SUB-THEME: Technology Transfer And Entrepreneurship: 'Traditional and New Science-Industry Interface Organizations, Mechanisms, Organizational Designs, Networks

TITLE: Product Innovation, Growth and the Profitability of University Spin-off Companies

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Introduction

Since 1980s, besides teaching and research, new functions progressively have been assigned to universities. This is known as the "third mission", which refers to transferring knowledge and technology and commercializing the knowledge or technology. The term "entrepreneurial university" was coined by Etzkowitz (1983) to describe the occurrences in which universities have proven themselves to be critical to economic development. As confirmed by Bozeman (2000), universities now play a central role in a policy model described as a "corporative technology paradigm", which means the university role is expanded to embrace technology-based economic development programmes. University spin-offs are regarded as key mechanisms for commercializing technologies and innovations and act as a medium to create wealth (Robert and Malone, 1996). The establishment of spin-offs can also have a positive impact on job creation, technology and innovation, including contributing to changes in the economic structure of a region (Acs and Audretsch, 1990). There has been a rising expectation for universities to be involved in the process of transferring knowledge for commercial exploitation, specifically, by turning novel scientific innovations into spin-off ventures (Rasmussen, 2004; Kinsella and McBrierty, 1997; Leitch and Harrison, 2005).

In examining the basis of these spin-off arrangements, scholarly studies have concentrated generally on the impact of economic and external factors including legislation towards academic spin-offs (Shane 2004), the 'entrepreneurial orientation' policy of universities (O'Shea *et al*., 2005), and the preconditions of institutions in which spin-offs are developed (Lockett *et al.*, 2005). However, these studies appear to focus more on the macro economic and infrastructural perspectives that support the creation of university spin-offs rather than on the firm (Druilhe and Garnsey, 2004). Only a handful of studies in academic entrepreneurship discipline have explored the survival and performance of spin-offs over time; this exclusion is significant (Lawton Smith and Ho, 2006). Additionally, the study of the continuous innovation inside university spin-off companies is under-explored.

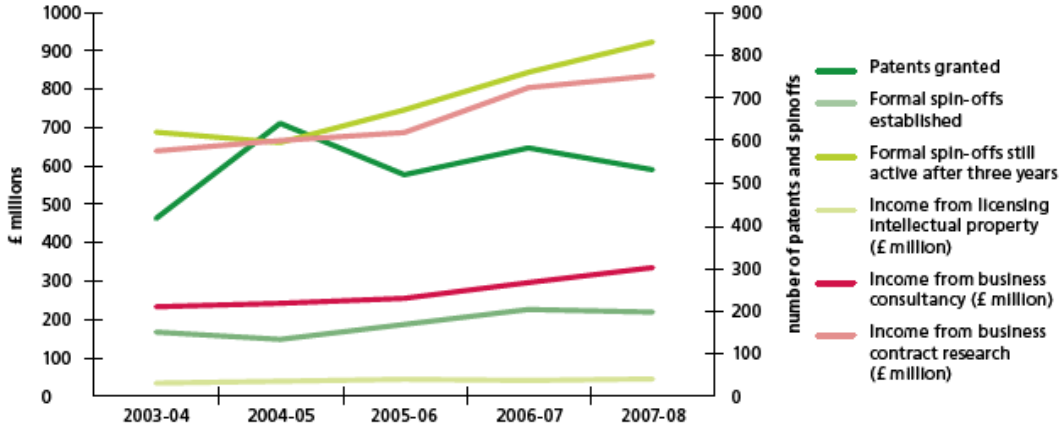
This paper's contribution is to present new angles, interpretations and additions to the existing databases. Product innovation, i.e., number of products and number of patents is aimed to be measured in relation to growth and profitability. It presents initial data collected from 155 companies spun off from universities in Oxfordshire and in the London region. In both, databases of firms and supporting studies exist on the characteristics, performance and growth of university spin-off firms.

The paper begins with an explanation of the university spin-off phenomena. It focuses particularly on macro and infrastructural conditions which influence the formation of university spin-offs. Next the methodology and results are presented. The latter provide new insights and perspectives on university spin-off firms. In the last section, some conclusions are drawn on the limitations and recommendations for further research.

