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Spin-outs from Universities: Strategy, Financing, Monitoring and Incubation Models

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Abstract. Spin-outs of ventures from universities are growing in importance yet their process is little understood. This paper reviews evidence from the spin-out and university level relating to four key research questions: What mechanisms are in place to facilitate the spinning-out of new technologies into companies? What financial resources are made available by universities and outsiders to facilitate spin-out companies and at what stage? What mechanisms and processes are in place to monitor spin-out companies once they have been established? How effective are these systems and processes from the viewpoint of the participants and in terms of spin-out company success. Implications for practice and areas for further research are identified.

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

1. Introduction

There is increasing policy focus on universities' ability to exploit their science base and transferring their scientific knowledge to the private sector. The majority of existing research on the performance of university technology transfer has emphasized the licensing activities of US universities (see, for example, Thursby and Thursby, 2002; Thursby and Kemp, 2002; Siegel, Waldman and Link, 2003; Sine, Shane and DiGregorio, forthcoming). However, the focus of attention is increasingly being directed towards the creation of new ventures (Siegel *et al.*, 1999). Through spin-outs (USOs), universities may be able to capture the full value of their technology (Franklin, Wright and Lockett, 2001). The more active universities in this respect, in the UK at least, tend to be more willing to cede significant amounts of equity to academic inventors (Lockett, Wright and Franklin, 2003).

This increased interest in USOs is being observed in North America, the UK, Australia and Continental Europe (DiGregorio and Shane, 2003; Shane and Stuart, 2002; Wright, Vohora and Lockett, 2002). Small sample survey evidence indicates that taking equity in a USO company produces a greater average return in the long run compared to the average return available from the average license

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(Bray and Lee, 2000). Some research attention has been addressed towards the inputs associated with the number of USOs created by US universities (DiGregorio and Shane, 2003) and the survivability of start-ups that exploit academic knowledge (Nerkar and Shane, 2003). However, there is concern, expressed for example in the Lambert Review, that many USOs that are created may not generate significant wealth that greater focus should be placed on identifying whether a USO was the most appropriate means to exploit technological inventions produced in universities (Lambert, 2003). A central issue, therefore, is the need to examine the factors influencing the generation of wealth in spin-outs.

Although universities are being encouraged by a number of government pronouncements and initiatives to commercialise their intellectual property by launching entrepreneurial spin-outs companies, this mode of technology transfer is not well-understood. Their ability to create wealth from spin-outs has, therefore, important implications for how well universities are equipped to respond to this new agenda.

Strictly defined USOs involve ventures created on the basis of innovative, and typically patentable intellectual property in which the university and the academic entrepreneur are the main equity holders, possibly together with outside investors such as surrogate entrepreneurs, business angels and venture capitalists. However, ventures may also be created by university academics which do not depend on such intellectual property but which may nevertheless have wealth generating possibilities (we return to these differences in our discussion of the different spin-out development models that universities may adopt). The academic may either remain in full-time employment with the university or leave to concentrate effort on the spin-out (Nicalaou and Birley, 2003a). In other cases, the venture may be a joint one with an existing corporation. Druilhe and Garnsey (2004) distinguish between spin-outs in terms of development companies based on a novel scientific breakthrough, product companies involving opportunity recognition that builds on the scientist's knowledge, and software companies.

The process of spinning-out companies is – arguably – much more complex than licensing. DiGregorio and Shane (2003), in their examination of why some universities generate more start-ups than others, focus on university level factors, including a university's propensity to undertake industry sponsored research, intellectual eminence and policy towards IP commercialization; and external factors such as the availability of venture capital in a region. However, a number of key issues are raised concerning the processes involved in the development of successful spin-out strategies. Opportunity recognition is a key first step in enterprise creation and there is a need, therefore, to consider how this is achieved in universities. The realisation of university aims to recognise and exploit commercial opportunities may be influenced by the expertise and approaches adopted by university technology transfer officers to screen and prepare potential ventures. Similarly, there are questions concerning the feasibility and desirability

of academic inventors becoming heavily involved in the commercialisation process. Franklin, Wright and Lockett (2001) show that those universities that were more active in spinning-out companies made greater use of external [surrogate] entrepreneurs with commercial experience, who would enter the firm and take the lead in developing it. These points, in turn, raise questions concerning the feasibility and desirability of developing external commercial links. The problems for new start-ups in accessing finance are well-recognised and are expected to be particularly pertinent with regard to university spin-outs (USOs) because of the restricted resources available to universities for funding this kind of venture and attitudes and access to external finance. Close monitoring is a key aspect of early stage venture capital investment. This raises questions concerning the expertise of university personnel and the nature of the monitoring they undertake to enable a new technology to become commercially viable.

