt-Dundas 2015). This is largely due to the fact that in each UEE spinoff companies are incubated in their respective university departments, a crucial aspect given the decay effect of knowledge spillovers (Rodríguez-Pose and Crescenzi 2008). This is especially clear in the Midlands and London UEEs' 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).

Although business incubators have no direct role in spinoff company success, their limited input at certain points on a spinoff'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 UEE improves its connectedness by using links developed by business incubator with business angel investors and external entrepreneurs. Nevertheless, a similar utility of business incubator has not been observed in case of London UEE, suggesting perhaps a role that is non-essential to spinoff company outcomes. Furthermore, this indicates that for TTOs that are expected to play central roles in UEEs (Alexander and Martin 2013), those which do not fully develop their connectedness attempt to bridge their gaps using business incubators. As with Scottish UEE, 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 spinoff companies. In effect, UEEs without business incubators should not be affected in their spinoff companies' success outcomes. However, in poorly connected UEEs, business incubators improve their linkage functionality.

5. Geography, Connectedness and Filtration

From the analysis performed on the data collected from the four distinct university entrepreneurial ecosystems a number of themes were identified that explain the varied spinoff outcomes. These themes reflect core aspects that help explain university spinoff company outcomes, based on the frequency of occurrence across all UEE actors. These are: *connectedness*, and *filtration*, both underpinned by *geography*. Table 8 presents these characteristics with related interview material.

Table 8 About here

Connectedness represents a crucial feature of any UEE and describes the level of network density or centralization 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 spinoff company and its ability to invest in network capital (Huggins 2010). Poor connectedness is expressed by actors in a network being largely disconnected from each other, constraining the size of such network. Consequently, a central actor in a UEE such as TTO would have limited access to resources and opportunities with which to support its commercialization efforts in forming spinoff companies and ensuring their success. Conversely, high connectedness is a manifestation of a UEE that is large and has multiple linkages between actors. This translates into good access to

resources and opportunities to support spinoff company generation and survival, representing a high level of network capital (Huggins 2010).

Furthermore, connectedness is strongly related to the geography of UEEs which defines their reach, and to quality, as the density of connections translates into outcomes for spinoff companies. For example, urban-based UEEs in core regions benefit from connections to mostly spatially proximate actors, as evidenced in the four illustrative cases. These spatially-concentrated UEEs tend to be characterised by dense connections. The elemental part of this are evolutionary processes behind their development, characterised by clustering of core actors relevant to spinoff company success (Bekkers et al. 2006), much in the notions of the wider entrepreneurial ecosystems (Stam 2015; Spigel 2017), learning region (Morgan 1997; Storper 1993) or regional innovation systems (Cooke 1992). However, there is a possibility (unobserved here) that such UEEs, 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 2010), given the high costs of such activities (Patzelt and Shepherd 2009). Conversely, UEEs characterised by poor connectedness can be found in less urban and more remote locations. As such, to overcome these spatial issues networks of such ecosystems would include connections to key actors that are spatially more distant, as suggested by Huggins (2010) in his deliberations on characteristics of network capital. Although in the four illustrative cases, it was observed that such a UEE has a low level of connectedness, there could be a UEE 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 organizations has not been captured in this paper. Furthermore, there is an inherent problem with such alternatives, given extant literature suggesting that the density of networks has a proximate character (Howells 2002; Scott and Storper 2003). Therefore, it is expected

that proximate UEEs would be dense in connections as a consequence of social capital (Huggins 2010), signifying strong connectedness, whilst distant UEEs would be characterised by poor quality connections and a consequently low level of connectedness. These architectures would translate into outcomes for spinoff companies, with UEEs of high level of connectedness related to greater numbers of spinoffs formed and improved survival results.

The other factor relates to decision-making and is identified as filtration, signifying a UEE's actors' ability to select disclosures and later spinoff companies with the highest probability of successful outcome. Filtration is concerned with the quality aspects of UEEs, which consider returns on investments in the relationships (Huggins 2010). 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/actors (e.g. TTO, seed investor, VC investor, the market of consumers), and types of catalysts, including the TTO's rigid or flexible approach to supporting spinoff companies, which spatially move further away from the locale of the university towards the national and global sphere. This suggests that the geography underpinning the filtration process broadens in scope with the venture development. What this means for the commercialization process that results in successful spinoff companies is that, from the disclosure stage until spinoffs become successful, the intermediate spinoff 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 UEEs whose actors actively engage in selectivity processes, and is most visible in the number of disclosures translated into spinoff companies at early stages, and an overall high survival rate of spinoffs later in their development. This reality

contrasts with UEEs with porous filtration, where a greater number of spinoff companies is incorporated from their disclosures, and reveal passive involvement of their actors in assessing the commercial potential of primarily disclosures. Once spinoff companies from such porous UEEs reach later stages, when investors and markets evaluate their commercial viability, survival outcomes become distinctly low. Clearly, UEE actors need to appropriate returns from their investments in developing connectedness (Huggins 2010), and strong filtration delivers these outcomes.

