

# Universities and Technology Transfer: A Review of Academic Entrepreneurship Literature



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## ABSTRACT

The commercial exploitation of new knowledge created in universities has become increasingly important to universities and to the governments that fund university research. One of the key avenues through which commercialisation occurs is the spin-off of new venture companies, often headed by faculty or staff of the originating university. It is interesting to note, however, the degree to which universities differ in their spin-off activity across different institutional contexts. The importance of this topic to policy makers is reflected in a rapid increase in the number of journal publications that seek to explain this variation in spin-off activity and that suggest policies that would increase this activity. In this paper, we review the academic entrepreneurship literature to identify the determinants of spin-off activity in universities. We suggest that the literature can be categorised into six separate streams. We then outline the limitations of existing research. We seek to synthesise existing research by presenting a framework that captures the determinants and consequences of spin-off activity.

## INTRODUCTION

The rapid rate of technological change, shorter product lifecycles and more intense global competition has radically transformed the current competitive

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position of many regional economies. With the drive to generate knowledge-based employment opportunities, policy makers are now placing a greater emphasis on the role of universities in the commercialisation of scientific and technological knowledge produced within research laboratories.

This increased emphasis on technology-transfer from universities to industry and the need to develop more "rapid" linkages between science, technology and utilisation (Allen, Tushman and Lee, 1979; Allen, 1995; 1997) led to the emergence of a number of entrepreneurial initiatives within academic institutions.

The term "entrepreneurial university" was coined by Etzkowitz (1998) to describe instances in which universities have proven themselves critical to regional economic development. Although some authors refer to European universities (Chiesa and Piccaluga, 2000; Jones-Evans, 1999), the case of MIT is the reference example (Etzkowitz, 2002; Roberts, 1991). By encouraging faculty members to pursue private ventures outside the research lab, the Bank of Boston (1997) calculated that MIT start-up companies generated \$240 billion worth of sales per year and provided an additional 1.1 million new jobs to the US economy. Another known example cited in the literature relates to the University of Texas at Austin in promoting the emergence of the city of Austin, Texas, as a *technopolis*. UT-Austin contributed to local economic development by launching and running one of the most successful business incubators in the US, the Austin Technology Incubator (Gibson and Smilor, 1991).

Explaining spin-off behaviour and why some universities are better at it has become an important research objective within the domain of entrepreneurship research. Referred to broadly as "academic entrepreneurship", this domain has received increased attention from scholars in recent years.<sup>1</sup> The objective of this article is to review the academic entrepreneurship literature systematically, to synthesise this research and to provide directions for future research. Extant research has sought to identify the determinants and the consequences of university spin-off activity. We argue that the existing literature can be divided into six distinct research streams: 1) studies that focus on the individual and the personality of the individual as the key determinant of whether spin-off activity occurs; 2) organisational configuration studies that seek to explain spin-off activity in terms of the resources of the university; 3) socio-cultural development studies that explain spin-off activity in terms of culture and the rewards within the university; 4) studies that explain spin-offs in terms of external environmental influences; 5) studies that measure the performance of spin-offs; and 6) studies that seek to measure the economic impact of spin-off activity. While these research domains are clearly not orthogonal, we employ them as classifications of convenience to facilitate a discussion on the literature and the development of a conceptual framework that explains the determinants, constituents and consequences of university spin-off activity.

This paper is organised as follows: first, we provide an overview of the evolving role of the university in economic development; secondly, we outline six distinct research streams that we have identified in the "academic entrepre-

neurship" literature; thirdly, we identify the limitations of existing research and we suggest new avenues for future research; finally, building on our review of the literature, we present a theoretical framework of the determinants, constituents and consequences of spin-off activity.

#### THE ROLE OF THE UNIVERSITY IN ECONOMIC DEVELOPMENT

The primary mission of the traditional university is to engage in research and disseminate knowledge across both academic and student communities. The importance of this function of the university is well documented in the literature (Bok, 2003; Geisler, 1993; Newman, 1854). Universities can also play a key role in technology transfer activities by providing Research and Development (R&D) activities, by assisting in patenting innovations and by providing students with the skills that allow them to become highly qualified personnel (Roberts and Malone, 1996; Smilor et al., 1990). According to Segal (1986), universities not only provide a source for technical expertise for faculty members, but their students also acquire a wealth of codified and tacit knowledge through learning and living at the university. Rogers (1986) supports this view and contends that universities influence the innovation process through a number of mechanisms, such as: scientific publications that expand the technological opportunity set of firms; training of engineers and natural scientists; training of PhDs with its essential provision of background knowledge, skills and personal networks; and participation in common informal networks, joint R&D projects, research funding and contract research with an associated sharing of explicit and tacit knowledge. In essence, such universities place a strong emphasis on training, tacit knowledge and indirect benefits rather than codified information (or products) as being the main output of academic research into industry (Bok, 2003; Mansfield and Lee, 1996).

