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Voodoo Institution or Entrepreneurial University? Spin-off Companies, the Entrepreneurial System and Regional Development in the UK

Richard T. Harrison^a & Claire Leitch^a

^a Queen's University Management School, 25 University Square, Belfast, BT7 1NN, UK E-mail:

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Voodoo Institution or Entrepreneurial University? Spin-off Companies, the Entrepreneurial System and Regional Development in the UK

RICHARD T. HARRISON and CLAIRE LEITCH

Queen's University Management School, 25 University Square, Belfast BT7 1NN, UK. Emails: r.harrison@qub.ac.uk
and c.leitch@qub.ac.uk

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HARRISON R. T. and LEITCH C. Voodoo institution or entrepreneurial university? Spin-off companies, the entrepreneurial system and regional development in the UK, *Regional Studies*. University spin-off companies occupy a prominent position in both government and university policies and aspirations for the commercialization of university research for economic benefit at regional and national levels. However, most university spin-off companies start small and remain small, reflecting founder aspirations, capabilities, and resource endowments. Based on detailed analysis of university spin-offs in Northern Ireland, it is concluded that these companies are technology lifestyle businesses not dynamic high-growth potential start-ups, and it is suggested that the prominence given to spin-offs in the analysis of technology transfer and in discussions of the economic impacts of universities is misplaced.

Technology transfer Spin-off companies Entrepreneurial system Regional development Entrepreneurial university

HARRISON R. T. and LEITCH C. 教义性学院或是企业性大学? 英国的高校附属公司 (Spin-off companies)、企业体系以及区域发展, 区域研究。大学附属企业在政府及学校推进大学研究产业化以在区域和国家层面谋求经济利益的政策考量中占据了主导地位。然而, 大多数高校附属企业的起步规模以及运营规模较小, 反映出创始人的野心、能力以及资源禀赋 (不足)。基于对北爱尔兰大学附属企业的分析, 文章认为, 这些公司都是技术型企业, 并非多样化的高增长潜力型创业体。同时, 文章认为, 在分析技术变迁以及大学对经济的影响力时, 过度强调高校附属型企业的重要性并不妥当。

技术变迁 附属公司 产业体系 区域发展 企业型大学

HARRISON R. T. et LEITCH C. Une institution vaudou ou une université entrepreneuriale? La création d'entreprise, le système entrepreneurial et l'aménagement du territoire au R-U, *Regional Studies*. La création d'entreprise par les universités jouit d'une importance de premier plan pour ce qui est des politiques du gouvernement et des universités, et vu l'aspiration de commercialiser la recherche universitaire pour en tirer un profit économique au niveau régional et à l'échelle nationale. Cependant, la plupart des nouvelles entreprises créées par les universités sont de petite taille et continuent de l'être, ce qui reflète l'aspiration, les capacités et la dotation en capital du créateur. A partir d'une analyse détaillée de la création d'entreprise par les universités situées en Irlande du Nord, on conclut que ces entreprises—là sont des entreprises technologiques par styles de vie et ne sont pas des créations d'entreprise dynamiques à croissance forte. On laisse supposer aussi que l'importance accordée à la création d'entreprise dans l'analyse du transfert technologique et le débat sur l'impact économique des universités s'avère déplacée.

Transfert technologique Création d'entreprise Système entrepreneurial Aménagement du territoire Université entrepreneuriale

HARRISON R. T. und LEITCH C. Voodoo-Institution oder Unternehmertum an Universitäten? Spin-off-Firmen, Unternehmenssysteme und Regionalentwicklung in Großbritannien, *Regional Studies*. Spin-off-Firmen von Universitäten spielen in der Politik von Regierungen und Universitäten sowie bei den Bestrebungen zur Kommerzialisierung der universitären Forschung für einen wirtschaftlichen Nutzen auf regionaler und nationaler Ebene eine wichtige Rolle. Die meisten universitären Spin-off-Firmen sind jedoch zu Beginn und auch später von geringer Größe und reflektieren die Bestrebungen, Fähigkeiten und Ressourcen der Gründer. Anhand einer detaillierten Analyse der Spin-off-Firmen von Universitäten in Nordirland ziehen wir den Schluss, dass es sich bei diesen Firmen weniger um dynamische Start-up-Firmen mit hohem Wachstumspotenzial als vielmehr um technologische Lifestyle-Unternehmen handelt und dass die starke Beachtung, die Spin-off-Firmen bei der Analyse von Technologietransfer und in den Diskussionen über die wirtschaftlichen Auswirkungen von Universitäten finden, fehl am Platze ist.

Technologietransfer Spin-off-Firmen Unternehmenssystem Regionalentwicklung Unternehmertum an Universitäten

HARRISON R. T. y LEITCH C. ¿Institución vudú o universidad empresarial? Empresas *spin-off*, el sistema empresarial y el desarrollo regional en el Reino Unido, *Regional Studies*. Las empresas *spin-off* universitarias ocupan un lugar destacado en las políticas gubernamentales y universitarias así como las aspiraciones para la comercialización de la investigación universitaria para el beneficio económico a nivel regional y nacional. Sin embargo, la mayoría de empresas *spin-off* universitarias comienzan como empresas pequeñas y siguen siendo pequeñas, lo que refleja las aspiraciones y capacidades de los fundadores y las dotaciones de recursos. Basándonos en un análisis detallado de las empresas *spin-off* universitarias en Irlanda del Norte, concluimos que estas sociedades no son empresas emergentes dinámicas con un alto potencial de crecimiento sino empresas de estilo de vida tecnológico, y sugerimos que la importancia que se otorga a las empresas *spin-off* en los análisis de transferencia tecnológica y en las charlas sobre las repercusiones económicas de las universidades queda fuera de lugar.

Transferencia tecnológica Empresas spin-off Sistema empresarial Desarrollo regional Universidad empresarial

JEL classification: R11

INTRODUCTION

[there are] growing doubts surrounding university spin-outs, the 1,000 or so new businesses set up to commercialize university research. ... [There are] no figures ... to prove that costs – including public investment – were less than the sales of products, intellectual property or spin-out equity. The businesses could as easily have been destroying value as creating it. [There is a] need for better measurement of the returns produced by university spin-outs. Without this, it is impossible to see whether they are creating value – leaving the debate on whether spin-outs beat collaboration or licensing to fall back on the voodoo of anecdotal evidence.

(GUTHRIE, 2004, p. 13)

A central theme in economic, industrial, and technology policy discussions in recent years has been the link between wealth creation and competitiveness in a knowledge-driven global economy and the exploitation of scientific and technological developments in universities (EUROPEAN COMMISSION, 2002; ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD), 2002; DEPARTMENT OF TRADE AND INDUSTRY (DTI), 2002; LAMBERT, 2003; H. M. TREASURY *et al.*, 2004). Indeed, governments at national and international levels increasingly consider the higher education sector as having a significant role to play in economic development (LAWTON-SMITH, 2007; RUTTEN *et al.*, 2003; WINK, 2004; SHANE, 2004a). While the key modes of commercialization include patenting, licensing, and research collaboration, it is the formation of spin-off companies to commercialize university research and intellectual property (IP) which has been identified as the archetypical manifestation of commercialization in the entrepreneurial university, and is attracting increased attention (LOCKETT *et al.*, 2005; BANK OF ENGLAND, 2001; QUARNBY, 2002; BEKKERS *et al.*, 2006; COLYVAS *et al.*, 2002; DI GREGORIO and SHANE, 2003), not least in the context of the potential contribution to regional economic development (LEITCH and HARRISON, 2005). However, there are growing concerns that the focus of universities and of policy-makers has been on the number, rather than on the quality and commercial viability, of these

start-up ventures (LAMBERT, 2003), with correspondingly less attention given to their wider and longer-term impact (BOZEMAN, 2000).

This is part of a wider problem of a ‘cargo cult’ mentality in contemporary UK innovation policy (HUGHES, 2007), which mimics the behavioural characteristics of the American system, including the role of spin-off companies in innovation, productivity enhancement, and economic development. However, spin-offs account for a tiny proportion of all United States start-ups (462 university IP-based start-ups as against around 500 000 start-ups in the United States in 2004), although spin-offs appear more durable than other high-technology start-ups (SHANE, 2004a) the returns to start-ups are very highly skewed (MOWERY *et al.*, 2001; TARGETING INNOVATION, 2008), and the costs of running the technology transfer function virtually outweigh the returns to the university (HUGHES, 2007). This suggests that universities, and the regional and national governments that provide support for commercialization activities, spend more in nurturing these spin-offs than the benefits they generate.

This paper is structured as follows. First, it reviews the concept of the entrepreneurial system, as the:

complexity and diversity of actors, roles, and environmental factors that interact to determine the entrepreneurial performance of a region or locality

(SPILLING, 1996, p. 91)

and identifies the role of the university, and of the spin-off company formation process in particular, within this. Second, it considers the recent trends in spin-off activity within the UK, and concludes that university spin-offs, with a few notable exceptions, do not represent a major source of entrepreneurial dynamism in a regional economy, and do not therefore operate as a central element in an entrepreneurial system. Third, it reviews the dynamics of spin-off development in the context of the entrepreneurial system in Northern Ireland drawing on case study data from fifteen spin-offs established over the past twenty years. Finally, it identifies the implications of this phenomenon of technology lifestyle businesses for universities, technology

entrepreneurs, and policy-makers with an interest in regional and national economic development.

Based on this discussion it is argued that the belief in the efficacy of spin-off company formation as one mode of technology transfer (ROTHAERMEL *et al.*, 2007) is fundamentally misplaced. In this area, the rhetoric of aspiration appears to have overtaken the reality of achievement. The economic impact of university spin-off activity outside the unique environment of technology intensive core regions is likely to be very much less than advocates believe. As such, belief in the efficacy of the university spin-off is based less on substantive rationality than on voodoo, the 'melange of superstitious beliefs used for deceptive purposes' (BARTKOWSKI, 1998, p. 559). As BARTKOWSKI (1998) critically points out, this use of the term 'voodoo' is pejorative, implying a religion that is impotent, innocuous, and ineffectual. Usage of the term in the present context recognizes this, and follows MCCLOSKEY (1991), who draws the more general analogy with the rhetoric of magic as that which 'leaps outside our "production possibilities." The "fiat" in a spell is the desire to get outside what is ordinarily possible' (p. 288). As such, the deception referred to in Bartkowski's critique is a form of self-deception about the efficacy (or otherwise) in practice of what is desired in principle.

THE ENTREPRENEURIAL SYSTEM

Defining the entrepreneurial system

Based on the argument that economic development is a result of the localized operation of complex entrepreneurial processes, SPILLING (1996) has developed the concept of the entrepreneurial system to represent the diverse set of actors and institutions that influence the evolution of the economy (Table 1). Fundamental to this is the recognition that new venture creation is a function of interdependencies within the system (VAN DE VEN, 1993; NECK *et al.*, 2004). Equally, an entrepreneurial system perspective also recognizes the importance that individual components of the system may have in

the overall economic development of an economy (SPILLING, 1996; PREVEZER, 2001; MALECKI, 1997). This framework has been applied to the holistic examination of the development of regional technology clusters (NECK *et al.*, 2004) and, through the adoption of a population ecology perspective (ALDRICH, 1999; HANNAN *et al.*, 1992), in the examination of sectoral and place-based entrepreneurial ecosystems (ZACHARAKIS *et al.*, 2003; COHEN, 2005; MATTHEWS, 1997).

Central to the entrepreneurial system framework is the entrepreneurial event (SHAPERO and SOKOL, 1982) through which individual actions and the new venture creation process can be analysed (Fig. 1). While Shapero and Sokol's model, as with other representations of the entrepreneurial event (FELDMAN, 2005), can be criticized for being static rather than dynamic, these events are the outcome of entrepreneurial processes that:

take place within the framework of existing economic and socio-cultural structures. The entrepreneurial activity is based on knowledge, competence, and role models embedded in these structures.