A common link between these issues concerns the availability of resources within universities. In the traditional non-commercial environment of universities, the development of spin-outs may be constrained by major deficiencies in resource endowments and capabilities (West and De Castro, 2001). Our approach builds on the general resource based view of the firm and capabilities framework (Barney, 1991; Teece, et al., 1997; Eisenhardt and Martin, 2000) and specifically on the work of Brush, Green and Hart (2001) who adapt this perspective to new ventures.

In this paper we examine four key research questions:

1. What mechanisms are in place to facilitate the spinning-out of new technologies into companies?

2. What financial resources are made available by universities and outsiders to facilitate spin-out companies and at what stage?

3. What mechanisms and processes are in place to monitor spin-out companies once they have been established?

4. How effective are these systems and processes from the viewpoint of the participants and in terms of spin-out company success?

In answering these research questions we consider both the spin-out firm level and the university level of analysis.

2. Method

The evidence reviewed in this paper is based on data gathered in two stages:

1. Qualitative

Data were collected using in-depth face-to-face and telephone interviews with representatives from twelve USOs, as well as each of their financial investors and seven associated universities over the period July 2001 to July 2002. These universities were selected on the basis that they are among the top ten research elite universities in the UK and that they are actively pursuing a programme of university technology transfer. In each case we obtained considerable cooperation from the relevant parties in the spin-out process. Each university had a different orientation towards the commercialisation of research, which is reflected in their idiosyncratic cultures and institutional norms. Therefore, each university was at a different point in transforming its policies, routines and incentive mechanisms towards commercialisation through USOs. To assist in theory generation we also selected a range of different ventures in terms of their technology and stage of development. We found it more difficult to obtain detailed access to spin-out companies than universities.

For each case, interviews were carried out with the head of the university technology transfer office (UTTO) or equivalent, business development managers (BDMs) and the members of a spinout company who had taken the venture through the process including both the academic entrepreneur and the "surrogate" entrepreneur where applicable. We also gained access to the seed stage investors in each of the USOs. In addition, we interviewed the head of each department from which the USO originated. The interviews lasted from one to two hours and were openly recorded and afterwards transcribed. By using a number of key actors from each university we ensured that we elicited views on the universities' role in the spinout process to cross-check our interpretation of events.

2. Quantitative

It was recognised that it would be crucial to obtain support and cooperation in advance from potential respondents who might otherwise be reluctant to complete another questionnaire. We established a collaborative link with the University Companies Association (UNICO) who agreed to circulate their members to alert them to the survey and to lend their support in designing the questionnaire and encouraging responses. We also subsequently had a meeting with HEFCE who expressed a view that they would be interested in the findings; this was useful in helping us to encourage responses.

A complete listing of 167 institutions was obtained from the funding bodies. In total, 122 universities were contacted, the remaining 45 universities accounting for just 0.2% of total research grants and contract expenditures by UK universities in financial year 2001. In February 2002, a joint letter from the principal researcher and the Chair of UNICO requesting cooperation and the nomination of

a respondent was sent to the vice-chancellors. In most cases the nominee was either the head of the technology transfer office (TTO), the research office, or the commercial office. As it was recognised that various information requests would need inputs from different departments or units, two questionnaires were developed: one seeking quantitative responses (number of spin-outs, licences, etc.) and one asking for qualitative information concerning the technology transfer process (Likert scales). The quantitative metrics were harmonised with the US Association of University Technology Managers (AUTM) Licensing Survey to enable international comparisons to be made at a later date. The draft questionnaires were sent to a selected sample of UNICO members to obtain comments.

In late March 2002, hard copies and electronic versions of both questionnaires were sent to the nominated respondent. Versions of the survey were available to be completed on the Internet and submitted electronically. The nominated respondents were contacted to confirm receipt of the questionnaires and a dialogue was maintained to ensure progress was being made in completing the questionnaires. These procedures enabled us to identify more accurately the appropriate respondents and to reduce delays in obtaining information.

In total, 98 institutions responded to the survey, accounting for 84.9% of the total amount spent on research in UK universities during financial year 2001. We obtained responses from 18 of the top 20 institutions. Among the 98 responses, we received 81 completed numerical data questionnaires and 77 completed process questionnaires. In addition, we received 17 nil responses (i.e. the data was unavailable) to the numerical data questionnaire and 21 nil responses to the process questionnaire.