However, recent research suggests that traditional universities could play a greater role in regional and national economic development. A number of factors explain why universities are increasingly important to economic development: the growing role of knowledge in the development of national economies and employment; technical advances in information and communication technologies; and the increasing importance of regional high-technology clusters. These factors are explained in greater detail below.

#### The Contribution of Knowledge to Economic Development

There is a growing recognition among policy makers of the need to place more emphasis on knowledge creation and knowledge exploitation, and specifically on technology-based entrepreneurship, which converts new scientific discoveries into new opportunities (Chiesa and Piccaluga, 2000). Economic development is increasingly linked to a nation's ability to acquire and apply technical and socio-economic knowledge and the process of globalisation is accelerating this trend. A recent World Economic Forum global competitiveness report states that "without technological progress, countries may

achieve a higher standard of living through a higher rate of capital accumulation, but they will not be able to enjoy continuously high economic growth" (2003). As such, comparative advantages come less from abundant natural resources or cheap labour and more from technical innovations and the competitive use of knowledge. Economic growth can be seen as much as a process of knowledge accumulation as of capital accumulation.

Economies looking to meet the aim of developing a comparative advantage based on the enhancement and exploitation of the national knowledge base must look to foster university-based entrepreneurship as a central component of their strategy to develop a knowledge-based society (OECD, 1998). This is particularly so because of the rapid acceleration in the rhythm of creation and dissemination of knowledge, which means that the life span of technologies and products gets progressively shorter and that obsolescence comes more quickly. The ability to develop technologically sophisticated and knowledge-led regions has already provided Greater Boston and Silicon Valley regions with wealth creation and quality of life improvements (Kenney, 2000; Roberts, 1991). As a result, governments increasingly recognise the need to support the process of technological change with the aim of spawning more high-growth, knowledge-intensive companies from university research.<sup>2</sup>

### **The Information and Communications Technologies Revolution**

Advances in information and communication technologies have revolutionised the way people work, the way organisations are structured and the way businesses compete. For example, rapid developments in information and communication technologies have eased the difficulty of communicating and enabled the development of widespread ventures and global supply chains. This has resulted in what is popularly referred to as the knowledge-based, interdependent, global village. Competition is much less likely to be localised and may now come from any corner of the world. To compete in such an environment, economies have to accelerate the generation of new knowledge, which in turn requires a continuous process of learning. Universities have historically been the centre for the accumulation, creation and dissemination of new knowledge and must now use this knowledge to enhance the competitive advantage of their regions.

### **The Role of Regional High-Technology Clusters**

In many national economies, policy makers argue that universities need to place increased emphasis on transferring and commercialising knowledge, as opposed to solely generating and disseminating knowledge within the academic community itself, in order to stimulate regional technological clusters. Universities and high-technology clusters are important to the attraction of inward foreign direct investment because human capital and R&D capability play a key role in determining where high value-added R&D projects from multinational corporations are located (Etzkowitz, 2000). Economies that possess a sophisticated technology infrastructure and that are populated by

start-ups are better positioned to attract knowledge-seeking investment from multinational corporations.

For example, traditional pharmaceutical companies such as Novartis and Wyeth located their R&D facilities around successful universities such as Harvard and MIT and spin-offs such as Alnylam and Genzyme in Cambridge (US) to access critical expertise in biotechnology. The clustering effect resulting from the interchange of knowledge among such corporations and universities resulted in high quality employment and increased wealth for the greater Boston region.