(SPILLING, 1996, p. 92)

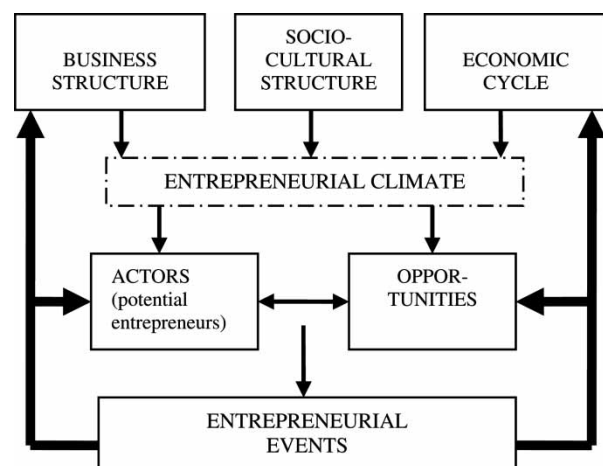


Fig. 1. Model for the interaction between environmental factors and entrepreneurial events

Source: Based on SPILLING (1996), p. 93

Table 1. Entrepreneurial ecosystem components applied to sustainable entrepreneurial ecosystems

System component	Definition applicability to traditional systems
Informal network	An entrepreneur's friends, family, colleagues, and informal relations with similar companies (NECK <i>et al.</i> , 2004; BIRLEY, 1985)
Formal network	A diverse group of actors in an economic community including research universities, government, professional support services, talent and large organizations (NECK <i>et al.</i> , 2004; BIRLEY, 1985)
Research university	Primary and applied research which may be commercialized, and educator of the potential workforce (skills development) (BRUNO and TYEBJEE, 1982; NECK <i>et al.</i> , 2004)
Government	Policy initiatives applied at local, regional, and national levels can foster or hinder the functioning of an entrepreneurial system, for example, tax incentives, subsidies and grants (SIEGEL <i>et al.</i> , 2003)
Professional, support	This includes financial and legal support, management and service consultants and other firms in the supply chain (NECK <i>et al.</i> , 2004)
Capital services	Access to start-up capital including formal and informal sources (PREVEZER, 2001; NECK <i>et al.</i> , 2004)
Talent pool	Access to a large number of qualified employees (NECK <i>et al.</i> , 2004)

Sources: Adapted from NECK *et al.* (2004) and COHEN (2005).

In the short run entrepreneurial events are the outcome of the interaction between actors (potential entrepreneurs) and opportunities (FIET, 2002; SHANE, 2000b). These in turn are the manifestation of the entrepreneurial climate in the region, which is itself influenced by the region's business structure, economic cycle position, and socio-cultural structure. As both the entrepreneurial systems literature and other analyses of spatially differentiated regional economic development indicate, not all regional economies will have entrepreneurial systems that function at the same level (LUNDVALL, 1992; LUNDVALL *et al.*, 2002; NELSON, 1993; COOKE and MORGAN, 1998; KEEBLE and WILKINSON, 2000; MALMBERG and MASKELL, 2002; MARTIN and SUNLEY, 2003; LAWTON-SMITH, 2007).

In the UK, for example, there is a long tradition of research on the dynamics of the regional entrepreneurial system, or ecosystem, including acknowledgement of the role of science parks and spin-off companies. This research, for the most part, has focused on analysis of the Cambridge and Oxfordshire regions (SEQAL QUINCE & PARTNERS, 1985; MASSEY *et al.*, 1992; LAWTON-SMITH, 2007; LAWTON-SMITH and WATERS, 2005; GLASSON *et al.*, 2006; COOK *et al.*, 2008; LESTER, 2008) as the broad equivalents of Massachusetts Institute of Technology (MIT) and Stanford (California) in the United States (ETZKOWITZ, 2002, 2003; DEGROOF and ROBERTS, 2004; KENNY and GOE, 2004). While it can be argued that in the longer run the unfolding portfolio of entrepreneurial events will itself shape the evolution of the actor/opportunity nexus and the determinants of the entrepreneurial climate itself, this will not necessarily play out in the same way in different places with resource, sectoral, and institutional endowments.¹ If:

an emphasis upon the commercialization of science through university based spinouts and licensing routes in high-technology producing sectors

(HUGHES, 2007, p. 1)

is one of the key ritual structures in UK cargo cult innovation policy, then it is important to assume neither that the United States model will transfer unequivocally to the UK (or indeed, to other national contexts; LINDHOLM DAHLSTRAND, 2008; MCNAUGHTON, 2008; LAWTON-SMITH, 2003; GARNSEY, 2006), nor that practice and experience in one region will transfer to another. Specifically, recent research in the UK has argued that, firstly, it is unrealistic to expect the same pattern, process, and impact of spin-off company development in less successful regions as in technological core regions; and secondly, that the economic impact of spin-offs in such regions is enhanced when they are embedded in a strong local entrepreneurial ecosystem, or knowledge pool (LEITCH and HARRISON, 2005; BENNEWORTH and CHARLES, 2005; BENNEWORTH, 2001; BENNEWORTH and HOSPERS, 2007).

Universities in the entrepreneurial system

As SPILLING (1996) argues (see also NECK *et al.*, 2004; and COHEN, 2005):

at the regional level it is not the individual entrepreneurial actions per se that are of interest. It is the multitude of these actions and their contribution to the dynamism, performance, and long-term transformation of regional economies that are of interest – that is, it is about the entrepreneurial capacity of a region.

(p. 92)

A key element in this is the presence of university and research institutions as enhancers of the region's human capital stock and as the source of knowledge capital which can stimulate entrepreneurial development through licensing, consulting, education and training, research joint ventures and spin-off company development (BAHRAMI and EVANS, 1995; ZACHARAKIS *et al.*, 2003; SHANE, 2004c; SIEGEL *et al.*, 2007). This view of the role of the university reflects a fundamental shift in how it is understood as a social institution: from a perspective on the university as an institution of education and research (GRAHAM, 2002, 2005) there has been a progressive shift to the re-imagining of the university as a consumerist 'knowledge factory' (ARONOWITZ, 2000; HOLBROOK and HULBERT, 2002), collaborating ever more closely with business and industry, funded increasingly from industry and corporate contracts, and developing a wide range of client-specific degree and training programmes.² As a result, expectations (by university administrators and policy-makers alike) for commercialization have risen, the commercialization agenda has provided a new justification for public investment in the higher education sector, and the outcomes of commercialization have assumed the status of a 'silver bullet' for regional economic development. Accordingly, universities are 'important engines of technological development and growth' and can potentially act as 'catalysts for the enhancement of employment opportunities [either directly or indirectly] for local industry', most particularly in the high-technology and knowledge-based sectors (KLOFSTEN and JONES-EVANS, 2000, pp. 299–300).

This view is reflected in increased attention to the whole area of business–university interaction (ROTHAERMEL *et al.*, 2007; POYAGO-THEOTOKY *et al.*, 2002; LAMBERT, 2003). A number of approaches to conceptualizing these interactions have been developed. There is a distinction in this between those studies that emphasize a broad perspective on the development of a third mission for higher education institutions (CLARK, 1998, 2004; WALSHOK, 1995; VORLEY and NELLES, 2008) and a more narrow interpretation of entrepreneurship and technology transfer (JONGBLOED *et al.*, 2008). Among the latter are the triple helix model and its extension to a quadruple helix model (ETZKOWITZ, 1998; ETZKOWITZ and LEYDESDORFF, 1997; LEYDESDORFF and ETZKOWITZ,

1996, 1998; SCHINN, 2002; BRIOSCHI and CASSIA, 2006; REICHERT, 2006) and the idea of the entrepreneurial university (ETZKOWITZ, 2004; FLORIDA, 1999; BRANSCOMB *et al.*, 1999). Among the former is the debate over the emergence of a Mode 2 perspective on knowledge creation which is problem oriented and user driven (GIBBONS *et al.*, 1994; NOVOTNY *et al.*, 2001).

The policy emphasis on university spin-offs arises specifically from the entrepreneurship/technology transfer perspective. The commercialization of scientific and technological knowledge produced in publicly funded research institutions, including universities and research centres, is considered by policy-makers as the raw material by which to develop and sustain economic growth (BEKKERS *et al.*, 2006; WRIGHT *et al.*, 2007). This has been particularly the case in the United States where:

efforts to promote research cooperation and interaction between industry and university have been one of the most stable and widely supported elements of the US science and technology (S&T) policy over the past three decades.

(BREHENS and GRAY, 2001, p. 179)

This policy has been based on the premise that research universities command enormous scientific and technological resources that have not been fully exploited in the search for gaining industrial competitiveness (BOZEMAN, 2000). Thus, while universities have long been regarded as sources of knowledge and research, what marks current activity as significant is that the relationship of universities to industry has become increasingly more strategic, formalized, and commercialized (BRANSCOMB *et al.*, 1999; WINK, 2004; SLAUGHTER and LESLIE, 1997; SLAUGHTER and RHOADES, 2004; KIRP, 2003; MASKELL and ROBINSON, 2002).

Furthermore, in the late twentieth century universities appear to be arriving at a common entrepreneurial format (ETZKOWITZ, 1998; ETZKOWITZ *et al.*, 2000), and universities are undergoing a 'second revolution', involving the incorporation of economic and social development as part of their core mission (BOK, 2003; MASKELL and ROBINSON, 2002). According to Etzkowitz, the emergence of the entrepreneurial university is a fairly universal phenomenon reflected in a new type of institution integrating economic development as an academic function alongside teaching and research, with significant implications for national and regional economic development (ETZKOWITZ, 2004; ETZKOWITZ and KLOFSTEN, 2005). However, while a link between university expansion and economic growth has long been established, for the most part this has been premised on the development of human capital not the exploitation of research. What has changed is that there has been a progressive shift in the perceived role of the university from a conservator of knowledge to an originator and exploiter of

knowledge for local economic development (SMILOR *et al.*, 2007; GOLDSTEIN and RENAULT, 2006; GOLOB, 2006). Perhaps the clearest expression of this comes from KERR's (2001) definition of the role of the research university (see also CLARK, 2006):

the basic reality, for the university, is the wide spread recognition that new knowledge is the most important factor in economic and social growth. We are just now perceiving that the university's invisible product, knowledge, may be the most powerful single element in our culture, affecting the rise and fall of professions and even of social classes, or regions and even nations

(p. 30)

Fundamentally, the exploitation of university research is premised on the development of much greater interaction and collaboration between universities and the commercial sector. In the policy domain this collaboration is desirable, even necessary, but not yet on a scale required to meet economic goals:

although there is much good collaborative work underway already, there is more to be done. Universities will have to get better at identifying their areas of competitive strength in research. Government will have to do more to support business–university collaboration. Business will have to learn how to exploit the innovative ideas that are being developed in the university sector.

(LAMBERT, 2003, p. 2)

However, these arguments remain based on advocacy rather than evidence and analysis. According to some critics, the entrepreneurial university is a failed idea (ARMBRUSTER, 2008), one of the shibboleths of contemporary American-style university technology transfer policy (VASS, 2008) in that it raises unreasonable expectations, as expected returns fail to materialize and ultimately compromises, or threatens to compromise, the creation of the science itself (SNOWDON, 2003). For TUUNAINEN (2005), the 'entrepreneurial university' construct pays insufficient attention to 'the problems and contradictions universities encounter as they cater for the new economic functions' (p. 174). Extending this, VESTERGAARD (2007) argues specifically that efforts to commercialize university research are more often than not impeded by role conflicts and tensions between researchers and university management. In terms of economic development, BOZEMAN (2000), among others, has argued that what he has referred to as the 'cooperative technology policy paradigm', which sees technology transfer as a key mechanism for impacting markets, industry competitiveness, and economic development, has only a modest potential for creating new jobs or businesses.

However, in the absence of detailed empirical research (except that on specific elements of the entrepreneurial university; SHANE, 2004a; SLAUGHTER and LESLIE, 1997) it is difficult to identify the extent to which the concept of the entrepreneurial university is more rhetoric than substance. Indeed, what LESTER

(2005) describes as the 'standard model' of universities, innovation, and economic development assumes impacts from commercialization activities on the institutions themselves and on their host economies which are not reflected in observable reality. This disjunction between what is believed to happen and what actually happens is likely to be even more pronounced as the United States model of spin-offs and IP is emulated in Europe (GARNSEY, 2006). Accordingly, the increased inclination of universities and politicians to act on the basis of belief rather than evidence suggests the status of university commercialization as a voodoo that, in the words of an eighteenth-century commentator, 'deprives its adherents of their senses' (cited in BARTKOWSKI, 1998, p. 599).