The University Spin-offs Landscape

Even though university spin-off activity is a global phenomenon, a significant disparity within that movement is observed (Clarysse *et al*. 2001). This is that the trend towards the creation of university spin-off's trend is more widespread in some countries than in others. In the UK, for instance, by the year 2000, the number of spin-offs began to rise substantially. This was associated with an increase in the number of personnel working on technology transfer UK's universities (Lawton-Smith and Ho, 2006). A survey conducted by Higher Education Business-Community Interaction (HE-BCI) (2004) showed that in the UK, there has been a rapid growth in the number of spin-off firms between 1999 and 2002. In 2007/08, spin off companies from higher education institutions (HEIs) employed almost 4,500 people, had a turnover of more than £73 million and had acquired over £52 million in external investments (BIS 2009) (*see Figure 1)*. Generally, university spin-offs are small in size with low growth rates and revenues. Their product generation is also moderate, notably at least in the first ten years of their formation (Lerner, 2005).

Figure 1: Knowledge Exchange Output from UK Higher Education Institutions



Source: Higher Education Business-Community Interaction Survey 2009.

Numerous explanations of factors contributing to the formation of university spin-offs have been outlined. Firstly, legislative initiatives are widely regarded as an acceleration of the formation of spin-off ventures. For example in the UK, universities have been given autonomy to arrange their own rules and policies on IP ownership (Lawton Smith and Ho, 2006). Secondly, universities with cultures that embrace entrepreneurial activity not only have better rates of commercialization such as patents and but also have high numbers of academic spin-offs than those which do not (O'Shea *et al.,* 2004). Earlier Roberts (1991) proposed that a university's social norms and expectations are key factors in encouraging commercial activity. Thirdly, reputations including research prominence of universities are strongly linked to the rate of spin-off creation (Di Gregorio and Shane, 2003). Fourth, the regional knowledge infrastructure also plays a vital role in supporting university spin-offs activity. Saxenian (1994) has illustrated that the formation of university spin-offs are more likely to happen in high-technology clusters because of easy access to local expertise, networks and knowledge.

However, the factors outlined above are arguably inadequate to justify the survival and growth of university spin-offs. It is widely perceived that too many university spin-off firms have been created in recent years and that the quality of them differs considerably between universities. Consequently, a great number of them will not survive in the long run (Lambert, 2003). Mustar *et al*. (2006) found that spin-off ventures are confronted with barriers to their growth because commercial resources are generally lacking in a university environment. Vohora *et al.* (2004) also pointed out that the inability of some university spin-offs to progress through each critical stage necessary for them to achieve significant growth is because of key deficiencies in their make-up. These include limited resources and an inadequate level of social capital - which means that they lack the networks through which they can obtain resources such as finance and information. Hence, the resource-based view (RBV) (Penrose 1959, Barney 1991) can be employed to shine a light on what resources and capabilities university spin-offs own or lack; they can, consequently, develop their own resources and capabilities to gain competitive advantage.

Few studies, however, have examined the differing characteristics of university spin-offs for example according to their product development. In addition, the process of spin-out formation is often explained as a linear process, i.e., a technology-based idea is generated from research or the laboratory, then protected by patents, and transferred to establish a firm to commercialize the innovation (Charles and Conway, 2002; Autio, 1997). This conceptualization of the spin-off process has been challenged by Druilhe and Garnsey (2004); they proposed typology of university spin-offs based on the "resource-based view", since the entrepreneurial process in general is dynamic and nonlinear. Their approach provides a foundation for conceptualizing the emergence of university spin-off firms and for distinguishing between the following types of science-based ventures:

i) Consulting companies – are involved in consulting or research services; this is the most accessible opportunity in relation to the scientist's knowledge and experience and to resources needed.
ii) Development companies – refer to high-tech companies, which commercialise their patented technologies through a licensing model.
iii) Product companies – engage in prototype production or high quality low volume production. They tend to aim at a niche market and remain small.
iv) Software companies

The 'resource-based view' sees a firm as a bundle of resources and builds on the foundation of heterogeneity of the firm's resources (O'Shea *et al*, 2005). This means the heterogeneity of resources that firms own will give them uniqueness and competitive advantage derived from market imperfections hence market opportunities (Lockett and Thompson, 2001). In the RBV, there has been a strong emphasis on performance as major outcome attributes and the intangible resources such as know-how and corporate culture are clearly acknowledged (Russo and Fouts, 1997). In other words, resources comprise all assets, both tangible, intangible and personnel based, controlled by a firm, e.g. capabilities, organizational processes, information, staff and knowledge (Daft, 1983; Grant, 1991). In addition, Dierickx and Cool (1989) and Prahalad and Hamel (1990) pointed out that a firm's competitive advantage is embedded inside a firm, in valuable and inimitable assets. These include a firm's capabilities as well as the skills of management to assemble assets to produce higher performance leading to competitive advantage (Grant, 1991). Additionally, when such

resources are simultaneously inimitable, non-substitutable, and non-transferable, those may create a competitive advantage that is long-lasting (Wernerfelt, 1984; Barney, 1991; and Teece *et al.* 1997).