#### THE DETERMINANTS AND CONSEQUENCES OF UNIVERSITY START-UP ACTIVITY

The study of university spin-offs within the "entrepreneurial university" framework came to the fore with Roberts' seminal study on entrepreneurial activity in MIT (1991). Many subsequent studies of spin-off activity have followed Roberts' early work by investigating the factors that stimulate the creation of spin-off companies from universities. Indicative of this research, and of the general prescriptive findings that characterise this literature, is a cross-national study of five highly successful European universities that identified elements common among successful entrepreneurial institutions (Clark, 1998). They include:

1. Strong top-down leadership and policies that support and encourage the process of academic entrepreneurship and which merge entrepreneurial orientation objectives with the traditional academic values of the university;
2. Strong ties between the university and industry in research projects of mutual gain and "robust" structures, policies and procedures to enable such activity (for example, industrial liaison offices and flexible contracting procedures);
3. A diversified funding base such as industry and private benefactors, though much of university funding is still derived from government sources;
4. A strong academic base, what the authors referred to as "a steeple of excellence approach", whereby the universities recruited the top candidates in those fields where it has built its "steeple". Tenure and academic promotions are granted solely on academic achievement and not due to individual entrepreneurial endeavours;
5. An entrepreneurial culture that embraces change and sustains the fundamental values of the institution.

Such findings are underpinned by a body of research that has explored individual determinants of spin-off activity. Our review of the literature suggests six primary research groups or domains. The first four focus on the determinants of spin-off activity within a university context: 1) the attributes and the

personality characteristics of academic entrepreneurs; 2) the resource endowments and capabilities of the university; 3) university structures and policies facilitating commercialisation; 4) environmental factors influencing academic entrepreneurship. The remaining two factors focus on the consequences of spin-off activity; 5) the performance of spin-off businesses; and 6) studies that measure the economic impact of spin-offs on regional economies. We present each of these in more detail below.

For the purposes of this paper, we define university spin-offs as the transfer of a core technology from an academic institution into a new company, where the founding member(s) may include the inventor academic(s) who may or may not be currently affiliated with the academic institution (Nicolaou and Birley, 2003).

### **Individual Attributes as Determinants of Spin-off Activity**

A number of studies highlight the importance of entrepreneurial attributes in shaping the individual's behaviour and whether an academic will establish a spin-off business. Other researchers have stressed the role personality, motivation and disposition play in influencing academic entrepreneurship. Some studies have used psychological models to explain spin-off departure from universities. These studies emphasise the impact of individual abilities and dispositions on the entrepreneurial behaviour of academics. This stream of research shares a common theme: that spin-off behaviour is a reflection of individual actions and therefore is largely due to the personality, ability or willingness of the individual to engage successfully in entrepreneurial behaviour.

Roberts (1991), for example, found that academic entrepreneurs with outgoing, extroverted personalities were more likely to engage in spin-off activity. Furthermore, from a study of almost 130 technical entrepreneurs and almost 300 scientists and engineers, he concluded that personal characteristics such as the need for achievement, the desire for independence and an internal locus of control were common in both groups. Tenure in universities and occupational and research skill levels amongst academics are also found to impact university spin-off behaviour. Audretsch's (2000) analysis of academic entrepreneurs found that university entrepreneurs tended to be older and more scientifically experienced than "typical" high-technology entrepreneurs. Similarly, Zucker et al. (1998), using data on California biotechnology companies, found that scientific "stars" collaborating with firms had substantially higher citation rates than pure academic "stars".

### **Organisational Determinants of University Spin-Off Activity**

Social scientists operating at the organisational level have adopted a different approach to the study of spin-off activity. Organisational theories of university spin-off behaviour are generally concerned with the impact of environmental forces on academic entrepreneurship. But rather than focusing on broad social or economic forces, such researchers have centred their attention on organisational and human resource aspects of the university. Specifically, researchers

have sought to establish links between spin-off activity and the level and nature of research funding; the quality of the researchers, the nature of the research within the university; and the presence of technology incubators and technology transfer offices.

#### *Level and Nature of Research Funding*

Several investigators have focused their attention on the level and nature of funding for R&D activities within the university. For example, Lockett and Wright (2004) find that the number of spin-off companies created from UK universities is positively associated with R&D expenditure; the number of technology transfer staff; expenditure on intellectual property protection; and the business development capabilities of the university. Blumenthal et al. (1996) surveyed 2,052 faculties at 50 universities in the life sciences field and found industry-funded faculty members to be more commercially productive (i.e. patent applications and new products brought to the market) than those who are not industry funded. Similarly, in a cross-sectional study of doctoral granting research universities, Powers and McDougall (2005) found a positive and statistically significant relationship between annual university-wide R&D expenditure and spin-off activity. Furthermore, Wright et al. (2004) found evidence to suggest that involvement of industry functioning as venture capitalists via joint venture spin-offs may facilitate the emergence of university spin-offs because they have the necessary financial resources and commercial expertise to transfer technologies successfully to the marketplace.

