Entrepreneurial academics and regional innovation systems: the case of spin-offs from London's universities

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Abstract

This paper explores the spin-off process from London's universities using a regional innovation systems (RIS) framework. It examines the pattern of spin-offs in the context of changes in institutional support systems, both within the universities and in the London region. The majority of the university-related spin-offs are small and medium-sized (SMEs), concentrated in biomedical sectors as elsewhere (Shane 2006, Lawton Smith and Ho 2006). However, over a third has left London. The paper explores these patterns, the implications for understanding the role of universities in RIS and consequent policy implications.

1. Introduction

Encouraging academics and universities to be more entrepreneurial is part of an overall focus on an innovation-based policy agenda in the UK dating from the mid-1980s. The UK was first to develop a national university commercialisation policy (Geuna and Muscio 2009). It was in the 1980s that Conservative Governments (1979-1997) introduced radical changes to both funding of universities and rules governing exploitation of rights for publically funded research thus establishing the paradigm of universities as wealth creators.

This was continued by Labour governments (1997-2010) through university-focused funding programmes introduced in the late 1990s and early 2000s. The commercialization of research through spin-offs and other technology transfer activities such as patents has been backed by significant public financial resources (Sainsbury 2007, DIUS 2008). Recording the performance of universities' commercialization activities such as patents and university spin-offs was established in the 2001 with launch of the Higher Education Business and Community Interaction (HE-BCI) surveys. The regional agenda associated with the commercialization and other "third stream" missions became explicit with the introduction of the English Regional Development Agencies (RDAs) in 1999.

Numerous studies have identified patterns of university spin-offs in different countries and regions, highlighting the uneven distribution of spin-offs by type of university and by region. In this paper we focus on the specifics from a study of university-related companies in London, involving 12 of London's 42 higher education institutes (HEIs), including two of the world's top research universities University College London (UCL) and Imperial College of Technology and Engineering (Imperial). A dataset was established to include firms that were formed by academics and students. Firms were identified from universities' official sources, through interviews with technology transfer officers and academics and through other routes. Data on the firms and their location was collected through such sources as public and privately owned databases on indicators of performance such as employment and turnover growth and date of initial public offering. Hence we examine the spin-off process in a specific context, taking into account the timing of the formation process and firms'

subsequent growth within the context of changes in the technology transfer processes in universities and in the entrepreneurial environment in London since the 1980s.

The analysis is positioned within a regional innovation systems (RIS) framework (Cooke 1998). As Huggins (2008) points out, theory concerning regional innovation systems and knowledge systems of innovation must be clear about context and the specific actors within those contexts. The paper addresses two questions: what is the role of universities in RIS? And, what does a regional innovation system look like in supporting the academic spin-off process?

The rationale for using the RIS framework is that in principle universities are institutionally embedded in regional contexts (Asheim and Gertler 2005). As their firms tend to stay local, the region will provide for them to a greater or lesser extent an entrepreneurial environment. Therefore the paper it explores the co-evolution of policy and practice; the limitations to the conceptualisation of the former and the reality of the latter. Theoretically, this paper links to the literature on regions as entrepreneurial environments or regional innovation systems, with reference to classic literature on agglomeration theory and industrial clusters. In its critique, it considers the fragmentation within the London 'entrepreneurial environment', challenging the notion of systemness (see Clark et al. 2002). The paper considers the policy implications for improving the academic spin-off process in London.

Moreover, in examining the spin-offs process, it should be borne noted that other forms of commercialisation activity such as professional training of graduates, and that consultancy and collaboration may be more significant than university-based entrepreneurship (see Wood, 2009).

The reference point is a study in the mid-2000s by Huggins (2008) who presented a negative view of London's knowledge-based venturing activities, suggesting that its universities were underperforming in creating technology spin-off companies. It addresses this issue and compares London with other UK regions.

2. RIS, universities and entrepreneurial regions

2.1 Defining RIS

We define RIS in order to position universities within a framework which allows consideration of the supply side (the universities as sources of new firms) and the demand side, the different regional needs for universities' outputs (Lendel 2010). The spin-off process can be seen as contributing to place-based development within RIS arising from institutional knowledge exploitation, both from the supply and demand side.

Asheim et al. (2011,878) summarise the RIS approach as 'an emphasis on economic and social interaction between agents, spanning the public and private sectors to engender and diffuse innovation within regions embedded in wider national and global systems'. Similarly Doloreux and Parto (2004, 3) define it is as a 'set of interacting private and public interests, formal institutions and other organizations that function according to organizational and institutional arrangements and relationships conducive to the generation, use and dissemination of knowledge (Doloreux, 2002).

The RIS approach draws on theoretical strands which emphasise social as well as economic attributes of regions in national and international contexts. These include

national innovation systems, Marshallian industrial districts and critiques of thinking on clusters and agglomeration (Gordon and McCann 2000) and innovative milieu which collectively have been referred to by Moulaert and Sekia (2003) as territorial innovation models. It encompasses such concepts as learning regions offering positive external economies of scale from specific factor endowments (economic, socio-cultural and institutional) (Asheim et al 2011). Innovation is a key element in these conceptualisations. The combination and extent of localisation and urbanisation advantages (land, labour capital, specialist suppliers) and knowledge as sources of positive and negative externalities, increasing returns to scale and spillovers as well as forms of governance systems and the business superstructure are also elements in the conceptualisation of the different forms that systems take (Cooke 1998).

The main institutional actors in the external context (the demand side) are the national system of innovation, the regional system of government, and public and private sector organisations with an interest in high-tech entrepreneurship. Specific needs depend on the structural composition of the regional economy and the prevailing knowledge bases (Asheim and Gertler 2005).

