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Academic Entrepreneurship, Strategy and Technology Transfer Ventures

Mike Wright
Nottingham University Business School and University of Ghent

Bart Clarysse
Tanaka Business School, Imperial College, London and University of Ghent

Abstract. This paper draws on literature relating to a series of studies at university, spin-out, and individual academic scientist level to examine key issues in the creation and development of academic entrepreneurship. Different types of involvement of academic scientists in ventures are defined along with different types of spin-offs. The challenges during the different phases and junctures in spin-off growth are examined. University strategies are examined in terms of strategic choices, strategies to attract venture capital, incentives, and incubator models and the role of technology transfer offices (TTOs). At the individual academic level, the characteristics of academic entrepreneurs are reviewed, their entrepreneurial experience, the impact of entrepreneurial activity on publication output and their networks. Finally, some brief conclusions are drawn and recommendations for academic scientists seeking to engage in spin-out activity highlighted.

Keywords: technology transfer, spin-offs, universities, venture capital.

1. Introduction

Academics have long been entrepreneurial in the way that they spot opportunities for new research areas, and to raise grants to fund their research. The licensing of innovations, whereby the scientists receives a royalty, has been a traditional means of commercialization of academic research (Thursby and Thursby, 2002). Academics can also be entrepreneurial in terms of the consultancy they undertake and the patents they take out (Wright et al., 2008). Today, there is considerable worldwide attention to more conventional entrepreneurship in the form of ventures created by academics that are spun-off from the university or research institute. These ventures are the focus of this paper.

While many academics have created ventures for many years (Lawton Smith and Ho, 2006), the recent resurgence of interest in the development of spin-offs has been driven by decreases in public funding for research at universities, a growing public debate about the role of universities in society and legislative changes regarding the ownership and exploitation of intellectual property created in universities (Wright et al., 2008). Targeted legislation designed to stimulate research joint ventures between universities and firms (e.g., the European Union

Framework Programmes) and a major shift in the intellectual property regime in favour of universities such as through enactment of legislation similar to the Bayh–Dole Act of 1980 in the USA have given impetus to these developments (Siegel et al.,2003). These changes have meant that universities have a greater incentive to take equity stakes in spin-offs in anticipation of generating significant capital gains when the spin-offs are sold or floated on a stock market.

Trends in the development of different modes of academic entrepreneurship are summarized in Table 1. While spin-offs can be traced to the early 1960s and even before that, activity began to increase from the mid-1990s. The years 2001-2002 were especially notable for activity, but numbers declined subsequently as universities reassessed their approaches and licensing agreements grew rapidly.

Table 1: Academic Entrepreneurship in the UK

	1997-00	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Spin-outs	380	248	213	197	161	148	187
Patents	n.a.	250	198	377	463	711	576
Licensing agreement	n.a.	728	615	758	2,256	2,099	2,699
IPOs of Spin-outs	n.a	n.a	1	1	10	10	4
IPO Value (£m)	n.a.	n.a	n.a.	214	604	204	246

Source: Authors; UNICO

Universities target the creation of spin-offs by academics in the belief that these ventures will create significant profit streams and capital gains when they are sold that will exceed returns from more traditional licensing agreements and contract research. There is some debate about whether this is in fact the case or whether universities have been successful at creating spin-offs but not at growing them to create value gains. This raises interesting challenges for both universities and academics, who traditionally have operated in a non-commercial environment, to be able to realize the potential for capital gains that are believed to lie in new inventions and innovations. This paper examines these challenges and how they might be addressed.

The following sections discuss the nature and variety of academic entrepreneurs, and the ventures they create. First, we discuss definitions of academic entrepreneurship including the different ownership role of academics and different types of spin-offs. Second, we draw on recent studies to consider the differences in the growth of spin-offs in terms of the phases of growth and growth strategies. Third, we examine university strategies in terms of general strategies,

incentive strategies, strategies to raise finance and incubation strategies. Fourth, we discuss the academic entrepreneurs in spin-offs in respect of their characteristics, their entrepreneurial experience, entrepreneurial teams, and networks. Finally, we present some short conclusions and highlight recommendations for academic scientists seeking to engage in spin-off activity.

2. Definitions of Academic Entrepreneurship

Types of ventures owned by academic entrepreneurs

Narrowly defined, university spin-offs are new ventures dependent upon licensing or assignment of an institution's intellectual property (IP) for initiation. Where legislation allows, a university may own equity in the spin-off in return for the patent rights it has assigned or in lieu of licence fees. In general these spin-offs are the easiest to identify for University Technology Transfer Offices as they are by definition based upon university IP.

A substantial proportion of ventures that are spun-off from universities do not build upon formal, codified knowledge embodied in patents and which likely do not involve universities acquiring equity stakes. These start-ups by university faculty draw on the individual's own IP or knowledge. To some extent academics have for many years created such ventures. Recent developments have attempted to limit if not eliminate these informal ventures.

The relative importance of both spin-offs that involve formal IP and those that do not depends upon the research composition at the university, the country context (as in some countries the IP belongs to the scientist not the university), university policy regarding IP rights and the entrepreneurial activity of the academics themselves. Ventures may also be created by graduates after they have left the university or by outsiders who draw on IP created by universities. Although there are likely to be substantial numbers of these kinds of ventures, it is usually unclear whether the start-up can be linked to specific knowledge created and transferred in the university setting or whether it is based on knowledge which the graduate cumulated outside the university. As such, these ventures would not usually be included in studies of academic entrepreneurship.

