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Title: Who should be spinning out firms? A Structural Evidence from the UK.

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Introduction

As the demand for university knowledge commercialisation has grown in significance (Etzkowitz et al., 2000), universities are more frequently engaging in Third Mission activities, partly through their own initiative to improve institutional budgets (Chiesa & Piccaluga, 2000), and partly due to government initiatives to support the generation of wealth and competitiveness (DTI, 1993). Across many university knowledge commercialisation modes - e.g. licensing patents, consultancy, and collaborative research - a growing attention is being given to the academic spinout companies by both institutional investors (Chiesa & Piccaluga, 2000; Bank of England, 2001; Library House/UBS, 2006) and economic development policymakers (Lambert, 2003; Shane, 2004), especially from a regional perspective (Huggins et al., 2008).

The role played by universities in securing the success of academic spinouts goes beyond considerations of IP protection, and involves the provision of business incubators (Library House/UBS, 2006) and science parks (Link & Scott, 2005), referred to as hard infrastructure – as well as networks of investors, experienced entrepreneurs (Lockett et al., 2003; Library House/BVCA, 2005), and specialist commercialisation intermediaries/firms – categorised here as soft infrastructure - that can be considered as a university's (typical) social capital (Lin, 2001). These elements form the entrepreneurship support infrastructure of universities, including Technology Transfer Offices (TTOs).

The current development of knowledge concerning the role of the university infrastructure in the success of academic spinouts is largely fragmented (Phan & Siegel, 2006), often focused on internal institutional or spinout characteristics (Jensen & Thursby, 2001; Di Gregorio & Shane, 2003; Lockett et al., 2003; Shane, 2004; Debackere & Veugelers, 2005; Clarysse et al., 2011). Furthermore, the literature concerning the critical perspectives and problems of academic spinouts and spinout company formation has been growing in strength (Lambert, 2003; Siegel et al., 2007; Swamidass & Vulasa, 2008; Harrison & Leitch, 2010), emphasizing the evident need for a more holistic approach to researching the topic.

The aim of this paper is to systematically review the importance of the infrastructure indicated above in the process of university spinout creation by applying a structural perspective. It is based on an empirical study of 784 spinout companies and the 160 HEIs (Higher Education Institutions) in the UK. The key question this paper attempts to answer is: Are all universities equally equipped to support spinout company creation? It leads to the consideration of structural disparities between spinout company creation performance across the UK universities, and offers recommendations on reducing these disparities.

The state-of-the-art

Academic Spinouts and Economic Development

The 'Third Mission' extension of the key roles (i.e. teaching and research) of the universities has drawn an increased and intensified interest from academia (Goldstein, 2010) and government (e.g. Lambert, 2003) to the now officially ascribed responsibility of universities for a significant part of economic development (in most part regional) (Etzkowitz et al., 2000; Etzkowitz & Leydesdorff, 2000; Goldstein & Renault, 2004; Lawton Smith, 2007; Etzkowitz & Dzisah, 2008; Lopez et al., 2009; Goldstein, 2010). The fact that the university contribution to the economic development has been formalised does not mean there was no such contribution before. The difference between the two is the recent focus on the university research commercialisation as playing the more important role in the economic development, rather than typical university inputs, e.g. employment, expenditure, quantity of students (Goldstein et al., 1995; Garrido-Yserte & Gallo-Rivera, 2010) which do not capture the full scale of economic contribution of the university (Thanki, 1999). These effects could also be observed from the creation of academic spinout companies (Berggren & Lindholm Dahlstrand, 2009), accredited with greater economic potential (Lambert, 2003; Shane, 2004; Phan & Siegel, 2006; Siegel et al., 2007; Huggins et al., 2008).

As the academic spinout firms are based on certain innovation/technology (Etzkowitz, 1998; Shane, 2004), it is important to note that the size of those companies – mostly small – (Harrison & Leitch, 2010) may not necessarily act against them in the competitive markets, as small firms have been reported to experience better rates of innovation than their larger counterparts (Gellman Research Associates, 1976; The Futures Group, 1984; Audretsch, 1991; Chakrabarti, 1991; Audretsch, 1995). Furthermore, small innovative firms attracted by university R&D intensity are found to contribute positively to the local/regional economic development both directly and indirectly through related multiplier effects (Kirchhoff et al., 2007). However, these localised effects could migrate outside if the local/regional absorptive capacity and resources to support the innovative firms will not be adequately developed (Christopherson & Clark, 2010).