The RIS configuration of the RIS and the innovation and absorption capacities of the knowledge application subsystem are central to specifying how university outputs translate into regional economic development. In a ‘well found RIS’ there would be connections between the universities and the external environment, in effect a co-evolution of subsystems bringing benefits to both (see Clark et al. 2002).

Doloreux and Parto (2004) in a critique of RIS identified two issues which are relevant. The first is the interactions between different actors in the innovation process, particularly that between users and producers, but also that between business and the wider research community. The second is the role of institutions and the extent to which innovation processes are institutionally embedded. They argue that interactions between the actors in RIS have been insufficiently explored and the institutional context of these interactions has been largely overlooked. This issue is conceptualised in Cooke's (1998) scheme for the classification of RIS to demonstrate their diversity. This includes scales of interaction at which they are co-ordinated or governed: grassroots, network, dirgiste, and whether they are localist, interactive or globalised, hence the relative importance of national systems of innovation (Lundvall 1992). A further shortcoming is captured by the inability to address the fundamental question of how one recognises a regional innovation system (Markusen 1999, in Doloreux and Parto 2004). This is irrespective of ambiguities of defining regions and boundaries of a RIS (Lawton Smith and Waters 2011).

To link those criticisms, the analysis which follows identifies the main elements that comprise the system, the key institutional actors, structural elements and interactions amongst them (Cooke et al. 2000). The intention is to identify what a regional system would look like where universities are engaged in supporting the spin-off process, and to consider the main elements of a "well found" RIS.

2.2 What does the regional innovation system look like where universities are engaged in supporting the spin-off process?

2.2.1 The RIS model and the university

Universities are conceptualised in the RIS framework as having a fundamental role in interactive learning processes, and as important actors in regional systemic interdependencies leading to innovation (Cooke et al. 2004; Asheim and Gertler 2005). Where universities are engaged in the spin-off process, they do so from interactions between two regional subsystems of knowledge generation and exploitation (Asheim and Gertler 2005) and from two types of function in RIS: generative and developmental (Gunasekara 2006). University spin-offs are part of the system of knowledge generative role and have an associated developmental role in the form of teaching, but also in human capital formation through their supply of graduates, as entrepreneurs and increasingly through entrepreneurship education. Here they are part of the regional institutional context (Cooke, 1998) because they supply commercially exploitable knowledge and the people to do that exploitation (the entrepreneurs and the employees). Where they are involved in decision-making processes relating to regional entrepreneurship policies they are important actors in regional systemic interdependencies through which innovation is supported.

As universities as institutions change over time, their positions within RIS change within a regional entrepreneurial ecosystem infrastructure (Harrison and Leitch 2009). Factors which might be associated with internal changes include national policies

relating to commercialisation of university research as well as internal missions (see Clark 1998) and characteristics of their researchers (Wright et al 2007), for example, age, gender, discipline and seniority. In some cases the university and its relationship with local economic growth reflect changes in both: organisations mirror their contexts through a process of co-evolution (Aldrich 1999).

2.2.2 RIS and the university spin-offs' environment

The availability of local resources and institutions for supporting innovation capability and competitiveness of firms and regions, and the nature and extent of interaction amongst agents are components which distinguish varieties of RIS. The entrepreneurial decision, such as the decision by an academic or student to start a firm, is embedded socially, culturally and functionally in particular institutional contexts (Doloreux, 2002).

RIS vary in scale from world cities such as London and Tokyo to smaller regions with no universities. Metropolitan regions are judged to be the most active sites for innovation (Audretsch and Feldman 1999). They are characterised by economic and social resource availability in the form of finance, skills, infrastructure and services, scientific, technological and analytical capacities, their science bases (universities and research institutions); and through networks and entrepreneurial cultures (see Bathelt et al 2004, Huggins 2008).

Boucher et al (2003) offer a taxonomy of universities in territorial development: single player universities in peripheral regions, traditional universities in core regions,

newer technologically-oriented universities in core regions, and other categories. The notion of the "excellent region" (Power and Malmberg 2008) as an ideal type is characterised as a three stage model: excellent research takes place in strong localised milieus, innovation and commercialisation occur in direct interaction with such strong localised research milieus, and value creation (new and growing firms etc) happens in proximity to innovation and commercial milieus.

Some universities seem to fit the schema of universities as key institutions within a RIS but in practice, there is a limit to how far the system idea can be taken. For example, larger and more prestigious universities as in London which are the 'most active knowledge ventures' are more likely than less research intensive universities to create the conditions under which spin-offs contribute to the stock of local knowledge intensive firms (or service-based firms), creating specialist local demand for factors of production. The impact of universities, however, is most substantial in small and medium-sized regions (Goldstein and Drucker 2006) which have the advantage that the existence of networks is more transparent (Huggins 2008).

Decisions by academics to start, stay with and grow their companies are affected by continuing relative importance of different kinds of resource and the attributes of the region (Lawton Smith and Bagchi-Sen 2011). Some regions possess the most advantageous conditions for incubating new firms, and for supporting the technological capability of firms related to their products, production technology and their need to develop new products and markets (Frenkel 2001). This includes the relative propensity for students to stay post-graduation (Faggian and McCann 2009, Harrison and Leitch 2010), which will in turn affect the location of young and

innovative firms (Frenkel 2001). Venture capital funded companies tend to be located in areas where there are strong social structures of innovation (Warren et al. 2008). Firms in locations with high-levels of entrepreneurship and surviving and growing firms, including spin-offs, are more likely to be able to create a local demand because of a cumulative effect with more high quality firms creating more opportunities for investors and professional services (localised increasing returns to scale, Gordon and McCann 2000). A key element in a RIS is the ability for universities and their spin-offs to recruit and retain entrepreneurs capable of putting into place growth strategies for the new firms (the developmental role (Gunasekara 2006). Where spin-offs have local university advisers, local expertise and local investors they are more likely to survive, grow and develop network ties (Mosey and Wright 2007).