Academics creating spin-offs have a number of options. They may leave the university to devote themselves completely to the venture. Alternatively, they may remain with the university and work with the venture part-time. There is some debate about the efficacy of academics as entrepreneurs given their traditionally non-commercial background. Franklin et al., (2001) distinguish between academic and surrogate entrepreneurs. Surrogate entrepreneurs are individuals with commercial experience who are brought in to academic spin-offs to provide the entrepreneurial input that will enable the innovation to be developed from the laboratory to a product in the market place. Franklin et al.

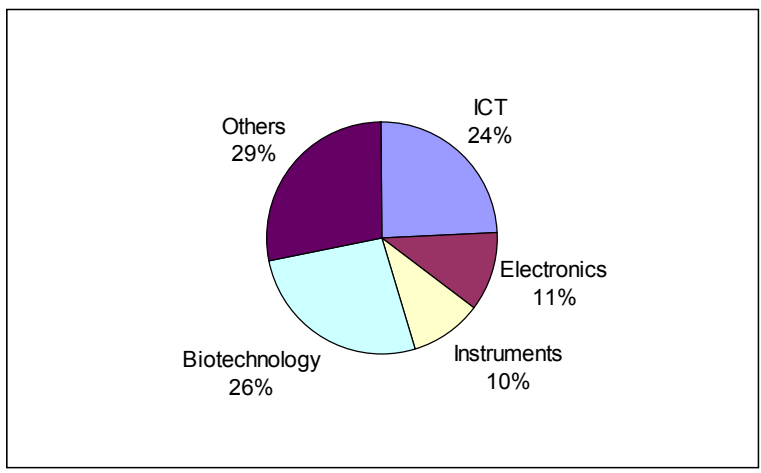
suggest that the best approach for universities that wish to launch successful technology transfer start-ups is a combination of academic and surrogate entrepreneurship. This would enable universities to simultaneously exploit the technical benefits of inventor involvement and the commercial know-how of surrogate entrepreneurs.

Although spin-offs have been viewed as mechanisms to generate significant capital gains and revenue for universities and academics, by no means all ventures have the potential to do this.

Our evidence using Library House data shows that the vast majority of the spin-offs, more than 80%, are still active as independent companies. Remarkably, very few companies (less than 10%) had failed. This may be partially explained by the large number of spin-offs that received external financing from venture capital funds (48%). There are also a number of spin-offs that realized an exit through an IPO (26) or via a trade sale (72). Some increase in IPOs of spin-offs was notable in 2004 and 2005 (Table 1). For example, Proximagen**,** a spin-off established by King's College researchers in the neuroscience fields, achieved an IPO on the London Alternative Investment Market (AIM) in 2005, within 18 months of its creation (Wright and Filatotchev, 2007).

About half of spin-offs are in ICT and Biotechnology sectors according to our analysis of Library House data (Figure 1). Spin-offs operating in Electronics and Instruments account for 11 and 10 percent of the sample respectively. The remaining 29 percent of the sample firms are active in other sectors, which include for example business services and advanced materials.

Figure 1: Sector Distribution of Spin-offs



Spin-offs are quite heterogeneous and the support provided by universities also quite varied. Three distinct types of spin-off can be identified based on the nature of their link with their parent institutional, their resource base and their business model: *'venture capital backed type'*, the *'prospector type'* and the *'life style type'* (Table 2). Estimates suggest that about 10% of research based spin-offs are VC-backed, 50% prospector and 40% life style (Wright et al., 2008).

The *'venture capital backed type'* is probably the most attractive from a policy perspective since it is these firms that are believed to have technology that has the potential to create large new markets with a capital gain likely to be realized through a stock market flotation (i.e., Initial Public Offering (IPO)), or sale to an established multinational corporation. Venture capital backing is sought in the early stages to enable the technology to be developed into products that will subsequently generate revenue. In many cases, these ventures may not have generated revenue streams from their products (apart from consultancy income) prior to their IPO because of the extremely long lead times and high risk in their development through various stages of clinical trials and regulatory approval.

For example, Renovo is a university spin-off which developed novel techniques to heal wounds that do not leave disfiguring scar tissue (Barnes, 2004). The company achieved an IPO in April 2006 while its four lead product candidates were still going through their clinical trials. Over the previous five years the company had developed its management team through the recruitment of executives with commercial experience, non-executives as well as building up its scientific advisory board. The company went through several rounds of fund raising to finance the development of its products. Following an initial venture capital investment of £8million, in January 2003 Renovo's second round funding led by HealthCap was over-subscribed and raised £23 Million (US$37.5 Million). In March 2008, almost two years after the IPO, Renovo announced Phase II clinical trial results for its lead drug, Juvista (human recombinant TGF3) in scar revision (RN1001-1009) and breast augmentation (RN1001-1010) surgery. The company lost half its value on the stock market after announcing the failure of the latest trial of Juvista, its scar prevention drug, which had been touted as a breakthrough product with a potential $12 billion (£6 billion) market. In August 2009, the company's shares tumbled by more than 20 percent after the expected launch of Juvista was delayed by around two years and its partner Shire decided against proceeding with final-stage trials of the product, despite promising Phase II test results.

Venture capital backed academic spin-offs need to attract a significant amount of venture capital at start-up to be credible and must be able to attract most of the researchers that were working on the technology at the university to retain the scientific credibility. Most universities are likely to have very few research groups with world-leading research capable of generating this kind of

company. As a result, it is unrealistic to set quantitative targets for PROs in terms of the number of spin-offs they should create each year.

Most academic spin-offs will have more limited potential as the technology base which underpins their founding is not sufficiently novel to generate radically new growth businesses and markets. These ventures typically have a patent protected prototype or maybe a beta version that can be sold to generate revenue. The *'prospector'* category of companies attract external funding from public or private equity funds linked to the university or public research lab. These companies begin with a business model which essentially follows a contract research or consulting path and attempts to identify a product to commercialize. In the early phases of the start-up, especially when the business model is not clear, pre-seed sources of finance should allow the company to fail or to be free to adopt a different business model that is not in line with a seed fund investor's expectation.