Although the role of the university in a functioning entrepreneurial system has been articulated in a number of regional contexts (notably in the case of Austin, Texas; SMILOR *et al.*, 1989, 1990; SMILOR and FEESER, 1991), there have been relatively few attempts to examine this within an entrepreneurial system framework. This is an important issue as different single elements of an entrepreneurial system may have a major influence on the overall development of a region. These elements may be a mega-event (SPILLING, 1996), venture capital provision (FLORIDA and KENNEY, 1988), or the new venture creation process (NECK *et al.*, 2004). In the context of the process dynamics of an entrepreneurial system (Fig. 1) the contemporary university is seen not just as part of the institutional infrastructure of the region but as a direct source of both entrepreneurial opportunities (arising from the research it undertakes) and entrepreneurial actors (the academic or surrogate entrepreneurs who can be the locus of entrepreneurial enactment).

Universities, spin-offs and the entrepreneurial system

As universities increasingly seek to contribute to their region's economic development, the university spin-off company formation process has become a primary focus of attention (MIAN, 1997). This is because spin-offs tend to locate near their parent organization (in this case the university) and thus their economic benefits in terms of job creation and taxable wealth tend to accrue locally. This is in contrast to technology transfer from a university to a large corporation, where benefits are more likely to be transferred out of the immediate region because of a lack of absorptive capacity in the regional economic infrastructure (STEFFENSEN *et al.*, 2000; DOWNES and EADIE, 1998). As well as being viewed by some commentators as an efficient means by which to transfer technology from universities to industry, the creation and growth of spin-off companies can also provide employment for a university's graduates and in some cases can also contribute to university revenue (BIRLEY, 2002; STEFFENSEN *et al.*, 2000; LEITCH and HARRISON,

2005; DOUTRIAUX, 1987). This is particularly the case in the UK where increasingly, in response to reductions in central government support, there has been a shift from a grant to an exchange economy in higher education (ETZKOWITZ *et al.*, 2000). Attention has thus been focused on commercialization activities, including the development of spin-off companies, as a means of generating alternative sources of income (JONES-EVANS, 1998).

Realizing the potential of a university's intellectual assets, therefore, has been driven largely by immediate financial pressures and the need to generate income in the short-term. Attention, thus, has focused on activities such as contract research and licensing and not on spin-off companies (DOWNES and EADIE, 1998), as the spin-off route requires more effort over a longer-term and for more uncertain returns. In other words, if a university prioritizes its revenue stream from licensing, this tends to produce lower financial returns than taking equity in start-ups (MARKHAM *et al.*, 2005).

Recent UK data, for example, suggest that income from the sale of shares in spin-offs accounts for less than one-third of all income from the exploitation of protected IP (HIGHER EDUCATION FUNDING COUNCIL (HEFCE), 2007). Relative to other revenue streams arising from business and community interaction this is trivial (Fig. 2); across all regions IP income in general and revenues from the sale of shares in spin-offs in particular are insignificant relative to other sources of income, including contract research, consultancy, and courses for business and the community (continuing professional development and continuing education). Nationally, the sale of shares in spin-offs accounts for less than 1% of total revenues, and revenues from IP other than spin-off realizations is under 2% of income nationally: in both absolute and relative terms this is not a major contribution to the financial position of the university sector (Table 2).

Regionally, there are considerable variations in the relative importance of IP and university spin-off revenues: only in the North West, South East, South West, and London regions is income from spin-off realizations above average; only in the West Midlands, Scotland, and South East is IP income above average. At a regional level (and, hence, at an institutional level as each higher education institute (HEI) will determine its own IP exploitation strategy), and with the exception of the South East, there may be a trade-off choice being made between seeking revenues from the protection and licensing or sale of IP and the creation of spin-off companies that will in due course realize a capital gain through the sale of shares. Scotland, among other regions, provides a very clear illustration of this, with a strong relative performance in IP income generation and a low performance in revenue from university spin-off sales. With the exception of the North West, higher than average university spin-off sales are confined to the economic core regions,

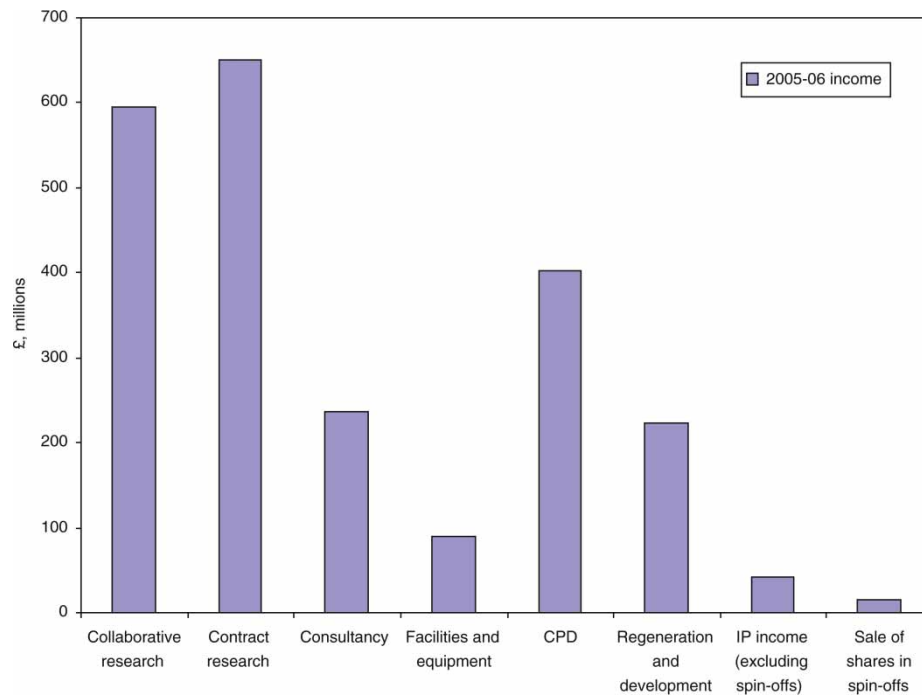


Fig. 2. Income from business and community interaction, 2005–2006
Source: HIGHER EDUCATION FUNDING COUNCIL (HEFCE) (2007)

suggesting not just a regional variation in institutional policies and practices but also of access to capital markets and the advisors (venture capital investors, corporate finance advisors, and stockbrokers/nominated advisors) that support the process of listing a company on public stock markets. This is consistent with the argument that a heavily spatially centralized financial system, like that in the UK, militates against the ready access to capital by new and small firms in peripheral regions (KLAGGE and MARTIN, 2005).

For this reason, the argument for the wholesale adoption of this strategy by HEIs does not appear to be compelling (GUTHRIE, 2004). Indeed, generating an income stream for the university from spin-off activity is not always of prime consideration for university management. For instance, HAGUE and OAKLEY (2000, p. 14) discovered during their survey of a sample of eighteen UK universities that 'the raising of revenue was not and could not be the sole, or even the most important, reason for the activity'. Instead, reasons advanced to explain involvement in spin-off company formation, and also licensing technology, included retaining close links with business, an opportunity to 'market test' ideas when appropriate, and having access to the best and most current equipment. In addition, for the more research-intensive universities in the UK, engaging in this activity is viewed as a means of attracting and retaining the best staff as well as supporting the university's core research mission (HAGUE and OAKLEY, 2000). In this regard, there is a growing recognition that the overall significance of the now widely accepted technology transfer model

is based on the atypical experience in technology hotspots, such as Silicon Valley and the Route 128 area (NICOLAOU and BIRLEY, 2003). This experience has often been exaggerated. New business formation around university science and technology represents no more than 2–3% of all US new business starts; even the most prolific patenting universities in the United States file fewer than 10% of the number of patents filed by the most active corporations; and universities derive only about 4% of their total research and development income from licensing (LESTER, 2005).

RECENT TRENDS IN SPIN-OFF COMPANY FORMATION IN THE UK

Based on data drawn from the annual higher education–business and community interaction (HE-BCI) survey (HEFCE, 2003, 2004, 2005, 2007), it is possible to develop a picture of spin-off company formation in the UK.³ Although the level of formal spin-off company formation (with or without HEI ownership) has declined from a peak in 2000–2001, there has been an increase in the number of companies that are still active three years or more after start-up (Table 3). In 2005–2006 there were 746 surviving university spin-offs, the vast majority of which had some HEI ownership, and over 1100 active spin-off firms in total. These active firms employed over 16 000 people with annual turnover in excess of £500 million.⁴ At one level these figures are impressive. However, more

Table 2. Regional analysis of income (£, millions) from business and community interaction, 2002–2006

	North East	North West	Yorkshire and the Humber	East Midlands	West Midlands	East of England	London	South East	South West	Scotland	Wales	Northern Ireland	UK total
Collaborative research	183.8	277.8	111.4	170.3	81	218.5	244.1	268.2	54.5	270.3	205.7	60.7	2145.5
Contract research	88.6	114.4	230	88.9	194.7	159.3	570.1	256.7	117.1	184.8	92.4	31.1	2127.6
Consultancy contracts	63.8	61.1	38.2	28.6	58.6	48.8	168.3	126.7	81.8	81.7	70.4	6.3	644.8
Facilities and equipment-related services	3.4	25.7	26.3	26.8	20	4.4	41.2	70.5	11.2	67.2	14	1.4	311.7
Courses (CPD/CE) for business and the community	37.5	110.7	68	69.5	85	135.3	288.7	176.7	49.9	106.4	65.3	7.2	1205.9
Regeneration and development	87.9	155.4	43	41	98.6	44.9	46.1	25.9	39.5	78	82.9	30.9	612
IP income (excluding spin-offs)	1.3	2.8	3.4	5.3	24.4	10.6	22.2	21.8	2.2	34.1	6.5	0.8	134.8
Sale of shares in spin-offs	0.15	15.1	1.0	0.67	0	0.59	13.6	15	6.4	1.4	1.35	0.45	55.4
Regional total	466.45	763	521.3	431.07	562.3	622.39	1394.3	961.5	362.6	823.9	538.55	138.85	7237.7
IP income (excluding spin-offs) as a percentage of the regional total	0.28	0.37	0.65	1.23	4.34	1.70	1.59	2.27	0.61	4.14	1.21	0.58	1.86
Sale of shares in spin-offs as a per- centage of the regional total	0.03	1.98	0.19	0.16	0.0	0.10	0.98	1.56	1.77	0.17	0.25	0.32	0.77

Note: IP, intellectual property.

Sources: HIGHER EDUCATION FUNDING COUNCIL (HEFCE) (2003), p. 34, (2004), p. 30, (2005), p. 22, and (2007), p. 28.

Table 3. Spin-offs and new commercial companies from UK higher education institutes (HEI)

		Spin-offs with some HEI ownership ^a	Formal spin-offs, not HEI owned ^b	Staff start-ups ^c	Graduate start-ups ^d
Number established	2005–2006	155	32	58	1172
	2004–2005	123	25	56	974
	2003–2004	133	34	50	512
	2002–2003	177	20	74	489
	2001–2002	199	14	35	337
	2000–2001	220	28	60	238
	1999–2000	187	16	48	179
Number still active that have survived for more than three years	2005–2006	669	77	112	867
	2004–2005	592	69	92	635
	2003–2004	562	126	136	206
	2002–2003	506	60	122	23
	2001–2002	434	57	152	278
	2000–2001	425	57	166	140
	1999–2000	303	55	n.a.	n.a.
Number of active firms (total) ^e	2005–2006	1020	125	252	2811
	2004–2005	937	104	212	2058
	2003–2004	920	154	206	905
	2002–2003	849	96	134	732
Estimated employment of all active firms (FTE)	2005–2006	8650	7575	549	5477
	2004–2005	8539	7443	503	4438
	2003–2004	7546	7716	886	1999
	2002–2003	6150	6635	1988	1607
	2001–2002	6168	5997	1479	2263
	2000–2001	4979	5731	356	531
	1999–2000	3996	1805	n.a.	n.a.
Estimated turnover of active firms (£, thousands)	2005–2006	427985	100657	26910	84808
	2004–2005	421645	93078	20088	111861
	2003–2004	308819	139427	51466	128567
	2002–2003	242089	116286	40262	105643
	2001–2002	242801	469636	27871	66890
	2000–2001	181851	30586	26240	53600
	1999–2000	98066	35800	n.a.	n.a.
Average employment per active firm	2005–2006	8.5	60.6	2.2	1.9
	2004–2005	9.1	71.6	2.4	2.2
	2003–2004	8.2	50.1	4.3	2.2
	2002–2003	7.2	69.1	14.8	2.2
Average estimated turnover per active firm (£, thousands)	2005–2006	419.6	805.3	106.8	30.2
	2004–2005	450.0	895.0	94.8	54.4
	2003–2004	335.7	905.4	249.8	142.1
	2002–2003	285.1	1211.3	300.5	144.3

Notes: ^aSpin-off companies established using HEI intellectual property and in which there is some element of HEI ownership.

