

**SUB-THEME: University entrepreneurship and Entrepreneurial universities:
The role of Universities in the Triple Helix**

**TITLE: Demystify Product and Service Innovation of University Spin-off
Companies in the UK**

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1.Introduction

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 set-up of spin-off ventures can also have a positive impact on job creation, technology and innovation, including changing the economic structure in a region (Acs and Audrechs, 1990). Even though university spin-off activity is a global phenomenon, a significant disparity within that movement is observed according to the study by Clarysse *et al.* (2001), the 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 as a result of devoted personnel working on technology transfer in most of the UK's universities (Lawton-Smith and Ho, 2006). The survey conducted by Higher Education Business-Community Interaction (HEBI) shows rapid growth in the number of spin-off firms, i.e., approximately 70 spin-off firms were formed a year in the previous 5 years, 203 were created in 1999/2000, 248 in 2000/2001 and 213 in 2001/2002 respectively (DTI, 2004). In 2007/08, spin off companies from higher education institutions employed almost 4,500 people, had a turnover of more than £73 million and had acquired over £52 million in external investments (BIS 2009).

The current research and literature on university spin-offs have studied this subject from numerous perspectives and theories, though the subject is still considered embryonic. Additionally, a greater number of the studies tend to focus more on the macroeconomic and infrastructural perspectives that support the creation of university spin-offs rather than on the firms themselves. Only a few researches in academic entrepreneurship field have investigated the characteristics and performance of spin-offs over time; this omission is rather imperative. 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. The study of the continuous innovation inside university spin-off companies is also under-explored. It is still a mystery on their characteristics, such as, size, years of operation, sector, regions and their products and services offered. Additionally, the studies on university spin-offs in the UK tend to focus or explore on specific regions or institutions, e.g. Oxford, Cambridge, or Northern Ireland rather than the UK overall.

This paper's contribution is to present new angles, interpretations and additions to the existing studies on university spin-offs in the UK. Therefore, in this study, we propose to address the following questions: *what are characteristics of UK university spin-offs? What are products/services created and offered by university spin-off companies?* The data will be collected from the search of public company database and company's websites of 1356 companies spun off from universities in the UK. Product/service innovation, i.e., number of products/services and number of patents will also be measured and analysed in relation to years of operation, size and business sector.

The paper begins with the studies and arguments on the concept of entrepreneurial university. It also focuses particularly on macro and infrastructural conditions which influence the formation of university spin-offs. Next, the landscape of university spin-off firms in the UK will be explained. Then, the methodology and findings are presented. The latter provide insights and perspectives on university spin-off firms. In the last section, some conclusions are drawn on the limitations and recommendations for further research.

2. The Studies on University Spin-offs

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.

On one hand, concerns are rising on the emphasis that universities and government have been given on the quantity, as opposed to the quality and commercial possibility, of these university spin-offs (Lambert, 2003). Consequently, less consideration is given to their extensive and long-term impact (Bozeman, 2000). In other words, 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). According to some critiques, the concept of university spin-offs or entrepreneurial university falls flat (Armbruster, 2008); the idea of entrepreneurial university gives inadequate thought to the complications and challenges that universities have to face when they accommodate for new economic roles (Tuunainen, 2005). With regards to economic development, Bozeman (2000), among others, has contended that technology transfer, regarded a main device for influencing markets, increasing competitiveness in industry, and developing economy, has a merely limited prospect to create employments or commerce.

On the other hand, despite all the criticisms to entrepreneurial university, there is deficiency of comprehensive empirical evidence; hence, it is rather difficult to substantiate to what extent the idea of entrepreneurial university contributes to the economic development (Harrison and Leitch, 2010). Only a handful of studies of academic entrepreneurship have explored the characteristics, performance, including product/service of spin-offs over time. For example, the study by Mustar *et al.* (2006) highlights the lack of commercial resources within university context as an impediment to growth for university spin-offs; or Vohora *et al.* (2004) also pointed out that key deficiencies in resources hinder university spin-offs to prevail over each critical stage. The importance of the study on characteristics and performance and of university spin-offs have been emphasized (Lawton Smith and Ho, 2006; Lindholm Dahlstrand, 1997) since this type of study will present and establish the accurate picture on their performance, survival rate and will determine whether the idea of university spin-offs is just rhetorical construct.