It is important to acknowledge that not all university generated knowledge may become disclosures that follow a formal commercialisation route at universities. Some intellectual property leakage has been observed (Markman et al. 2008; Gianiodis et al. 2016; Lindholm Dahlstrand et al. 2016), where academic staff bypass the technology transfer offices and establish companies outside of that channel. This has not been captured in the data collected for this paper. Such firms would not be considered academic spinoffs (as per Higher Education Statistics Agency's (www.hesa.ac.uk) definition based around higher education institution's ownership of the IP, current or released), therefore, the filtration mechanism presented here does not capture such activity.

It appears clear that UEEs characterised by greatest survival rates are both strongly connected and operate effective filtration of knowledge as depicted in Figure 1. Whilst numerically London and Welsh UEEs' annual disclosures translation into spinoff companies is virtually the same (respectively: on average 1.6 spinoff companies from 77 disclosures annually between 2002/3 and 2013/2014, and on average 1 spinoff company out of 45 disclosures per year between 2002/3 and 2013/2014; approximate early filtration equal to 0.02),[2] the volumes underlying their activities are clearly of different magnitudes. Midlands UEE is strongly connected, given its actors' networks; however, with the Midlands UEE's porous filtration (average of 2.5 spinoff 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 UEE. Finally, Scottish UEE suffers from low resource endowment, which is responsible for its poor connectedness and porous filtration (on average 1 spinoff company is formed from 20 disclosures per year between 2002/3 and 2013/2014; early filtration level of circa 0.05).

Figure 1 About here

6. Conclusion

This paper's focus is to offer an understanding why spinoff outcomes vary across university entrepreneurial ecosystems by examining in-depth four distinct illustrative examples of such ecosystems, exemplifying the dynamics and complexity of actors and processes involved. The UEE outcomes are dependent on geography, connectedness, and filtration. These aspects bring together the literatures of academic entrepreneurship and economic geography, where high technology entrepreneurial survival (Criaco et al. 2014; Prokop et al. 2019) appears dependent in large part on geographical characteristics, such as networks (Huggins and Prokop 2017) and evolutionary development (Krugman 1991). Critically, UEEs characterised by strong connectedness enjoy greater spinoff company formation and greater ability to support their future development. Such UEEs tend to have a proximate character (e.g. large urban locations) where availability or density of actors allows for the development of links.

A similar mechanism is found in filtration dimension, where UEEs with effective filtration engage in continuous evaluation of a spinoff company, with the most intense filtering activity concentrated in the early stages of the spinoff's lifecycle and in the university's local space. Filtration allows the selection of spinoff companies that have a higher probability of success, offering a return on investment in connectedness-oriented efforts. UEEs with porous filtration might enjoy high formation rates of spinoff companies, but low survival rates of these

firms. These findings contribute to the understanding of variable configurations of entrepreneurial ecosystems (Spigel 2017).

It is evident that university entrepreneurial ecosystems achieve better outcomes by engaging in the development of their links – both in terms of quantity and quality. There is, however, a role for policymakers to support spinoff companies that are located in poorly connected UEEs to stimulate the development of linkages, in particular at an interregional level that bridge the gaps in such local ecosystems. Given that disadvantaged UEEs are typically located in small-urban or peripheral regions, policy development should favour redistribution of outcomes by increased funding devoted to initiatives that support connectivity between ecosystems.

Successful academic spinoff companies undergo filtration processes where experienced and skilled university entrepreneurial ecosystem actors evaluate the commercial potential of such ventures as a feature of the system's self-organising nature (Martin and Sunley 2007). However, there may be a need to stimulate policy developments that support the creation of such functions at poorly performing UEEs and further enhance filtration processes at successful UEEs. These approaches require policymakers to understand their role in shaping the institutional factors related to inter-firm level growth dynamics (Huggins 2016) of the entrepreneurial ecosystems and the value of mechanisms created by the right mix of institutions (Rodríguez-Pose 2013) to the long-term development of spinoff companies.