The *'life style'* type of spin-offs start small in a market for products or services and optimize the time to break even. Often they involve consultancy services offered by academics around their research areas. Some of these companies might become high growth companies later, but this is often not clear at start-up. Even if they remain as low growth oriented companies, their value added as a population might be significant since they are large in number. Technology transfer officers usually overlook these initiatives and universities show very little support for researchers or academics that want to create a company which does not involve a formal transfer of technology. This is remarkable since these companies are less demanding in terms of human, financial and technological resources and might increase the visibility of the university in the region. They form the heart of what is often referred to as the entrepreneurial university. The University of Twente, for example, focuses its attention on stimulating self-employment oriented life-style businesses (Clarysse et al., 2005).

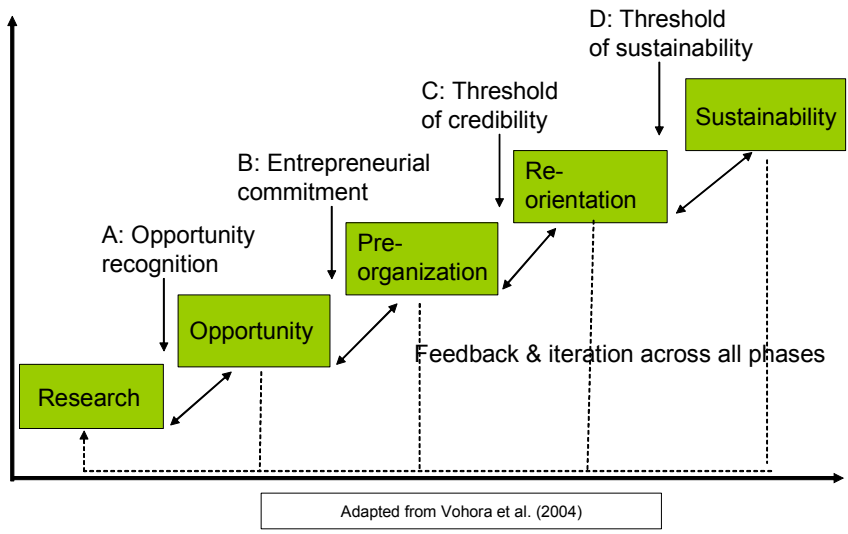
3. Development of Spin-Offs

Phases of development

The development of spin-offs involves an iterative process through a number of well-defined phases. In moving between phases, spin-offs needed to address specific critical junctures (Vohora et al., 2004) (Figure 2). The first critical juncture involving *opportunity recognition* typically requires the spin-off to acquire the capability to synthesise scientific knowledge with an understanding of the market to which it might apply. There may be a need for networks of market contacts outside the scientific environment of the university. The second critical juncture (*entrepreneurial commitment)* requires the venture to acquire an entrepreneurial champion committed to the development of the venture. Where

this is a problem, it appears to arise from universities not providing sufficient resources and network contacts or not developing appropriate incentives and policies. As a result, academic scientists or surrogate entrepreneurs fail to become sufficiently committed to developing the spin-off. The third critical juncture, that of *credibility*, is particularly problematical because of the lack of commercial track record of the academic entrepreneurs, the often intangible nature of the spin-off's resources at this early stage, and the non-commercial environment from which the spin-off was emerging. All these elements create barriers to the attraction of customers and financiers. Building links with surrogate entrepreneurs at earlier phases in the development process may help the spin-off overcome this juncture. However, universities need to devise policies to attract the surrogate in the first place, such as through building network links. The demonstration of proof of concept and the potential for a portfolio of products may also help to establish credibility in relation to financiers. Relocation in commercial premises away from the university can help signal a commercial approach to prospective customers. The fourth critical juncture relating to *sustainable returns* requires the spin-off to develop entrepreneurial capabilities that enable the venture to reconfigure deficiencies from earlier phases into resource strengths, capabilities and social capital.

Figure 2: Spinout Development Processes



Strategies to grow spin-offs

Despite all the effort to stimulate academic entrepreneurship, findings of studies across different countries are consistent in showing that the majority of public-research spin-offs are and stay very small enterprises. Most studies show that the majority of these high tech SMEs remain very small or grow slowly, even if these spin-offs are a fast growing subpopulation of the entire population of young technology based firms (Heirman and Clarysse, 2007). For example in France three-quarters are still in business six years after set up, but 80% of them have less than 10 employees (Mustar, 2000).

Given the different types of spin-offs we identified above, these ventures may adopt different types of growth (Clarysse et al., 2007). A *product market strategy* is more likely to aim at achieving growth in terms of revenues to create a sustainable growing business. A *financial market strategy* places greater emphasis on creating value to enable the business to IPO, or be sold to a strategic partner. In this latter instance the strategy is to grow value which can be through building up the value of the science and technology in the business, even if no product sales are generated, or through a hybrid strategy of both building the value of the technology and generating sales, perhaps initially from consulting and services. The nature of the venture's sector and appropriability regime, for example biotech versus ICT or engineering, may influence this choice. The choice of *commercialization strategy* will also be influenced by accessibility to the necessary complementary assets associated with each growth strategy (Gans and Stern, 2003). *Product market* strategies imply a need to acquire human capital with commercialisation expertise. *Financial market strategies* imply a need to access complementary human capital assets that can help develop the technology.