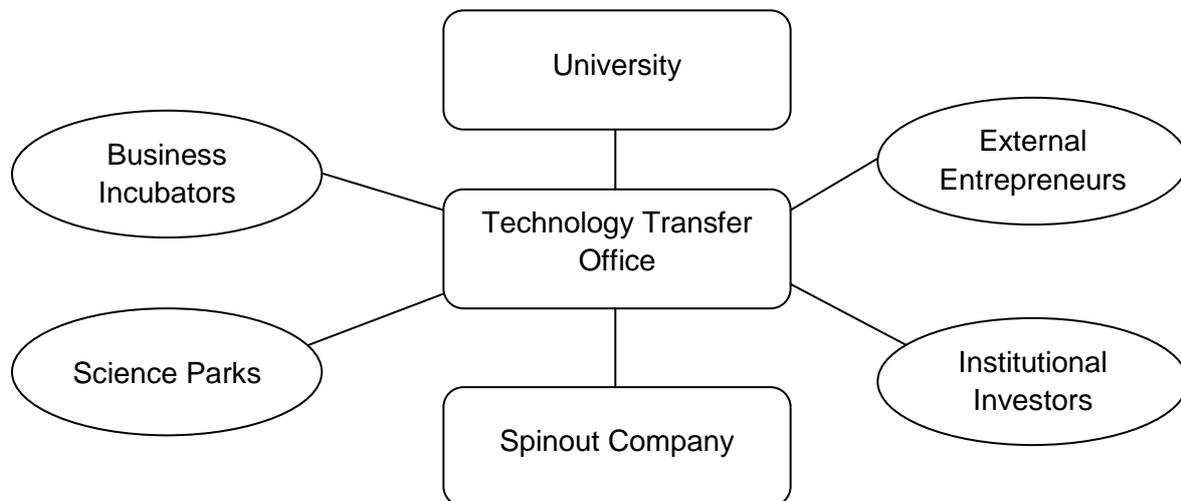
The studies that focused on the contribution of the university through academic spinouts have demonstrated positive effects on economic development (Chrisman et al., 1995; Lawton Smith, 2000; Dahlstrand & Jacobsson, 2003; Clarysse et al., 2004; Shane, 2004; Benneworth & Charles, 2005). In the UK some of the economic contribution of the academic spinouts could also be observed via IPOs (Initial Public Offerings) (Wright et al., 2007), with over 30 having taken place thus far (UNICO, n.d.; author's own research). However, not all the evidence is large enough in scope to provide a clear and robust picture of the spinouts' contribution to the economy. Thus some doubt could be observed as to the economic value of the university spinouts (Harrison & Leitch, 2010). Lambert Review (2003) already highlighted a problem of quality versus quantity orientation in university strategies towards academic entrepreneurship, with the evidence suggesting the second to be dominant. This is in many

instances a result of focusing support activities on creating rather than developing the spinouts (Siegel & Wright, 2007). However, this does not necessarily bring the negative connotations, as the sole quantity-orientation follows the logic of intensification of economy-developing activities performed by the universities. Similarly, although based on HEFCE's (Higher Education Funding Council for England) HE-BCI (Higher Education-Business and Community Interaction) survey data and their own research Harrison and Leitch (2010) argue that the spinouts' contributions to the economic development are rather insignificant, nonetheless, this could be rather a premature critique, as more large scale research is required to obtain significant and valid evidence.

University Entrepreneurship Support Infrastructure

The concern of many researchers in a recent decade was focused on the effectiveness of the academic spinout company creation (e.g. Franklin et al., 2001; Di Gregorio & Shane, 2003; Siegel et al., 2003; Shane, 2004). Since quantity-oriented research (Lockett & Wright, 2005; O'Shea et al., 2005) became less desirable (Lambert, 2003), this focus has identified specific 'elements' adding to the quality of academic entrepreneurship, briefly encapsulated in Figure 1 as represented by classification of literature findings (discussed below). This has drawn the attention to the resources provided by the university to the academic spinouts (Shane, 2004) which can broadly be referred to in terms of networks (especially human resources) (e.g. (Lockett et al., 2003; Shane, 2004; Wright et al., 2007) or infrastructure (Van Burg et al., 2008).

Figure 1 Classification of Current Research on University Resources – Forming the Infrastructure



Technology Transfer Office

From the literature we find that the primary development in the university commercialisation activities and its commitment to its increased economic role was the establishment of internal unit/department concerned with the knowledge transfer – Technology Transfer Office (TTO) (Etzkowitz et al., 2000; Siegel et al., 2007) (also known as Technology Licensing Office (TLO) (Shane, 2004; Kitagawa, 2007)). The role of the TTO is principally concerned with administrative burden of technology/knowledge transfer with a focus on legal aspects (IP – Intellectual Property) and commercial exploitation (Huggins et al., 2008; Goldstein, 2010) through, for example, creating a company or licensing the university IP. This administrative function is not definitive as can be found in Siegel et al. (2007) who discussed a much wider role of TTOs in relation to strategic decisions

concerned with invention disclosure and commercialisation, and institutional responsibility. Lockett et al. (2003) also stress the importance of TTOs in relation to identifying the commercial opportunities at the universities. In addition to that, Shane (2004; also Lockett et al., 2003) also points at another role – providing the ‘network of stakeholders’ (p.76), which he specifies as links with investors, and providers of ‘human and financial resources’ (p.78).

Business Incubators and Science Parks

Since the TTOs are tasked with creating the spinout companies, it is essential to focus on other university capacities in supporting these companies (Shane, 2004), which are attributed to the TTOs: business incubators and science parks. Business incubators are in essence institutions created to aid new firms, particularly technology-based, by providing a range of business support services, for example office space, equipment and business advice (Grimaldi & Grandi, 2005) to increase their initial survival chances (Sun et al., 2007). As noted by Sun et al. (2007) there is little doubt (Tamasy, 2007) in the effectiveness of business incubation, proving it to be a vital element of university entrepreneurship support infrastructure for academic spinout companies. The concept of science parks is very close to that of business incubators, with the difference in scope of support, location – usually being a separate building, and also the age of the firm – with those still in their infancy requiring incubation. This difference is not clearly visible in some literature (Lalkaka, 2002; Lindelof & Lofsten, 2006; Huggins et al., 2008), however the presented distinction is remained in this paper. Thus, science parks still ‘facilitate commercialisation of technologies, stimulate development of technology-based SMEs and promote regional development’ (Malairaja & Zawdie, 2008, p.729; Zeng et al., 2010) to as much a degree as business incubators do (Wynarczyk & Raine, 2005).