At the same time, it is important to acknowledge that the Third Mission approach and outcomes may differ across universities, as not all may generate spinoff companies. Consequently, policymakers need to recognise the heterogeneity of the higher education institutions and develop policies that respond to their individual needs (Compagnucci and Spigarelli 2020). These may be manifested in a multitude of commercialisation channels, e.g. licensing, contract research, consultancy, or public events, that better reflect individual

university teaching and research specialisations (Nelles and Vorley 2010), forming spinoffs being merely one of them.

The success of academic spinoff companies varies across UK regions. These differences in outcomes necessitate appropriate policy responses that would promote efforts that overcome such variations. In particular, UK policymakers need to become sensitive to the fact that spinoff company formation and survival require different ecosystem architectures. In order to maximise the positive economic impact of such commercialization activity, it is necessary to construct UEEs defined by diversity and strong local adaptation, allowing them to develop resilience characteristics (Bristow 2010).

Whilst this research intended to gather critical perspectives on the functioning of university entrepreneurial ecosystems, it has not engaged with university administrators. Crucially, in the knowledge commercialization domain where TTOs are institutional sub-units, there is a struggle over mission and strategy between the two parties. It remains largely unknown whether the outcomes of UEEs are down to structure, or whether it is a consequence of decision-makers with variable interests or understandings of university spinoff company formation and survival. Hence, there is a clear need for research that could tackle such complex problems, specifically examining power struggles between university administrators and TTOs. It is also important to stress that academic spinoffs are only one of many modes of university knowledge transfer, and as such the policy focus should not favour any particular mode, but instead be inclusive of these alternative mechanisms.

Notes:

1. Whilst the Spinouts UK data lists a large number of UK spinoffs, it is not a comprehensive, official or representative list, and as such it requires careful handling and cross-validating to ensure its accuracy.
2. 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.

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Table 1. Regional context of university entrepreneurial ecosystems

Region	Number of active spinoffs (2012/13)	Intra-regional variation* (2012/13)	Average number of active spinoffs per university (2012/13)	GVA per capita [£] (2013)	Net international migration per 1000 inhabitants (2013)	Firm birth rate (2013)	Firm death rate (2013)	Average venture capital stage investment per firm [£m] (2013)**
East Midlands	71	22	14.20	19902	2.75	13.68%	9.38%	0.77
East of England	76	59	15.20	22137	2.10	13.27%	9.49%	2.00
London	170	72	14.17	40516	9.48	17.93%	10.57%	1.29
North East	64	34	12.80	17697	2.51	14.70%	9.90%	0.19
Northern Ireland	60	28	30.00	18329	-0.48	8.70%	8.93%	0.23
North West	97	39	12.13	20455	1.37	14.70%	10.08%	4.00
Scotland	204	46	13.60	22174	0.39	13.28%	9.16%	0.27
South East	107	56	11.89	26276	1.83	13.06%	9.44%	0.34
South West	59	15	11.80	21644	2.02	12.19%	9.10%	0.36
Wales	124	45	20.67	17215	2.37	12.61%	9.20%	0.60
West Midlands	93	30	11.63	19630	2.47	13.39%	9.60%	0.49
Yorkshire and the Humber	106	31	15.14	19314	2.37	13.70%	9.85%	0.20
Total/UK	1231	72	14.15	24131	2.86	14.15%	9.70%	1.14

Sources: Higher Education Statistics Agency, Office for National Statistics, British Venture Capital Association.
Note: Universities and spinoff numbers presented correspond with the sample framework used in this paper, i.e. spinoffs from universities not included in the sample framework are not presented here (this excludes merely 46 spinoffs formed across the remaining universities).
* Intra-regional variation captures the within-region difference between the university with the highest number of active spinoffs and one with the lowest number. The Total/UK value represents intra-national variation.
** All VC-funded firms at this stage of investment, inclusive of spinoffs.