3. The Link between Performance and Products/Services Innovation

In a competitive market sphere that university spin-offs have to operate in, continuous development of new innovation is imperative in order to secure success beyond the launch of the company and 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 and create value 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.

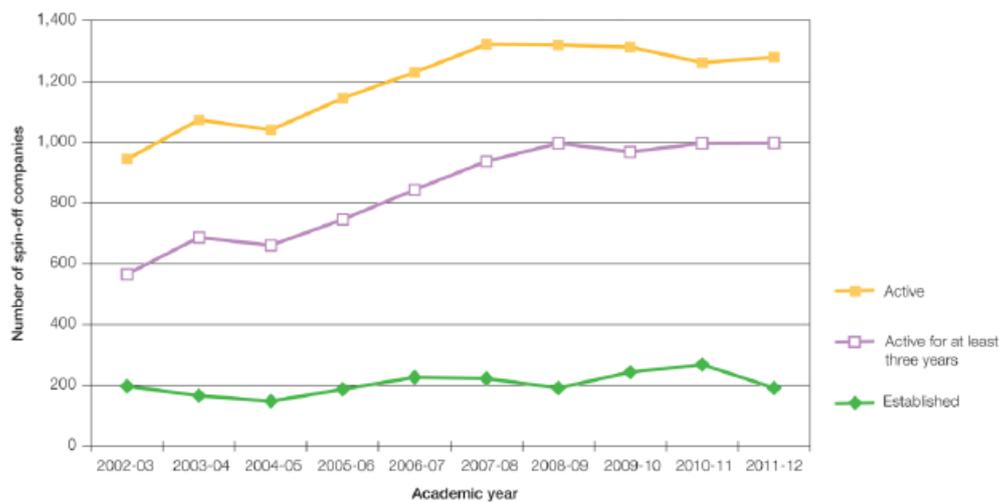
The development of successful products and services demands a greater deal than implementing a set of devices and methods. Besides, it involves not only a suitable organization and team, but also a clear process to facilitate and manage innovation (Tidd and Bessant, 2009). Different capabilities embedded 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 and capabilities 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). Hence, products and services can be included as one of various elements to measure the performance of university spinoffs since products and services are significant to the success and profits of the modern enterprise. Companies have to either be successful in product/service innovation or be in danger of failing as businesses (Cooper and Kleinschmidt, 2000).

4. The University Spin-offs Landscape in the UK

In the UK, 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) in 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.* There was a decline in the number of new IP-based companies established by UK HEIs from 268 in 2010/11 to 191 in 2011/12. Though, the number of those survives for three years or over has risen from 997 to 998. In addition, there were rises in both staff and graduate companies staying active three or more years, which indicates that, generally, UK higher education institutions gradually improve and are getting better at strategic commercialisation, particularly given the unfavourable economic environment (BIS, 2013). Generally, university spin-offs are small in size with small growth rates and

revenues. Their product generation is also moderate, notably at least in the first ten years of their formation (Lerner, 2005). The study by Harrison and Leitch (2010) also confirms that the majority of university spin-offs in the UK are small. University spin-offs, which set up by exploiting university owned IP and universities also have an element of ownership, there are less than 10 people employed per company on average with an estimated annual turnover under £500 000. Conversely, university spin-offs, which universities have equity involvement, are likely to be much bigger with employment of seventy staff on average and turnover is approximately £800 000. However, university spin-offs, found on the use of university-owned IP, whether with and without HEI equity stake, are not the only involvement of the university to new company formation. As classified by Pirnany *et al.* (2003), two types of university spin-off firms can also be described: student spin-offs and researcher spin-offs.