^bSpin-off companies to which the HEI has assigned or licensed intellectual property (IP) but in which it has no equity.

^cStart-up companies involving current or former HEI staff as founders where the HEI has neither ownership nor an IP agreement and where the HEI staff must be connected to the HEI immediately prior to the establishment of the company.

^dGraduate start-up companies that have originated through the direct involvement of the HEI or through a dedicated graduate start-up programme.

^eData not reported for previous years.

n.a., Not available.

Sources: HIGHER EDUCATION FUNDING COUNCIL (HEFCE) (2003), p. 34, (2004), p. 30, (2005), p. 22, and (2007), p. 28.

detailed examination suggests that UK spin-offs are for the most part small. For spin-offs established using HEI intellectual property and in which there is some element of HEI ownership, average employment per company is less than ten people and average estimated annual turnover is under £500 000. These are, in other words, small companies and although it is possible that some of these may grow significantly in the longer-

term, it would be unwise from a policy perspective to rely on this for regional economic development or income generation.

However, formal spin-offs in which the HEI has no equity stake appear to be very much larger: average employment is around seventy people (although this has fallen for the most recent year for which data are available) and average turnover is currently around

£800 000. While this may reflect differences in the age profile (longer established) and product/market orientation of formal spin-offs, these figures suggest that HEI ownership in a spin-off company is not necessarily associated with a significant economic impact by these firms, individually or collectively. However, formal spin-offs, based on the exploitation of HEI intellectual property (with and without HEI equity involvement) are not the only contribution of the university to new venture creation. PIRNAY *et al.* (2003) classify university spin-offs into two types: student spin-offs and researcher spin-offs. Since 1999 there has been a sharp increase in the number of start-up companies initiated by graduates (Table 3): there are now over 2800 such companies active in the UK, of which over 800 have survived for more than three years. This reflects significant efforts by government to stimulate such activity (LOCKETT *et al.*, 2005; PEARSON, 2000; OFFICE OF SCIENCE AND TECHNOLOGY (OST), 1998). These companies are, however, predominately small with on average two employees and less than £30 000 in annual sales, and can be interpreted as an alternative to participation in the 'paid employee' labour market rather than as the key driver of an entrepreneurial economy. Overall these figures suggest that spin-off numbers are not a useful indicator of the contribution of the university to the regional economy. One reason for this might be while some university spin-offs have been successful, the net return to universities from the majority is comparatively insignificant. Indeed, it is difficult to ascertain how successful spin-off companies are as hard data on how research translates into commercial success are not available in the UK (TOMES, 2003).

UNIVERSITY SPIN-OFFS IN A REGIONAL ENTREPRENEURIAL SYSTEM

To address the analysis of some of the longer-term and less easily quantified impacts of university spin-off activity, and to illustrate how the institutional structure, support processes, and resource endowments of the entrepreneurial system affect this, some results are reported from a detailed case study analysis of fifteen spin-off companies from Queen's University, Belfast. The research site is a 150-year-old, red brick, research-based university in Northern Ireland with over twenty years of formal commitment to the creation of spin-off companies. This study focuses on the development and growth of approximately 50% of the spin-off companies established with the support of the university's technology transfer company, QUBIS Ltd. In-depth, semi-structured interviews were conducted with the Chief Executive Officer (CEO) of QUBIS Ltd as well as with the founders and/or CEOs of the university's spin-off companies. These interviews lasted on average two-and-a-half hours and focused on identifying the

importance of a number of key resources on the development of these ventures. Specifically, information was gathered on company demographics (formation date, employment and sales history, technology, and market orientation), the founding process (the research and technology foundation, the relationship with the university, the career path of the founding team), and the business development process (formation and development of the management team, recruitment of key personnel, product development and diversification, development of market and customers, access to finance, and social capital networks). As such, this study has adopted a single case research design in which the emphasis is on analytical generalization rather than on statistical generalization. In other words, a research design has been adopted that:

systematically compares similarities and differences in patterns of interactions, the resulting meanings of the key variables, and their influences on various organizational outcomes

(BARTUNEK and SEO, 2002, p. 240)

in order to stimulate the development of a new understanding of the growth dynamics of university spin-off companies.

Characteristics of the spin-off companies

The spin-offs included in the sample are highly diverse (Table 4): they cover a range of sectors (five each in software and biotechnology/medical, with others in electronics, manufacturing, and environmental consultancy), and have been established for varying periods of time – eight are recent foundations (2000 or later), while three were established in the late 1980s. This pattern reflects the recent rise in the level of spin-off company formation in the UK. Given the age profile, it is not surprising that the majority of these spin-offs are small in employment terms: only four companies have more than forty employees. However, the relationship between company formation date and size is not absolute: software company K has grown rapidly, despite its recent formation (reflecting the fact that this is a second-order spin-out of an existing spin-out rather than an organically growing new venture; LEITCH and HARRISON, 2005), and company J has remained small, reflecting in part its continuing emphasis on local and national consultancy. What these figures do suggest is that there is, first, little evidence to suggest that university spin-off companies (even the relatively successful ones) will provide a substantive contribution to regional economic well-being, and second, that where benefits are being realized, even on a small scale, these are achieved only over the long-term.

With one exception (company B), these spin-outs are based on the exploitation of very small portfolios of protectable IP (in terms of patents and other forms of IP protection), and in the exceptional case

Table 4. Characteristics of case study spin-out companies

Company	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Year of formation	1996	1990	2002	1989	1993	2002	2002	2002	1986	1987	2001	2003	2001	1999	2002
Number of employees	10	45	1.5	111	5	4	7	15	170	11	75	4	0	5	1
Sector	Software	Electronics	Manufacturing	Electronics	Biotechnology	Medical	Software	Biotechnology	Software	Environmental	Software	High-technology textiles	Biotechnology	Software	Medical
Initial patents filed		14	1		1	1	n.a.	1	n.a.	n.a.	n.a.	Not yet	4	n.a.	n.a.
Current patents held		30		4		1	n.a.	3	n.a.	n.a.	n.a.			n.a.	n.a.
Initial market/customer		Broad base	Global	University research laboratories	Global	Hospital	Higher education	Academic laboratories	Medical/large organizations	Government agency	Large computer companies	European haulage sector	Effluent/waste treatment	Higher education	Medical education
Projected size		US\$ 2 billion	£60 000	US\$60 million	n.a.		Quite large	Over £1 million	Limitless	n.a.	Limitless	£200 million		Quite large	Large
Number of customers	Not trading	150	3	n.a.	Many	Not yet trading	9	>60	>100	350	>100	Not yet trading	Little trading activity	5	

Note: n.a., Not available.

this large IP portfolio is not yet associated with above-average venture performance. In the software sector, particularly with a services rather than products orientation which is characteristic of these companies (HARRISON *et al.*, 2004), the absence of formal IP protection is understandable, but it is less evident why this relatively low reliance on strong IP portfolios should be characteristic of the other companies in the sample, and it calls into question the extent to which these companies, for the most part, compete on the basis of specific complementary intellectual assets (TEECE, 1986, 2002). Given that universities place significant emphasis on the generation and formal protection of IP (POWERS and MCDUGALL, 2005), this suggests that the asset specificity of university spin-outs should be based on a wider understanding of intellectual assets and their exploitation than narrowly defined formal IP and its protection *per se* (GREGSON and HARRISON, 2004; HARRISON and SULLIVAN, 2000; SULLIVAN and SULLIVAN, 2000).

The role of the university in spin-off formation

If research commercialization is hindered by the existence of tensions and conflicts between researchers and the university management (RAPPERT and WEBSTER, 1998; SENKER, 1990) and if role separation is a requirement for effective commercialization (VESTERGAARD, 2007), then understanding the interaction between the university and the spin-off formation is central to understanding how this part of the regional entrepreneurial system functions. In terms of the perception of university support for spin-off companies, there has been considerable variation, depending on the precise area of potential support required by the spin-off venture. For most companies, the university-provided services that are most highly regarded (rated as 'important' or 'very important') are in the areas of general encouragement to exploit technology, in clarifying the legal IP position (not a surprise, given the university's own interests in this matter), providing IP protection through support for patent filing activities, providing pre-company formation business advice, and in their general support. This is consistent with the generally high level of satisfaction with the role of and relationship with the technology transfer office: only one respondent (company A) reported a poor relationship (using them only to secure 'political cover' for their venture). This level of positive response is significantly higher than reported in previous surveys of academics (JONES-EVANS, 1998), possibly because academics who have a negative view of the technology transfer office will be disproportionately concentrated among those who have tried and failed or never tried at all to commercialize their research.

Much less valued was the university support for venture and personal development, notably in identifying the market opportunity for the technology,

technology development, explanation of alternative exploitation options, and career options for academic entrepreneurs. What clearly comes across, therefore, is a university role characterized by general exhortation and specific IP-related advice, which is less extensively backed up by detailed advice and services in the strategic and operational development of the technology into a commercial venture: there is, therefore, an on-going gap in the provision of support in the commercialization process between proof of (and protection of) concept and commercial venture development which is not currently covered by the university technology transfer office. Unless there are other actors in the entrepreneurial system providing this support and advice (and in peripheral regional economies where university technology transfer offices play an economic development role rather than or as well as a technology transfer role, this may be problematic; LEITCH and HARRISON, 2005), there are resulting constraints on the development of these ventures. However, even in these circumstances it may be that the provision of high levels of institutional support may not be the optimum policy orientation for universities (ROBERTS and MALONE, 1996; DEGROOF and ROBERTS, 2004).

In terms of specific support, most respondents identified benefits from being associated with the university/technology transfer office. For many, these benefits were in the form of the advice and support offered through the start-up process, described by the CEO of company C as 'looking after the company's interests while a VC [venture capitalist] may not'. Others pointed to the provision of business services (for example, office support), and networking and communication opportunities that made a contribution to the development of the business through identification of partners, staff and market opportunities. For a small number of respondents there was also a benefit in terms of credibility and reputation: the association with the university to some extent overcame or helped to overcome the liabilities of newness that constrain new ventures (STINCHCOMBE, 1965).

On the other hand, there are also disadvantages of being associated with the university, identified by almost half of the respondents. For some, these were represented in the tensions between spin-off company development and other aspects of the academic role (teaching, departmental administration, and research) and in interdepartmental tensions within the institution, tensions which have been intensified by the pressures (in a UK context) associated with the Research Assessment Exercise (RAE) (LOCKETT *et al.*, 2003; LEE, 1996; SNOWDON, 2003). For others, the association was deemed responsible for problems in resource acquisition strategies, in terms of attracting outside investors and the investment capital required (companies C and M) and good business-experienced recruits (company B). What is not clear from these few cases where resource constraints have been identified is the extent to which

they will influence negatively the development of the company. Company B has grown to above average spin-off size over fourteen years, and the other two companies are still very new: the problems in accessing external equity, and the potentially negative signals that association with the university sends out, are, however, consistent with the wider UK issue that spin-outs have problems in obtaining development capital (LAMBERT, 2003).

External support and resources in spin-off formation

In terms of university spin-off companies' use of external support and resources, the overall impression is that they appear to be self-reliant to a significant extent. The only exceptions to this are advice and early-stage seed funding from public sources. In the case of advice from both the public and the private sector, half of the respondents indicated that this was either not provided or very unimportant in the start-up process, and it appears that in this area there was a heavy reliance on the technology transfer office of the university.