Considerable effort was involved in collecting the data because often they did not exist in a collated form in a number of institutions, while in others they were located in several places requiring the questionnaire to be circulated around the relevant departments. As a result, we feel we have now obtained a unique, novel and very rich dataset. We identified that 175 spinouts had been created in universities in 2001, compared to an average of 95 per year during the period 1997-2000. However, experience is highly skewed. A quarter of responding institutions did not create any spinouts during the period 1997-2001 while 27% created 10 or more spinouts each during the same period.

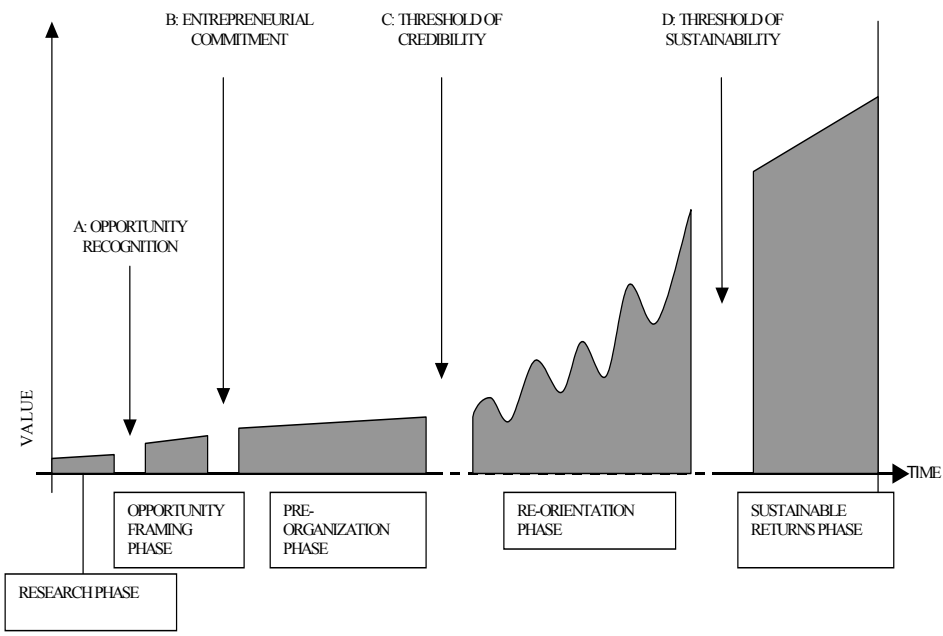
3. Results

3.1. Mechanisms for Spinning-out Companies

To examine the systems and mechanisms for spinning-out companies we developed an approach that linked a resource-based view of the process with a

dynamic perspective based on the phases in the life-cycle of the development of the spin-out company. The resources required to facilitate the spin-out process can be categorised into human capital, financial, physical, technological and organizational. Our analysis of the process identified five phases (see Figure 1 below) in the development of a spin-out company: research phase, opportunity phase, pre-organization phase, re-orientation phase and sustainable high-growth phase. It was evident that each venture needs to pass through the previous phase in order to progress to the next stage of development. Importantly, this is not a linear activity but rather involves a non-linear, iterative process. Druilhe and Garnsey (2004) see the development of spin-out phases as a continuous process of adjustment but observe that the phases that the spin-out passes through depends on the maturity of the entrepreneurs initial resources and the business model selected.

Figure 1: The Critical Junctures in USO Development (adapted from Vohora, Wright and Lockett, 2004)



At the four interstices between the five phases of development, we found that ventures face 'critical junctures' which must be overcome to enable progress to the next stage to occur. However, such progress was not automatic. The critical junctures were identified as opportunity recognition, entrepreneurial commitment, credibility and sustainability and were found to arise due to

deficiencies in social capital, other resource weaknesses and inadequate internal capabilities. The main features and implications of each critical junctures are as follows (see Vohora, Wright and Lockett, 2004 for detailed discussion).