Figure 1: Spin-off companies formed from 2002/03 to 2011/12



Source: Higher Education Business-Community Interaction (HE-BCI) Survey 2011/12

5. Methodology

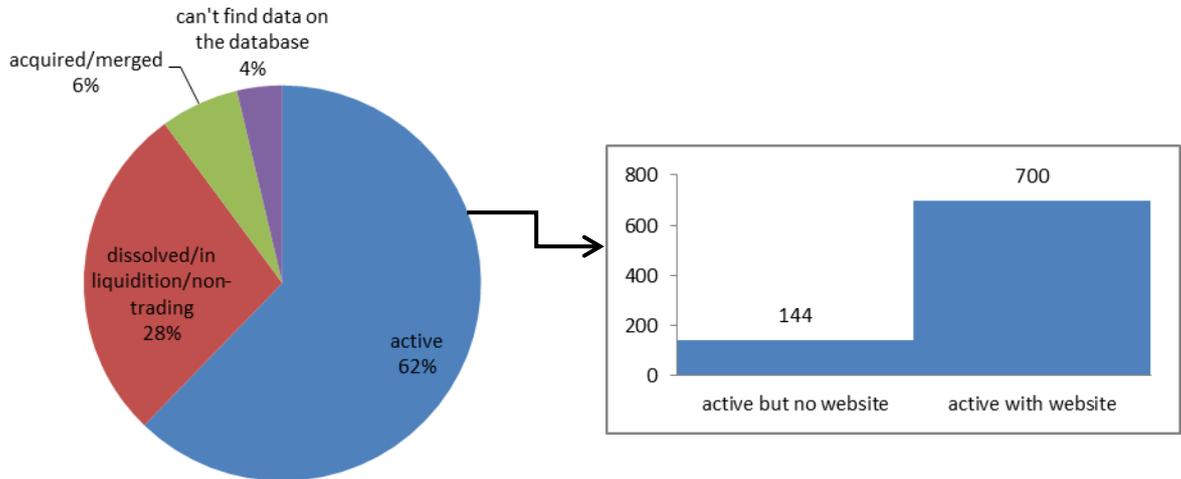
The main objective of the study is to examine the characteristics of UK university spin-offs and shed the light on products/services offered by university spin-off companies. The linkages between types and profile of companies and product innovation are also expected to explore.

The Sampling Process

The research reported here is drawn from the existing database of 1300 companies spun out from 126 universities, covering all regions in the UK. The database of university spin-offs is constructed by search through the business and innovation centres of universities, such as Isis Innovation (Oxford University), UCL Advances (UCL), University of Manchester Innovation Centre (University of Manchester) and Imperial Innovation (Imperial College London) as well as departmental websites. Then, it was merged and reconciled with the company list shown on website: www.spinoutsuk.co.uk. From 1356 spin-out companies in the database, 844 companies are active in operation. In addition, 87 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). Within the active companies in the database, 144 have no information available.

Therefore, in this study we concentrated on the collation of data of 700 spin-out companies, which have information with regards to number of products and number of patents available in their public domains. *See figure 2.*

Figure 2: Status of Spin-offs



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

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

* 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.

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). Their approach provides a foundation for conceptualizing the emergence of university spin-offs 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

6. Findings

Characteristics of Spin-off Firms

In this section, we are presenting demographic facts about the university spin-offs from all UK universities. We begin by looking at years of operation; the majority of active firms, 89%, operate between 1-15 years. Only 89 firms have been in business longer than 16 years (Figure 3).

Figure 3: Years of Operation

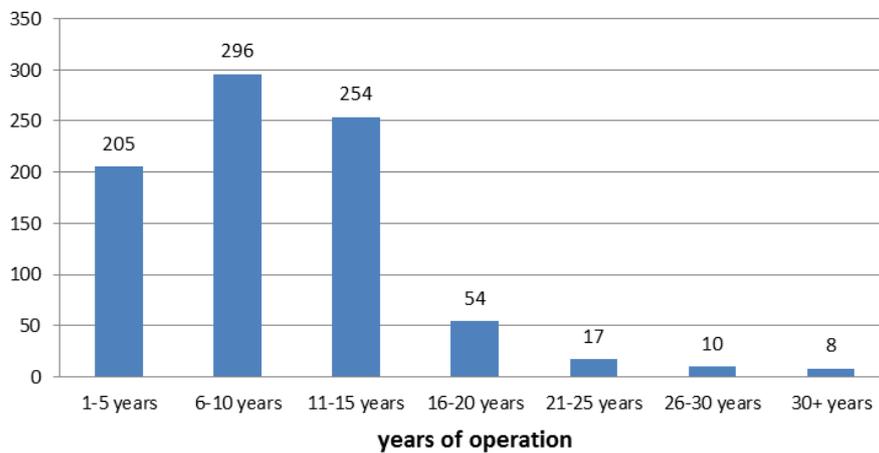


Figure 4: Sector

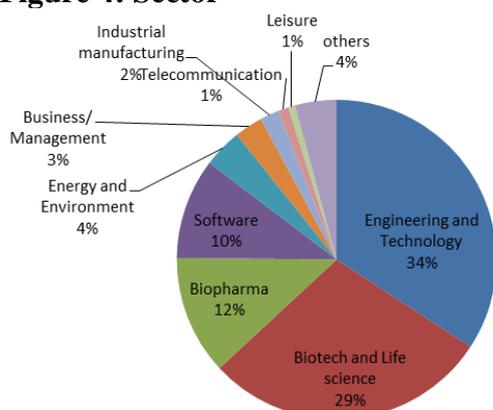


Figure 4 shows the diversity of sectors where the university spin-offs are based. The university spin-offs presented in the sample operate in diverse sectors; the largest group within the sampling is in engineering/technology sector, followed by biotech/life science, biopharmaceutical, software, energy and environment, business/management, manufacturing sector respectively.