A different picture emerges in the case of early-stage seed funding from public sources, where almost two-thirds of spin-offs reported this to be important or very important in establishing the business. This funding came from a number of sources: some came in the form of equity investment by QUBIS itself (companies B, C, G, H, I, L, and N), from the University Challenge Fund and the Northern Ireland Programme⁵ (companies B, C, H, and L), and in the form of SMART awards (companies B, E, and M). There is very little reported reliance on early-stage funding from institutional venture capital investors (with the exception of companies D, I, and K, which are the best performers in growth terms within this sample), and many of the respondents identify the limited availability of locally managed venture capital funds for start-ups to be a development constraint (LEITCH *et al.*, 2006). The paucity of regional sources of venture capital investment is likely to be compounded by differences in understanding and communication between universities and potential external funders. In the absence of skills within the university to prepare spin-off companies from the earliest stage for venture capital investment (ZACHARAKIS *et al.*, 1999), it is likely that they will experience additional difficulty in raising venture capital (WRIGHT *et al.*, 2006). To an even greater extent, only one company identified business angels as having played a role in the start-up and early development of the company, reflecting the general under-development of the business angel market in the region (HARRISON *et al.*, 1996).

Overall, the experience of respondents in seeking start-up funding was, as several of them put it, 'awful', 'deflating', and 'tough', and in one case at least (company G) this 'nearly stopped the deal from going ahead'. In eight cases the company received less finance, from all sources including public sector

grants, than it was seeking and this in some cases at least had a negative impact on companies' ability to execute their strategic plans. Company C, for example, identified funding constraints 'slowing down their strategy of global growth'. In the case of company F, the failure to raise institutional venture capital meant that it had to 'move from taking one big bite to a series of smaller bites ... [which was] initially disappointing'. For three companies in particular the difficulty in raising all the finance they required had a substantive tangible impact. For company H, finance problems, which were intensified as they were trying to raise finance just after the 2000/2001 collapse in the technology and venture capital markets, led to a complete reorientation of strategy, which is now focused on revenue generation rather than on the development of a strong IP portfolio. One consequence of this is that the growth prospects of this company will be lower than it otherwise would have been. In the two other companies (K and M), the failure to raise all the capital they required slowed product development and reduced their ability to promote their products as planned. For company K, the consequence was that a strategy of growth was replaced, at least in the short-term, by the need for retrenchment and redundancies.

From the interviews, it is clear that these university spin-offs make relatively little use of external service provision and support networks. For example, there is relatively little use made of management consultancy and legal advice, possibly reflecting the provision of these services through the technology transfer office. More importantly, from a business development point of view there is a very low level of reliance on informal support in the form of mentoring, and where this support has been important it has tended to be provided by mentors from within the university community rather than from within the business community. As such, this reinforces the impression, alluded to by other commentators (STOCKHAMMER, 2005; WRIGHT *et al.*, 2004), that university spin-offs tend not to develop strong external commercially oriented relationships. This gap is reflected in the desired improvements in the assistance available to start-up university spin-outs: for eight of the fifteen companies interviewed the availability of advice and in particular access to a mentor or equivalent who could act as a sounding board and a reality check through the formation process was a priority. This suggests that there is a failure by both the university and the wider business development community to support this critical element in the business development process adequately. The consequence is that commercial decisions are taken without access to all of the appropriate expertise and advice. From an entrepreneurial system point of view, the picture painted by the respondents is of a regional ecosystem that is far from munificent in terms of access to business development resources. To use Eliasson's terminology, the regional competence

bloc in Northern Ireland is incomplete and, as a result, the business development and economic impact potential of university spin-offs is constrained (ELIASSON, 1996; ELIASSON and ELIASSON, 2006).

Companies' reflections on the spin-off process

In terms of the lessons for future spin-off activity, the respondents made a number of observations. Fundamentally, they reported that their origins as university spin-offs were inherently problematic. The culture of being, through at least the early stages of company development, an academic as well as a company developer was reflected in outcomes: 'because of constraints [of being a university employee] such as not being able to travel [I . . .] essentially established a life-style business' (company A). In other cases there was a recognition that the spin-off occurred too early in the development process, exposing the embryonic company to pressures and challenges before it and the academic entrepreneur is fully in a position to cope with them: there is a need to:

make use of the position [in the university] to establish a market before spinning-off and line up a champion for the day to day management of the company.

(company C)

On the other hand, the dangers of becoming too dependent on the safety net of the university are also recognized: as company D, one of the most successful companies in the sample, expressed it, it should 'be independent from the university [. . . the company was] in the apprenticeship phase for too long'. As the above discussion has shown, this is reflected in the long, slow development of this company before a relatively recent and significant growth spurt.

One significant issue identified in the survey is the constraining influence of the regional environment. A number of elements contribute to this. First, there is a problem for several of these companies in the context of the costs of staffing up to develop and service international markets: 'there is a lack of substantial local market for most products or services' (company I):

there is a poor local market [and a] need to look overseas, but how do you do this? If by yourself it is very expensive and if not, that is, using others, it is less expensive but less secure [as you are] further down someone else's agenda.

(company K)

Second, although some companies see a more supportive university environment ('things have changed – with growing success with respect to spin-outs the perception problem has disappeared and there is more support'; company B), this view is not universally held:

from a university perspective [there is] a lack of support to release [academic entrepreneurs] from the day-to-day burden . . . the university believes everyone establishes a

company for money and therefore why should they support it.

(company C)

and:

there is a gap in understanding between the university's strategy and Invest NI⁶ in what they are trying to achieve with Northern Ireland and business starts. The university's position regarding spin-offs is very unclear.

(company G)

Third, and of greatest significance in terms of the implications for company development, the absence of a viable scale of clustered industrial activity in biotechnology, electronics, and software is highlighted: 'there is a lack of clustering in Northern Ireland – it is too small' (company B); and 'we do not have the benefits of a cluster effect' (company E). However, clustering is a two-edged sword. On the one hand 'the clustering of like-minded high tech companies in different sectors' (company D) offers a number of benefits: 'sparks flying around re R&D' (company E); and 'the culture and mentality of employees' (company D). On the other hand, the presence of a strong clustering of cognate firms is believed to 'lead to too much job hopping and a reduction in competitive advantage' (company D) and to the poaching of staff (company E). Given that the involvement of the university in supporting or encouraging spin-out activity in a peripheral regional economy is motivated as much by a desire to contribute to regional economic development as it is to increase the university's revenue streams, although one of the respondents did suggest that the university may not help itself in this regard:

the aim in starting the company was to bring money into the department . . . any money made has stayed in the company [because there is] no mechanism for transferring money from the business to the university

(company O)

the absence of an accommodating entrepreneurial milieu represents a fundamental constraint on the development of these companies and on their ability to translate leading-edge knowledge assets into high-growth-potential businesses.

DISCUSSION

Overall, spin-off companies in Northern Ireland report more negative than positive experiences of resource acquisition and support (Table 5), and it is clear that a lack of munificence in the regional entrepreneurial system is not compensated for by commercial expertise within the university (SWAMIDASS and VULASA, 2008). From this detailed analysis it is also evident that university spin-off companies are not homogenous with comparable needs and prospects (STANDEVEN, 1993; MASON and HARRISON, 1994). It is concluded that,

Table 5. Impact of university and external support on spin-off company development

Topic	Positive impacts	Negative impacts
Role of university in spin-off formation	General encouragement to exploit technology Clarifying legal IP position Providing IP protection through patent filing Pre-company formation business advice General support Proof and protection of concept	Support for company and personal development Identifying a market opportunity for the technology Technology development Advice on alternative exploitation options Advice on career options for academic entrepreneurs Commercial venture development
Association with university/technology office	Advice and support in the start-up process Provision of business services Networking and communication opportunities Credibility and reputation	Tension between spin-off development and academic role Research Assessment Exercise (RAE) pressures Interdepartmental tensions Problems in resource acquisition (outside investors)
External support and resources from the public and private sector	Early-stage seed funding (for example, SMART and University Challenge Fund)	Business development advice Little use made of external support provision and support networks Access to business angel and venture capital (VC) funding Absence of mentoring of business community
Reflection on the spin-off process		Academic versus company development pressure Spin-off too early in the development process Dependency on the safety net of the university Constraining influence of the regional environment (for example, recruitment and market size) Absence of viable scale of sectoral clusters

Note: IP, intellectual property.

in the UK, the vast majority of university spin-off companies are small business new technology-based firms, set up to exploit limited portfolios of technological/intellectual assets, and with limited growth aspirations or potential. While these represent an important element in a functioning entrepreneurial system, they do not have the capacity to transform that system in a way that will significantly accelerate the economic development trajectory of the region (COHEN, 2005; NECK *et al.*, 2004; HILL *et al.*, 2006).

From an entrepreneurial system perspective, university spin-off companies represent a very specific, and potentially problematic, target for development (LEITCH and HARRISON, 2005). In addition to the significant barriers, which any new venture potentially has to overcome, spin-off companies encounter additional entrepreneurial challenges beyond those faced by new technology-based firms in general. First, many spin-off companies are formed not by classic entrepreneurs, but by an entrepreneurial academic. MEYER (2003) differentiates the entrepreneurial academic from the academic entrepreneur by suggesting that the former may not necessarily be growth-oriented or aware of their businesses innovation and development needs. Furthermore, as the academic might still be working within the university, growth of the spin-off company might not be his/her first priority. Indeed, they may not have either a unique idea or a high need for achievement in this area but may instead be pursuing more independence or looking for ways in which to overcome

dissatisfaction with their current role (ROBERTS, 1991). Second, university spin-offs are founded primarily on the basis of some technological advance rather than on the presumption of some sort of competitive advantage based on marketing, sales, or distribution (PÉREZ PÉREZ and MARTÍNEZ SÁNCHEZ, 2002). Typically the founders of such ventures tend to have limited business experience (FRANKLIN *et al.*, 2001; RADOSEVICH, 1995). Third, the specific challenges and obstacles encountered in the evolution of an initial idea in a non-commercial environment to the establishment of a competitive rent-generating firm are associated with conflicting objectives of key stakeholders which may adversely impact the spin-off's growth trajectory (VOHORA *et al.*, 2004).

Given this profile of university spin-off companies, the role of the university in providing institutional support should be reconsidered (ROBERTS and MALONE, 1996; DEGROOF and ROBERTS, 2004). POWERS and MCDUGALL (2003, 2005) have suggested, using United States data, that public universities are more likely than private universities to have a low support, low selectivity policy orientation – in other words, they are prepared to exploit all technologies generated commercially but have less infrastructure to support technology transfer (for example, business incubation programmes, seed capital funds and other internal support mechanism for start-up companies). In regional environments, which are characterized by weakly functioning entrepreneurial systems,

there may well be a need for the development of a much more highly supportive business development infrastructure (ROGERS *et al.*, 2000; SIEGEL *et al.*, 2003). As such, in weak entrepreneurial environments the ROBERTS and MALONE (1996) prescriptive model of a moderately selective, moderately supportive university policy may need to be amended. The evidence from the UK suggests that, faced with budgetary constraints, the restriction of university support to IP protection and management may well have negative implications for the realization of growth potential in spin-off companies.

CONCLUSIONS AND IMPLICATIONS

For the most part, spin-offs from UK universities appear to start and remain small (STEWART, 2006; TARGETING INNOVATION, 2008). This has implications in three domains: for the university sector, for academic research into the spin-off phenomenon, and for policy-makers interested in technology transfer and economic development.

From the university sector point of view, spin-offs are not likely to be a major source of income, as compared with licensing or other technology transfer activities, and neither is significant relative to other sources of income. Furthermore, the formal involvement of the university, in terms of an equity position in return for assignment of IP rights to the new venture, may be counterproductive: in seeking to maximize its return from the spin-off process, the university may in fact be diminishing it. In other words, there is the possibility that there is an adverse selection process in operation (ACKERLOF, 1970) such that universities do not retain involvement in the 'best' spin-offs. This implies that although they are closer to the technology and the founders than other potential investors and surrogate entrepreneurs, they gain no substantive information advantages from this. To compensate for this, those involved in the university spin-off process increasingly seek to complicate, professionalize, and mystify the process.⁷ In so doing, they are adopting one of the key characteristics of voodoo economics, or magic, which is:

often elaborate . . . an image of mysterious wisdom won by toil. The rites can last hours or days or weeks. Magic is repetitious, covering every new possibility – or else it does not work, since tiny failures to follow the prescription protect the magician from responsibility.