Opportunity Recognition: Universities and academic entrepreneurs involved in creating USOs were found to lack the necessary human entrepreneurial capital and social capital synonymous with commercial awareness and prior business experience. As a result, there is an inability to conceptualise how a technological discovery can be best applied to satisfy a market need. It was also common in all but one USO case for the parent universities to provide little incentive for their scientists to think and behave entrepreneurially. In the case of Biomedical Co. [a pseudonym], during studies to investigate how a particular technology could be applied to new areas of science the research team recognized a new application that presented a real commercial opportunity. In contrast, in the case of 3G Wireless Co [also a pseudonym], the scientist had been working for nearly 10 years on science that did not have an obvious market application. The technology provided a solution to a market need that was only recognised by a surrogate entrepreneur.

Our interviews suggested it was important for universities to devote more resources to increasing their social capital (networks) through developing and exploiting existing external partnerships, links and interactions with industry, venture capital firms and surrogate entrepreneurs so that academics and UTTOs may become better positioned to recognise entrepreneurial opportunities. In a related study, Niclaou and Birley (2003b) examine the networks of academic entrepreneurs and note the importance of non-redundant ties, that is the links that academic scientists have with the external commercial world.

Entrepreneurial Commitment: For a venture to succeed, there is a need for a 'champion' committed to the entrepreneurial development of the spin-out. These champions may be academics or entrepreneurs from outside with commercial expertise, so-called surrogate entrepreneurs (Franklin, Wright and Lockett, 2001). Primarily as a result of universities: allocating insufficient resources to encourage and facilitate the spin-out process, failing to realign institutional incentives, an institutional culture that discriminates against those with an entrepreneurial orientation, neglecting to devise clear policies and guidelines, and not developing a deep network of external relationships with key actors, academic scientists and surrogate entrepreneurs did not become sufficiently emotionally and financially committed to championing the commercialisation of university scientific discoveries. These factors appear different from those present in a normal start-up in holding back initial progress towards exploiting the value that has been recognised in an opportunity. In Biomedical, early test results encouraged one member of the academic team to carry out market research and to develop a business plan in order to assess the potential in commercializing the research. The academic formed a company and initially ran the business in his spare time, in order to test the market. In 3G Wireless the scientist's biggest

weakness was that he did not have the business experience or the managerial expertise to grow a business. He did not want to give up his research post at the university because it provided him with the infrastructure to create new technologies.

Credibility: Credibility is a general problem for new ventures (Birley and Norburn, 1985). While similar issues arise for USOs, lack of credibility of USOs with respect to potential trading partners and financiers particularly arises from their intangible initial resources, the typical lack of commercial track record of the founding entrepreneur, the effect of the academic culture and values, and the absence of clear policies on the commercialisation of scientific discoveries, despite the rhetoric of senior university management (Lockett, Murray and Wright, 2002). Universities can demonstrate the credibility of their USOs by presenting intellectual property as a potential portfolio of products, demonstrating proof of concept of technological assets, clarifying the route to market and profitability, being able to locate the venture off the university campus, and implement mechanisms to attract surrogate entrepreneurs. However, in order to attract a potential surrogate entrepreneur it may first be necessary for the nascent pre-organisation stage USO to develop some credibility with the surrogate. We noted differences in the existence and quality of formalised systems and mechanisms through which USOs were formed and created in the seven universities we examined, as well as the level of social capital that had been developed with external sources of expertise and resources. In Biomedical, the team realized it needed quickly to assemble resources to create a professional image for the firm in order to attract customers and more revenue. In 3G Wireless, the credibility of the entrepreneurial team and the potential of the technology were excellent. The entrepreneurial team was able to package and sell itself as a business with all the necessary resources ready to be put in place in order to attract venture capital investment.

Sustainability: Sustainability depended on a USO's social capital for identifying opportunities and accessing resources, as well as integrating them with existing resources to create organisational capabilities that enables the USO to cope with the challenges of growth. There was a need to move from entrepreneurial individuals in the early phases to the development of entrepreneurial teams. In Biomedical, the team struggled to maintain its high rate of growth and become a market leader, whilst continuing to develop and commercialize new innovations. It became more difficult to co-ordinate and control activities as the venture became more successful. In 3G Wireles, although a team was developed, unfortunately they raised too little seed finance to support their growth plans and the venture stagnated in a period when the venture capital market for high-tech investments had gone flat.