When looking at the size of the firms by number of employee, we only found number of employees for only 195 companies. Approximately 72% of firms in the sampling are in micro to small company categories. Only 6 university spin-off firms in the sample are in large company category, i.e. having more than 250 employees. *See Table 1.* This data confirms with other studies on university spin-off firms that they are generally small in size (Lawton Smith and Ho, 2006; Harrison and Leitch, 2010)

Table1: Company Size

No. of employees	No. of companies
N/A*	649
1-10 (micro)	68
11-50 (small)	73
50-250 (medium)	48
250+ (large)	6

*N/A = data not available in the database

Figure 5 presents the number of active spin-off firms in each region including the number of those still remain in the regions where they are originated. Scotland has the highest number of active spin-off firms, 174 companies, in which 171 companies still stay within the region. London is the second highest region with 106 spin-off firms, but only 79 companies (62%) still stays within the region. In general, on average 83% of university spin-off firms stay within their breeding regions, except London and the South West, where only 63% and 67% of firms respectively stay within their original regions. This is due to the lack of vital city-wide infrastructure of dedicated property in London, except for biomedical sector, which has just recently been established in 2006 (Lawton Smith *et al.*, 2013).

Figure 6 shows the top 20 UK universities that create spin-off firms. Cambridge, Oxford, Imperial College London, UCL and University of Edinburgh respectively are the top five institutions in terms of number of spin-off firms created. These top 5 UK universities are in the top 40th world university rankings published by Times Higher Education in 2012/13 with Cambridge at 7th, Oxford at 2nd, Imperial College London at 8th, UCL at 17th and University of Edinburgh at 32th. Fourteen institutions out of these top 20 are in Russell Group, which is an elite group of UK universities similar to the Ivy League institutions in the US. The Russell Group represents 24 leading UK universities which have research excellence with an outstanding teaching and learning experience including unrivalled connections with industry and business. This point corresponds with the study by DiGregorio and Shane (2003) that academics, who invent cutting edge technologies, may want to take advantage from asymmetric information and to benefit economically from rents. Additionally, it is noted that it may be easier for academics from top quality universities to bring together resources to create spin-offs because of the reputation and trustworthiness of the institutions.

Figure 5: Number of Spin-off Firms in Regions vs Number of Those Stay within the Original Region