Developing links with trading partners is an important means to access these complementary assets but may contain challenges for university spin-offs in particular. While larger corporations may be important trading partners for spin-off firms, the technology from spin-off firms may be a minor part of a larger corporation's portfolio; there is therefore likely to be an asymmetry of inter-dependence between the trading partners (Pfeffer and Salancik, 1978). This raises a number of central issues concerning the nature of the contractual agreement between the spin-off and the corporate partner, such as pricing, length of contract, milestones, expectations about the contribution of each partner, and whether there is an anticipation that the trading relationship will be a precursor to acquisition by the corporate partner. The spin-off may need to ensure that it can deliver on the contract it has entered into with the trading partner, which may require it to continue to develop the technology into a commercializable product.

The problems that can arise are illustrated by the university spin-off Idmos which was created in 2001 and which listed on the London-based Alternative Investment Market (AIM) but which subsequently entered bankruptcy

proceedings in April 2008. Idmos entered into an agreement with NASDAQ listed Dentsply in 2005 for the latter to invest in product development and distribute the product. Dentsply would have exclusive global rights to market and sell dental products based on IDMoS ACIST technology and to participate in the development of products, the products being branded by Dentsply with co-branding as 'powered by IDMoS' technology. The agreement foundered with accusations by Dentsply that Idmos had not met milestones or provided product that were commercializable. Idmos made counter-accusations that Dentsply had unrealistic expectations about the capability of the technology.

4. University Strategies and Spin-Offs

General strategies

The existence of an entrepreneurial culture that is social norms that give at least tacit approval to entrepreneurs is a critical determinant of academic entrepreneurship (Roberts, 1991). Universities that generate the most start-ups have clear, well-defined strategies regarding the formation and management of spin-offs (Lockett et al., 2003; Degroof and Roberts, 2004). This involves a support policy for generating start-ups that can exploit ventures with high growth potential. Part of such a policy is the necessity for TTOs to have appropriate commercial expertise and capabilities built up over time (O'Shea et al., 2005). There is a positive correlation between start-up formation and a university's expenditure on intellectual property protection, the business development capabilities of TTOs, and the extent to which its royalty distribution formula favours faculty members (Lockett and Wright, 2005). Thus, universities wishing to generate more start-ups and spin-offs should devote greater attention to the recruitment and development of technology transfer officers with broad-based commercial skills. However, UK TTOs are significantly less efficient in their licensing and spin-offs activities than their US counterparts (Siegel, Wright, Chapple and Lockett, 2008).

In principle, TTOs acquire the specialist expertise to locate new inventions, sort profitable ones from unprofitable ones, and assess the appropriate commercialisation option, that is whether to license the technology or develop a spin-off (Lockett, Siegel, Wright and Ensley, 2005). If TTOs have developed specialist expertise, they likely have an advantage over academic scientists in identifying opportunities and developing spin-offs through their commercial networks and business development expertise. However, if scientists' expertise is necessary for the development of the technology and their preference is for a spin-off rather than a licensing agreement they may be able to influence the development route, especially if they are star scientists (Lockett, Siegel, Wright and Ensley, 2005). Star scientists may be very forceful in wishing to develop the

idea as a spin-off even though assessments suggest it is unlikely to be a viable entity. If the individual concerned is a star scientist in an important research department the university may need to make important trade-offs or risk losing the academic to another institution.

A number of problems arise with the role of TTOs from the point of view of academic scientists. TTOs are dual agent, i.e., they are acting on behalf of both the scientists and the university. TTOs likely follow university-wide policies for the shares of licensing income and/or equity stakes in spin-off ventures. The dual agent role of TTOs and their need to convince their own boards of their achievements in attracting investment funds may lead them to over-value projects compared to their underlying quality (Clarysse et al., 2007).

Furthermore, the availability of TTOs with the appropriate set of skills required to develop spin-offs, has been questioned. Mosey and Wright (2007) note that more experienced academic entrepreneurs were highly critical of the role of TTOs in negotiating deals and typically preferred to developed their own networks. The contribution of TTOs seemed to be relevant in assisting novice and nascent academic entrepreneurs to start out on the road to creating a spin-off. Similarly, there is evidence that external firms experience difficulties in dealing with the university as TTOs lack business experience; as a result firms may decide to by-pass the TTO and deal directly with the academic scientist (Hertzfeld, Link, and Vonortas, 2006).

These findings imply a need to upgrade the commercialization skills and capabilities in TTOs (Siegel, Veugelers and Wright, 2007), a finding echoed by government reports and which has helped prompt representative bodies to embark on professionalisation programmes for TTOs.

Incentive strategies

Incentives for academics are also important. Equity ownership tends to be more widely distributed among the members of the spin-off company in more successful universities (Lockett et al., 2003). The ability of the university and inventor(s) to assume equity in a start-up, in place of licensing royalty fees, are significant determinants of the number of start-ups (DiGregorio and Shane, 2003). A royalty distribution formula that is more favourable to faculty members reduces start-up formation, probably due to the higher opportunity cost associated with launching a new firm, relative to licensing the technology to an existing firm (Markman et al., 2005).

However, a major incentive concerns the link between the creation of spin-offs and academic career development. Universities need to integrate into promotion and remuneration systems mechanisms that value commercialization activities as well as or as an alternative to academic output. Standard royalty distribution and equity holding formulae might be adapted to specific case

contexts, for example if there is a need to retain star scientists. Formalized periods of leave mechanisms might be introduced to enable academics to focus on the development of a spin-off with the possibility of a return if the venture is not successful or the academic skills are no longer required.