#### *The Quality of the Researchers and the Nature of the Research*

A critical human capital resource for the development of cutting-edge technologies is access to persons with expert knowledge and talent (Powers and McDougall, 2005). Zucker et al. (1998) argue that "star" scientists from higher quality academic institutions create spin-off firms to capture the rents generated by their intellectual capital. Such capital is tacit and therefore it is difficult for lower quality institutions to imitate. DiGregorio and Shane (2003) suggest faculty members who develop leading edge innovations may wish to earn economic rents on valuable asymmetric information. They suggest it may be easier for academics from top tier universities to assemble resources to create start-ups for reasons of credibility. DiGregorio and Shane (2003), through regression analysis, provide support for this proposition finding that in 101 US universities from 1994 to 1998, *ceteris paribus*, a one-point increase in graduate school quality ranking as measured in the Gourman Report (Gourman, 1997) led to a 68 per cent increase in the spin-off rate.

The nature of university research and the industries where spin-off companies are more likely to emerge has gained prominence in the literature of late. For example, Shane (2004a) reports that the majority of MIT spin-off companies from 1980 to 1996 operated in the biomedical industry. Similarly, Golub (2003) found that half of all spin-off companies that emerged from Columbia

University operated in the biomedical industry while the remainder operated in the electronics and software fields. Furthermore, Shane (2001) provided a framework of favourable market preconditions for technology transfer to occur successfully. Using data from MIT patents, Shane demonstrated that the tendency for an invention to be exploited through firm creation varies with the attributes of the technology. These attributes include: 1) the age of the technical field; 2) the tendency of the market towards segmentation; 3) the effectiveness of patents; and 4) the importance of complementary assets. These studies suggest that "relevance of research" (Geisler, 1993) with regard to the lifecycle of industries may play a key role in explaining variation in university spin-off activity.

#### *Supports for Spin-Offs: Incubators and Technology Transfer Offices*

In recent years, the question of how universities are supporting the development of spin-offs is attracting increased attention. Tornatzky (1996) identified 50 best-practice incubator programs in the US and highlighted the role technology incubators could play in accelerating technology transfer. According to the author, incubators were involved in activities such as drawing up an R&D plan; obtaining the financial resources needed to carry out the project; team-building and tutoring; professional and administrative consulting, guidance and supervision; raising capital and preparing for marketing; giving secretarial and administrative services, maintenance, procurements, accounting and legal advice; giving professional and business guidance. However, a study of 101 universities by DiGregorio and Shane (2003) did not find any statistically significant results to support the argument that the presence of an incubator affiliated with a university increased spin-off activity.

Some universities operate a Technology Transfer Office as a vehicle to support the creation of spin-off companies (Hague and Oakley, 2000). For example, Oxford University ISIS Innovation is a wholly owned subsidiary of the university and its task is to promote and support the commercialisation of research ideas generated by Oxford academics. ISIS selects projects that it considers it should support and then uses its business network to attract investment into the spin-off business. According to Chugh (2004), the Technology Transfer Office plays a key role with respect to engendering academic entrepreneurship. The Technology Transfer Office achieves this by engineering synergistic networks between academics and venture capitalists, advisors and managers who provide the human and financial resources that are necessary to start a company; and by providing company formation expertise, as many technology transfer personnel have experience in evaluating markets, writing business plans, raising venture capital, assembling venture teams and obtaining space and equipment. Lockett and Wright (2004) and Powers and McDougall (2004) systematically analysed UK and US universities respectively. They found positive and statistically significant results supporting the proposition that the size and experience of a technology transfer office is positively associated with increased spin-off activity.



### **Institutional Determinants of Spin-off Activity**

The central tenet of the third stream of research is that university spin-off activity is a reflection of institutional behaviour. This research suggests that universities that have cultures that support commercialisation activity will have higher levels of commercialisation and higher rates of spin-off activity. In contrast, university environments that do not encourage entrepreneurship will have less spin-off activity.