From the quantitative survey, it was evident that the areas where universities had greater involvement than the founders of a spin-out were confined to carrying out intellectual property due diligence, serving as a sounding board, developing a

professional support group, obtaining alternative sources of financing and interfacing with financiers. Somewhat surprisingly, universities had less involvement in formulating strategy and monitoring financial performance than the founders. Universities' involvement in the spin-out process was generally confined to the pre-start-up and start-up phases rather than the later stages and had its greatest influence in carrying out intellectual property due diligence at the pre-start up phase. Notably, given the importance of recruiting commercial management and in gaining credibility with trading partners identified from the qualitative interviews, in a substantial proportion of cases, universities were not involved in these activities. Evidence from our interviews suggests that joint ventures with industrial partners may be an effective means by which universities can overcome some of their skills and resources shortcomings that may create difficulties in developing spin-outs to the point where they are ready to receive investment from external financial investors (Wright, Vohora and Lockett, 2004).

3.2. Financial Resources

Of the total 554 spinouts reported to have been created in the five years from 1996 to 2001, 339 (61.2%) were formed using external equity finance. An average of 4.2 spinouts per institution received external equity finance in this period. Experience was highly skewed, with 32 universities (41% of respondents) having no spinouts that were formed using external sources of finance. Almost a quarter of ventures were formed using finance supplied by venture capital firms, the most common source of external finance. This was followed by business angels (17% of spinouts formed in the last five years), other university sources of finance (15%), university challenge funds (12%), and equity joint ventures with industrial partners (6%).

The responses to the attitudinal/perceptions part of the quantitative survey supported these figures (Wright, Vohora and Lockett, 2002). We compared the perceptions of those universities that had created 6 or more spinout companies since 1996 using some form of external equity finance ("Top Performers") with the remaining institutions that had created spinout companies during this period. Initial analysis using Mann-Whitney tests showed that venture capital sources of finance and University Challenge Funds were significantly more important to the top performers. The significantly greater importance of University Challenge Fund finance to Top Performers reflects the fact that they were more likely to have access to this source of finance. Both top performers and non-top performers groups rated business angel finance as an "important" source of finance. Joint-ventures were also rated as "important" by all respondents.

3.3. Mechanisms and Processes to Monitor Spin-outs

We identified that the top-performing institutions, as defined above, operated a number of procedures and policies that were significantly different from the non-top performing institutions, as follows.

Management of Portfolio: A significantly greater proportion of the top-performers said that they managed the portfolio of equity in their spinouts closely. Both top-performers and non-top performers require board membership of the university at the USO, to a similar important degree. A greater proportion of non-top performers compared to top-performers agreed that they allowed spinout management teams a great deal of freedom and only became involved when there was a problem. The lower score for non-top performers is consistent with them having fewer skills and resources to engage in close monitoring. These findings suggest that the top performers on average are approaching the kind of degree of involvement of venture capital firms but that this is not the case for those universities that are less active in creating spinouts.

Reporting: Both top performers and non-top performers had a policy that required each spinout company to provide a set of audited accounts, and this item received the highest score for any item regarding the mechanisms for monitoring investments. While top performers showed a slightly higher agreement that they required spinouts to provide monthly management accounts, this was not significantly greater than for non-top performers. There was little difference between the approaches of both groups to using a stage system for monitoring spinouts at appropriate milestones. These findings suggest that universities in general obtain lower levels and frequencies of information for monitoring purposes than venture capital firms (Mitchell, Reid and Terry, 1995).

Valuation: Generally, least importance was attached to valuation aspects of monitoring. However, the top performers were significantly more likely than the non-top performers to report regularly on the valuation of their institutions' portfolios and to use the British Venture Capital Association (BVCA) guidelines for valuing their investment portfolios. Institutions did not regularly use a Discounted Cash Flow (DCF) or similar valuation approach. These findings are in line with other research regarding the use of such techniques by venture capital firms (Wright and Robbie, 1996).

3.4. Factors Impeding or Promoting Commercialisation Activities

Only one clear factor *promoting* spin-outs was identified: the commitment of the originating academic to commercialising the technology. The other factors presented to respondents acted as either an impediment or had "No Effect". Below, we summarise the main aspects of impediments to spinout company

development based on mean scores and Mann-Whitney tests for differences between top performers and non-top performers as identified above.

Availability of Finance: Lack of seed funding from the university was seen to be the greatest impediment to the creation of spinout companies. A lack of pre-seed funds for conducting market research was significantly more of an impediment for the non-top performers than the top performers. Difficulties in attracting funding from venture capital firms and business angels were rated higher by non-top performers than top performers. The differences between the two groups were, however, not significant in respect of these two source of finance variables.