Table 2. Spinoff company births

Years	Counts of spinoffs
1990	4
1991	3
1992	5
1993	8
1994	15
1995	16
1996	23
1997	39
1998	44
1999	58
2000	86
2001	117
2002	102
2003	85
2004	90
2005	81
2006	84
2007	85
2008	63
2009	59
2010	75
2011	62
2012	64
2013	20
Total	1288

Table 3. Classification of selected cases according to sampling criteria

		Spinoff generation	
		Low (below 24 firms)	High (24 or more firms)
Spinoffs' survival	Lowest	Scottish University	Midlands University
	Highest	London University	Welsh University

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

Table 4. Interview record

	Actor	Description
Scottish University	SU TTO (Sean)	Internal university unit. Research-intensive university. The institution has no access to business incubators or established networks with investors.
	Scottish Systems EE (Sholto)	A CEO who first worked on developing company A, and then moved to work on building company B - 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.
London University	LU TTO (Loxley)	Wholly-owned university firm. Research-intensive university. It has access to a business incubator located on-campus and established links with investors.
	LU BI (Lowell)	Wholly-owned university firm. High commercial focus on established firms that pay commercial rent and require custom-made office space (including sophisticated laboratory set-ups). Houses local firms and university spinoffs.
	London Tech. AF (Prof Louie)	Academic founder of a medical sciences company London Technologies. The spinoff 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.
Midlands University	MU TTO (Milton)	Wholly-owned university firm. Research-intensive university. It has access to science park (business incubator) and established network of investors.
	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 spinoffs. Runs accelerator type programmes for local firms.
	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.
Welsh University	WU TTO (Wynn)	Internal university unit. Research-intensive university. It has access to a local business incubator and established relations with investors.
	Welsh Sciences EE (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.
	Welsh Therapeutics EE (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.
	Welsh Therapeutics 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.
	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.
Investors		
London Investments	Irving	Nationwide VC investor specialising in academic spinoff companies. Invests in all stages of spinoff companies and offers comprehensive support to develop the business to investment exit. It has links with a number of universities in the country. Irving is part of executive team at London Investments.
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.

Note: TTO=Technology Transfer Office; BI=Business Incubator; AF=Academic Founder; EE=External Entrepreneur.

Table 5. Higher order codes

	Scottish UEE	Midlands UEE	London UEE	Cardiff UEE
Geography	connectedness urban/remote			
University (TTO)	resources	selectivity	connectedness	
		rigid	flexible	
Academic Founder	early stage	connectedness		
Management Team	early stage company builder resources connectedness			
Investor	early stage connectedness selectivity			long term
Business Incubator	incubation in department	office space	not formal path	
		connectedness		
Networks	connectedness networks of each actor			

Table 6. Summary of four university entrepreneurial ecosystems

	Scottish UEE	Midlands UEE	London UEE	Welsh UEE
Geography	• remote small urban location	• urban location	• large urban location	• urban location
University (TTO)	• university department • 2 FTEs • 10 disclosures/FTE per year // 1 spinoff per year	• wholly owned subsidiary • 7 FTEs • 1 disc/FTE per year // 2.5 spinoffs per year	• wholly owned subsidiary • 10 FTEs, and growing • 4.5 disclosures/FTE per year // 1 spinoff per year	• university department • 7 FTEs • 11 disclosures/FTE per year // 1.6 spinoff per year
Academic Founder	• key role in early stages	• key role in early stages	• key role in early stages, but also continual role in spinoff to ensure success	• key role in early stages, after that typically some limited engagement
External Entrepreneur	• recruited from region or beyond	• recruited from locality or region	• recruited from locality or region	• recruited from region or beyond
Investor	• no formal or informal relations	• informal relations with broader VC and local BA community	• formal relations with a specialist VC • informal relations with VC community	• formal relations with a specialist VC and VC in locality
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	• wholly owned subsidiary of TTO • late stage incubator • in vicinity of university campus	• 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

Table 7. Core themes across university entrepreneurial ecosystems

	Scottish UEE	Midlands UEE	London UEE	Welsh UEE
Geography	• reliance on regional government support (to recruit EE – increasingly from other parts of the country) • location affects connectedness given no benefits of agglomeration economies • necessary to form national networks • incubation in departments for as long as needed; typically investors would require spinoffs to relocate closer to them	• benefitting from agglomeration economies • good (central) location to benefit from international supply chains • relying on regional links with investors • incubation typically in departments, only for two years, some spinoffs housed in BI	• most advantageous position in terms of local access to investors, broadband etc. • benefitting from the best agglomeration economies in the UK • BI houses some spinoffs, also from universities in the region	• benefits from agglomeration economies • location limits access to Welsh investors, relies on VCs from London • at a local level, spinoffs exploit locational advantages of business incubator
Connectedness	• poor networks of the TTO team • EE recruited by TTO and relied on for network building (e.g. finding investors) • EE becomes a central actor early on in the network	• extensive industry networks brought in by AFs • TTO uses own, BI's or investors' networks to recruit EE • TTO and BI have good networks with VCs, business angels, EEs	• TTO has highly diverse and broad networks, well-connected • TTO has own network of EEs and investors, however, VC typically finds the EE • AF brings scientific network • EE brings industry/commercial network	• VC partner brings in EE and funding • AF has strong links with industry • specialist VC risk averse, invests after TTO commits seed funds, with another regional VC • EE's bring industry contacts at senior level
Filtration	• TTO under-resourced, processing high numbers of disclosures	• TTO has good resource endowment, but still insufficient to deal with all disclosures • TTO selective at disclosure evaluation stage; increasingly contacts VCs to discuss disclosures	• TTO very selective, specialist VC partner preselecting disclosures to develop • TTO seed funds spinoff companies not selected by the VC partner and uses own networks of investors early on to secure funding	• TTO very selective, specialist VC partner participates in early stage selection • highly selective specialist VC