Strategies to attract venture capital

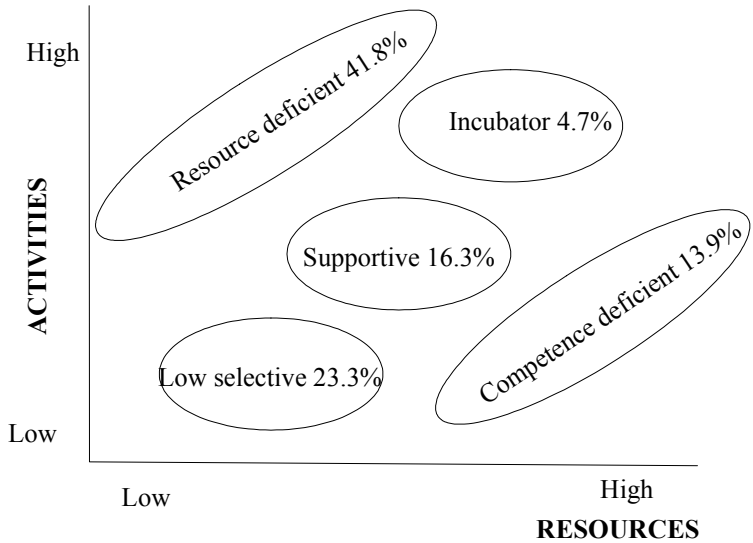
Universities also need to develop strategies to access equity finance to fund the start-up and growth of spin-offs. Venture capital firms find investing in spin-offs from universities can be more challenging than other high tech ventures given the non-commercial environment from which they emanate, the greater need to build management teams, the newness of the technology, the timescales to development, and the potential conflicts of objectives associated with investing alongside a public sector body (Wright et al., 2006). Venture capital firms also consider that universities fail to present proposals for the funding of spin-offs that are investor ready, which emphasizes the need for universities to have TTOs with the appropriate expertise and contacts (Wright, et al., 2008). Venture capital firms also note that universities' decision-making processes are often not conducive to the time-scales they require. Few venture capital firms have developed links with universities and even fewer with more than one university.

Incubator strategies and models

As academic entrepreneurs typically lack key resources to develop their spin-offs, considerable importance is attached to the incubator regime. Academic entrepreneurs can access these resources through the incubator arrangements in their universities. Incubators can provide a range of resources and activities to foster the growth of spin-offs.

Clarysse et al., (2005) identify three optimal cases where universities can adopt different approaches to the development of spin-offs depending upon whether they are seeking to create small numbers of start-ups that become global businesses generating significant capital gains, national level businesses generating revenue streams or larger number of smaller consultancy and service businesses generating local employment (Figure 3).

Figure 3: Different types of spin-off incubator



Source: Clarysse et al. (2005)

First, the *'low selective model'* has an objective of stimulating as many entrepreneurial ventures as possible, typically life-style companies that do not rely technology developed at the university. The 'low selective model' fits very well with the idea of an entrepreneurial university and can also serve the social science departments. Researchers or academics will have a tendency to set up a company with a business model that is familiar to their pre-start up activities and which needs little investment. The spin-off process is facilitated through granting small amounts of money to potential entrepreneurs and the provision of office space at the university.

The '*incubator model'* focuses on the creation of venture capital backed spin-offs. An incubation model might serve a research department which is leading in its field and which has developed a critical mass in a certain domain. As this model aims to stimulate the creation of growth oriented ventures, it is highly selective in projects it supports. As the technology is innovative and can be protected, technology transfer office (TTOs) in the incubator model devote significant time to the protection of the technology base in the incubation or pre-start up phase, including the licensing in of missing elements. Later on in the process, this model demands a well balanced founding team, preferably with experience in the sector. Again, during the incubation phase the TTO officer is actively searching to compose a *team* which can attract an investor. Finally, this model assumes that the spin-off can attract a sufficient amount of capital at start-

up. Again, the TTO office is actively looking for private venture capitalists that are willing to invest the capital at start-up. Because of its size at founding, public VCs cannot provide the capital required without the help of private VCs.

Finally, many universities have developed an in-between type, the *'supportive model'*. This model is less selective in terms of the kind of spin-offs it wants to stimulate. Companies with few growth prospects can receive support in this model. In contrast with the low selective model however, companies receiving support usually embody a formal transfer of technology from the university to the company. They also start with a larger capital basis than life style companies and they might attract surrogate entrepreneurs to complete the founding team. This model best fits the *'prospector'* type of company. The public money associated with the university allows these companies to start. The development of a structure to support academics that want to create a company within the university seems to be a key success factor in the development of such a model. In such a company, academics usually perform contract research or consulting. Without having to leave the university and with a business model very familiar to them, they can experience whether creating an entrepreneurial venture is attractive to them or not. The supportive model might be useful for those departments where the critical mass is lower but that have developed a specific type of technology which might be a success on the market place.

The *'incubator model'* represents around 10% of the incubators, the *'supportive model'* around 35% of the incubators and the *'low selective model'* around 55% (Clarysse et al., 2005). A major difficulty at most universities is that TTOs tend to be structured following one of these models and traditionally have had difficulties in allowing the existence of different models at the same institute. A uniform approach may be adopted to a heterogeneous set of spin-offs, many of which may not be suitable for support based on the model used by VCs. Moreover, some universities may adopt an incubator approach without sufficient resources or developing the necessary capabilities to enable their objective of high value spin-offs to be fulfilled. This mismatch between resources, capabilities and objectives gives rise to resource deficient and competence deficient incubator models. There is a need to match universities' objectives for commercialization, and for spin-offs in particular, with appropriate resources and capabilities and with a realistic perspective on the types of successful spin-offs that can be created given a particular university's science and resource base.

5. Academic Entrepreneurs and Start-Ups

This section discusses the nature and characteristics of academic entrepreneurs.