In regions there is no entrepreneurial ecosystem, its absence adversely affects technology transfer processes and growth-oriented ventures. Warren et al (2008) find that where universities are isolated from supportive innovation systems, using the availability of venture capital as a proxy, their ability to transfer technology is reduced. They also suggest that in areas with weak entrepreneurship communities, new firms rely more on the universities to provide early stage financing, facilities and other resources. Therefore, the presence or absence of 'sustained capacity building' (Feldman 2001) and regional planning are important components in shaping a RIS or entrepreneurial environment.

However, the understanding of entrepreneurial systems needs to be related to changing needs for resources and interdependencies with external organisations in specific contexts (Harrison and Leitch 2010). For example, the importance of the firm

being close to the founder's home may decrease with expansion and have other locational considerations (Frenkel 2001, Bathelt et al 2010). Both the regional significance change and the nature of the link to the home university change over time (Bathelt et al 2010). Harrison and Leitch (2010) found that university spin-offs in Northern Ireland generally made little use of external provision and existing support networks.

To summarise, the concept of RIS is a useful heuristic, with some caveats, for examining universities both as sources of new firms within a region (supply side), and on the demand side as the way in which the regional environment is shaped by and shapes the spin-off process. The spin-off process can be seen as contributing to place-based development within RIS arising from aspects of universities relating to knowledge exploitation within the national context.

We now turn to the London study beginning with the entrepreneurial context.

3. London's entrepreneurial system

This section defines the spin-off process and describes its study in London, and relates it to the concept of RIS from the university function: generation of types of firms and sectoral specialisation. This is followed by a discussion of universities and the regional environment.

3.1 The university sector in London

London is home to more than 42 HEIs and accounts for more than 20 percent of total UK spending on Higher Education[1] and 27 percent of UK research council grant funding. These institutions educate more than 56,000 graduates per annum on 11,000 undergraduate and nearly 4,000 postgraduate courses. They include large, multi-disciplinary institutions, such as UCL and Imperial, the other 15 colleges of the University of London, and 'modern' universities such as South Bank and London Metropolitan University, and many smaller specialist institutions, particularly in medical and other scientific areas, with a concentration of teaching hospitals, clinical trial facilities and major biotech firms (NESTA 2006). There are also some of the UK's leading creative art and design colleges offering training in technical and creative skills in media, journalism, art and design, the performing arts and information and communication technologies (ICT). These present a huge array of overlapping and complementary spin-off opportunities, ranging from the physical sciences, particularly biological and medical sciences, engineering, to architectural, media, and industrial and product design.

From a very low 1980s base, the university sector as 'knowledge exploiter' (Asheim and Gertler 2005) has become more institutionalised through internal changes such as the establishment of technology transfer offices (TTOs). Many universities now have student entrepreneur societies and mentoring activities for staff, student and external entrepreneurs (e.g. UCL Enterprise/UCL advances). Tables 1 and 2 show

[1] http://www.londonhigher.ac.uk/fileadmin/documents/HESAResourcesFinances2006_07.pdf (accessed October 12 2009).

developments at UCL and Imperial. Imperial Innovations invests in spin-offs from other universities and is collaborating with the UK's three other top university technology transfer arms, Cambridge Enterprise, Oxford Spin-out Equity Management and UCL Business[2]. UCL provided dedicated support for spin-offs in the biomedical field earlier than Imperial (see below).[3]

Date	*Milestone*
1986	IMPEL incorporated.
1997	Imperial Innovations business established.
2002	30% interest in unquoted spin-off portfolio sold to Fleming Family & Partners. £20m co-investment fund established.
2005	Private Placement of shares in Imperial Innovations raises £10m.
Jul-2006	Imperial Innovations Group plc floats on AIM raising £26m. It raised £66m over three years and at 2011 had equity holdings in 80 companies.

Table 1 Key milestones in Imperial College's TTO

Date	*Milestone*
1982	UCL Innovations (UCLi) established with dedicated TT staff
1991	UCL Ventures
2002	UCL Business established as union of Contracts Office, UCL Ventures and new, HEIF funded, Business Development and Consultancy functions..
2003	UCL Biomedica Plc formed to exploit BioScience Innovation through merger of life science TT activities at UCL and Royal Free (formerly, FreeMedic Plc).
2006	Creation of UCL Business Plc merging functions UCL Business and UCL Biomedica with contract office activity reverting to UCL.

Table 2 Key milestones in UCL's TTO

London in the mid-2000s had a weak 'entrepreneurial system' (Harrison and Leitch 2010), covering networks, research universities, professional services and skilled labour. Huggins (2008) suggested that many universities in London were not well connected to regional finance networks and there were weaknesses in informal networks. This problem is related to the size and number of financial players, 'leading to networks that are at best disjointed and at worse disconnected' (page 199). Resources were skewed towards London's larger and more prestigious universities.

[2] http://www.imperialinnovations.co.uk/about (accessed May 17 2011)
[3] Other HEIs in London have entrepreneurship centres e.g. UEL's centre for women's entrepreneurship http://www.uel.ac.uk/cewe/about/index.htm (accessed October 8 2008)

Basic weakness in the London RIS more generally was that informal investment in new companies in London had fallen (Bosma and Harding 2006). They found that gaps in the provision of early stage funding in both universities and the private sector had resulted in the public sector taking on an increasing role in supply. The flagship public sector early stage fund in London is the Capital Fund, one of nine English Regional Venture Capital Funds established in 2002 to provide risk capital to SMEs based in Greater London.

The size and diversity of London-based HE institutions resulted in a piecemeal approach to providing facilities to incubate and support new academic enterprises. Unlike Oxford and Cambridge, London lacks significant city-wide infrastructure of dedicated property, with the more recent exception of the biomedical sector. Prior to 2006, when the Imperial BioIncubator opened, the London BioScience Innovation Centre (LBIC) at the Royal Veterinary College in northwest London (established in 2001) was the only incubator for life-science start-up firms in London.