Institutional Investors

As new firms typically lack financial resources for growth it is important to consider the role of institutional investors in forming the university entrepreneurship support infrastructure. In 2006 approximately 19% of the UK Venture Capital market’s portfolios consisted of university spinouts or start-ups, with average investment of £3.6m per company, which was below the average for similar investments in independent start-ups (£4.1m) and corporate spinouts (£7.0m) (Library House/UBS, 2006). This could be related to the fact that academic ventures are often perceived as high risk investments by venture capitalists (Harding, 2000; Oakey, 2003; Shane, 2004), due to their very early stage of technology development and the consequent long time of product-to-market delivery (Shane, 2004). As a result, it is often hard for the inventors to fund their ventures, especially considering the low availability of early-stage funding (Murray, 1999; Lockett et al., 2002; Wright et al., 2006; Pinch & Sunley, 2009), and recent economic climate significantly affecting the European and British (in particular) private equity activity (BVCA, 2010; EVCA/Perop_Analytics, 2011). This, in particular, emphasises the need for the university TTOs to develop links with investors which may often mean ‘life or death’ for the new ventures (Shane, 2004).

External Entrepreneurs

Another important element adding to the university entrepreneurship support infrastructure as recognised in the literature is concerned with external entrepreneurs (Franklin et al., 2001; Lockett et al., 2003; Shane, 2004; Library House/BVCA, 2005). This, to a large extent, reflects the VC role in and perspective on investment in new businesses with decisions frequently focused on the experience of the firm’s management team. The Library House/BVCA (2005) report specifically stresses the importance of Technology Transfer Offices engaging with experienced entrepreneurs in

order to develop academic spinouts. Furthermore, the report indicates that the management has been found to frequently lack experienced entrepreneurs, which is stressed by the fact that technology transfer offices themselves have difficulties in recruiting entrepreneurs with a background in running technology firms (Library House/BVCA, 2005).

Some of these elements have already been classified as university infrastructure provided to academic spinouts (Van Burg et al., 2008), however, as infrastructure is associated with the tangibles (e.g. buildings) there has been little or no consideration given to treating the human capital elements as unequivocally embedded elements of this infrastructure. This paper, therefore, introduces the notion of university entrepreneurship support infrastructure (UESI), with a distinction on 'hard' – typical physical assets: business incubators and science parks, and 'soft' elements: external entrepreneurs and institutional investors.

Networks

As can be found in the literature on the academic spinout companies, the elements of the university entrepreneurship support infrastructure are linked to the university-formed networks (Lockett et al., 2003; Shane, 2004; Wright et al., 2007; Van Burg et al., 2008). This is particularly important as networks and innovation are well connected concepts in the literature (Vonortas, 2009; Morone & Taylor, 2010). For this reason it is important to refer to the concept of social capital which is concerned with the value of links between different social actors, and particularly in the meaning of: 'investment in social relations with expected returns' (Lin, 1999, p.30). As the social capital concept originates from the focus on social actors – people, it may be over-stretched in the considerations of more institutionalised actors, i.e. organisations, firms. A more adapted to organisational character concept has been proposed in a form of network capital (Huggins, 2010). Huggins (2010) argues that network capital can be managed, unlike the difficulty related to the social capital concept – being based on social actors difficult to control at an organisational level. This paper acknowledges the two concepts, as the university entrepreneurship support infrastructure involves both human and institutional actors.

Within the network considerations there is a clear relationship between densely populated networks and better performance of firms or organisations (Fleming et al., 2007; Hochberg et al., 2007; Schilling & Phelps, 2007), as this better connectedness increases the flow of knowledge. In this paper I propose that those universities/TTOs with larger infrastructure (i.e. having more elements/more connected) would experience better spinout rates. Conversely, those with less developed infrastructure would be characterised by lower rates of spinouts created. Using the results of this paper, a conceptual model of successful university entrepreneurship support infrastructure (presented from literature findings in Figure 1) is tested, and recommendations are offered as to how the worse performing universities could improve their chances by reviewing their infrastructure's construct.

The key purpose of this paper is to add to the discussion on the effectiveness of TTOs (Phan & Siegel, 2006; Siegel et al., 2007) (or – to shift the responsibility – the universities) by providing empirical evidence through a structural perspective supported by descriptive statistics and social network analysis (SNA). This perspective is provided through expanding and cementing the knowledge on university entrepreneurship support infrastructure elements already apparent in the literature by looking at them altogether – as forming a network – rather than separately – as unrelated.

Methodology

This paper explores the topic of the university entrepreneurship support infrastructure from a structural perspective. It utilises data on 784 UK academic spinouts. The data includes infrastructure information on the following elements: business incubators, science parks, and venture capital investors (i.e. institutional investors) identified in HE-BCI survey (HEFCE). Additionally, using the data on venture capital investors, the external entrepreneurs element was identified by classifying the links of universities with external venture capital firms as indicative (as a proxy) of having links with the entrepreneurs. This is based on the premise that external venture capital investors would require a management team – including experienced entrepreneurs – in order to commit to investing in any company. The data from HE-BCI survey relates to 2007-08 academic year for the analysis of university support infrastructure, and refers back to 2002-03 to present trends in technology transfer surrounding the spinning out activity.