On the other hand, in a competitive market sphere in which university spin-offs operate, continuous development of new innovation is imperative in order to secure success beyond the first launch of the product and thereby create economic value. The concept of innovation is generally well-regarded in business and it is viewed as the core of many companies' operations. As Freeman (1984) outlined in his celebrated work on the economics of innovation, "not to innovate is to become extinct". Therefore, innovation has been a driver for the growth of firms. Companies that have sustained their superior position in the market have demonstrated a capability to innovate products successfully. Schumpeter (1934) was among the first thinkers to underline the importance of innovation and new products as a catalyst for the acceleration of the economy; there is also an obvious linkage between innovation and main economic growth. He asserted that it is more vital for firms to compete in developing products, which are always considered as the physical productions of the innovation process, rather than to compete on prices of current products. As later supported by Zirger and Maidique (1990), the introduction of new products is essential to the growth and profitability of most firms.

The development of successful products and services demands a greater deal than implementing a set of tools and methods. Besides, it involves not only a suitable organization and team, but also a clear process to facilitate and manage innovation (Tidd and Bessant, 2009). Different capabilities embedded in an organization have a positive effect on the outcome of the product development process (Verona, 1999). In essence, competitive firms, especially in high technology industries, require a set of core resources to develop new products; in addition other organizational resources have an impact on successfully commercialising new products deriving from R&D (Löfsten and Lindelöf, 2005). The future achievement of firms will certainly rely on the ability to gain, exploit and turn knowledge into the launch of new products (Cohen and Levinthal, 1990). As highlighted, capabilities and resources established inside firms contribute to the product development process. In other words, the RBV is a valuable concept in understanding how product innovation can lead to the growth and profitability of a firm.

In addition, only a handful of studies of academic entrepreneurship have explored the survival and performance of spin-offs over time; this exclusion is significant. According to Lawton Smith and Ho, (2006), this type of study is very important, since it shows that spin-off companies' survival rate is likely to be high, though it in many cases it takes at a number of years before their growth rate starts to advance (Lindholm Dahlstrand 1997). Besides, the study of the continuous innovation inside university spin-off companies is under-explored, i.e., how product innovation processes are linked to the growth and performance of university spin-offs. Therefore, in this study, we address the following questions: what is the link between product innovation and growth and profitability of university spin-offs; and, on what resources do university spin-offs capitalize for product innovation?

Methodology

The main objective of the study is to examine the product innovation processes linked to the growth (turnover) and performance (profitability) of university spin-offs. The linkages between types and profile of companies and product innovation are also expected to explore. Moreover, through the data collection and analysis, the relationships between product innovation and years of operation will be discussed.

The Sampling Process

The research reported here is drawn from the existing database of 340 companies spun out from universities in the Oxfordshire and in the London regions, which were collected as part of the previous research projects in 2006 and 2009. In both, there are databases of firms and supporting studies on the characteristics, performance and growth of university spin-off firms in these areas. The sample used is intended to represent the entire populations of the two data sets.

From 340 spin-out companies in the database, 246 companies are active in operation, divided into 164 companies originated from universities in London and 82 from Oxford University respectively. In addition, within the active companies in the database, 56 companies have been merged or acquired (we excluded these companies simply because after M&A, they have become part of a big conglomerate and tend to be less constraint on resources) and 35 have no information available. Therefore, in this study we concentrated on the collation of data of 155 spin-out companies, which have information with regards to number of products and number of patents available in their public domains.

The selection criteria for the sample are specified as follows:

i) Companies that have active website open to the public
ii) Companies that operate in a competitive business environment
iii) Companies that have information on their product and technological innovation

The key database used was the ICC Directory of UK Companies provided by Lexis Nexis* <http://www.lexisnexis.com/uk/nexis/search> and Companies House** <http://wck2.companieshouse.gov.uk>, which contained detailed profiles of the companies including the company's registered address, date of incorporation, board of directors, any subsidiaries which the company may own, key facts about the companies, and financial data. The second primary source of information on the firms

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* The ICC Directory of UK Companies (ICCDIR) file provides a comprehensive reference tool covering all UK-registered companies -live and dissolved. The data contains registration details and statutory filings as well as links to other ICC products.