Academic Entrepreneurs' characteristics

Entrepreneurs at universities are different than other entrepreneurs in certain respects. They tend to be older and more scientifically experienced than other entrepreneurs (Audretsch, 2000). Faculty quality in terms of generating world class research of sufficient novelty is also associated with start-up activity (DiGregorio and Shane, 2003; O'Shea et al., 2005). Analysis of the propensity of life-science faculty to engage in various aspects of technology transfer, including commercialization shows that the most important determinant of involvement in technology commercialization was local group norms (Louis et al., 1989). While some departments and schools are resistant to the creation of spin-offs, others have developed a more proactive and supportive approach where more experienced faculty can provide support for junior faculty. This situation seems to be changing with more favourable approach becoming more evident.

An important issue, which to some extent lies behind the attitude of schools' towards spin-off creation, concerns the potential for conflicts with high level research output. There is evidence that faculty members creating firms are more productive researchers than equivalent colleagues before they established their firms and that their research productivity does not decline following their entrepreneurial activity Lowe and Gonzalez-Brambila (2007). Similarly, engagement in entrepreneurial activity may be associated with an increase in research output (publications), without affecting the nature of the publications involved (Van Looy et al., 2004). However, Lowe and Gonzalez-Brambila (2007) note a differential discipline effect with faculty entrepreneurs in engineering experience a more positive effect than their colleagues in chemistry and biomedicine. This finding indicates that academic entrepreneurship in some disciplines requires more time and resources than in others, so that support for spin-offs may need to be more fine-grained.

However, it is notable that some faculty who are not star researchers but who are frustrated by lack of academic recognition may also have research contracts with companies that generate possibilities for joint venture spin-offs. There may be a need to move beyond standard royalty distribution and equity holding formulae adopted by TTOs to make them negotiable in specific case contexts, such as for star researchers. Formalized periods of leave mechanisms might be introduced to enable academics to focus on the development of a spin-off with the possibility of a return if the venture is not successful or the academic skills are no longer required.

Examination of the outcomes of collaborations between 'star' university scientists and biotechnology firms in Japan shows that such interactions substantially enhance the research productivity of Japanese firms, as measured by the rate of firm patenting, product innovation, and market introductions of new products (Zucker and Darby, 2001). However, the wider benefits of such collaborations to local regions appears to differ between countries depending on

institutional differences. In the United States, academic scientists typically work with firm scientists at the firm's laboratories and the local benefits are strong. In contrast in Japan, firm scientists typically work in the academic scientist's laboratory and the local benefits are absent.

Entrepreneurial experience

Differences in the human capital derived from the entrepreneurial experience of academic entrepreneurs influence their ability to develop networks that can address the barriers to venture development. Using a longitudinal study of 24 academic entrepreneurs supplemented with interviews with 20 technology transfer officers (TTOs) and heads of schools, Mosey and Wright (2007) examined the development of networks by three types of academic entrepreneurs with differing levels of entrepreneurship experience. A distinction was made between nascent, novice and habitual entrepreneurs (Westhead and Wright, 1998; Ucbasaran et al., 2008). They propose that habitual entrepreneurs (i.e., those with prior business ownership experience) have broader networks and are more effective in developing network ties to gain equity finance and management knowledge. Conversely, less experienced nascent and novice academic entrepreneurs are likely to encounter disconnects (sometimes referred to as *structural holes*) between their scientific research networks and industry networks. This constrains their ability to recognize opportunities and gain credibility for their fledgling ventures. While support initiatives, such as technology transfer offices (TTOs) and proof of concept funds, help attract industry partners to selected novice entrepreneurs, there appears to be no obvious substitute for business ownership experience to learn how to build relationships with experienced managers and potential equity investors. Development of social capital for nascent and novice entrepreneurs is influenced by the human capital related to the entrepreneurs' discipline-base, with individuals from engineering and material sciences being more likely to build network ties outside their scientific research networks than those in biological sciences and pharmacy.

Entrepreneurial teams

The growth of spin-offs may require different types of skills and investment in human capital. A particularly important issue is the evolution of entrepreneurial teams as the spin-off progresses through its phases of development. Some researchers who are actively involved in the first phase of the spin-off process exit at subsequent stages and new members enter, especially those with commercial human capital (Vanaelst et al., 2006). Exiting members make a career choice to

stay with the university, preferring to continue their research but often having a part-time role providing the spin-off with continuing technological development.

TTO officers play an important role as "privileged witnesses" in nurturing the emergence of entrepreneurial teams in spin-offs. They should recognize the need for different personalities in the team (Vanaelst, et al., 2006). More successful teams tend to be those which are diverse in their functional background but combine this with joint working experience and possibly different view on how the spin-off should develop. This "cognitive diversity" stimulates members of a team to challenge each other about the strategy the spin-off should ideally follow and hence make better decisions (Vanaelst, et al., 2006). It is important that these discussions do not result in affective conflict, which means that founders start to dislike each other. Teams who know each other and who have developed non-instrumental relations, such as joint working experience or even social relations, before starting the spin-off have much less chance of experiencing affective conflict than those who do not know each other (Wright et al., 2008).

Team members that combine flexibility and external orientation tend to be "innovative" persons that embody a high degree of creativity and vision (Wright, et al., 2008). Many high flying academics tend to have a high degree of this orientation. In contrast, people with a high degree of external orientation but also a high degree of focus on control, tend to be "goals oriented". A founding team needs to have a person with such a vision to ensure that the necessary steps in the development of the spin-off are achieved. The surrogate entrepreneurs attracted to form a founding team with researchers often have the same kind of "innovative" orientation as the researchers themselves, producing team homogeneity rather than heterogeneity.