The data sources on the sample of 784 spinouts used in this study are primarily available in the public domain, specifically consisting of university research reports, and have been collected from sources published in 2005-2008 period of time. The sample data was complemented using the MINT (Bureau van Dyke) database, which holds financial and other descriptive data on UK companies. For the purpose of this paper data on the firms' incorporation date and status was mainly collected. The status of firms that were found to be in receivership, liquidation, dormant or ceased trading is referred to as 'inactive' in this paper for simplification purpose.

The analysis performed in this paper focuses on the descriptive statistical and social network analysis (SNA), which is performed using open-source software Pajek 1.24. The SNA provides not only statistical but also graphical perspective, what enhances the understanding of the relations between the variables.

Findings and Interpretation

HE-BCI survey

The HE-BCI survey data provides an overview of UK HEIs' spinning out activity from 160 institutions. Figures 2 – 5 capture a 6-year period and reveal some trends in academic spinout formation. From Figures 2 and 3 it can be observed that the number of spinouts established each consecutive year was growing since 2004-05 period (Figure 2), however this increase was not attributed to a greater participation of the UK HEIs in creating spinouts (Figure 3), but rather intensified activities of the HEIs already actively involved in academic entrepreneurship.

Figure 2 Established Spinouts: 2002-03 – 2007-08

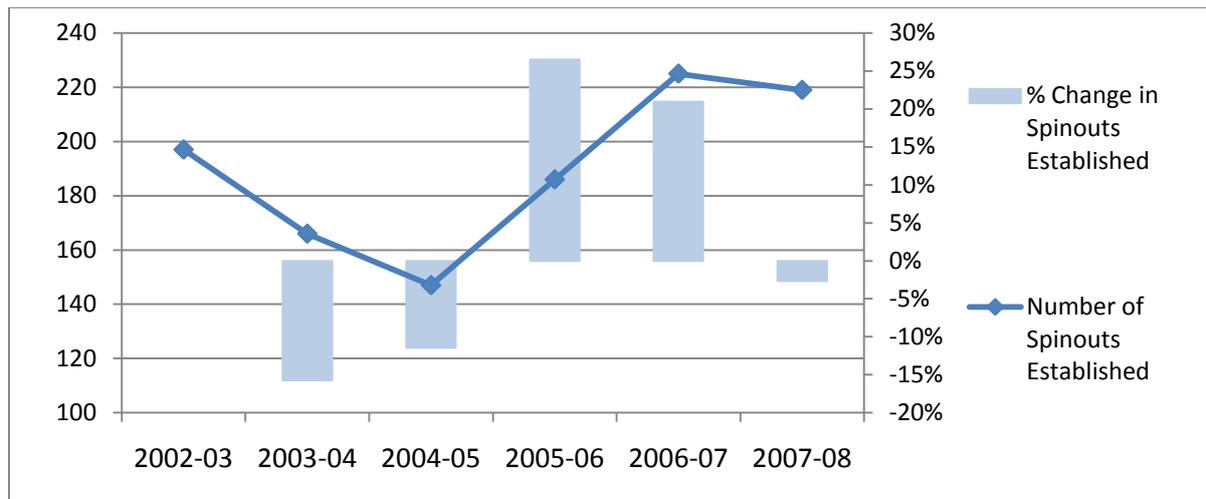
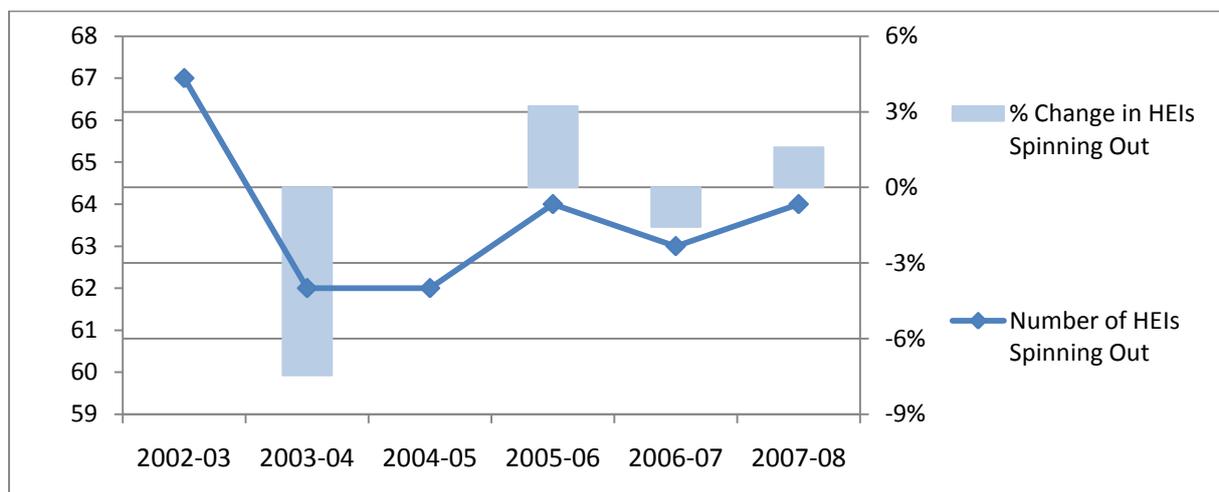