** The Companies House is a UK government agency incorporating and dissolving limited companies; examining and storing company information delivered under the Companies Act and related legislation; and making this information available to the public.

was their websites. Most have published company histories, key facts, their products and services, including their commercial technology.

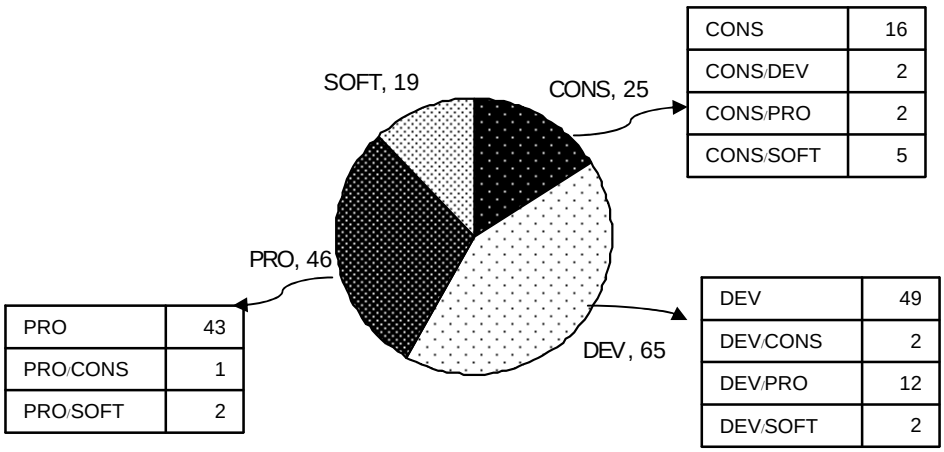
Searches were also made through the business and innovation centres of universities, such as Isis Innovation (Oxford University) and UCL Advances (UCL) and Imperial Innovation (Imperial College) (London) as well as departmental websites. The discovery of IP and patent filed by the companies was also included as part of this study as proxy to product innovation, especially for companies which commercialize their patented technologies through a licensing model. Patent searches were done via the free public databases but are less exhaustive in their contents than the subscription database. ESP@CENET on the European Patent Office website includes records of the patents filed by companies which can be accessed and searched by a range of criteria such as applicant name, inventor name, and so on.

The data is analyzed by taking into consideration different categories of university spin-offs by employing a typology proposed by Druilhe and Garnsey (2004) (above) since each category of university spin-offs tends to exploit different resources and capabilities to allow them to develop new products.

Findings

We begin by categorizing and summarizing four broad groups identified by Druihle and Garnsey (2004): 1) consulting companies 2) development companies 3) product companies and software companies. Figure 2 provides an overview of number of companies in each category.