Roberts (1991) argues that the social norms and expectations of the university are a key determinant of commercialisation activity. He suggests that MIT's tacit approval of entrepreneurs was a key factor in explaining successful academic entrepreneurship at MIT. Golub (2003) supports this perspective and credits the growth in spin-off activity at Columbia University, at least in part, to the knowledge spillovers provided by academic inventors in life sciences who had established companies in the early 1990s. Similarly, Kenney and Goes (2004) argue that Stanford University faculty members were more motivated than their Berkeley counterparts to become entrepreneurs because of the inspiration provided by prior academic entrepreneurs at their university. Shane (2004a) argues that faculty members' decisions to start companies in MIT were socially conditioned. He suggests that efforts by pioneering entrepreneurial faculty members to create start-ups led new academics to believe that firm formation was an acceptable and desirable activity.

By contrast, university environments that do not encourage entrepreneurship have been shown to inhibit spin-off activity. More specifically, an academic's reluctance to engage in spin-off behaviour may be exacerbated by the attitudes and behaviours of superiors such as professors or departmental heads. For example, Louis et al. (1989) found that local group norms were important in predicting active involvement in commercialisation. They argue that this may be due to self-selection, which produces behavioural consensus and behavioural socialisation, where individuals are influenced by the behaviour of their immediate peers.

One reason why a university may not have a supporting culture is the issue of reward systems and the possible conflict between the institutional rewards for research publication and commercial rewards of ownership (Birley, 2003). For example, Thursby and Kemp (2002) found that less than half of faculty inventions with commercial potential are disclosed to the technology transfer office. In some cases this may be because those involved do not realise the commercial potential of their ideas, but often it is due to the unwillingness to delay publication that results from the patent and licensing process. Restrictive leave of absence policies, whereby academics find it difficult to move between academia and the private sector, have been shown to negatively impact spin-off activity. According to Goldfarb and Henrekson (2003) the risk of forming inventor-led ventures is increased when leave of absence policies to start companies are restrictive. Furthermore, DiGregorio and Shane (2003) found evidence that university technology transfer policies that allocate a higher share of inventors' royalties decrease spin-off activity because the opportunity cost in

engaging in firm formation (rather than licensing technology to established firms) is increased. Other cultural factors such as the "publish or perish" drive, the ambiguous relationship of researchers to money and the "disinterested" nature of academic research to industry are also seen as inhibitors to the valorisation process of academic research (Ndonzuau et al., 2002).

Universities that lack a culture supportive of commercialisation activity may take a number of actions. For example, studies in the UK suggest universities that are favourably disposed toward the use of surrogate entrepreneurs are more likely to be effective at university spin-off activity (Franklin et al., 2001). Similarly, Siegel et al. (2004) propose that in order to foster a climate of entrepreneurship within academic institutions, university administrators should focus on five organisational and managerial factors: reward systems for University Industry Technology Transfer (UITT); staffing practices in the technology transfer office; university policies to facilitate university technology transfer; increasing the level of resources devoted to UITT; and working to eliminate cultural and informational barriers that impede the UITT process.

### **External Determinants of Spin-Off Activity**

This stream of research emphasises the impact of broader economic factors on academics within universities. Three factors that it could be argued will impact on spin-off activity are access to venture capital, the legal assignment of inventions (or, more specifically, in the US, the enactment of the Bayh-Dole Act) and the knowledge infrastructure in the region.

Florida and Kenney (1988) highlight the central role of the availability of venture capital in encouraging the formation of high-technology companies. Several studies have provided empirical support for the geographic localisation of venture capital investments. Sorenson and Stuart (2001) found that the probability that a venture capital firm will invest in a start-up decreases with the geographical distance between the headquarters of the venture capital firm and the start-up firm: the rate of investment in companies 10 miles from a venture capitalist's headquarters is double the rate of investment in companies located 100 miles away. However, more recently, DiGregorio and Shane (2003), using a dataset collected from 101 universities between 1993 and 1998, found no evidence that the number of venture capital investments, the amount of venture capital invested, the number of venture capitalists, the amount of their capitalisation or the presence of university venture capital funding are related to the amount of spin-off activity in a locale. In terms of seed capital, Franklin et al. (2001) found that those universities in the UK that generated a large number of spin-offs tended to provide their spin-offs with better access to sources of pre-seed stage capital than universities that did not generate a large number of spin-offs.