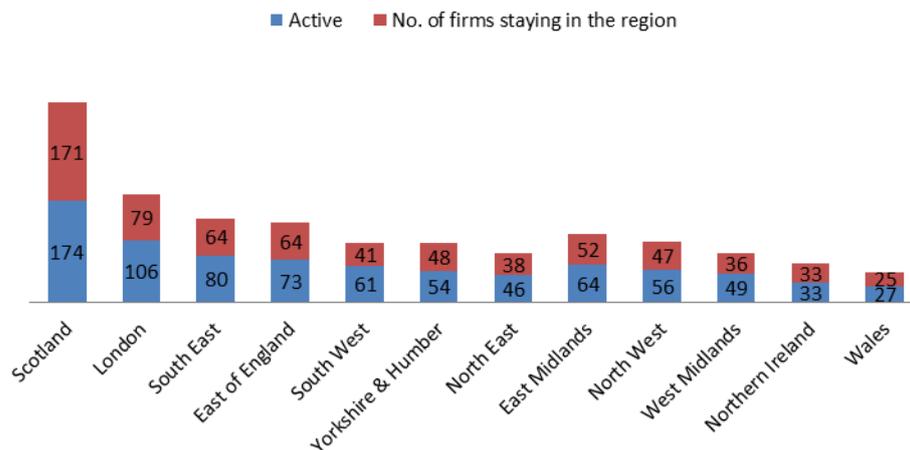


Figure 6: Top 20 Universities that Create Spin-off Firms

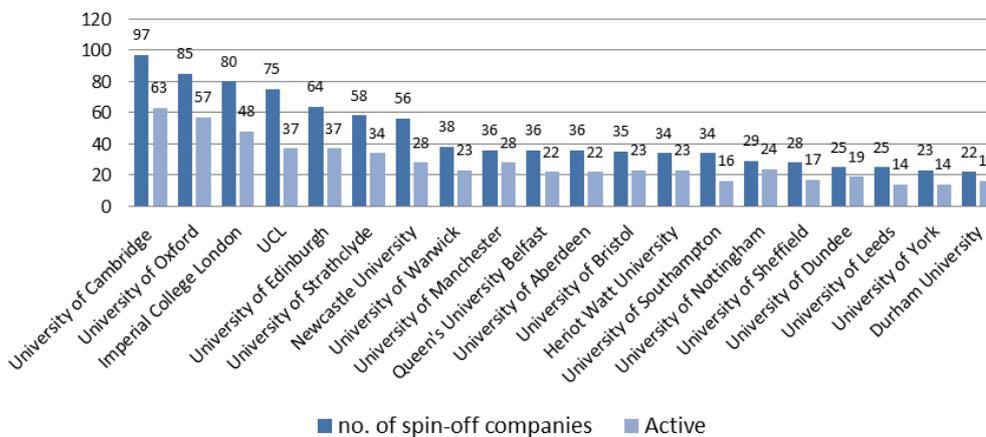
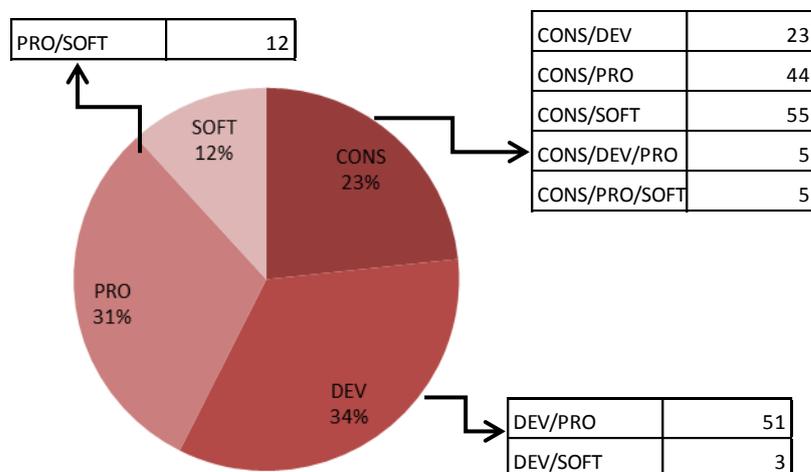


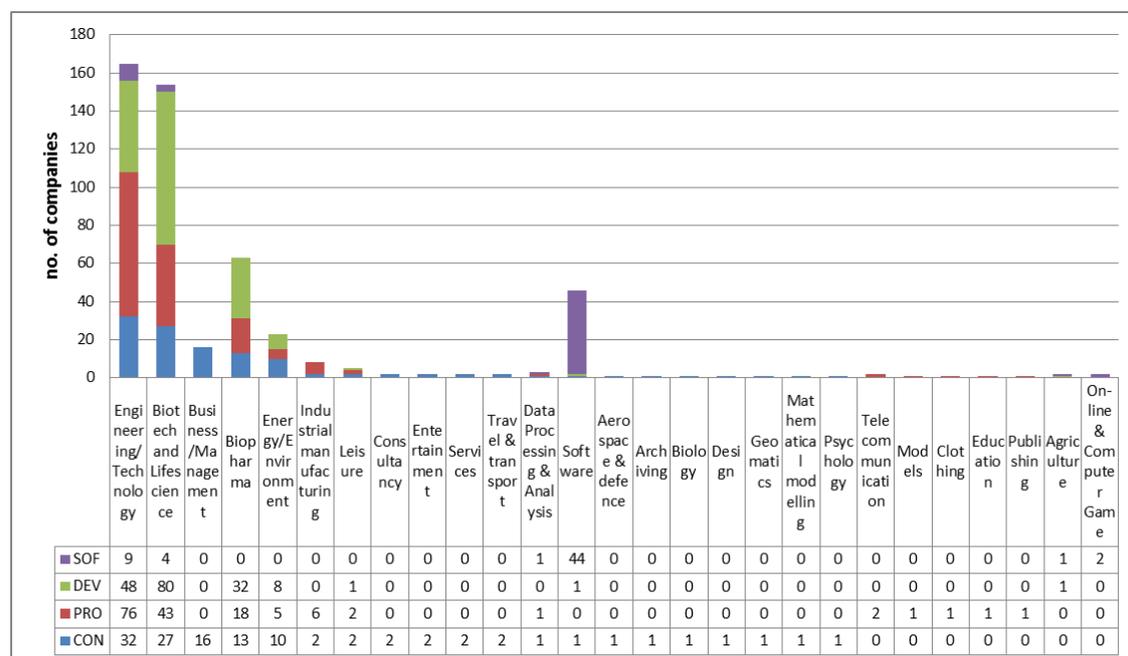
Figure 7: Number of Companies Categorized by Typologies