People: The amount of time university staff have available to help spinout companies was a highly important inhibitor to the creation of spinout companies. For academics to be able to commit themselves to developing a spin-out, they may need space from other activities such as administration and academic research. The demands of the Research Assessment Exercise may pose problems in diverting academics from their research and, indeed, continuing to research may be important in generating follow-on products for the venture. But expecting a potential academic entrepreneur to also be a head of department and/or dean of a faculty, for example, may be counter-productive to the university's aims to generate income from spin-outs. The second most important people issue was related to the clash of commercial and academic cultures as all respondents rated the lack of understanding regarding university, corporate or scientific norms and environments as an impediment. Manifestations of this problem are the need to appreciate the amount of effort required to take an invention from the laboratory to a marketable product, and the need to appreciate the skills needed to make that shift. These problems give rise to the role of surrogate entrepreneurs who have the expertise to develop the spin-out commercially, leaving the academic to continue with their university responsibilities and to become technical director of the spin-out with a role to provide the research skills necessary to adapt the product to perceived market needs.

Infrastructure: The most important infrastructure related impediment was the availability of suitable space on a science park for spinout companies. A lack of suitable space outside the university to accommodate spinouts may impact how quickly these firms are recognised as credible business entities by suppliers, customers and investors.

Incentives and Rewards: The availability of incentives and rewards for university staff to spend time on spinouts was ranked as the fourth most important impediment towards the creation of spinouts. This barrier was significantly more important for non-top performers. Negotiations over the ownership of intellectual property rights impeded the creation of spinouts for both top performers and non-top performers. Closely related to this factor was the impediment of deciding on the distribution of equity in the spinout company. The availability of incentives and rewards to attract commercial management into spinouts was a significantly

greater impediment to the creation of spinouts for non-top performers. Those universities that were more active in spinning out were more willing to provide larger equity stakes. Jealousies in relation to the prospect of some staff earning significant capital gains may lead some universities to be reluctant to provide significant equity stakes, and some universities also want potential academic entrepreneurs to carry heavy administrative and other burdens that distract their attention from focusing on developing the spin-out.

Process Related Impediments: The availability of a clear process for spinning out companies was highly significant in distinguishing between the impediments to spinout development cited by top performing and non-top performing institutions. Top performing institutions found that the procedures, and processes that they had in place promoted their efforts.

4. Typology of Approaches to Spinning-out Companies

At the university and research institute level, different approaches may be adopted to create viable spin-outs (Clarysse, et al., 2004). Adopting a resource-based approach and cross-case analysis involving 56 university case studies in the UK and Continental Europe, Clarysse et al. identify three main approaches: Low selectivity; Supportive and Incubator.

Low selectivity organisations have low selection criteria and are rather passive in their support. They are typically public organisations linked to universities, with small spin-out teams with public sector experience, no technological focus or specialism, offering office space and infrastructure in universities, basing their financial support on public money and fostering an entrepreneurial climate within the university. The University of Twente in the Netherlands is an example of this model. The region surrounding the University of Twente was confronted in the mid 1980s with relatively high levels of unemployment and the university deliberately chose to play a major role in the rejuvenation of the region by engendering an entrepreneurial climate and promoting itself as the "entrepreneurial" university.

The Supportive model also involves a relatively passive approach to identifying potential ventures but growth is an important selection criterion. Support is provided in terms of patent and licence negotiation with industry, specialized incubation space at market prices, helping start-up companies become viable. They are typically private organizations linked with universities (e.g. a university owned company) with a larger multidisciplinary team with commercial experience and links to financial community, focusing on the best performing applied science departments in universities, having public/private financial partners and an important entrepreneurial context. The Leuven R&D case represents an example of this model. The Leuven R&D spin-out service was formally created in the early 1970s, but was only professionalized in the mid-

1990s. The nearby university and the presence of IMEC (see below) had resulted in several high tech spin-outs and had attracted several technology intensive companies in the science park, some of which were highly successful. In order to support spin-outs that were struggling in the early years and to enhance the creation of spin-outs in a more consistent way, the interface service was restructured and further professionalized.

The Incubator model is based on centres of excellence with close links with industry. Opportunity seeking is proactive with selection criteria close to those of venture capital firms. IPR platforms may be acquired at an early stage with significant in-house support being provided at all stages of the spin-out process. Human resources comprise experienced in-house specialists in a relatively narrowly defined area with commercial experience. The technology transfer activity may have its own significant venture capital fund and the funds invested are private sector. Internal research space and infrastructure are offered for free. Scientific Generics, located in the Cambridge (UK) region is an example of this model. Generics was founded in 1986 with four main objectives: top level technology consulting; creating and licensing out IP; investing in the creation of spin-outs; investing in other high tech start-ups. Being located in a known high tech pole, it is able to attract top researchers to its base in Cambridge. The motivation of creating spin-offs is purely a financial one.