According to Shane (2004b) another significant impetus in the generation of university spin-offs in the US was the enactment of the Bayh-Dole Act whereby inventions were assigned to academic institutions rather than individual inventors. According to some European studies, national policies which

allow inventions to be assigned to academic inventors have inhibited spin-off activity. In Sweden, for example (Wallmark, 1997), academic inventors are reluctant to bear the upfront costs and risks associated with patenting technology. Other researchers suggest that national policies of assigning inventions to individuals can lead to an anti-entrepreneurial attitude among faculty and university administrators who do not gain from inventors' entrepreneurial activity (Goldfarb and Henrekson, 2003).

The knowledge infrastructure of a region is also cited as a key factor determining spin-off activity. For example, Saxenian (1994) has shown that spin-off activity is more likely to occur in high-technology clusters because of ease of access to critical expertise, networks and knowledge.

### **The Performance of University Spin-Offs**

A small but growing number of studies deal with the performance of academic spin-offs. In terms of performance, the survival rate of university spin-off companies is extremely high. According to AUTM, of the 3,376 university spin-offs founded between 1980 and 2000, 68 per cent remained operational in 2001. This number is much higher than the average survival rate of new firms in the US. Similar results have been found in other countries. Mustar (1997) found that only 16 per cent of the French spin-offs he studied failed over the six-year period that he tracked them. Dahlstrand (1997) found that only 13 per cent of the spin-offs from Chalmers Institute of Technology in Sweden founded between 1960 and 1993 had failed by 1993. Furthermore, Nerkar and Shane (2003) analysed the entrepreneurial dimension of university technology transfer, based on an empirical analysis of 128 firms that were founded between 1980 and 1996 to commercialise inventions owned by MIT. Their findings suggest that new technology firms are more likely to survive if they exploit radical technologies and if they possess patents with a broad scope. Shane and Stuart (2002) offered empirical evidence of the network-performance relationship, analysing how social capital endowments of the founders affect the likelihood of three critical outcomes of spin-offs: attracting venture capital financing, experiencing initial public offerings (IPOs) and failure. Direct and indirect linkages to investors were found to be important determinants of whether the business received venture funding and in reducing the likelihood of spin-off failure.

Franklin et al. (2001) focus on the academic entrepreneur in the context of the growth and development of the university spin-off company. They suggest that a combination of academic and surrogate entrepreneurs might be the best approach for developing successful technology-based spin-offs. While the academic entrepreneur may bring a strong commitment to the spin-off process, they argue it will ultimately be the surrogate entrepreneur with the business acumen and experience that will drive the company forward. At a university level of analysis, Vohora et al. (2004) identified four stages that spin-offs undergo during their development: the research phase, the opportunity framing phase, the pre-organisation phase and the re-orientation phase. However,

they also identified four critical junctures a spin-off must pass in order to progress to the next phase of development. These include opportunity recognition, entrepreneurial commitment, threshold of credibility and threshold of sustainability.

Doutriaux's (1987) study of the "passive" university found that the university was an impediment to growth as it prevented academics focusing their efforts solely on the commercialisation of their product. From his analyses of 200 companies created by researchers from university environments, Mustar (1997) found that the success of these companies depended upon their ability to establish linkages with a broad range of different actors such as financial institutions, research labs and clients. Furthermore, Daniels and Hofer (1993) found that new ventures in universities are more successful when the entrepreneurs have experience of taking ventures to the marketplace.

### **The Economic Impact of Spin-Offs**

University spin-offs are an important subset of start-up firms because they are an economically powerful group of high-technology companies (Shane and Stuart, 2002). According to the Association of University Technology Managers (AUTM, 2001), spin-offs from American academic institutions between 1980 and 1999 have contributed 280,000 jobs to the US economy and \$33.5 billion in economic value-added activity (Shane, 2004a). University spin-offs are also important economic entities because they create jobs, particularly for a highly educated workforce.

#### **A CRITIQUE OF EXISTING RESEARCH**

University spin-offs have received increased attention from both scholars and policy makers during the last decade. While this research has provided many insights into why some universities have higher levels of spin-off than others, there is still much we do not know about spin-offs. We outline seven limitations to extant research. The first four refer to the attempts to explain the determinants of spin-off activity; the next two refer to the policy context of the research; and the last refers to the research methods employed.