(MCCLOSKEY, 1991, p. 293)

A major challenge, therefore, for the development of a meaningful debate on the effectiveness of university spin-offs as an economic development mechanism or a source of revenues and economic rents:

it is natural for a magician to take refuge behind questions of procedure and technicalities, to protect himself in case of failure in magical prowess.

(MAUSS, 1902–1903/1972, p. 62)

From a research point of view, the initial evidence on the development and performance of university spin-off ventures suggests that the identification of the determinants of the overall performance of university spin-offs over the long run, and of variations in that performance, is an important area for further more detailed research. In so doing, and in the light of the evidence on the services provided by the university to spin-offs (CLARYSSE *et al.*, 2005), that research could usefully focus on the resource acquisition strategies of spin-off companies: access to adequate resources in terms of finance, skilled personnel, advice and business development support and entrepreneurial capital are crucial to venture development. Technology transfer is more than just university spin-off company creation and this entrepreneurial role is only one aspect of the wider relationship between universities and territorial development (LAWTON-SMITH, 2007). Nevertheless, there is a widespread lack of clarity in which 'the rise of entrepreneurial activity at universities and its organizational and societal implications' is understood to be archetypically represented in universities that 'are increasingly emphasizing the creation of new companies as a mechanism for commercialization of intellectual property' (SIEGEL *et al.*, 2007, p. 1). Given the apparent lack of large-scale economic impact from spin-off company activity, there is a pressing need for research into the totemic significance of the spin-off company itself.

From a public policy perspective, spin-off companies are at best only going to make a minor contribution to economic development: they do not, on present evidence, represent a platform for sustained economic transformation at either national or regional level. Specifically, in an economically less developed regional context universities and the university spin-off company formation process do not appear to be well connected into or make a contribution to the entrepreneurial system. While it may be necessary outside of technology intensive regions to see the university as playing a surrogate economic development agency role (LEITCH and HARRISON, 2005), this is a situation which constrains rather than supports the development of these companies. As LESTER (2005) has recently argued, if the basic unit of observation and analysis is the local industrial economy (or entrepreneurial system, in present terms) rather than the:

university itself or the flows of people, technology, and ideas that emerge from it, we can deal more straightforwardly with situations in which the university is only a minor supporting player in a larger industrial development process.

(LESTER, 2005, p. 14)

From this perspective, much of the emphasis in current commercialization policy, as it is related to spin-off company formation, rests on a social engineering mind-set, the belief that if one has effective practices and policies, interventions and incentives, one will have

(economically and socially) effective university spin-off companies. However, to return to the metaphor of voodoo, or magic, with which this paper began:

to engineer something, you must be able to predict it. And to predict profitably, you must be a magician. Profitable predictions are as good as magic carpets, love potions, and efficacious prayers.

(McCLOSKEY, 1991, p. 296)

Few would argue about the desirability of all three; equally, few would argue about the desirability of economically significant university spin-offs. Unfortunately, the latter seem in reality to be no more likely of being seen in the everyday world of experience than the former.

NOTES

1. For example, there is some evidence to suggest that the evolution of the biotechnology sector has been associated with a high level of spin-off activity, particularly where there are significant concentrations of both university and commercial biotechnology activity (COOKE, 2002; ZUCKER and DARBY, 2005; ELIASSON and ELIASSON, 2006). However, as in the case of technology core regions such as Silicon Valley and Route 128, experience in such mega-cluster ecosystems does not necessarily translate into practice and potential in other contexts (NICOLAOU and BIRLEY, 2003).
2. This is a very twentieth-century phenomenon, and it should be noted that the emergence of the modern university, in the UK at least, in the nineteenth century was predicated on the development of useful knowledge in close collaboration with industrial and commercial interests (SANDERSON, 1975).
3. The metrics available from this survey to measure the scale and impact of spin-off activity focus on the short-term and immediately quantifiable benefits. As a number of commentators have pointed out, over the longer-term spin-offs may be seen as an alternative financial flow for

universities (FELDMAN *et al.*, 2002). However, LESTER (2008) and HUGHES (2007), among others, argue that the probability that any given university will derive significant financial benefits from its technology transfer activities (spin-offs, patents, and licensing) is fairly low. Indeed, Lester suggests, based on an analysis of the costs of maintaining the technology transfer function, that technology transfer might be better viewed primarily as a public service function (see also LEITCH and HARRISON, 2005).

4. Interpretation of these figures is complicated by improvements in data capture and reporting, and accordingly the apparent increases in employment and turnover reported should be viewed with caution (HEFCE, 2005, p. 22; 2007). Similarly, regional disaggregations of the data, available in the HEFCE reports, are subject to response variations (in coverage, but more particularly comprehensiveness and consistency) from year to year, making detailed comparisons problematic.
5. For the current round of European Union funding (2000–2006), Northern Ireland exceeded the qualifying criterion, having a per capita gross domestic product greater than 75% of the community average. However, Northern Ireland was able to avail of newly introduced transitional arrangements that provided former Objective 1 regions access to the four Structural Funds, but on a declining basis so that by the end of the funding period, the Region would have adjusted to the lower and more limited financial support likely to be made available to an Objective 2 Region. Under these arrangements, Northern Ireland secured €890.5 million for a Transitional Objective 1 Programme, Building Sustainable Prosperity (for more details, see http://www.eugrants.org/bsp_summary.pdf or http://www.europe-dfpni.gov.uk/Upload/BSP_docs/bsp_summary_aug.pdf).
6. The regional development agency that has a declared policy of increasing the number of spin-offs in the region.
7. For an illustration of this, see the increasingly professionalized and credentialized approach to managing the university spin-off process adopted by the Association for University Research and Industry Links (AURIL) in the UK and The Association of University Technology Managers (AUTM) in the United States.

REFERENCES

- ACKERLOF G. A. (1970) The market for lemons: quality uncertainty and the market mechanism, *Quarterly Journal of Economics* **84**, 488–500.
- ALDRICH H. E. (1999) *Organizations Evolving*. Sage, London.
- ARMBRUSTER C. (2008) *Research Universities: Autonomy and Self-Reliance After the Entrepreneurial University*. Max Planck Institute, Jena.
- ARONOWITZ S. (2000) *The Knowledge Factory: Dismantling the Corporate University and Creating True Higher Learning*. Beacon, Boston, MA.
- BAHRAMI H. and EVANS S. (1995) Flexible re-cycling and high-technology entrepreneurship, *California Management Review* **37**, 62–89.
- BANK OF ENGLAND (2001) *Financing of Technology-Based Small Firms*. Bank of England Domestic Finance Division, London.
- BARTKOWSKI J. P. (1998) Claims-making and typifications of voodoo as a deviant religion: hex, lies, and videotape, *Journal for the Scientific Study of Religion* **37**, 559–579.
- BARTUNEK J. M. and SEO M. (2002) Qualitative research can add new meanings to quantitative research, *Journal of Organizational Behaviour* **23**, 237–242.
- BEKKERS R., GILSING V. and VAN DER STEEN M. (2006) Determining factors of the effectiveness of IP-based spin-offs: comparing the Netherlands and the US, *Journal of Technology Transfer* **31**, 545–566.

- BENNEWORTH P. (2001) Academic entrepreneurship and long-term business relationships: understanding 'commercialization' activities, *Enterprise and Innovation Management Studies* **2**, 225–237.
- BENNEWORTH P. and CHARLES D. (2005) University spin-off policies and economic development in less successful regions: learning from two decades of policy practice, *European Planning Studies* **13**, 537–557.
- BENNEWORTH P. and HOSPERS G.-J. (2007) The new economic geography of old industrial regions: universities as global–local pipeline, *Environment and Planning C: Government and Policy* **25**, 779–802.
- BIRLEY S. (1985) The role of networks in the entrepreneurial process, *Journal of Business Venturing* **1**, 107–117.
- BIRLEY S. (2002) Universities, academics and spin-out companies: lessons from Imperial, *International Journal of Entrepreneurship Education* **1**, 133–153.
- BOK D. (2003) *Universities in the Marketplace. The Commercialization of Higher Education*. Princeton University Press, Princeton, NJ.
- BOZEMAN B. (2000) Technology transfer and public policy: a review of research and theory, *Research Policy* **29**, 627–655.
- BRANSCOMB L. M., KODAMA F. and FLORIDA R. L. (1999) *Industrializing Knowledge. University–Industry Linkages in Japan and the United States*. MIT Press, Cambridge, MA.
- BREHENS T. R. and GRAY D. O. (2001) Unintended consequences of cooperative research: impact of industry sponsorship on climate for academic freedom and other graduate student outcome, *Research Policy* **30**, 179–199.
- BRIOSCHI M. S. and CASSIA L. (2006) Common trajectories of regional competitiveness in the knowledge economy: a European investigation, *Industry and Higher Education* **20**, 387–401.
- CLARK B. (1998) *Sustaining Change in Universities*. Society for Research into Higher Education, Open University Press, Buckingham.
- CLARK B. (2004) *Creating Entrepreneurial Universities: Organisational Pathways of Transformation*. Elsevier, Oxford.
- CLARK W. (2006) *Academic Charisma and the Origins of the Research University*. University of Chicago Press, Chicago, IL.
- CLARYSSE B., WRIGHT M., LOCKETT A., VAN DE VELDE E. and VOHARA A. (2005) Spinning out new ventures: a typology of incubation strategies from European research institutions, *Journal of Business Venturing* **20**, 183–216.
- COHEN B. (2005) Sustainable valley entrepreneurial ecosystems, *Business Strategy and the Environment* **15**, 1–14.
- COLYVAS J. M., CROW A., GELIJNS R., MAZZOLENI R., NELSON N., ROSNEBERG N. and SAMPAT B. (2002) How do university inventions get into practice?, *Management Science* **48**, 61–72.
- COOK T., DWEK R., BLUMBERG B. and HOCKADAY T. (2008) Commercialising university research: threats and opportunities – the Oxford model, *Capitalism and Society* **3**, article 4 (available at: <http://www.bepress.com/cas/vol3/iss1/art4>).
- COOKE P. (2002) Regional innovation systems: general findings and some new evidence from biotechnology clusters, *Journal of Technology Transfer* **27**, 133–145.
- COOKE P. and MORGAN K. (1998) *The Associational Economy*. Oxford University Press, Oxford.
- DEGROOF J. and ROBERTS E. B. (2004) Overcoming weak entrepreneurial infrastructures for academic spin-off ventures, *Journal of Technology Transfer* **29**, 327–352.
- DEPARTMENT OF TRADE AND INDUSTRY (DTI) (2002) *Investing in Innovation: A Strategy for Science Engineering and Technology*. H. M. Treasury and DFES, London.
- DI GREGORIO D. and SHANE S. (2003) Why do some universities generate more startups than others?, *Research Policy* **32**, 209–227.
- DOUTRIAUX J. (1987) Growth patterns of academic entrepreneurial firms, *Journal of Business Venturing* **2**, 285–297.
- DOWNES R. and EADIE G. (1998) The creation and support of academic spin-out companies, in O'KEY R. (Ed.) *New Technology Based Firms in the 1990s: Volume 5*, pp. 247–267. Paul Chapman, London.
- ELIASSEN G. (1996) Spillovers, integrated production and the theory of the firm, *Journal of Evolutionary Economics* **6**, 125–140.
- ELIASSEN G. and ELIASSEN A. (2006) The pharmacia story of entrepreneurship and as a creative technical university – an experiment in innovation, organizational break-up and industrial renaissance, *Entrepreneurship and Regional Development* **18**, 393–420.
- ETZKOWITZ H. (1998) The norms of entrepreneurial science: cognitive effects of the new university–industry linkages, *Research Policy* **27**, 823–833.
- ETZKOWITZ H. (2002) *MIT and the Rise of Entrepreneurial Science*. Routledge, London.
- ETZKOWITZ H. (2003) Research groups as 'quasi-firms': the invention of the entrepreneurial university, *Research Policy* **32**, 109–121.
- ETZKOWITZ H. (2004) The evolution of the entrepreneurial university, *International Journal of Technology and Globalisation* **1**, 64–77.
- ETZKOWITZ H. and KLOFSTEN M. (2005) The innovating region: toward a theory of knowledge-based regional development, *R&D Management* **35**, 243–255.
- ETZKOWITZ H. and LEYDESORFF L. (Eds) (1997) *Universities in the Global Economy: A Triple Helix of University–Industry–Government Relations*. Cassell Academic, London.
- ETZKOWITZ H., WEBSTER A., GEBHARDT C., and CANTINSO TERRA B. R. (2000) The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm, *Research Policy* **29**, 313–330.
- EUROPEAN COMMISSION (2002) *An Assessment of the Implications for Basic Engineering Research of Failure to Publish, or Late Publication of, Papers on Subjects Which Could be Patentable*. Report from the Commission to the European Parliament and Council COM (2002) 2 final. European Commission, Brussels.
- FELDMAN M. P. (2005) The entrepreneurial event revisited: firm formation in a regional context, in BRESCHI S. and MALERBA F. (Eds) *Clusters, Networks, and Innovation*, pp. 136–168. Oxford University Press, Oxford.
- FELDMAN M. P., FELLER I., BERCOVITZ J. and BURTON R. (2002) Equity and the technology transfer strategies of American research universities, *Management Science* **48**, 105–121.
- FIET J. O. (2002) *The Systematic Search for Entrepreneurial Discoveries*. Quorum, Westport, CT.
- FLORIDA R. (1999) The role of the university: leveraging talent, not technology, *Issues in Science and Technology* **Summer**, 67–73.