When we categorize and summarize the spin-off firms into four broad groups identified by Druihle and Garnsey (2004): 1) consulting companies 2) development companies 3) product companies and software companies. Figure 7 provides an overview of number of companies in each category. This shows that 34% of the sampling firms fall into the category of development companies. The next largest group is that of product companies which account for 31% 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. It is apparent that most of software companies operate in software sector, while the high proportion of product companies is in engineering/technology sector. It is also interesting to see that consulting firms operate in sectors spreading across from engineering/technology to psychology. This is possibly due to the nature of lower resources involved in setting up, since it predominantly bases upon scientific and technological knowledge of founders. *See Figure 8.*

Figure 8: Number of Companies by Sectors and by Typologies



University Spin-offs Products and Services

With regards to the number of products and services, more than 70% of the university spin-offs have up to 5 products/services in their portfolio whereas only 16 companies (4%) own more than 15 products/services (see Figure 9). The number of products/services by sector in figure 10 shows the high number of patents and products in engineering/technology sector, 2071 patents and 1749 products respectively, followed by biotech and life sciences and biopharmaceutical sector.

Figure 9: Number of products and services

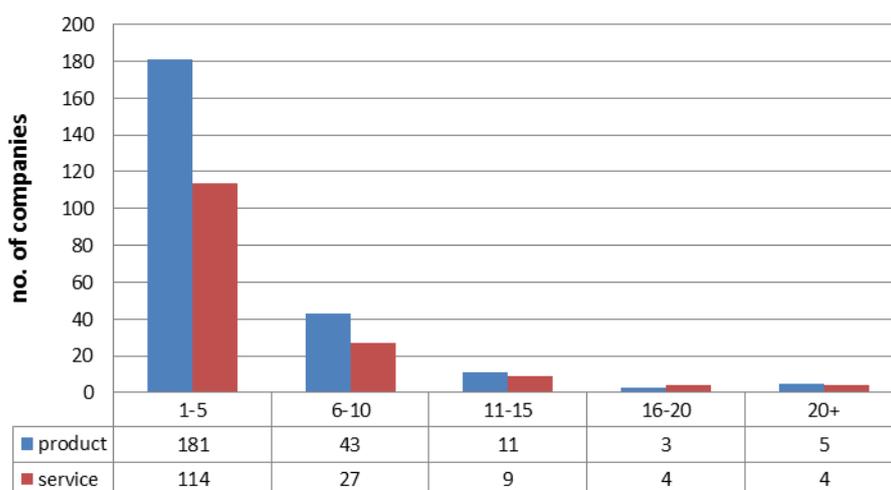
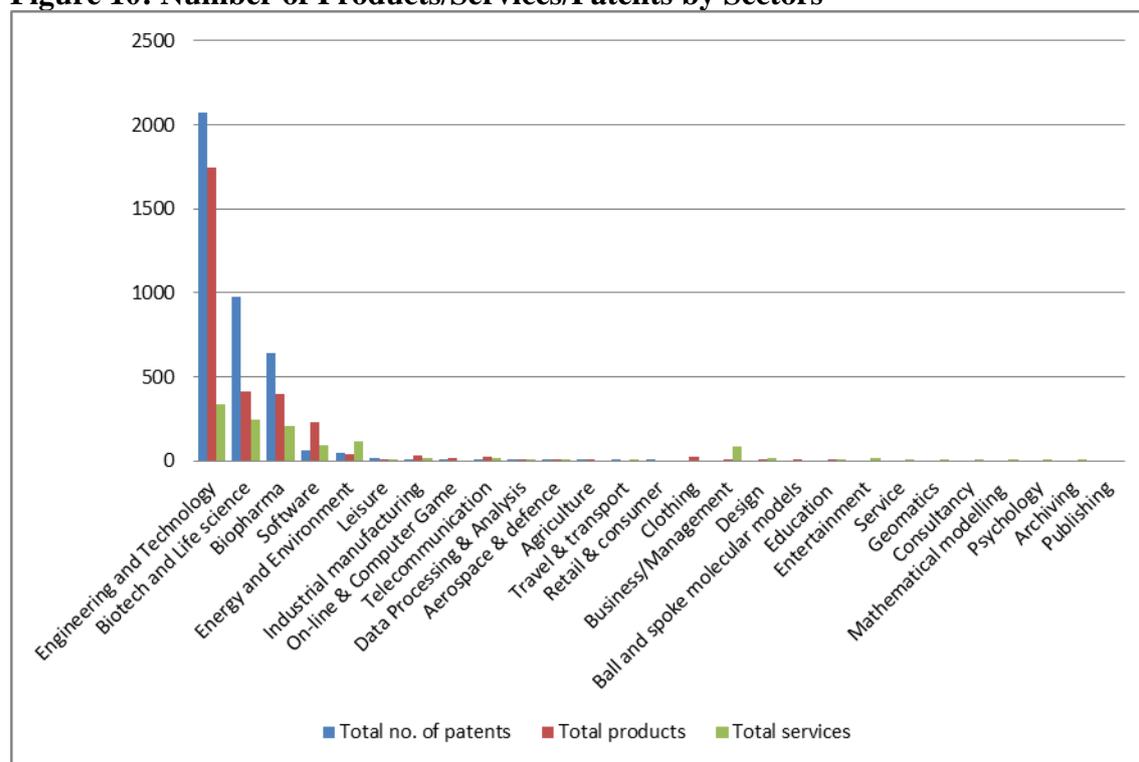