Figure 2: Number of Companies Categorized by Typologies

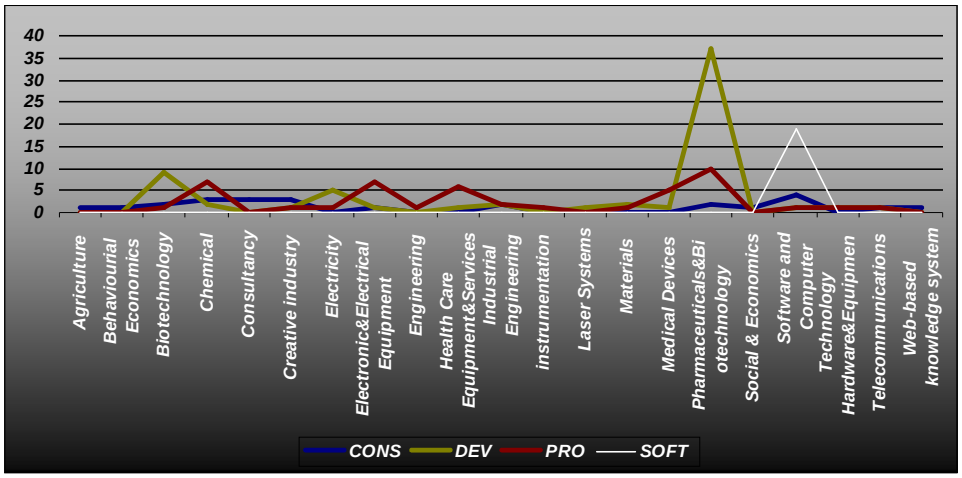


This shows that over 40% of the sampling firms fall into the category of development companies. The next largest group is that of product companies which account for 30% of the total samples. Even though the typologies are based on the specifications proposed by Druilhe and Garnsey (2004), firms do not fall rigidly in one single category. A number of firms tend to engage in or further develop their business model by building on existing resources, products and services. For example, development companies engage in developing products based on their existing patents and product

companies develop application software bundling those with their products. Hence, the sub-categories of each typology have been proposed in order to encompass the actual business operations.

The data also showed that the majority of development companies are in the pharmaceutical and biotechnology sector, which can be explained by its specific characteristics of radical technologies with strong IP. *See Figure 3.*

Figure 3: Number of Companies by Sectors and by Typologies



With regards to the number of product innovations, more than 80% of the university spin-offs have up to 5 products/patents in their portfolio whereas only 7 companies (5%) own more than 15 products and innovations (s*ee Figure 4).* The number of product innovations by typologies in Figure 5 shows that over 55 development companies possess up to 5 products and innovations or more in their portfolios; this is possibly because of the number of the patents recorded.

However, it is shown that consulting firms do not have more than 10 products and innovations. This can be explained by the fact that most of consulting firms base their offerings on consulting and research services. Since service is intangible by nature, it is therefore difficult to measure by merely counting products and innovations.

Figure 4: Number of Products and Innovations

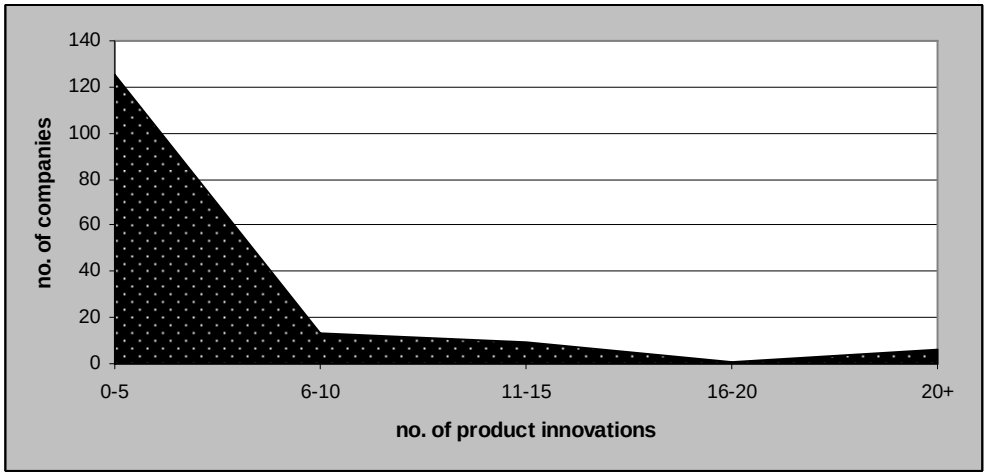
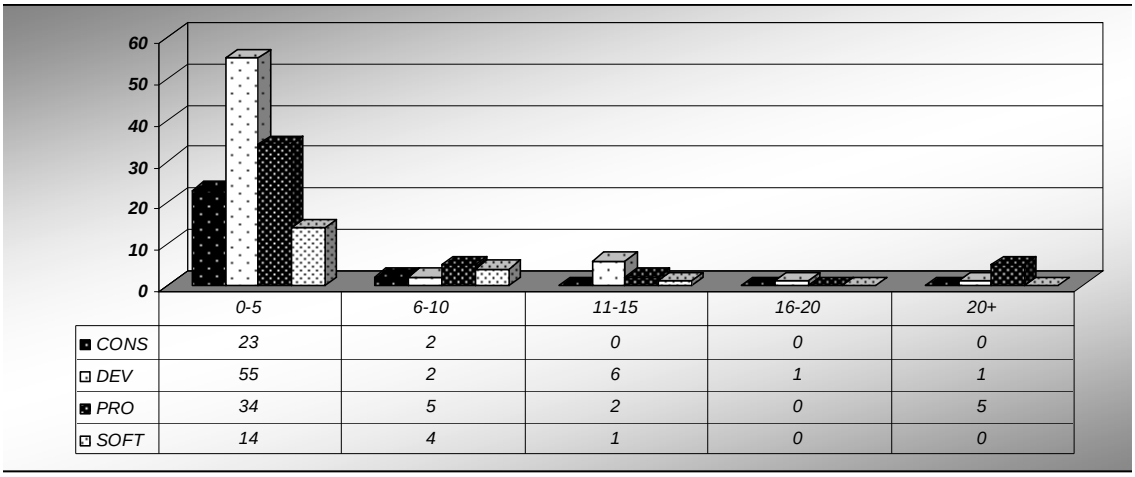