In November 2005 the LDA made a commitment to improve the infrastructure to support HE enterprise in the capital. The formation of London's Science and Industry Council[4] brought together leaders from industry, academia, finance and the public sector to promote London's strengths in science, technology and design to a national and international audience and advise the LDA in its long term economic development interventions. London Higher, formed in 2000, representing the 42+ HEIs in London collaborates extensively with the LDA and London Mayor's Office's

[4] http://www.lda.gov.uk/upload/pdf/Part_2_Item_03.1_20080612.pdf (accessed August 8 2009).

as well as central government and the Higher Education Funding Council for England (HEFCE).[5]

The newly formed London Economic Partnership (LEP)[6] will focus on enterprise and innovation, skills and innovation more generally. The Regional Growth Fund (2011-2014) aimed at creating jobs and "rebalancing" the economy in the face of public sector spending cuts, is also intended to stimulate entrepreneurship[7]. Recent images of London's high tech economy include Silicon Roundabout' (a concentration of firms in North east London) and the East London 'Tech City' [8]. Moreover there are a number of company-led ICT and media incubators led for example by Google. However, the extent to which the university spin-off process will be embedded in the broader RIS of which these incubators are a part is not yet apparent.

4. Research approach, methodology and context

The first task of the study was to establish a database of spin-offs. The annual Higher HE-BCI survey's definitions (below) were used in order to ensure consistency. This approach encompasses a variety of university-related companies and different routes to the exploitation of academic expertise through research and teaching (which narrower definitions would not). Bathelt et al (2010) drawing on Pirnay et al (2003) go to some lengths to capture the different types of spin-off. They note a distinction between spin-offs sponsored by a university and others not (equivalents to staff start-ups).

[5] http://www.londonhigher.ac.uk/fileadmin/documents/Publications_2011/BusinessStrategy_2011.pdf
[6] LEPs replace the nine English Regional Development Agencies
[7] http://www.bis.gov.uk/policies/economic-development/regional-growth-fund
[8] http://www.demos.co.uk/projects/cfl-eastlondontechcity (accessed October 8 2012)

- **Spin-offs** are defined as companies set-up to exploit IP that has originated from within the HEI.
- **Formal spin-offs, not HEI-owned** are those companies set-up on IP that has originated from within the HEI but on which the HEI has released ownership (usually through sale of shares and/or IP).
- **Staff start-ups** are those companies set-up by active (or recent) HEI staff but not based on IP from the institution.
- **Graduate start-ups** include all new business started by recent graduates (within 2 years) regardless of where any IP resides.

For 2008-9, the HE-BCI survey detailed a total of 982 spin-off companies nationally still active after three years, a rise of about 300 since 2003. In the period 2003-2009 the number being formed fluctuated, ranging from 167 in 2003 to 2226 in 2006-7 to 191 in 2008-9. It should be noted that the number of graduate spin-offs from this source is likely to be an underestimate: many UK institutions make no return in this category. However, Harrison and Leitch (2010) find that the number of student and researcher spin-offs has increased sharply since 1999. In addition, some successful spin-offs were formed before their university's TTO. Moreover, reliable data on outputs such as the value of spin-out companies is underreported (PACEC 2009). In general university start-ups represent a very small proportion of overall start-ups in the economy (Swinney 2011).

Universities are an increasing source of new firms increasing over time as more firms are formed, more survive but most remain small. Although student start-ups are also

relatively small in number, there has been rapid growth in the UK. In 2009, institutions reported 2,045 start-ups, an 11-fold increase in nine years. Elsewhere, for example in Italy, Canada and Sweden the same pattern is evident.

The explanation relates to the internal characteristics of the firms, the nature of the market they enter, and to weaknesses in the external environment, particularly raising finance. For example Iacobucci et al (2011) found for that Italian spin-offs most of which were in the centre and north of Italy, size was related to problems of building new resources such as in marketing. Others had staff retention problems. Growth capacity, however, was in firms of most recent origin. Bathelt et al (2010) found that in Canada size was also related to limited opportunities in market niches. These authors distinguish university start-ups which are less likely to grow, arguing that university start-ups and spin-offs from pure university research have less market legitimacy than firms produced from combined university-industry collaboration, benefiting from existing industry networks and third party referrals.

An alternative explanation of UK spin-offs remaining small in the chemical sector (Royal Society of Chemists, RSC, 2006) is many spin-outs seemed to be vehicles for further research rather than genuine attempts to set up commercial companies. Too many companies were formed on the basis of a single idea or patent leaving them with a weak base. Most universities spent their University Challenge Seed Fund monies[9] but had no mechanism for seeding new companies after the proof of concept stage. Consistent Huggins (2008) and Harrison and Leitch (2010) in the UK and Iacobucci et al (2011) in Italy, this was exacerbated by a shortage of seed investors

coupled with difficulties in attracting private investment into proof-of-concept funding.

Lindholm Dahlstrand (1997) found that in the Gothenburg region, university spin-offs are very small with low growth. Corporate spin-offs were found to out-grow other technology-based firms; they expanded employment about twice as fast as the non-spin-offs and about 10 times as fast as university spin-offs. Harrison and Leitch (2010) similarly found that formal spin-offs with no university stake appear to be larger than those based on university intellectual property. The Oxford city-region appears to be a partial exception to the pattern. Although most spin-offs from Oxford University are small, some have been established for many decades (1950s, 1980s) are now very large (Lawton Smith and Ho 2006).