Figure 10: Number of Products/Services/Patents by Sectors



The relationship between years of business and number of products and services 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 (*See Table2*).

In addition, we have seen the correlation between size of company and number of products and services. Micro to small companies only have 1-3 products on average, while medium to large firms have a much bigger products portfolio. This can be explained that larger companies have more resources and capabilities to develop and expand more products in their portfolio. *See Table 3*.

Table 2: Mean of Product/Services by Years of Operation

years of operation	mean products	mean services
1-5 years	2	1
6-10 years	3	2
11-15 years	3	2
16-20 years	6	3
21-25 years	32	2
26-30 years	30	4
30+ years	59	5

Table 3: Mean of Product/Services by Size

No. of employees	mean products	mean services
N/A*	0	0
1-10 (micro)	1	1
11-50 (small)	3	1
50-250 (medium)	10	2
250+ (large)	106	2

7. Conclusions and Further Research

This paper attempts to illustrate initial data and findings relating to characteristics and product innovations within university spin-off firms covering all regions in the UK. 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 services are consequently relatively moderate. The results are consistent with previous academic studies, which explain that UK university spin-off firms tend to start and stay small (Stewart, 2006; Harrison and Leitch, 2010). Generally, it takes university spin-offs at least 10 years before the grow rate starts to show (Lawton Smith and Ho, 2006). Also, during the first decade of their formation, their product generation is also modest (Lerner, 2005).

Due to the incomplete data from public web portal on number of employees including up-to-date financial statements of the majority of university spin-off firms, this study identifies methodological difficulties in conclusively demonstrating relationships between size, profitability and product/services. The preliminary result on the performance of university spin-off ventures shows the importance to i) identify the determining factors of the comprehensive performance of spin-off firms over time, ii) carry out detailed research when discrepancies identified in the performance. In other words, measuring performance of university spin-off firms should take into considerations of different elements that contribute to growth and survival. Clarysse *et al.*, (2005) proposed that more research could practically aim at the resource procurement of spin-off firms, such as, gaining access to financial resources and capital, acquiring skilled employee, and receiving market and business development advice. In addition, the study on product/service innovations will therefore advance a better understanding of the contribution that university spin-offs make to technological change and to existing and new markets. Specifically, firms' capabilities (e.g. technological, internal integrative, external integrative, and marketing) employed to develop effective products (fit with market needs and quality of product) should be further examined.

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