- FLORIDA R. L. and KENNEY M. (1988) Venture capital, high technology and regional development, *Regional Studies* **22**, 33–48.
- FRANKLIN S. J., WRIGHT M. and LOCKETT A. (2001) Academic and surrogate entrepreneurs in university spin-out companies, *Journal of Technology Transfer* **26**, 127–141.
- GARNSEY E. (2006) The entrepreneurial university: the idea and its critics, in SHAHID Y. and NABESHIMA K. (Eds) *How Universities Promote Economic Growth*, pp. 227–238. The World Bank, Washington, DC.
- GIBBONS M., LIMOGES C., NOVOTNY H., SCHWARTZMAN S., SCOTT P. and TROW M. (1994) *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. Sage, London.
- GLASSON J., CHADWICK A. and LAWTON-SMITH H. (2006) Defining, explaining and managing high-tech growth: the case of Oxfordshire, *European Planning Studies* **14**, 503–524.
- GOLDSTEIN H. A. and RENAULT C. S. (2006) Contributions of universities to regional economic development: a quasi-experimental approach, *Regional Studies* **38**, 733–746.
- GOLOB E. (2006) Capturing the regional economic benefits of university technology transfer: a case study, *Journal of Technology Transfer* **31**, 685–695.
- GRAHAM G. (2002) *Universities: The Recovery of an Idea*. Imprint Academic, Exeter.
- GRAHAM G. (2005) *The Institution of Intellectual Values: Realism and Idealism in Higher Education*. St. Andrews Studies in Philosophy and Public Affairs. Imprint Academic, Exeter.
- GREGSON G. and HARRISON R. T. (2004) A real-time evaluation of intellectual capital and intellectual property rights in early-stage on-line enterprises, in SEPPA M., HANNULA M., JÄRVELIN A.-M., KUJALA J., RUOHONEN M. and TIAINEN T. (Eds) *Frontiers of E-Business Research*, pp. 710–719. University of Tampere/Tampere University of Technology, Tampere.
- GUTHRIE J. (2004) Why university spin-outs are spinning out of control?, *Financial Times (London)* **11 May**, 13.
- HAGUE D. and OAKLEY K. (2000) *Spin-offs and Start-ups in UK Universities*. CVCP, London.
- HANNAN M. T., CARROLL G. R., DUNDON E. A. and TORRES J. C. (1992) *Dynamics of Organizational Populations: Density, Legitimation and Competition*. Oxford University Press, New York, NY.
- HARRISON R. T., MACINTYRE P. and MASON C. M. (1996) Informal investment in Northern Ireland. Paper presented at the Institute of Small Business Affairs Annual Conference, Belfast, UK, November 1996.
- HARRISON R. T., MASON C. M. and GIRLING P. (2004) Financial bootstrapping and venture development in the software industry, *Entrepreneurship and Regional Development* **16**, 307–333.
- HARRISON S. and SULLIVAN P. H. Sr (2000) Profiting from intellectual capital: learning from leading companies, *Journal of Intellectual Capital* **1**, 33–46.
- HIGHER EDUCATION FUNDING COUNCIL (HEFCE) (2003) *Higher Education–Business Interaction Survey 2000–01*. HEFCE, London.
- HIGHER EDUCATION FUNDING COUNCIL (HEFCE) (2004) *Higher Education–Business Interaction Survey 2001–02*. HEFCE, London.
- HIGHER EDUCATION FUNDING COUNCIL (HEFCE) (2005) *Higher Education–Business and Community Interaction Survey 2002–03*. HEFCE, London.
- HIGHER EDUCATION FUNDING COUNCIL (HEFCE) (2007) *Higher Education–Business and Community Interaction Survey 2004–05 and 2005–06*. HEFCE, London.
- HILL F., LEITCH C. M. and HARRISON R. T. (2006) Desperately seeking finance? The demand for finance by women owned and led businesses, *Venture Capital* **8**, 159–182.
- H. M. TREASURY, DEPARTMENT OF TRADE AND INDUSTRY, and DEPARTMENT FOR EDUCATION AND SKILLS (2004) *Science and Innovation: Working Towards a Ten-Year Investment Framework*. HMSO, London.
- HOLBROOK M. B. and HULBERT J. M. (2002) What do we produce in the ‘Knowledge Factory’ and for whom? A review essay of *The Knowledge Factory* by Stanley Aronowitz, *Journal of Consumer Affairs* **36**, 99–114.
- HUGHES A. (2007) *Innovation Policy as Cargo Cult: Myth and Reality in Knowledge-Led Productivity and Growth*. Working Paper Number 348. Centre for Business Research, University of Cambridge, Cambridge.
- JONES-EVANS D. (1998) *Universities, Technology Transfer and Spin-Out Activities – Academic Entrepreneurship in Different European Regions*. Final Report. Targeted Socio-Economic Research Project Number 1042. European Commission, Brussels.
- JONGBLOED B., ENDERS J. and SALERNO C. (2008) Higher education and its communities: interconnections, interdependencies and a research agenda, *Higher Education* **56**, 303–324.
- KEEBLE D. and WILKINSON F. (Eds) (2000) *High-Technology Clusters, Networking and Collective Learning in Europe*. Ashgate, Aldershot.
- KENNY M. and GOE W. R. (2004) The role of social embeddedness in professional entrepreneurship: a comparison of electrical engineering and computer science at UC Berkeley and Stanford, *Research Policy* **33**, 691–707.
- KERR C. (2001) *The Uses of the University*, 5th Edn. The Godkin Lectures on the Essentials of Free Government and the Duties of the Citizen. Harvard University Press, Boston, MA.
- KIRP D. L. (2003) *Shakespeare, Einstein, and the Bottom Line: The Marketing of Higher Education*. Harvard University Press, Cambridge, MA.
- KLAGGE B. and MARTIN R. (2005) Decentralized versus centralized financial systems: is there a case for local capital markets?, *Journal of Economic Geography* **5**, 387–421.
- KLOFSTEN M. and JONES-EVANS D. (2000) Comparing academic entrepreneurship in Europe – the case of Sweden and Ireland, *Small Business Economics* **14**, 299–309.
- LAMBERT R. (2003) *Lambert Review of Business–University Collaboration*. H. M. Treasury, London.
- LAWTON-SMITH H. (2003) Knowledge organisations and local economic development: the cases of Oxford and Grenoble, *Regional Studies* **37**, 899–909.
- LAWTON-SMITH H. (2007) Universities, innovation, and territorial development: a review of the evidence, *Environment and Planning C: Government and Policy* **25**, 98–114.

- LAWTON-SMITH H. and WATERS R. (2005) Employment mobility in high-technology agglomerations: the cases of Oxfordshire and Cambridgeshire, *Area* **37**, 189–198.
- LEE Y. S. (1996) Technology transfer and the research university: a search for the boundaries of university–industry collaboration, *Research Policy* **25**, 843–863.
- LEITCH C. M. and HARRISON R. T. (2005) Maximising the potential of university spin-outs: the development of second-order commercialisation activities, *R&D Management* **35**, 257–272.
- LEITCH C. M., HILL F. M. and HARRISON R. T. (2006) The growth and financing of women-led ventures: the Northern Ireland experience, in BRUSH C., CARTER N., GATEWOOD E., GREENE P. and HART M. (Eds) *Growth Oriented Women Entrepreneurs and Their Businesses: A Global Research Perspective*, pp. 308–329. Edward Elgar, New York, NY.
- LESTER R. (2008) Comment on ‘commercialising university research: the Oxford model’ (by Tim Cook, Raymond Dwek and Baruch Blumberg), *Capitalism and Society* **3**, 1–5.
- LESTER R. K. (2005) *Universities, Innovation, and the Competitiveness of Local Economies. A Summary Report from the Local Innovation Systems Project – Phase I*. Working Paper Number 05–010. MIT Industrial Performance Center, Cambridge, MA.
- LEYDESORFF L. and ETZKOWITZ H. (1996) Emergence of a triple helix of university–industry–government relations, *Science and Public Policy* **23**, 279–286.
- LEYDESORFF L. and ETZKOWITZ H. (1998) The triple helix as a model for innovation studies, *Science and Public Policy* **25**, 195–203.
- LINDHOLM DAHLSTRAND A. (2008) University knowledge transfer and the role of academic spin-offs, in POTTER J. (Ed.) *Entrepreneurship and Higher Education*, pp. 235–254. Organisation for Economic Co-operation and Development (OECD), Paris.
- LOCKETT A., SIEGEL D. A., WRIGHT M. and ENSLEY M. D. (2005) The creation of spin-off firms at public research institutions: managerial and policy implications, *Research Policy* **34**, 981–993.
- LOCKETT A., WRIGHT M. and FRANKLIN S. (2003) Technology transfer and universities’ spin-out strategies, *Small Business Economics* **20**, 185–200.
- LUNDVALL B.-Å. (1992) *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. Frances Pinter, London.
- LUNDVALL B.-Å., JOHNSON B., ANDERSEN E. S. and DALUM B. (2002) National systems of production, innovation and competence building, *Research Policy* **31**, 213–231.
- MALECKI E. J. (1997) Entrepreneurs, networks and economic development, *Advances in Entrepreneurship, Firm Emergence, and Growth* **3**, 57–118.
- MALMBERG A. and MASKELL P. (2002) The elusive concept of localization economies: towards a knowledge-based theory of spatial clustering, *Environment and Planning A* **34**, 429–449.
- MARKHAM G. D., PHAN P. H., BALKIN D. B. and GIANIODIS P. T. (2005) Entrepreneurship and university-based technology transfer, *Journal of Business Venturing* **20**, 241–263.
- MARTIN R. and SUNLEY P. (2003) Deconstructing clusters: chaotic concept or policy panacea?, *Journal of Economic Geography* **3**, 5–35.
- MASKELL D. and ROBINSON I. (2002) *The New Idea of a University*. Imprint Academic, Exeter.
- MASON C. and HARRISON R. T. (1994) The role of informal and formal sources of venture capital in the financing of technology-based SMEs in the United Kingdom, in O’AKEY R. (Ed.) *New Technology-Based Firms in the 1990s*, pp. 104–124. Paul Chapman, London.
- MASSEY D., QUINTAS P. and WIELD D. (1992) *High Tech Fantasies: Science Parks in Society, Science and Space*. Routledge, London.
- MATTHEWS J. A. (1997) A Silicon Valley of the east: creating Taiwan’s semiconductor industry, *California Management Review* **39**, 36–54.
- MAUSS M. (1902–1903/1972) *A General Theory of Magic* [1902–1903]. Norton, New York, NY.
- McCLOSKEY D. (1991) Voodoo economics, *Poetics Today* **12**, 287–300.
- McNAUGHTON R. (2008) Technology commercialisation and universities in Canada, in POTTER J. (Ed.) *Entrepreneurship and Higher Education*, pp. 255–270. Organisation for Economic Co-operation and Development (OECD), Paris.
- MEYER M. (2003) Academic entrepreneurs or entrepreneurial academics? Research-based ventures and public support mechanisms, *R&D Management* **33**, 107–115.
- MIAN S. (1997) Assessing and managing the university technology business incubation: an integrative framework, *Journal of Business Venturing* **12**, 251–285.
- MOWERY D. C., NELSON R. R., SAMPAT B. N. and ZIEDONIS A. A. (2001) The growth of patenting and licensing by US universities: an assessment of the effects of the Bayh–Dohle Act of 1980, *Research Policy* **30**, 99–119.
- NECK H. M., MEYER G. D., COHEN B. and CORBETT A. C. (2004) An entrepreneurial system view of new venture creation, *Journal of Small Business Management* **42**, 190–208.
- NELSON R. R. (1993) *National Innovation Systems: A Comparative Analysis*. Oxford University Press, New York, NY.
- NICOLAOU N. and BIRLEY S. (2003) Academic networks in a trichotomous categorization of university spinouts, *Journal of Business Venturing* **18**, 333–359.
- NOVOTNY H., SCOTT P. and GIBBONS M. (2001) *Rethinking Science. Knowledge and the Public in the Age of Uncertainty*. Polity, Oxford.
- OFFICE OF SCIENCE AND TECHNOLOGY (OST) (1998) *Science Enterprise Challenge*. OST, London (available at: <http://www.ost.gov.uk/enterprise/knowledge/sec.htm>).
- ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD) (2002) *Benchmarking Industry–Science Relationships*. OECD, Paris.
- PEARSON I. (2000) *Universities and Innovation: Meeting the Challenge*. Social Market Foundation, London.
- PÉREZ PÉREZ M. and MARTÍNEZ SÁNCHEZ A. (2002) The development of university spin-offs: early dynamics of technology transfer and networking, *Technovation* **23**, 823–831.