Clarysse et al. (2004) also identify two other problematical categories where universities face difficulties in achieving their objectives for spinning-out: the resource deficient and the competence deficient cases. The resource deficient model has similar features at a superficial level to the Supportive model but the human capital involved in the technology transfer officers is largely derived from a public sector context with limited (mainly public) funds being available. Hence, while the model is attempting to be supportive in a commercial manner it does not possess the necessary resources to enable significant wealth creation to be achieved from the spin-outs created, except by accident. The competence deficient model involves cases where universities have committed resources but have not developed sufficient specialist capabilities, especially in terms in human capital skills to develop the spin-outs to meet the institution's objectives.

5. Implications and Effectiveness of Spin-out Processes

The case and quantitative analysis reviewed here suggests a number of areas where the effectiveness of the spin-out process might be enhanced. First, findings indicate that more focus should be applied to how universities can overcome their existing culture, values and incentives that primarily reward academics for their research efforts. Those universities that had attempted to address this issue, had managed to create a more accommodating culture for those academics that were entrepreneurially oriented, resulting in more technologies being commercialised.

Second, evidence shows a clear difference between universities in their ability to commercialise technologies due to the existence and quality of internal capabilities and organizational routines as well as clearly communicated policies and guidelines. This includes resources of expertise and pre-seed finance. It also emerges that to enhance the effectiveness of the process there is a need to address the role of academic entrepreneurs' head of department in the context of universities' overall strategies. Third, the process could be enhanced where UTTOs devoted more attention to identifying how ventures would achieve proof of market and proof of technology and to carrying out effective IP due diligence prior to submitting proposals to external financiers.

Fourth, the process might be enhanced by the provision of greater career support and entrepreneurial training to those academics who wish to participate in the commercialisation of their academic research in order to gain their commitment to the commercialisation process in some form, otherwise the tacit knowledge necessary to make the technology function in the marketplace is likely to be missing. A key role in the provision of training and support for the development may be provided by business schools. Wright et al. (2004) find that much of the involvement of business schools in the development of entrepreneurship for spin-outs relates to courses for Masters and Undergraduate students as well as for academics. There are some specific schemes designed to build capabilities among scientists to effect academic entrepreneurship, such as the Medici scheme where science-based fellows are trained by business school & others to be able to bridge networks between scientists and external commercial networks. In contrast, direct involvement of business school academics on boards of spin-outs is unusual. The role of MBA/MSC students was found to be important in preparing business plans and MBA alumni databases may be a useful source of recruitment of managers for spin-outs.

Wright et al. (2004) identify a number of barriers to the involvement of business school academics in spin-outs. First, the scope of BS academic skills is typically too 'late stage' for spin-outs. Second, there may be a mismatch of language and codes. Third, business schools, spin-outs and TTOs may have different goals and incentives. Fourth, the large corporation based skills of BS academics may mean that they fail to understand entrepreneurs. They suggest there is a need to build university processes & policies that help develop links between the networks of business schools, TTOs and scientists.

6. Conclusions

This paper has reviewed the evidence on USOs, with particular emphasis on the European context. It is evident that this topic is an emerging one. Existing research is limited and there is scope for further research in this area. A first priority is to continue to develop quantitative analysis at the university level in a

multivariate framework that establishes links between the extent of spin-out activity, university characteristics and perceived impediments to the development of spin-outs. Initial evidence by Lockett and Wright (2004) indicates that the number of spin-out companies created is significantly positively associated with total research expenditure, the number of employees engaged in spin-out activities, expenditure on IP protection and the business development capabilities of technology transfer offices. They also find that equity investments in spin-out companies are positively associated with a university's investment in IP protection, the experience of the university and its business development capabilities. These results highlight the importance not just of resources but also the skills of the TTOs in spinning-out companies. Further research is required to examine the nature of the skills of TTOs and how these are being developed over time.

Second, there is a need to develop longitudinal datasets at the university level which will enable the analysis of the development of spin-out activity over time including its extent and nature as well as changes in the factors restricting or facilitating such development.