Figure 3 HEIs that Established Spinouts: 2002-03 – 2007-08



When considering the ‘survival’ of academic spinouts, it is observable that nearly each year consistently (excluding 2004-05) the number of active spinout firms was increasing (Figure 4). This trend seems again unrelated to a greater participation of UK HEIs in ‘developing’ firms (Siegel & Wright, 2007), and draws attention to only a certain (decreasing) amount of universities that appear to be successful in having created sustainable (i.e. surviving) firms (Figure 5). This evidence compared with the average of 15 years (n=145) that the UK TTOs have been established for could be indicating that the accumulated experience in technology transfer is not utilised by all HEIs that have such a unit or department. Furthermore, Figures 2 and 3 suggest that the fact that new spinout company creation started to fall in numbers whilst the experience of TTOs is theoretically growing (subject to staff rotation) suggests 3 explanations: 1) TTOs have reached a plateau in their productivity, 2) TTOs are shifting from quantity to quality orientation in spinout formation (as noticeable in Figure 4), or 3) there was significantly less research that could be commercially exploited in 2007-08 than in the previous years.

Figure 4 Active Spinouts: 2002-03 – 2007-08

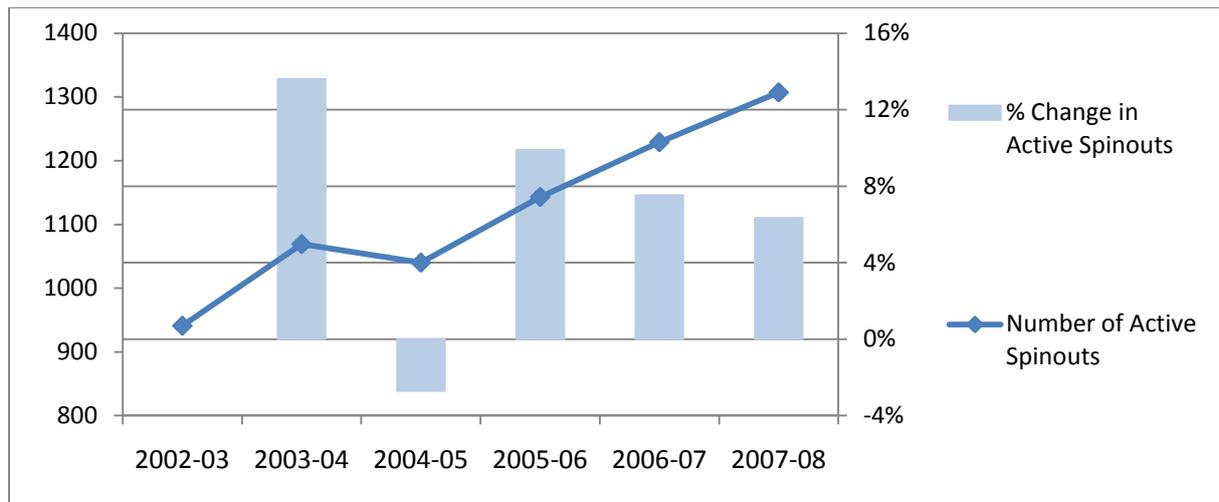
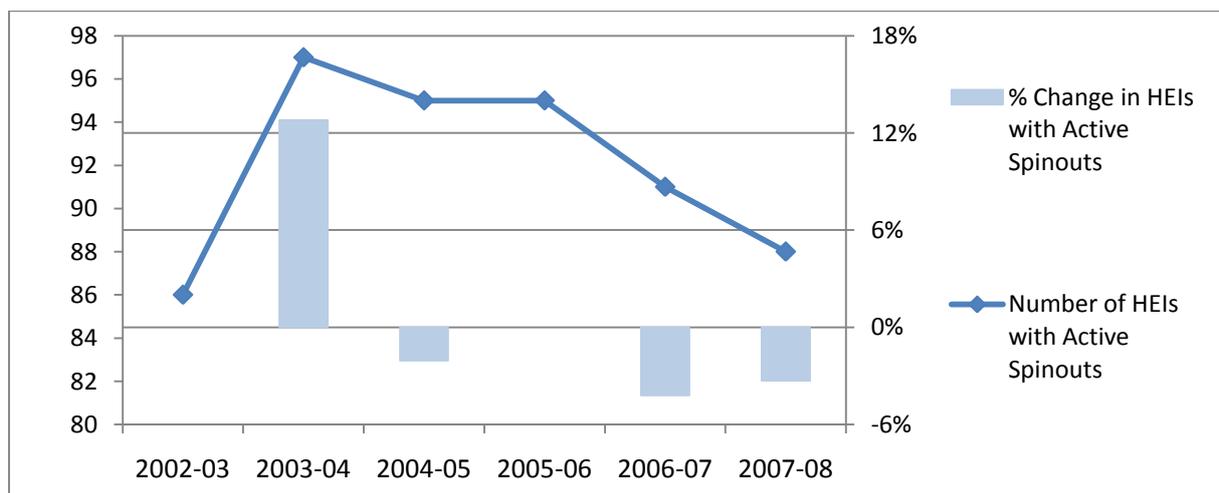


Figure 5 HEIs with Active Spinouts: 2002-03 – 2007-08



As identified in the literature the university entrepreneurship support infrastructure consists of four key elements: business incubators, science parks, institutional investors and external entrepreneurs. Table 1 depicts the percentage of HEIs with access to each particular element of the UESI. This evidence suggests that many universities have already developed a certain infrastructure for commercialising their knowledge through creating spinout companies. Specifically, over 80% of UK HEIs have access to business incubators, either on campus or provided by a partner organisation. This suggests that the majority of UK HEIs are capable of providing some sort of facilities for their new innovative firms. However, it remains still unknown as to what mode of the UESI (which elements together) mean that universities are well equipped for spinning out firms. As HE-BCI survey data captures only those spinouts that are still active it does not give a clear picture of absolute spinout rates (as it excludes firms that ceased trading). Thus, in the next section the collected data on UK academic spinouts is utilised as the main source of information about the spinout firm rates, complemented with HE-BCI survey data.