### **Explaining Spin-Off Activity**

1. Many of the studies conducted to-date are based on theories that are actually atheoretical in nature (Nicolaou and Birley, 2003), e.g. the research suggests relationships between events in the form of a model without providing a consistent explanation to account for those relationships. As a consequence, there is a need for more studies to systematically explain from an organisational perspective why some universities are more successful than others at generating technology-based spin-off companies (DiGregorio and Shane, 2003; Vohora et al., 2004).
2. While existing research has sought to map-out the dimensions of the patterning and rates of spin-off departure, it has only recently begun to

explore the complex processes within institutions that give rise to these patterns. Research needs to address the different forms of spin-off companies and the complex causes that lead some, but not all, academics to engage in technology-based spinoff ventures.

3. Past models and research of spin-offs has underestimated the role that the social setting of the institution plays in the spin-off process. This is despite evidence from, for example, Roberts (1991) that demonstrated that differences in spin-off rates can only be understood within the context of the social environment established by other faculty members in the university. Roberts argued that differences in spin-off rates in differing universities were a direct reflection of the degree to which the work peer culture made spin-off activity an important determinant of academic status. As such, differences in academic entrepreneurial intentionality seem to be a function of the ethos and culture which pervades the daily life of university and which informs the actions of academics alike. Therefore, research needs to investigate the behavioural and normative manifestations of academic entrepreneurship.
4. The question of the role of personality is still unresolved. Though it is obvious that individual personality may affect university spin-off rates, researchers have yet to discern anything resembling a "personality of spin-off creation". Although very insightful work has been carried out by Shane and Roberts in an MIT context, constructs of personality have yet to capture in a reliable fashion specific attributes which underlie individual responses to experiences within different institutions of higher education.

### **The Policy Context of Spin-Off Activity Research**

5. Many of the studies conducted to date have not been particularly suited to the needs of institutional officials who seek to enhance spin-off activity on campus (Lockett and Wright, 2004; Shane, 2004a). Some researchers have tended to ignore and sometimes confuse the varying forms which spin-off activity takes in higher education and to downplay the role the institution plays in the start-up activity.
6. There is insufficient research that addresses the (unintended) consequences of engaging in commercialising academic research. For example, authors such as Callon (1994), Nelson (2001) and McMillan et al. (2000) caution policy makers in other countries who wish to emulate the US experience in university technology transfer. They call for more reflection on the potential drawbacks to the US system of innovation regarding the tensions that may arise between departments and colleges within a university that are "successful" and "unsuccessful" at technology transfer. They also highlight a strong concern with the Bayh-Dole Act, suggesting that it may inhibit a long-standing tradition of "open science and training".

### **The Research Methods Used**

7. Much of the technology transfer literature is characterised by cross-sectional studies. Since the process of spin-off creation is longitudinal in

character, more studies need to be longitudinal in structure. From a methodological perspective, to be effective in assessing university spin-off programmes, researchers must employ multiple methods for collecting data. In addition to the need to accurately record, document and explain inter-institutional variations of spin-off rates, research must also capture the complexity and richness of the dynamics of academic entrepreneurship. For that reason, assessment systems in the literature should employ more combined quantitative and qualitative methods to understand the nature of spin-off activity. However designed, survey methods are not able to tap fully the complexity of academics' views and the character of their understanding of the quality of their entrepreneurial experiences. Therefore there is a need for the use of a variety of qualitative methods ranging from focus-group interviews to qualitative interview techniques to explain academics' perceptions of their experiences within their institutional context. Though such methods are typically unable to demonstrate a representative picture of academic entrepreneurial intentionality, they enable research scientists to uncover how academics make sense of their decisions. And they do so in ways not constrained by prior judgements that sometimes frame the questions of survey questionnaires.