- PIRNANY F., SURLÉMONT B. and NĪMEVO F. (2003) Toward a typology of university spin-offs, *Small Business Economics* **21**, 355–369.
- POWERS J. B. and McDUGALL P. (2003) University entrepreneurship: testing a typology and its performance effects on technology licensing to firms that go public, in BYGRAVE W., BRUSH C., DAVIDSSON P., FIET J., GREENE P., HARRISON R., LERNER M., MEYER G., SOHL J. and ZACHARAKIS A. (Eds) *Frontiers of Entrepreneurship Research*, pp. 594–603. Babson College, Babson Park, MA.
- POWERS J. B. and McDUGALL P. (2005) Policy orientation effects on performance with licensing to start-ups and small companies, *Research Policy* **34**, 1028–1042.
- POYAGO-THEOTOKY J., BEATH J. and SIEGEL D. S. (2002) Universities and fundamental research: reflections on the growth of university–industry partnerships, *Oxford Review of Economic Policy* **18**, 10–21.
- PREVEZER M. (2001) Ingredients in the early development of the US biotechnology industry, *Small Business Economics* **17**, 17–29.
- QUARNBY L. (2002) The financing of university spin-outs, *Finance for Small Firms – A Ninth Report*. April, pp. 65–86. Bank of England, London.
- RADOSEVICH R. (1995) A model for entrepreneurial spin-offs from public technology sources, *International Journal of Technology Management* **10**, 879–893.
- RAPPERT B. and WEBSTER A. (1998) Links between universities and their spin-offs, *Industry and Higher Education* **12**, 332–338.
- REICHERT S. (2006) *The Rise of Knowledge Regions: Emerging Opportunities and Challenges for Universities*. European University Association (EUA) Publ. Brussels.
- ROBERTS E. B. (1991) *Entrepreneurs in High Technology – Lessons from MIT and Beyond*. Oxford University Press, New York, NY.
- ROBERTS E. B. and MALONE D. E. (1996) Policies and structures for spinning off new companies from research and development organizations, *R&D Management* **26**, 17–48.
- ROGERS E. M., YIN J. and HOFFMAN J. (2000) Assessing the effectiveness of technology transfer offices at US research universities, *AUTM Journal* **12**, 47–80.
- ROTHAERMEL F. T., AGUNG S. D. and JIANG L. (2007) University entrepreneurship: a taxonomy of the literature, *Industrial and Corporate Change* **16**, 691–791.
- RUTTEN R., BOEKEMA F. and KUIJPERS E. (2003) in RUTTEN R., BOEKEMA F. and KUIJPERS E. (Eds) *Economic Geography of Higher Education. Knowledge Infrastructure and Learning Regions*. Routledge, London.
- SANDERSON M. (Ed.) (1975) *The Universities in the Nineteenth Century*. Routledge & Kegan Paul, London.
- SCHINN T. (2002) The triple helix and new production of knowledge: prepackaged thinking on science and technology, *Social Studies of Science* **32**, 599–614.
- SENKER J. (1990) Conflict and cooperation: industrial funding of university research, *Journal of General Management* **15**, 55–62.
- SEGAL QUINCE & PARTNERS (1985) *The Cambridge Phenomenon: The Growth of High Technology Industry in a University Town*, Segal Quince & Partners, Cambridge.
- SHANE S. (2004a) *Academic Entrepreneurship. University Spinoffs and Wealth Creation*. Edward Elgar, Cheltenham.
- SHANE S. (2004b) *A General Theory of Entrepreneurship: The Individual–Opportunity Nexus*. Edward Elgar, Cheltenham.
- SHANE S. (2004c) Encouraging university entrepreneurship: the effect of the Bayh–Dole Act on university patenting in the United States, *Journal of Business Venturing* **19**, 127–151.
- SHAPERO A. and SOKOL L. (1982) The social dimensions of entrepreneurship, in KENT C. A., SEXTON D. L. and VESPER K. H. (Eds) *Encyclopaedia of Entrepreneurship*, pp. 72–90. Prentice-Hall, Englewood Cliffs, NJ.
- SIEGEL D. S., WALDMAN D. A. and LINK A. N. (2003) Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study, *Research Policy* **32**, 27–48.
- SIEGEL D. S., WRIGHT M. and LOCKETT A. (2007) The rise of entrepreneurial activity at universities: organizational and societal implications, *Industrial and Corporate Change* **16**, 489–584.
- SLAUGHTER S. and LESLIE L. L. (1997) *Academic Capitalism. Politics, Policies, and the Entrepreneurial University*. The John Hopkins University Press, Baltimore, MD.
- SLAUGHTER S. and RHOADES G. (2004) *Academic Capitalism and the New Economy: Markets, State and Higher Education*. The John Hopkins University Press, Baltimore, MD.
- SMILOR R., O'DONNELL N., STEIN G. and WELBORN R. S.III (2007) The research university and the development of high-technology centers in the United States, *Economic Development Quarterly* **21**, 203–222.
- SMILOR R. W. and FEESER H. R. (1991) Chaos and the entrepreneurial process: patterns and policy implications for technology entrepreneurship, *Journal of Business Venturing* **6**, 165–172.
- SMILOR R. W., GIBSON D. V. and DIETRICH G. B. (1990) University spin-out companies: technology start-ups from UT-Austin, *Journal of Business Venturing* **5**, 63–76.
- SMILOR R. W., GIBSON D. V. and KOZMETSKY G. (1989) Creating the technopolis: high-technology development in Austin, Texas, *Journal of Business Venturing* **4**, 49–67.
- SNOWDON K. (2003) *Spin-off and Entrepreneurial Training Model*. Working Paper. University of Newcastle, Newcastle upon Tyne.
- SPILLING O. R. (1996) The entrepreneurial system: on entrepreneurship in the context of a mega-event, *Journal of Business Research* **36**, 91–103.
- STANDEVEN P. (1993) *Financing the Early Stage Technology Firm in the 1990s: An International Perspective*. Discussion Paper prepared for the Six Countries Programme Conference on 'Financing the Early Stage Technology Company in the 1990s: An International Perspective', Montreal, QC, Canada.
- STEFFENSEN M., ROGERS E. M. and SPEAKMAN K. (2000) Spin-offs from research centers at a research university, *Journal of Business Venturing* **15**, 93–111.

- STEWART J. (2006) The Spin-Out Process from a Founder's Point of View. Unpublished Working Paper. Centre for Entrepreneurship Research, University of Edinburgh Management School, Edinburgh.
- STINCHCOMBE A. L. (1995) Social structure and organisations, in MARCH J. G. (Ed.) *Handbook of Organisations*, pp. 142–193. Rand McNally, Chicago, IL.
- STOCKHAMMER C. (2005) *Why Some Research Insights Find Their Way to Market and Some Do Not – Social Capital as Resource Within the Triple Helix*. Paper Number A204 (available at: http://www.triplehelix5.com/pdf/A204_THC5.pdf) (accessed on 6 February 2006).
- SULLIVAN P. H. JR and SULLIVAN P. H. SR (2000) Valuing intangibles companies: an intellectual capital approach, *Journal of Intellectual Capital* **1**, 328–340.
- SWAMIDASS P. M. and VULASA V. (2008) Why university inventions rarely produce income? Bottlenecks in university technology transfer, *Journal of Technology Transfer* **34**, 343–363.
- TARGETING INNOVATION (2008) *Scottish University Spin-out Study*. Targeting Innovation, Glasgow.
- TEECE D. (1986) Profiting from technological innovation: implications for integration, collaboration, licensing and public policy, *Research Policy* **15**, 285–305.
- TEECE D. (2002) *Managing Intellectual Capital*. Oxford University Press, Oxford.
- TOMES A. (2003) UK government science policy: the 'Enterprise Deficit' fallacy, *Technovation* **23**, 785–792.
- TUUNAINEN J. (2005) Contesting a hybrid firm at a traditional university, *Social Studies of Science* **35**, 173–210.
- VAN DE VEN A. H. (1993) The development of an infrastructure for entrepreneurship, *Journal of Business Venturing* **8**, 211–230.
- VASS T. E. (2008) *Unchallenged Assumptions about Innovation Meet Shibboleths of University Tech Transfer*. The Technology Transfer and Innovation Series: The Private Capital Market Working Paper Number 2008-09-01, 4 June. Social Science Research Network (SSRN) (available at: <http://ssrn.com/abstract=1271670>).
- VESTERGAARD J. (2007) The entrepreneurial university revisited: conflicts and the importance of role separation, *Social Epistemology* **21**, 41–54.
- VOHORA A., WRIGHT M. and LOCKETT A. (2004) Critical junctures in the development of university high-tech spinout companies, *Research Policy* **33**, 147–175.
- VORLEY T. and NELLES J. (2008) (Re)conceptualising the academy: institutional development of and beyond the Third Mission, *Higher Education Management and Policy* **20**, 109–126.
- WALSHOK M. L. (1995) *Knowledge Without Boundaries: What America's Research Universities Can Do for the Economy, the Workplace and the Community*. Jossey Bass, San Francisco, CA.
- WINK R. (Ed.) (2004) *Academia–Business Links. European Policy Strategies and Lessons Learnt*. Palgrave Macmillan, London.
- WRIGHT M., CLARYSSE B., MUSTAR P. and LOCKETT A. (2007) *Academic Entrepreneurship in Europe*. Edward Elgar, Cheltenham.
- WRIGHT M., LOCKETT A., CLARYSSE B. and BINKS M. (2006) University spin-out companies and venture capital, *Research Policy* **35**, 481–501.
- WRIGHT M., VOHORA A. and LOCKETT A. (2004) The formation of high-tech university spinouts: the role of joint ventures and venture capital investors, *Journal of Technology Transfer* **29**, 287–310.
- ZACHARAKIS A. L., MEYER D., DE and CASTRO J. (1999) Differing perceptions of new venture failure: a matched exploratory study of venture capitalists and entrepreneurs, *Journal of Small Business Management* **37**, 1–14.
- ZACHARAKIS A. L., SHEPHERD D. A. and COOMBS J. E. (2003) Research Note: The development of venture-capital-backed internet companies: an ecosystem perspective, *Journal of Business Venturing* **18**, 217–231.
- ZUCKER L. G. and DARBY M. R. (2005) *Socio Economic Impact of Nanoscale Science: Initial Results and Nanobank*. Working Paper Number W11181. National Bureau of Economic Research (NBER). Cambridge, MA.