4.1 The London study

The database of university-related companies in London (the London Universities University-related companies Database, LUCD) was designed to fill gaps in the official data. It was established from a range of published and informal sources including: HE-BCI survey returns; institutional technology transfer managers; TTO websites; informal primary sources including: interviews with academics; London Technology Network (LTN) Business Fellows[10]; and personal contacts.

Most of the data were available through the various institutions' TTOs. In a significant number of cases local departmental sources accessed by LTN Fellows

10 http://www.ltnetwork.org/bfora/systems/xmlviewer/default.asp?arg=DS_LTN_PARTART_24/_firsttitle.xsl/20 (accessed 9 October 2009). It closed in 2011

supplemented and extended official records of spin-off activity. Academic founders were identified from a variety of sources including, personal contacts, university and company press releases and the merging of academic staff directories with official records of company officers. LTN Fellows were particularly useful in contributing additional information about staff (and to a lesser extent graduate) start-up companies.

Secondary data sources included: an on-line survey of companies in the database; the Bureau van Dijk FAME database; Companies House; the European Patent Office and the US Patent and Trademark Office. Information gathered on academic entrepreneurs and their enterprises comprised company profiles: company name, founders' names, founders' university and department affiliation, date of incorporation, sector (SIC); location; and other information about the history of the company. Performance indicators included current status; employment; financial performance; market share; and ongoing R&D activities.

The results presented here are from study of 12 universities (Table 3), reflecting the diversity of London's universities and represent potential entrepreneurial activity in science and technology.

Elite	**High research intensity**	**Medium research intensity**	**Low Research intensity**
Imperial UCL	Kings Queen Mary London School of Pharmacy Birkbeck (all University of London)	Brunel City Goldsmiths (University of London)	South Bank University London Metropolitan University University of Westminster

Table 3 London HEIs project

Table 4 ranks the institutions according to research-type. Imperial College and UCL are ranked 9th and 22nd on the THE (2010) World's Top 200 Universities. Imperial specialises in science, engineering, management and medicine and is a self-governing institute since leaving London University in 2003. In the next box, are four London University colleges. Birkbeck is 'London's evening university'. The majority of its students are in full-time employment. The London School of Pharmacy is a free-standing specialist school in the UK dedicated entirely to teaching and research in pharmacy. The next three are all pre-1992 universities. City and Goldsmiths are over hundred years old whereas Brunel, a campus university was established in the 1960s. The final three are former polytechnics, post-1992 universities. Table 4 provides HE-BCI figures relating to company formation where we have derived a Location Quotient that normalises for the number of academic staff (FPE) in each region.

	Academic Staff	**Spin-offs with some HEI ownership**		**Formal spin-offs, not HEI owned**		**Staff start-ups**	
Area		07-08	06-07	07-08	06-07	07-08	06-07
North East	6550	1.7	0.4	0.0	0.0	0.0	0.0
North West	15790	0.8	1.6	2.7	2.4	2.0	0.7
Yorkshire and the Humber	13795	1.5	1.3	0.0	0.0	0.3	0.4
East Midlands	11375	2.2	1.7	2.3	1.1	1.2	1.7
West Midlands	11360	0.9	0.4	0.0	0.5	0.4	0.7
East of England	10540	0.4	0.3	0.0	0.0	0.4	0.8
London	36415	**1.0**	**1.1**	**1.4**	**1.2**	**0.7**	**0.8**
South East	21500	0.5	1.0	0.4	0.9	0.0	0.8
South West	9860	0.6	0.3	0.9	1.9	5.4	3.9
England	137185	1.0	1.0	1.0	1.0	1.0	1.0

Table 4 Regional Location Quotients for key HE-BCI (2007-8) indicators

In London, sales of shares in spin-offs as a percentage of the regional total are well below North West, South West and neighbouring South East (Harrison and Leitch

2010). It should also be noted that the number of patent applications generally has risen faster than the rate of spin-off formation, by over a third, although the number of patents granted has fluctuated. Moreover, income from collaborative research and especially contract research has risen. This suggests that the spin-off process is not particularly profitable as income from sales of shares accounts for less than one-third of all income from the exploitation of protected IP (Harrison and Leitch 2010). Hence universities as a major contributor to the knowledge exploitation role in RIS (Asheim and Gertler 2005) is better than in other parts of the UK, but the impact generally is very small.

5. Results

Given the uncertainties associated with the recording of start-up companies we restrict analysis to spin-off companies including HEI owned, not owned, and staff start-ups. Graduate start-ups are only discussed where reliable data is available.

5.1 Date of formation of spin-offs from London and their location.

The formation of academic spin-offs in London is relatively recent with UCL and Imperial having a considerable track record of establishing firms prior to 2000 (Table 5). The earliest identified surviving London spin-off was established in 1965. The majority were formed in the 1980s around the time of the establishment of TTOs and therefore could be associated with formal measures by these universities to foster spin-offs. The formation rate, however, was low until 1997, with an average number

of spin-outs per year between 1965 and 1997 of around two. Most were formed between 1998 and 2006 and almost 70% were established between 2000 and 2006.

Year of incorporation	*< '00*	*'00*	*'01*	*'02*	*'03*	*0'4*	*'05*	*'06*	*'07*	*'08*	***Grand Total***
Imperial College	24	13	13	10	5	6	3	6			**80**
UCL	38	9	5	9	4	7	3	3	1		**79**
King's College	7	2	4		1	3	1	1		1	**20**
Brunel University	2		2	2	3	2	2				**13**
South Bank University		1	1	2	2	2	1	4			**13**
Queen Mary	3	1	2	1	1	2		1			**11**
Royal Holloway	1				3				1		**5**
Goldsmiths			1	1				1			**3**
University of Westminster			2								**2**
Birkbeck College			1								**1**
London School of Pharmacy		1									**1**
Metropolitan University										1	**1**
Grand Total	**75**	**27**	**31**	**25**	**19**	**22**	**10**	**16**	**2**	**2**	**229**

Table 5 University related companies identified within Company House data (229 of the 244 companies)

The absence of older firms may relate to the lack of a long term 'institutional memory' pre-dating the creation of TTOs. It is possible but unlikely that unidentified others exist. However, there are implications for non-survival for the data. Unlike in Oxfordshire where there are readily identified people with good memories, it is less easy to find such people in London. Moreover, other processes of exit such as takeovers and mergers could obscure the origins of many firms. The data, however, does show that around 8% have been acquired or have merged mainly in biotech, a pattern similar to Oxford (Lawton Smith and Ho 2006).