Academic Entrepreneurs' networks

Networks of academic scientists who become entrepreneurs may be important influences on the performance of spin-offs. Mustar (1997) classified spin-offs depending on their cooperation arrangements with other public and / or private bodies and highlighted the relation between the breadth of the social network and the growth trajectory and attrition rate. Different embeddedness of academics in a network of ties external or internal to the university is associated with different growth trajectories (Nicolaou and Birley, 2003). Zucker et al., (2000) assessed the impact of university scientists on the research productivity of new United States biotech firms and find that ties between star scientists and firm scientists have a positive effect.

There may be a need for universities to recruit and develop individuals who can act as intermediaries or boundary spanners between the university scientist and the commercial market place and providers of finance. Schemes such as the Medici Fellowship Scheme in the UK, which involves the inculcation of skills

relating to marketing, finance, opportunity identification etc. to individuals who typically are post-docs with a science background suggests that these can have a positive impact but for the schemes to be effective there is a need to provide sustained support rather than short term schemes and to establish defined career paths for fellows so that the skills developed are quickly lost if the individuals leave (Wright et al., 2008).

6. Conclusions

Universities seeking to promote spin-offs face important challenges if they are to realize the significant capital gains that they are seeking. In what has traditionally been a non-commercial environment, the development of spin-offs raises distinct issues compared to high tech ventures that start-up in a commercial context. In particular, these issues concern gaining access to entrepreneurial competences and building entrepreneurial teams involving individuals who may also be seeking to maintain an academic career, developing networks with commercial trading partners and accessing venture capital, and developing incentives for academic scientists.

Universities have developed and adapted their approaches to the stimulation of academic entrepreneurship as they have begun to learn what works and what does not. Major shifts concern a pulling back from too much emphasis on spin-offs to a case-by-case assessment of whether an innovation is likely to be a viable business or not. A major challenge that remains relates to how ventures can be supported in their growth since although high numbers of spin-offs have been created, relatively few have gone on to generate the substantial capital gains that were envisaged. To some extent there remains a need for universities to attract and incentivize both the right calibre of TTOs and surrogate entrepreneurs. There is also a need for universities to incentivize academics and resolve conflicts with promotion systems that focus on academic output and pay insufficient attention to commercialization activities. There is also a need to understand more the disconnect between universities' espoused strategies for commercialization at the top and what actually happens in schools. We still need to know more about the nature of these barriers to commercialization and how they might be resolved.

The analysis presented in this article suggests a number of lessons for academic entrepreneurs:

- Consider carefully whether the focal venture is really suitable as a spin-off or whether this innovation is more appropriate for a licensing agreement.

- Assess carefully whether the venture has the potential for significant growth or is little more than a lifestyle venture since this will heavily influence the commitment and support that will be needed.

- Be aware that the venture will develop across various well-defined phases that will require adaptability and changes to the entrepreneurial team and to the product configuration.

- Consider the appropriate growth strategy. Product market versus financial market strategies will require different skills and financial support.

- Build networks both inside the School and university as well as externally. Colleagues who have previously developed ventures may one of the best sources of insights.

- Consider carefully the level of support that the university's TTO and incubator can provide. Is this appropriate for the focal venture? If not, what alternatives are there? Would a relocation to another university be appropriate?

- Consider negotiating strength with the university in relation to the equity stake that can be obtained and support provided.

- Develop cultures in scientific and engineering schools that foster academic entrepreneurship in the context of academic research.

- Build balanced entrepreneurial teams that include those with scientific expertise as well as commercial skills.

- Finally, decide career priorities. Do you want to be a full time entrepreneur or a full time academic or somewhere in-between? What are the downsides if the venture does not succeed? The answer to these questions will largely determine the role that the academic plays in developing the venture.

References:

Audretsch, D. (2000). *Is University Entrepreneurship Different?* mimeo, Indiana University.

Barnes, S. (2004). The Renovo Story: Venture Capital at the Cutting Edge. *International Journal of Entrepreneurship Education*, 2: 379-404.

Clarysse, B., Bruneel, J., and Wright, M. (2007). *Growth Strategies of Young, Technology-Based Firms*. Paper presented at the Babson Entrepreneurship Conference, Madrid.

Clarysse, B., Wright, M., Lockett, A., van de Elde, E., and Vohora, A. (2005). Spinning Out new Ventures: A typology of Incubation Strategies from European Research Institutions. *Journal of Business Venturing*, 20 (2): 183-216.

Degroof J. J., and Roberts, E. B. (2004). Overcoming Weak Entrepreneurial Infrastructure for Academic Spin-off Ventures. *Journal of Technology Transfer*, 29 (3-4): 327-357.

Di Gregorio, D., and Shane, S. (2003). Why Do Some Universities Generate More Start-ups than Others? *Research Policy*, 32: 209-227.

Druilhe C., and Garnsey E. (2004). Do Academic Spin-Outs Differ and Does it matter? *Journal of Technology Transfer,* 29 (3-4): 269-285.

Franklin, S., Wright, M., and Lockett, A. (2001). Academic and Surrogate Entrepreneurs in University Spin-out Companies. J*ournal of Technology Transfer*, 26 (1-2): 127-141.

Heirman, A., and Clarysse, B. (2007). Do Intangible Assets and Pre-Founding R&D Matter for Innovation Speed in Start-Ups? *Journal of Product Innovation Management*, 24: 303-315.

Hertzfeld, H.R., Link, A.N. and Vonortas, N.S. (2006). Intellectual property protection mechanisms in research partnerships. *Research Policy*, 35: 825–839.

Lawton Smith**,** H. and Ho, K.W. (2006) Measuring the performance of Oxfordshire's spin-off companies. *Research Policy*, 35(10): 1554-1568

Lockett, A., Wright, M., and Franklin, S. (2003). Technology Transfer and Universities' Spin-out Strategies. *Small Business Economics,* 20: 185-201.