Table 1 HEIs and Infrastructure Elements (HE-BCI survey 2007-08)

Business Incubators	80.6%
Science Parks	41.9%
Institutional Investors	60.6%
External Entrepreneurs	58.8%

The sample

The sample on 784 UK academic spinout companies was identified from a study of all UK HEIs, however it relates only to 73 HEIs. Table 2 below represents the regional character of the sample, based on the region of the HEI a spinout originated from. From the table it is evident that the East of England is the most 'productive' region in spinout company formation, and when considering the average lifespan (both active and inactive) of the academic spinouts from the region it appears the universities located in the East of England are characterised by more and longer experience in the academic entrepreneurship. The table also shows that the typical prevalence of the Greater South East regions (in many economic activities) is disrupted by high performance of the Scottish universities in the creation of academic spinouts.

Table 2 Regional Classification of the Spinouts in the Sample

N=785*	Number of universities in the dataset	% Number of Spinouts	% Active spinouts	% Inactive Spinouts	Average Lifespan of Active Spinouts	Average Lifespan of Non-Active Spinouts
East of England	5	17.5%	14.1%	3.4%	11.7	8.3
London	13	13.6%	11.3%	2.4%	8.2	5.1
Scotland	12	14.6%	12.4%	2.3%	10.6	5.5
South East	8	10.7%	9.3%	1.4%	10.1	6.5
West Midlands	8	8.7%	7.1%	1.7%	10.6	4.8
Yorkshire and the Humber	5	8.5%	6.9%	1.5%	8.1	6.7
East Midlands	4	6.4%	5.6%	0.8%	9.7	8.0
South West	6	6.4%	5.4%	1.0%	10.0	6.5
North East	2	4.4%	3.5%	0.9%	10.6	8.0
North West	3	4.6%	4.1%	0.5%	9.2	5.3
Wales	7	4.5%	3.6%	0.9%	7.9	2.4
Northern Ireland	1	0.1%	0.1%	0.0%	11.0	n/a

*The number of spinouts used in this table includes John Innes Centre (JIC) and its 1 spinout, however, as JIC is not listed in HE-BCI survey data, it is excluded from further analysis.

From merging two datasets: the sample of 784 academic spinouts and the HE-BCI survey (2007-08) a clearer picture is observed on the role played by the infrastructure elements. As Table 3 depicts it appears there is a strong link between the UESI completeness and spinning out rates. The higher spinout creation rates are observable among the universities that have a TTO and a more developed UESI, with the universities that have a complete 4-element infrastructure having created on average over 10 spinout firms. This is approximately 2.25 times more than those universities with the TTO that have a 3-element infrastructure, circa 4.79 times more than those universities with the TTO that have a 2-element infrastructure, and circa 22.03 times more than those universities with the TTO that have a 1-element infrastructure. Furthermore, it appears that 61 HEIs with TTOs and up to 2 elements in their UESIs are responsible for spinning out approximately 6.27% of academic spinouts, whilst a

lower number of universities (50) with complete UESIs is responsible for nearly 2/3 of all spinouts. This evidence provides 2 key interpretations: 1) TTOs need to be better connected with access to all elements of the infrastructure to increase their spinout rates (importance of building networks), 2) it appears that the average experience of the TTOs of 15 years shows that fairly many TTOs did little commercialisation (start-up) activity, self-questioning their existence at nearly every such institution.

Table 3 Infrastructure Completeness and Spinout Rates

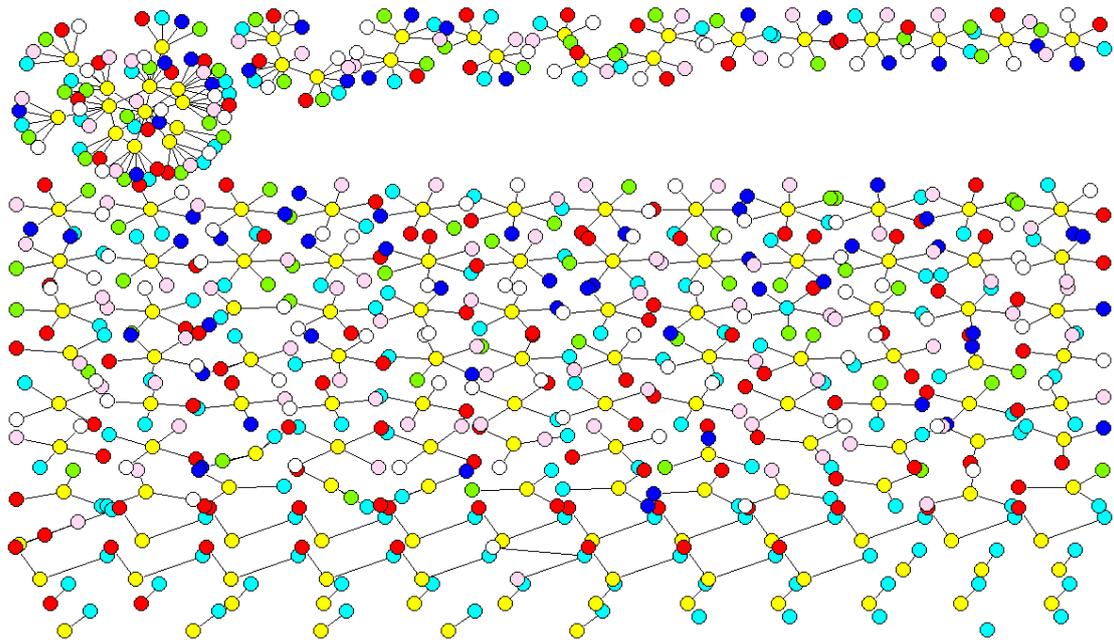
Number of elements in the UESI	Universities and TTOs (n=160)		% of Total Number of Spinouts (n=784)		Average of Spinout Creation Rates (n=784)	
	TTO	No TTO	TTO	No TTO	TTO	No TTO
0	19	5	0.04%	0.00%	0.02	0.00
1	25	2	1.51%	0.00%	0.47	0.00
2	17	1	4.72%	0.00%	2.18	0.00
3	40	0	23.66%	0.00%	4.64	n/a
4	50	1	66.50%	3.57%	10.43	28.00