Assumptions about the existence of a RIS as a supportive environment for university spin-offs which provide locational advantages of urbanisation economies for high tech firms (Frenkel 2001) are challenged by this study. By geo-coding the companies in the database it was possible to map the location of their registered offices (Figure 1).

This picture clearly shows that the footprint of university-related companies spreads well outside the city's geographic and administrative boundaries. Nearly a quarter (23%) are located beyond the M25 orbital motorway, a logical boundary for the capital. Given that many companies are likely to operate from locations other than their registered address this figure may underestimate this commercial diaspora.

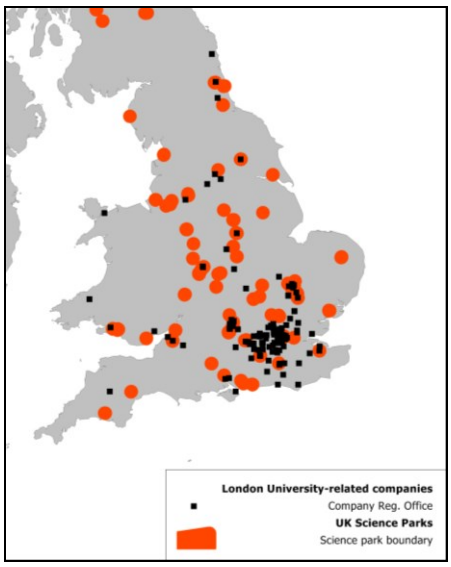

Figure 1 location of spin-offs

Comparing company locations on known science-park in the greater South-East it is clear that a significant number of firms are drawn to these dedicated facilities. This again is different pattern from Oxford University, where around a sixth had moved beyond the county boundary of Oxfordshire, possibly because of the high number of incubators and science parks (Lawton Smith and Ho 2006). It differs from other studies which suggest that university spin-offs stay close to the founders' homes (Zang 2008) but it is consistent with the argument that the importance of location of firm close to founder's home decreases as firms expand (Frenkel 2001, Bathelt et al 2010).

This migration raises questions regarding the infrastructure of London as a base for young university-related firms and what factors draw them away, in other words that the RIS is relatively weak where the spin-off process is involved. It has been demonstrated that there is lack of specialised incubator facilities for new science-based firms, compared to availability in places say Cambridge orOxford. For example classic agglomeration factors such as availability of land/premises and skills are important. The pattern around London may reflect the extended hinterland of academic commuters with firms located nearer home than work.

Further support for the fragmentation of the spin-off process in RIS in London, especially in relation to finance identified in other studies (Bosma and Harding 2006, Huggins 2008, is the lack of connections between investors and university spin-off firms i.e. between agents in the public and private sectors (Asheim et al 2011, Doloreux and Parto 2004). Figure 2 presents a 2-mode graph of the relationships between the *current* owners (Blue squares) and the university-related companies (Red circles) in the LUCD database. The network has been processed to remove pendants (i.e. investors in single companies or companies with only a single owner) leaving a web of co-investors who have an equity stake in two or more university-related companies. This graph suggests that the web of relationships may be loosely woven with relatively few investors having current holdings across different university portfolios. The graph also clearly identifies a group of pharmaceutical companies (circled in Red) in which the various Universities have cashed-in their equity stake.