Lockett, A., and Wright, M. (2005). Resources, Capabilities, Risk Capital and the Creation of University Spin-Out Companies. *Research Policy*, 34 (7): 1043-1057.

Lockett, A., Siegel, D., Wright, M. and Ensley, M. (2005). The Creation of Spin-off Firms at Public Research Institutions: Managerial and Policy Implications. *Research Policy*, 34(7): 981-993.

Louis, K., Blumenthal, D., Gluck, M. E., and Stoto, M. A. (1989). Entrepreneurs in Academe: An Exploration of Behaviors Among Life Scientists. *Administrative Science Quarterly,* 34: 110-131.

Louis, K., Jones, L. M., Anderson, M. S., Blumenthal, D., and Campbell, E. G. (2001). Entrepreneurship, Secrecy, and Productivity: A Comparison of Clinical and Non-Clinical Life Sciences Faculty. *Journal of Technology Transfer,* 26 (3): 233-245.

Lowe, R. A., and Gonzalez-Brambila, C. (2007). Faculty Entrepreneurs and Research Productivity. *Journal of Technology Transfer*, 32: 173-194.

Markman, G., Phan, P., Balkin, D., and Gianiodis, P. (2005). Entrepreneurship and University-Based Technology Transfer. *Journal of Business Venturing,* 20 (2): 241-263.

Markman, G., Gianiodis, P. and Phan, P. (2006). *An Agency Theoretic Study of the Relationship Between Knowledge Agents and University Technology Transfer Offices*. Troy, NY: Rensselaer Polytechnic Working Paper.

Marvel, M. R., and Lumpkin, G. T. (2007). Technology Entrepreneurs' Human Capital and its Effects on Innovation Radicalness. *Entrepreneurship Theory and Practice*, 31: 807-828.

Mosey, S., and Wright, M. (2007). From Human Capital to Social Capital, A Longitudinal Study of Technology-based Academic Entrepreneurs'. *Entrepreneurship Theory and Practice*, 31: 909-936.

Mustar, P. (1997). Spin-off Enterprises: How French Academies Create Hi-tech Companies: The Condition for Success or Failure. *Science and Public Policy*, 24 (1): 37-43.

Nicolaou, N., and Birley, S. (2003). Social Networks in Organizational Emergence: The University Spinout Phenomenon. *Management Science*, 49: (12): 1702-1725.

O'Shea, R., Allen, T., and Chevalier, A. (2005). Entrepreneurial Orientation, Technology Transfer, and Spin-off Performance of U.S. Universities. *Research Policy*, 34 (7): 994-1009.

Pfeffer, J., and Salancik, G. (1978). *The External Control of Organizations: A Resource Dependence Perspective*. New York: Harper and Row.

Roberts, E. (1991), *Entrepreneurs in High Technology, Lessons from MIT and Beyond*, Oxford, Oxford University Press.

Roberts, E., and Malone, D. E. (1996). Policies and Structures for Spinning Off New Companies from Research and Development Organizations. *R&D Management*, 26: 17-48.

Siegel, D. S., Westhead, P., and Wright, M. (2003b). Assessing the Impact of University Science Parks on Research Productivity: Exploratory Firm-Level Evidence from the United Kingdom. *International Journal of Industrial Organization*, 21 (9): 1357-1369.

Siegel, D., Wright, M., Chapple, W. and Lockett, A. (2008). Assessing the Relative Performance of University Technology Transfer in the U.S. and U.K.: A Stochastic Distance Function Approach. Economics of Innovation and New Technology, 17: 719-731.

Siegel, D., Veugelers, R. and Wright, M. (2007). Technology Transfer Offices and Commercialization of University Intellectual Property: Performance and Policy Implications. *Oxford Review of Economic Policy*, 23: 640-660.

Thursby, J. G. and Thursby, M. C. (2002). Who is Selling the Ivory Tower? Sources of Growth in University Licensing. *Management Science,* 48: 90-104.

Technology Strategy Board (TSB) (2008). Connect and Catalyse: A strategy for business innovation 2008-2011.

Vanaelst, I., Clarysse, B., Wright, M., Lockett, A., Moray, N., and S'Jegers, R. (2006). Entrepreneurial Team Development in Academic Spin-Outs: An Examination of Team Heterogeneity. *Entrepreneurship Theory and Practice*, 30: 249-272

Van Looy, B., Ranga L.M., Callaert J., Debackere K., and Zimmermann E. (2004). Combining Entrepreneurial and Scientific Performance in Academia: Towards a Compounded and Reciprocal Matthew effect? *Research Policy*, 33 (3): 425-441.

Vohora, A., Wright, M., and Lockett, A. (2004). Critical Junctures in the Growth in University High-Tech Spinout Companies. *Research Policy*, 33: 147-175.

Westhead, P. & Wright, M. (1998). Novice, portfolio and serial founders: are they different? *Journal of Business Venturing,* 12, 173 – 204.

Wright, M., Clarysse, B., Mustar, P., and Lockett, A. (2008) *Academic Entrepreneurship in Europe*. Cheltenham, UK Edward Elgar.

Wright, M. and Filatotchev, I. 2007. Stimulating Academic Entrepreneurship and Technology Transfer: A Case Study of Kings College London Commercialization Strategies. In Allen, T. and O'Shea, R. (Eds),

Zucker, L. G., and Darby, M. R. (2001). Capturing Technological Opportunity Via Japan's Star Scientists: Evidence from Japanese Firms' Biotech Patents and Products. *Journal of Technology Transfer*, 26 (1-2), 37-58.

Zucker, L. G., Darby, M. R., and Armstrong, J. (2000). *University Science, Venture Capital, and the Performance of U.S. Biotechnology Firms*. mimeo, UCLA.