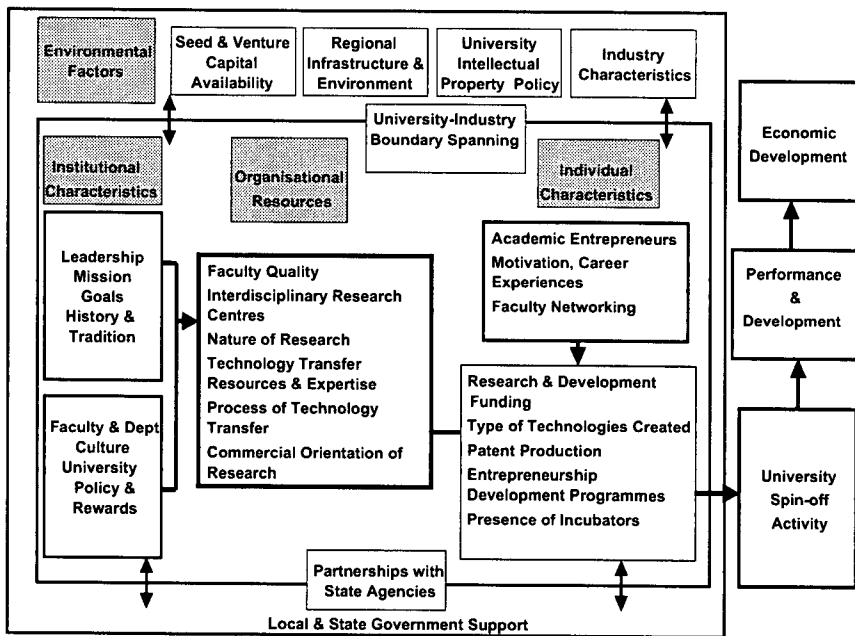
#### DEVELOPING A CONCEPTUAL FRAMEWORK FOR THE STUDY OF UNIVERSITY SPIN-OFFS

We have identified a number of streams of research within the domain of academic entrepreneurship. We have specifically focused on research that has sought to identify the determinants of spin-off activity within universities and the consequences of such activity. We now seek to integrate these perspectives into a university spin-off framework. We believe this framework provides a useful organising scheme for understanding existing literature on academic research and for explaining the determinants and consequences of spin-off activity.

This framework (see Figure 2.1) represents a conceptual integration of elements found in the academic entrepreneurship literature. The framework assumes a social-psychological perspective, in that we suggest that spin-off creation not only varies due to variation in the characteristics of individual academics but also due to variation in environments and university contexts. The framework suggests that four factors influence the rate of spin-off activity:

1. The academic's reasons for engaging in entrepreneurial activity (individual characteristics studies);
2. The attributes of universities such as human capital, commercial resources and institutional activities (organisational-focused studies);
3. The broader social context of the university, including the "barriers" or "deterrents" to spin-offs (institutional and cultural studies);

Figure 2.1: A University Spin-off Framework



4. The external characteristics such as regional infrastructure that impact on spin-off activity (external environment studies).

In addition, we incorporate two further streams of research that deal with the consequences of spin-off activity by suggesting that they can be considered in terms of:

5. The development and performance of spin-offs;
6. The spillover effect of spin-offs on the regional economy.

#### CONCLUSION

In this paper we organise the growing body of theory and research on university entrepreneurship into six different research streams. Specifically, we argue for the existence of an underlying set of individual and contextual factors that need to be recognised by universities implementing technology transfer policies. In addition, the two other primary streams of research identified (i.e. development and performance of spin-offs and the economic impact of spin-off activity) provide a parsimonious description of the outcomes of spin-off activity.

We provide an overview of the limitations of the university spin-off literature. We argue that a theoretical void exists in the research on university entrepreneurship. The literature on this subject is primarily subjective in that most writers develop conceptual models that are not empirically tested. Furthermore, much research in the spin-off literature has focused on a single university or on a very small number of institutions making it hard to draw any generalisations (Nicolaou and Birley, 2003). As a result, the conclusions of much of the current research concerning university spinout performance may not be generalisable to other settings. Therefore, empirical studies that provide a more fine-grained analysis of the nomological influences surrounding academic entrepreneurship are needed. We suggest that researchers need to test models of university spin-off activity. This should allow researchers to assess the relative influence of previously identified variables on spin-off activity.

To conclude, we argue that spin-offs are increasingly important for economic development. Policy makers and universities will increasingly seek to understand how best higher educational institutions can contribute to both their traditional functions and the added function of making the regional or national economy more competitive. In this paper we suggest a conceptual framework that should aid researchers in completing a much-needed assessment of the impact of organisational policies, practices and structures on university entrepreneurship. Specifically our framework should lead to the development of organisational interventions that facilitate technology transfer and spin-off activity. The integrative framework we present suggests that university heads and policy makers can encourage and develop university entrepreneurship by using a comprehensive systems approach for the identification, protection and commercialisation of university intellectual property.

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- 1 For example, Management Science and Research Policy have both devoted special issues to the topic.
  - 2 For example, Frank Ryan, Chief Executive, Enterprise Ireland stated, "In order to advance indigenous Irish industry, it is vitally important that we commercialise the knowledge we have emanating from third level colleges and create in greater numbers, new, ambitious and globally competitive companies", *Irish Independent*, 6 February 2004.

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