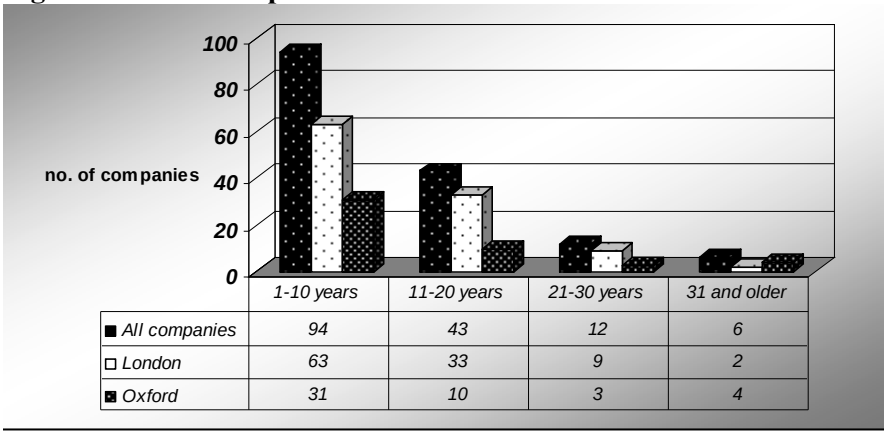
Figure 5: Number of Product Innovations by Typologies



	0-5	6-10	11-15	16-20	20+
CONS	23	2	0	0	0
DEV	55	2	6	1	1
PRO	34	5	2	0	5
SOFT	14	4	1	0	0

In addition, over 94 (61%) university spin-off firms are at early stage of their operations, between 1-10 years. They tend to be small in size and growth rate as a result. Only 18 companies have been operating longer than 20 years (See *Figure 6).*

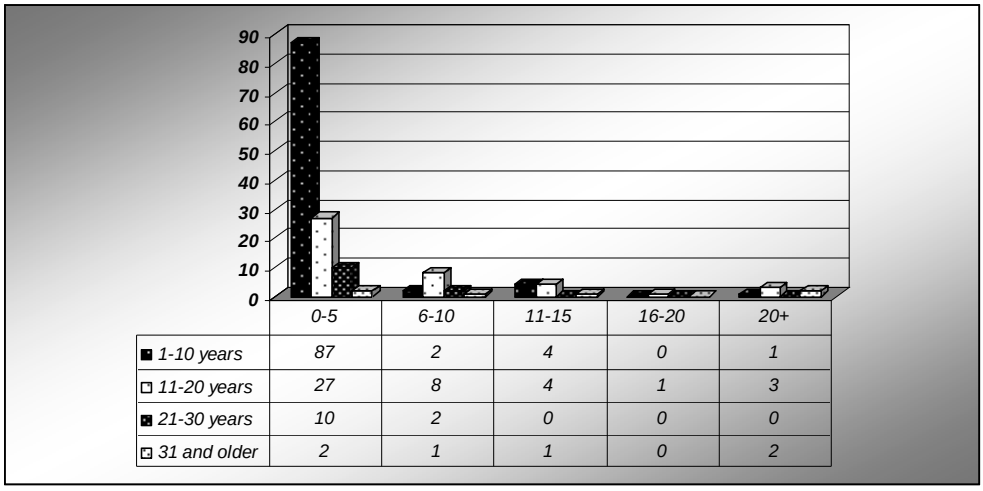
Figure 6: Years of Operation



	1-10 years	11-20 years	21-30 years	31 and older
All companies	94	43	12	6
London	63	33	9	2
Oxford	31	10	3	4

The relationship between years of business and number of products and innovations has also been observed. Firms established for less than 10 years tend to develop fewer products and innovations whereas very well established companies are likely to expand their product portfolio. The explanation can be given that companies at early stage have focused their resources and capabilities to growth and to expanding their markets based on their initial products and technologies in preference to developing new products and innovations (S*ee Figure 7)*.