Third, there is a need for international comparative analysis at the university level with a view to identifying the influence of institutional differences between the efficiency of the spin-out process between countries and to obtain insights that may be useful for development of spin-outs in the different contexts.

Fourth, as spin-out activity is developing across Europe, where there are differences in local contexts, there is a need for further analysis of the impact of internal and external university environments on the development of spin-out activity.

Fifth, there is a need to examine the specificities involved in developing spin-outs in different sectors and disciplines. Research to date has typically suggested that the processes involved and problems encountered are generic. However, there may be important differences, for example, between spin-outs in bio-technology sectors and those involved in computer software. Software firms may be able more easily to use a service business model to test the market whereas biotechnology firms may find this more difficult. Different sectors may require considerably different amounts of external funding for R&D and also have significantly longer lead times to development. There is, therefore, a need to understand the different business models and support processes that may be necessary to achieve success in these areas.

Sixth, at the spin-out firm level, there is a need for quantitative analysis of the development of the spin-out companies themselves, and in particular of the factors determining the performance of these firms.

Finally, at the individual level, there is limited research on the nature of the entrepreneurs involved in spin-outs. Further research might usefully examine the roles played by academic entrepreneurs, surrogate entrepreneurs and TTOs. In particular, there is a need to consider the nature of the entrepreneurial team

formation in spin-outs – e.g. what is the mix of skills? To what extent is there overlap or complementarity in these skills? (Clarysse and Moray, 2004). Importantly, there is growing recognition that entrepreneurial teams may be quite dynamic, with entry and exit occurring over the development cycle of the venture (Ucbasaran, Lockett, Wright and Westhead, 2003). Such changes in the ventures' teams seems to be especially important in the case of USOs, where gaps in the requisite commercial skills would appear to be more likely. Preliminary evidence suggests that some researchers that are actively involved in the first phase of the spin-out process, where the market opportunity is identified, do not show the entrepreneurial commitment to create the spin-out and leave this spin-out process before the formal creation of the spin-out (Vanaelst, et al., 2004). Alternatively, researchers may leave the spin-out during the phase in which the spin-out has to prove its viability since they found it was taking too long. Once the spin-out has survived this phase, the researchers stay and take the spin-out to maturity. While new team members bring in different kinds of experience but in contrast to existing literature reinforce shared cognition.

While this paper has focused on issues in the successful development of spin-outs, a number of issues need to be recognised in respect of the development of policy in this area. As we have noted, spin-out activity is highly skewed, reflecting the skewed nature of university research in the UK. Hence, it is unrealistic to expect all universities to develop spin-outs. Indeed, such signals lead to the creation of many spin-outs with no possibility of creating wealth. We have identified different models for universities to create spin-outs and have shown that the scope for high growth, high financial return spin-outs is likely to be limited to a few specialist research universities. Policies to promote these kinds of spin-outs, therefore, need to be focused on those universities with the appropriate science base. Policy to promote spin-outs may also have other objectives, in which case, as we have shown, other models may be appropriate. Whichever model is chosen, universities need to recognise that ventures such as spin-outs are likely to have high failure rates.

We would also emphasize, however, two further points. First, spin-outs may not be the appropriate mode of development of a new invention in all cases. Licensing agreements may be appropriate in many cases where the invention is likely to be viable as an independent entity. Second, in assessing the contribution of universities to so-called Third Stream activities [the others being research and teaching] there is a need for policy to recognise that some universities, while not having the science base to generate high wealth creating spin-outs, may have other significant contributions to make in the general reach-out area. More fine-grained policy, therefore, may need to be developed that recognises these other dimensions. One approach to addressing this issue is being developed by the Higher Education Funding Council for Wales, which aims to take account of social and cultural contributions as well as broadly defined economic returns, in assessing third stream activities conducted by Welsh universities.

We have provided some indication of the extent of spin-out activity. Obtaining data on the performance of spin-outs is difficult and is an area for further research. An indicator of the relatively low level of returns is provided by the finding in the 2001 survey that only nine universities reported to us that they had realised any money from selling all or part of an equity stake in a spin-out company. A few spin-outs are sold for significant sums but the issues we have identified above suggest that without further enhancement to the technology transfer process, opportunities for significant gains may be being missed. A further returns issue arises concerning the distribution of gains between the academic entrepreneurs and the universities. We have noted above the need for adequate incentives for academics and at the same time universities also need to ensure they are receiving a fair return. As the spin-out process develops, universities need to be more aware of negotiating an appropriate balance of risks and returns between the parties involved.

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