Social Network Analysis

The links between the elements of the university entrepreneurship support infrastructure based on Figure 1 are constructed into a network, with the spinout firms aggregated to represent one vertex (node) only – as an element of the structure. The graphical exploration of the network links between the components of the UESI allows to analyse the interactions from a range of perspectives. The analysis is performed using social network analysis software Pajek 1.24 as a means of exploring the network relationships quantitatively and graphically.

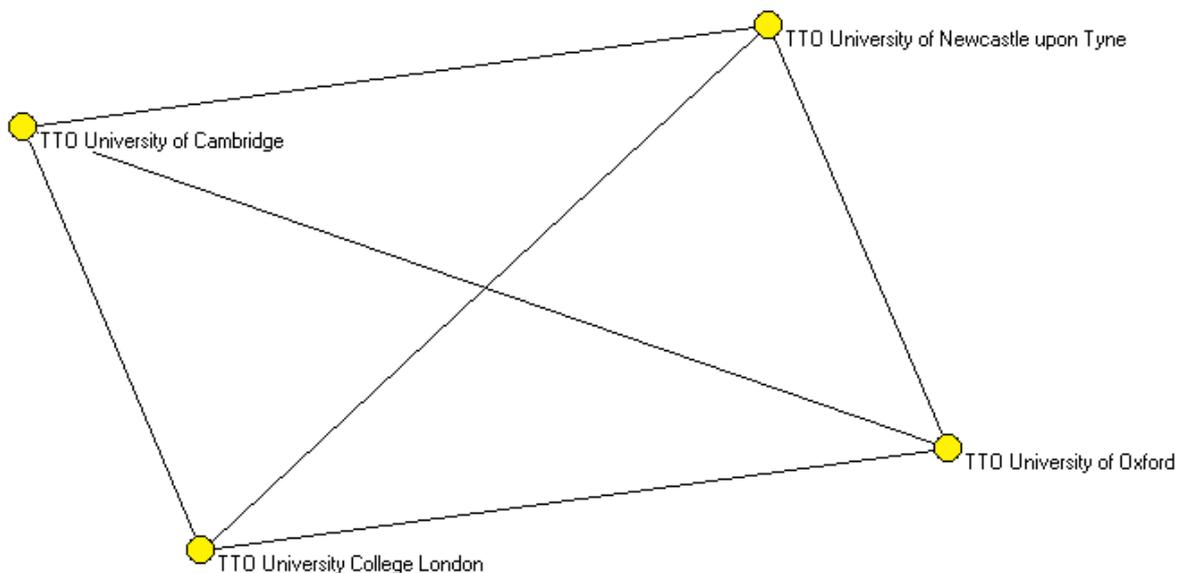
Figure 5 presents a macro perspective on the links of the components of UESI of 160 UK HEIs. The network was energised using Kamada-Kawai Separate Components algorithm. The light blue vertices represent universities, the yellow vertices TTOs, green vertices academic spinouts, red vertices business incubators, dark blue vertices science parks, pink vertices institutional investors, and the white vertices represent external entrepreneurs. In the dataset of 784 UK spinouts some of the firms have originated from more than one HEI, thus this is also captured in the network. Although the network appears to be densely populated, its actual density is very low – 0.00215, and resembles the isolation of most of the HEIs and their UESIs built into the network. The UESIs linked together forming the largest component in the network are represented by the following HEIs: Royal Veterinary College, Universities of Birmingham, Nottingham, Newcastle, Cambridge, Oxford, School of Pharmacy, Imperial College London, University College London, King's College London, Queen Mary (University of London), Birkbeck College, and Institute of Cancer Research. Although many of them are located in relatively close proximity (e.g. London), their network originates from more than one collaboration in creating a spinout company (e.g. University College London is found to have worked with 9 other HEIs in the process of creating spinout companies).