Table 8. Illustrative quotes demonstrating factors underpinning university entrepreneurial ecosystem outcomes.

	Quotes
Geography	*It's much easier to run virtual organisations now, so I'm quite used to having a start-up located in one area, but most of the team are spread out through the country. [Sholto]* *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. 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]* *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]* *I've heard some anecdotes of some investors [who] … 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]*
Connectedness	*A large part of my function is to build new networks for the right type of the organisation. [Sholto]* *If we don't have anyone [external entrepreneur] 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. [Milton]* *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]* *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. [Waljan]*
Filtration	*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]* *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]* *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]* *So when we first have an idea we put in 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 15-year journey so you don't want to spend a lot of time on one that's not going to work. [Irving]*

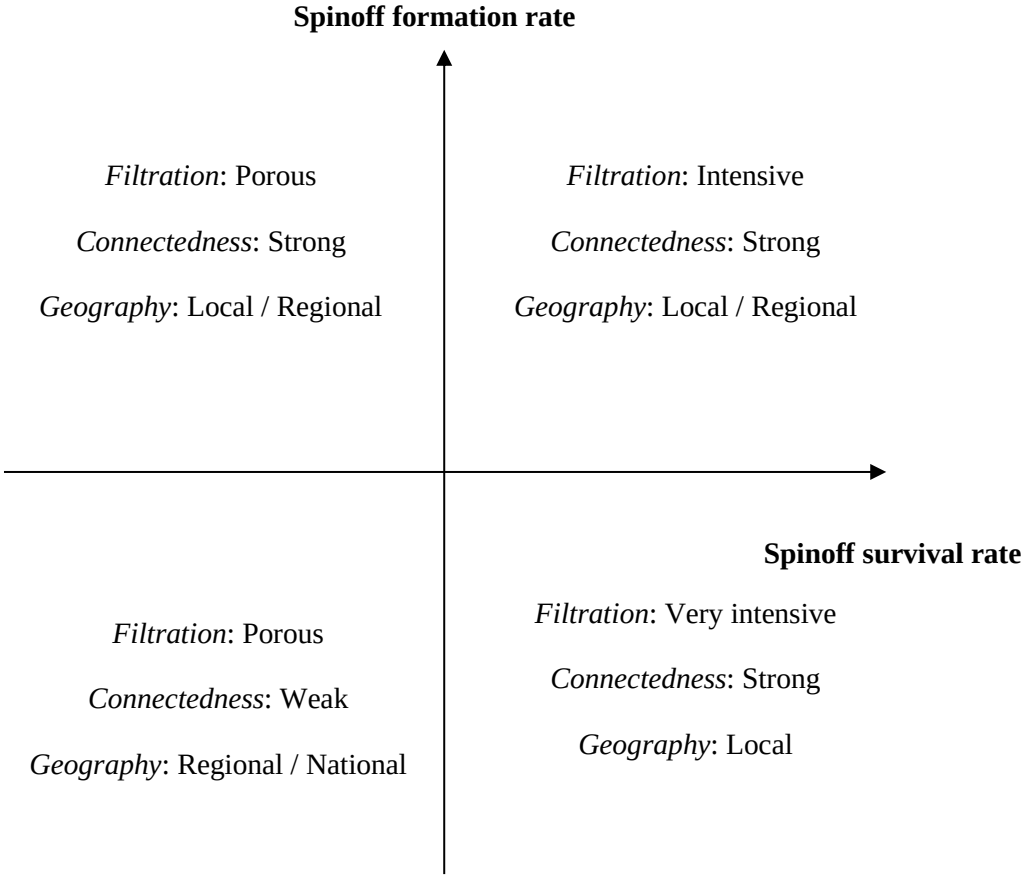

Figure 1. University entrepreneurial ecosystem configurations