Figure 7: Number of Product Innovations by Years of Operation



	0-5	6-10	11-15	16-20	20+
1-10 years	87	2	4	0	1
11-20 years	27	8	4	1	3
21-30 years	10	2	0	0	0
31 and older	2	1	1	0	2

However, problems and difficulties in retrieving the figures of profit and turnover on their income statement of more than 108 companies (69.7%) have been encountered. Most of university spin-off firms are set up and registered as “company limited”. Due to the fact that they are generally small in size and in their operation, they can be exempted from reporting full account details. This presents limitations to this study at this stage as the data is inconclusive and it is therefore impossible to justify making a link between product innovations and growth and profitability. Table 1 below gives an example and initial thoughts on the data on relationships between products and innovations and growth.

Here it is shown that the top 10 companies with strong growth are either development companies or product companies; their years of operation are between 5-11 years and their number of products and innovations are relatively low (1-15 products). The strong growth of these firms has been observed in comparison to well established firms, such as Oxford Instruments (Oxford) or KCI Medical Products (London), which have been operating for more than 50 years, each with more than 20 products and innovations in their portfolios.

It therefore can be reasonably assumed that these young firms are in their growth stage of the business cycle, reaping benefits from their original products and ideas, whereas those well established firms have already reached their maturity stage. Hence, their turnover and growth is stagnant. Yet, this assumption is not conclusive due to the limitation of the data access.

Table 1: Top 10 Spin-off Firms with Strong Growth – Initial Findings

Name of company	Typologies	Sector	Turnover 2007(£000)	Turnover 2008(£000)	Turnover 2009(£000)	Turnover 2010(£000)	Growth over years (%)	No. of Products & Innovations	Years of Operation
Oxford Catalysts	DEV	Biotechnology	163	1298	8655		5209.8%	2	5
Pentraxin Therapeutics Limited	DEV	Pharmaceuticals& Biotechnology		24	600	893	3620.8%	1	10
Sylus Pharmaceuticals Ltd	DEV	Pharmaceuticals& Biotechnology		2	0	25	1150.0%	2	9
ZinWave Ltd	DEV/PRO	Telecommunications		292	1132	2921	900.3%	3	9
Aurox Ltd	PRO	Medical equipment	80	83	726		807.5%	4	7
DeltaDot	PRO	Pharmaceuticals& Biotechnology		260	1114	n/a	328.5%	2	11
DNA Electronics	PRO	Pharmaceuticals& Biotechnology	43	61	172		300.0%	1	8
Proximagen Neuroscience PLC	DEV	Pharmaceuticals& Biotechnology		272	945	1027	277.6%	15	6
Apatech Ltd	PRO	Pharmaceuticals& Biotechnology		7641	22770	21865	186.2%	7	10
Oxford Immanutech	PRO	Pharmaceuticals& Biotechnology	1156	2001	2746	n/a	137.5%	2	9

n/a = no record in the income statement

Conclusions and Further Research

This paper has endeavoured to illustrate initial data and findings relating to product innovations within university spin-off firms in the London and Oxfordshire regions. Firms have been categorized and analyzed according to the typology developed by Druilhe and Garnsey (2004). The findings illustrate that the majority of firms in the sample are relatively young, small in size and are still at the emerging stage; the number of products and innovations are consequently relatively moderate. The results are consistent with previous academic studies which explain that during the first decade of their formation, their product generation is also modest (Lerner, 2005).

However, due to the difficulties encountered from retrieving financial data of the majority of spin-off firms in the sample from public web portal, this study identifies methodological difficulties in conclusively demonstrating relationships between growth, profitability and product innovations. Hence more comprehensive information will be obtained through interview surveys conducted with founders and directors of a sample of companies in both locations.

Patterns of products and innovations, such as incremental or disruptive product innovation, or when the new product innovation process begins and motivations and incentives to develop new product innovations will also be explored. In addition,

ways in which firms' capabilities (e.g. technological, internal integrative, external integrative, and marketing) are employed to develop effective products (fit with market needs and quality of product) will be further examined. In doing so, internal and external barriers to product development will be identified. The study on product innovations will therefore advance a better understanding of the contribution that university spin-offs make to technological change and to existing and new markets.

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