Figure 5 Network of UESI



The network shows that on average each university has at least 2 elements in its infrastructure, with the most frequent being: business incubators (16.7% of the network elements), then institutional investors (12.6%), external entrepreneurs (12.2%), and finally science parks (8.7%). In order to depict the most interlinked element of the network a cohesive subgroup is extracted from the network (Figure 6). This cohesive subgroup consists of a 3-core sub-network (each vertex has at least 3 links, or its degree is 3). The identified cohesive subgroup consists of those actors most highly involved in spinout-creating interactions with at least 3 different other actors. Such well connected actors form a network of trust, where each of them has the same or similar access to opportunities (Burt, 1992), here considered as commercial exploitation of university knowledge.

Figure 6 3-Core Cohesive Subgroup



After exploring the most interlinked component of the network is essential to consider the concept of centralisation of the network by looking at its betweenness, which treats as central the vertices that are the main, in this particular consideration, technology transfer hubs. In this network, it appears that the 3 key 'hubs' are University College London, Imperial College London and University of Cambridge TTOs (Table 4). It is also important to stress that those key 'hubs' have at least 3 elements in their university entrepreneurship support infrastructures.

Table 4 Key Technology Transfer Hubs (Betweenness Centrality)

Rank	Value	TTO*
1	0.0058	TTO University College London
2	0.0030	TTO Imperial College London
3	0.0029	TTO University of Cambridge
4	0.0026	TTO King's College London
5	0.0015	TTO University of Oxford
6	0.0015	TTO University of Nottingham
7	0.0015	TTO University of Newcastle upon Tyne
8	0.0012	TTO Queen Mary, University of London
9	0.0012	TTO University of Birmingham
10	0.0012	TTO Institute of Cancer Research

* All TTOs listed have at least one link with another TTO formed from creating a spinout company

Since the university technology transfer is very related to the commercial opportunities it is important to consider the structural holes in the network. Structural holes could be best described as actors linked indirectly by another actor – the lack of direct link is regarded as a structural hole, and thus an opportunity for the linking actor to convey information between the two (or more actors). When considering the structural holes present in the network University College London appears as one that can benefit the most in the network (Table 5). Furthermore, all of the universities in Table 5 have a UESI consisting of at least 3 elements.

Table 5 HEIs with Greatest Commercial Opportunities (Structural Holes)

Rank	Value*	TTO**
1	0.087	TTO University College London
2	0.105	TTO University of Cambridge
3	0.113	TTO Imperial College London
4	0.125	TTO University of Edinburgh
5	0.126	TTO University of Newcastle upon Tyne
5	0.126	TTO University of Oxford
7	0.130	TTO King's College London
8	0.133	TTO University of Nottingham
9	0.143	TTO Napier University
9	0.143	TTO University of Glasgow
9	0.143	TTO University of Aberdeen
9	0.143	TTO Keele University
13	0.157	TTO Institute of Cancer Research

* The values represent aggregate constraint; structural hole is an inverse of aggregate constraint

** All TTOs listed have at least one link with another TTO formed from creating a spinout company

The social network analysis points at structural disparities between universities and their entrepreneurship support infrastructures at a national level. Those technology transfer offices that had a chance to work together to commercially exploit knowledge residing at their institutions created links, and thus networks. Being networked provides them with greater opportunities compared to isolation (Vonortas, 2009), as observed from the empirical evidence presented through social network analysis, where none of the isolated TTOs was ranked high in betweenness centrality or structural holes. These inequalities found in the presented network confirm the dominating individualistic approach of universities to spinout formation.

Conclusions

The evidence presented in this paper, although subject to certain limitations, outlines major differences between university spinout company creation performances. It confirms the university requirement for a well designed university entrepreneurship support infrastructure consisting of both categories: hard and soft, and all elements: business incubators, science parks, institutional investors, and external entrepreneurs, to be in place if the spinout creation is to be continued in the future.

Furthermore, it is evident that although the dataset did not capture all existing links, being linked with other technology transfer offices improves network characteristics of the TTOs, as opposed to being in isolation. In addition to that, as the analysis focused on the links with the university entrepreneurship support infrastructure elements, it is even more essential for the technology transfer office professionals to work together forming cross-institutional alliances. The building of such alliances can be seen as accumulating the network capital, and eventually expanding the resources offered to academic spinouts – the university entrepreneurship support infrastructure. This should be especially important for the technology transfer offices (representing universities) with less developed infrastructures.

Policy implications

As the development of the TTOs and accumulated experience do not appear to be in line with drastic increases in the number of spinouts and universities spinning out firms, it could be indicative of a plateau reached in the productivity of technology transfer offices (Chapple et al., 2005). For some, there has been little productivity observed whatsoever. This might suggest a need to formally review the activities of the TTOs, and possibly consider reconfiguring their structure. In other words, in order to maintain the value of the TTOs and reduce the existing infrastructure disparities between universities, there are two possible solutions proposed: 1) a strong encouragement for the universities, in particular their technology transfer offices, to join forces on the field of technology transfer sharing experiences and exchanging access to resources, and 2) a centralisation of TTOs at a regional level could suggest reduced cost benefits as well as improved performance in spinning out firms, eventually, maintaining a high value of such structures to the regional economies.

Directions for further research

This study focused on a limited structural perspective, which encourages many questions. Therefore, further research is recommended to provide a more robust picture of the university spinning-out activity taking into consideration measures of spinout success, university characteristics and the existing links formed by all elements of the presented university entrepreneurship support

infrastructure. Additionally, it is suggested that a more concentrated evaluation of the importance played by each element of the university entrepreneurship support infrastructure is carried out.

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