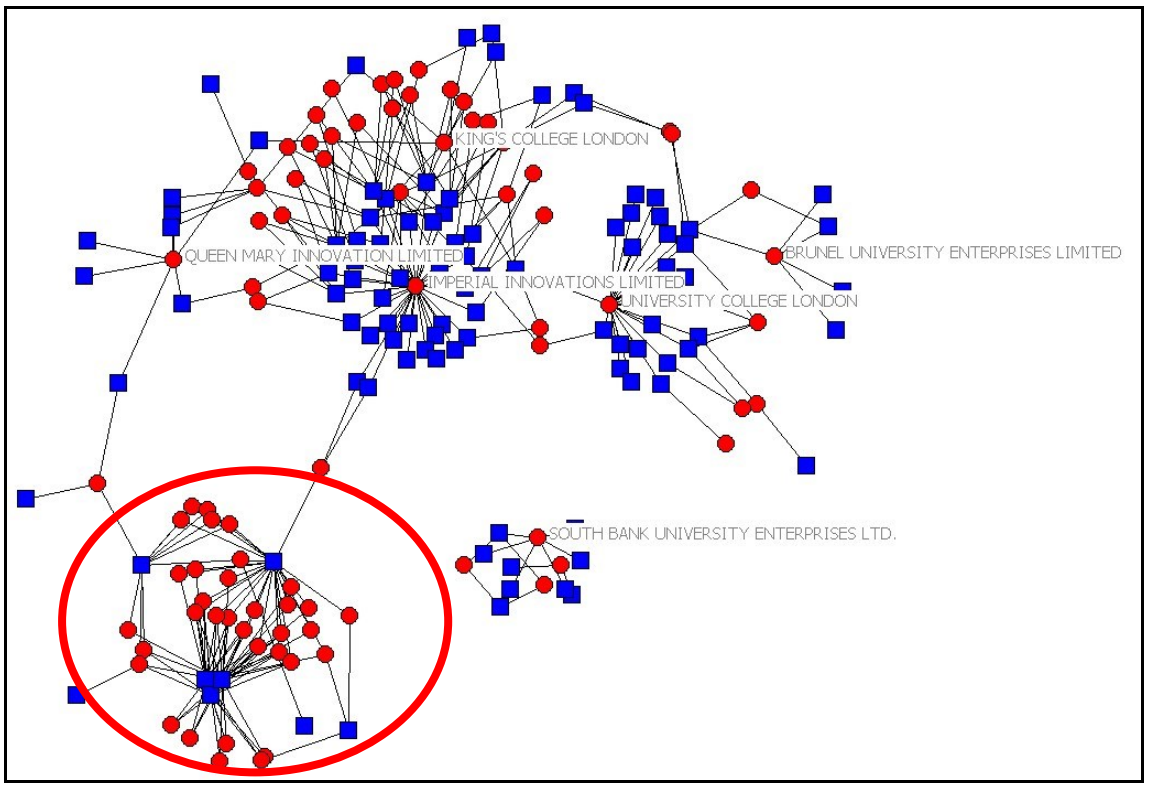

Figure 2 relationships between current owners and university-related companies

5.2 Performance of institutions

To standardise the spin-off data for the different sizes of institutions, which Huggins (2008) does not do, Table 6 compares the spin-off totals between 1998 and 2005 with their number of Full Person Equivalent (FPE) Academic Staff in 2007-8. It does not include students/student start-ups. The results indicate a wide range of spinout 'performances', with Imperial College, South Bank University and Brunel University, (but not UCL), showing above average.

	Spin-offs Jan (1998-Dec 2005)	Academic Staff (FPE, 2007-8)	STEM Academic Staff (FPE 2007-8)	LQ (FPE)	Average spin-offs per 1000 Staff	Average spin-offs per 1000 FPE(STEM) Staff
Imperial College	59	3300	3158	2.6	2.2	2.3
South Bank University	8	760	310	1.5	1.3	3.2
Brunel University	10	1040	394	1.4	1.2	3.2
UCL	37	4930	3418	1.1	0.9	1.4
Queen Mary	9	1780	1104	0.7	0.6	1.0
King's College	12	3050	1995	0.6	0.5	0.8
Royal Holloway	2	1085	298	0.3	0.2	0.8
University of Westminster	1	1795	658	0.1	0.1	0.2
Goldsmiths	1	565	50	0.3	0.2	2.5
Birkbeck College	1	1715	267	0.1	0.1	0.5
Total	**140**	**20020**	**12188**	**1.0**	**0.9**	**1.4**

Table 6 University spin-offs by size of institutions (Full Person Equivalents FPE[11]) for all academic staff and for those in STEM subjects.

To allow for the varying missions of institutions we standardise for the number of academic staff. Standardising spin-off activity against the number of research staff also allows comparison with the performance of European institutes which is captured on an annual basis by the ASTP (Arundel and Bordoy 2006). This reports a Europe wide average numbers of spin-offs per 1000 research staff of 1.48 (2004) and 1.63 (2005) based upon responses from 49 institutions. On this measure, only Imperial outperforms the European average.

As can be seen from Table 7, university-related companies are overwhelmingly found in STEM (Science, Technology, Engineering and Medical) fields, but are dominated by the biomedical field, a pattern found in other studies (Shane 2006, Lawton Smith and Ho 2006). The combination of Pharmaceuticals & Biotechnology and Health Care equipment and services accounted for 47% of spin-offs. This dominance was expected

[11]source: Higher Education Database for Institutions http://www.heidi.ac.uk/

for London's primacy nationally and internationally in biomedical research. It is similar to patterns found in other studies (see for example PACEC 2003, Shane 2006). Software and computer services are the second largest group, followed by chemicals. Hence the spin-off process reinforces the sectoral profile of London's economy or its RIS.

	Engineering	Humanities	Medical	Other	Science	Technical	(blank)	**Total**
Chemicals	5	1	4	1	11			**22**
Consultancy	3			1				**4**
Creative industry	3		1	1				**5**
Electricity	5				2			**7**
Electronic& Electrical Equipment	4		2		6			**12**
Health Care Equipment&Services	6		5		3			**14**
Industrial Engineering	6		3		3			**12**
Pharmaceuticals&Biotechnology	4		49	2	23	1	1	**80**
Software&Computer Services	8	1	4	2	4	16		**35**
Technology Hardware&Equipment	1							**1**
Telecommunications	2		1			1		**4**
#N/A	1		2		1	2		**6**
Total	**48**	**2**	**71**	**7**	**53**	**20**	**1**	**202**

Table 7 Counts of HEI spin-off companies by commercial and academic discipline[12]

[12]Using classification in PACEC (2009) Appendix F.

5.3 Growth of firms

For employment by university-related companies in London, data are available for 40% (101/244) of the sample. Using the definition of SME by European Commission[13], in 2005 the sample group of university-related companies is composed of 63 micro enterprises, 27 small enterprises, 10 are medium enterprises with only large enterprise. Almost 90% of university-related companies are micro or small enterprises, very similar to Gothenburg (Lindholm Dahlstrand 1997), in Italy (Iacobucci 2011) and in the UK overall (Harrison and Leitch 2010).

By 2008 the 10% of companies larger than 250 employees provide more than 50% of the total employment of 3,100. London university-related technology companies (average of 12.7 persons per firm) are generally smaller than those in Oxfordshire (Lawton Smith and Ho 2006), where 114 firms generated 9000 jobs (78.94 employees per firm). Total turnover showed a similar difference in magnitude (Oxford £1bn, London £248.6 million). Several companies have gone public. In total, 13 (8%) have been floated on UK stock markets (the London Stock Exchange (LSE) and/or the Alternative Investment Market (AIM), very similar to Oxfordshire (Lawton Smith and Ho 2008). This suggests that the London spin-offs are no worse and no better at being floated than those in other regions.

The percentage of high growth firms is small: only 31 from the entire population achieved high growth (Table 8). However, more than 60% achieve this within five years of incorporation and therefore classify as Gazelles (Bishop et al 2009). This is

[13] A company is a micro enterprise if the number of employees is less than 10, small enterprise if the number of employees is between 11 and 50, medium enterprise if the number is between 51 and 250, and large enterprise if the number is more than 251 (http://ec.europa.eu/enterprise/enterprise_policy/sme_definition/index_en.htm).

also consistent with the pattern in Italy where growth capacity was in the firms of most recent origin (Iacobucci et al 2011).

Years after incorporation	Companies Achieving High Growth
3	6
4	7
5	8
6	1
7	1
8	2
11	2
12	2
14	1
15	1
Total	**31**

Table 8 high growth firms in the London sample

Possibly that market opportunities in London are so varied that it is possible for firms can be in specialist markets and operate at a size where market position matches resource availability, a rather different perspective on localisation economies (see Gordon and McCann 2000). Therefore the university spin-off process in the formation and functioning of RIS environments needs to be seen from the perspective of the kinds of firms generated and the extent to which they might contribute to broader patterns of economic and social interaction (Asheim et al 2011).

This answer to the question of whether London's University-related companies outperform the general population of firms (comparison with NESTA data for 2005-8 period) is "maybe" (Table 9). For the UK population of high growth firms the corresponding figure is 6%. For Greater London the NESTA survey shows a rate of about 6.8%.

	2005-8 High Growth firms	Total population of surviving firms at 2005	Percentage
Pharmaceuticals&Biotechnology	9	80	11%
Software&Computer Services	2	34	6%
Electronic&Electrical Equipment	2	13	15%
Electricity	1	8	13%
Health Care Equipment&Services	1	15	7%
All sectors	15	196	8%

Table 9 high growth and surviving firms in the London sample

Although firms are generally small, consistent with HE-BCI data, these are high survival rates. Staff start-ups appear to be more robust than spin-offs with student start-ups the least likely to survive (Table 10). Academic and student entrepreneurs are slightly less likely to start firms that survive than staff start ups (see also Harrison and Leitch 2010). Software & computer services firms are least likely to survive, reflecting rapid technological and market changes. Electronic & electronic equipment and industrial engineering sectors are also vulnerable.

Category	Count	3 year survival	5 year survival
Spin-off	145	92%	82%
Staff Start-up	43	98%	91%
Student Start-up	9	89%	67%
Total	197	93%	83%

Sector	Count	3 year survival	5 year survival
Chemicals	18	94%	94%
Consultancy	1	100%	100%
Creative industry	4	100%	100%
Electricity	5	100%	100%
Electronic&Electrical Equipment	11	91%	73%
Health Care Equipment&Services	14	100%	93%
Industrial Engineering	14	79%	71%
Pharmaceuticals&Biotechnology	81	95%	84%
Software&Computer Services	34	88%	76%
Technology Hardware&Equipment	2	100%	100%
Telecommunications	4	100%	100%
Total	188	93%	84%

Table 10 survival

6. Conclusions

This paper has presented a study of university-related companies in London using a regional innovation systems (RIS) framework. It addressed two questions: what is the role of universities in RIS? And, what does a regional innovation system look like in supporting the spin-off process? In doing so it has considered the university and RIS and the RIS and the university spin-off environment.

The paper has shown that the spin-off process from London's universities can be dated back to the mid-1960s when the first firms were formed and institutionally from the early to mid 1980s when the major players established TTOs. The demand for engagement in the London RIS dates much later, with the formalisation of institutional arrangements, beginning to be institutionally embedded in regional contexts (Asheim and Gertler 2005). However, there is evidence particular with respect to property and finance, that the RIS in London is not 'well found'.

Moreover, fragmentation of impact is inevitable given the mix of institutional types within London, although the effect on the structure of the RIS is likely to be more by the larger colleges. Consistent with other studies we found that the spin-offs are more likely to be established by academics in the top research institutions and the generation, use and dissemination of knowledge (Doloreux, 2003) through this route in the pharmaceuticals & biotechnology sector (followed by software and computer services sector). As so many firms locate outside London, the policy implication is that there is a need for even more dedicated premises, both for start-up but particularly for follow-on premises.

The London study shows little differences to findings in numerous other studies of spin-offs (Lindholm Dahlstrand 1997, Bathelt et al 2010, Iacobucci et al 2011, Druihle and Garnsey 2004, Harrison and Leitch 2010). It seems that there is an optimal size of firms in these sectors and that London provides niche markets in which they can operate (Smart 2008); many are research vehicles rather than genuine Schumpeterian firms (see Schumpeter 1912/1934) and firms exhibit different exit strategies than in other locations. However, we have noted that there are data limitations due to incomplete records, especially for very small firms, in publically available datasets.

The implications of the London study are that the dynamics of RIS are changing: as universities spin-out more firms, more survive and the organisations set up to develop those become more engaged, then institutional structures of the RIS change. Moreover, the environment for spin-offs develops as a consequence of interdependencies between what happens in the universities and in a region. For example the spin-off process as a whole is changing the configuration of ways in which university outputs become translated into regional economic development (Asheim and Gertler 2005).

In exploring both the role of the university in the RIS and the spin-off environment, the paper has sought to address Doloreux and Parto's (2004) criticism of studies of RIS: that interactions between actors in regional innovation systems have been insufficiently explored with the institutional context largely overlooked. However, the existence of a system (Clark et al. 2002, Markusen 1999) and whether more

sustained capacity building (Feldman 2001) would make a difference is still open to debate.

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