FACULTEIT ECONOMIE
EN BEDRIJFSKUNDE

TWEEKERKENSTRAAT 2
B-9000 GENT
Tel. : 32 - (0)9 – 264.34.61
Fax. : 32 - (0)9 – 264.35.92

WORKING PAPER

The Technology Endowments of Spin-off Companies

Van de Velde Els [1]

Clarysse Bart [2]

Wright Mike [3]

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[1] Els Van de Velde, Faculty of Economics and Business Administration, Ghent University, Hoveniersberg 24, 9000 Gent, Email: els.vandevelde@ugent.be
2 Bart Clarysse, Faculty of Economics and Business Administration, Ghent University, Hoveniersberg 24, 9000 Gent
[3] Wright Mike, Nottingham University Business School, Jubilee Campus, Wollaton Road, Nottingham NG8 1BB, UK

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ABSTRACT

Innovative start-ups, including spin-offs from universities and companies, play a vital role in the development and growth of emerging, high-technology industries. Research attention has traditionally focused on the links between demographic, educational, psychological and financial influences on start-up activity and growth. The extent to which the characteristics of technology inherited from the parent, important for spin-offs, helps explain post start-up performance has been neglected. We analyse the scope and newness of the endowed technology as a predictor of post-spin-off growth for corporate and university spin-offs. Using a novel, hand-collected dataset, 48 corporate and 73 university spin-offs were identified, comprising the whole population of such spin-offs in Flanders over the period 1991-2002. We find that corporate spin-offs seem to benefit from a narrow scope of technology and a high level of newness of technology, while university spin-offs benefit from a broad scope of technology and a lower level of newness of technology. We conclude that the same choice of technology endowments may have a different impact on the spin-offs' growth, since spin-offs start with different knowledge inheritance.

KEY WORDS: technology endowment, corporate spin-offs, university spin-offs

INTRODUCTION

Technology's profound effect on the industrial landscape is pervasive and is felt in nearly every sector of the economy (Zahra, 1996a). Spin-offs play an increasingly important role in the development and growth of emerging, high-technology industries such as artificial intelligence, biotechnology, multimedia, personal computers, software, and telecommunication (Bell and McNamara, 1991). They are widespread in industries such as semiconductors (Braun and MacDonald, 1978), disk drives (Christensen, 1993), and lasers (Klepper and Sleeper, 2005). In these high-technology industries, spin-offs are also major innovators. For example, in the semiconductor industry, so many spin-offs can be traced back to one firm, namely Fairchild Semiconductor, that they have been called Fairchildren (Klepper, 2001). Oakey (1995) has argued that two major sources of new high-technology firms are higher-education institutions and well-established industrial firms. Goldman (1984) found that 72 percent of the high technology companies in the Boston area in the early 1980s were based on technologies originally developed at MIT laboratories. As a result, the Route 128 economic infrastructure might not have existed in the absence of MIT and its spin-offs, even though most of these spin-off companies were not based on technologies formally licensed from MIT.

The effect of originating from a parent may influence the spin-off beyond formation, as the transfer of knowledge from parent to progeny organizations can both constrain and empower the spin-off (Brittain and Freeman, 1986; Romanelli, 1991; Sapienza et al., 2004). Heterogeneity in a spin-off's resources has been related to the prior affiliation of the spin-off with its parent firm (Carroll et al., 1996; Helfat and Lieberman, 2002; Klepper and Simons, 2000). Klepper and Sleeper (2005) found that differences in spin-offs can be traced directly to their parents, who provide them with distinctive knowledge and resources. They argue that spin-offs inherit general technical and market-related knowledge from their parents that shapes their nature at birth. In addition, more recent studies have found that entrepreneurial origin has an impact beyond the starting configuration and may affect survival (Agarwal et al., 2004) and growth (Sapienza et al., 2004) of spin-offs. In this paper, we attempt to develop a thorough understanding of the impact that technological resource endowments have on the performance of spin-off companies.

In the spin-off literature, two types of parent institution have been identified. First, incumbent firms are supposed to generate corporate spin-offs (CSOs) (Sapienza, Parhankangas and Autio, 2004). A corporate spin-off (CSO) is defined as “a separate legal entity that is concentrated around activities that were originally developed in a larger parent firm. The entity is concentrated around a new business, with the purpose to develop and market new products or services based upon a proprietary technology or skill.” Second, universities and public research institutes are supposed to generate university spin-offs (USOs) (Wright, Clarysse, Mustar and Lockett, 2007). A university spin-off (USO) is defined as “a new company that is formed by a faculty, staff member, or doctoral student who left the university or research organization to found the company or started the company while still affiliated with the university, and/or a core technology (or idea) that is transferred from the parent organization” (Roberts and Malone, 1996; Smilor et al., 1990; and Steffenson et al., 1999).

Although each spin-off population has been analysed separately (Agarwal et al., 2004; Lockett et al., 2005), researchers have overlooked the impact of the resource endowments and more specifically of the technological resources that are inherited from the parent organization. Since universities and corporations have different research foci and expertise in marketing, production and distribution (Zahra et al., 2007); we might expect them to transfer different technological resources to their spin-offs. Universities usually focus more on radically new and disruptive technologies that may create new industries and redefine existing markets (Christensen, 2003; Danneels, 2004), while large corporations tend to focus on incremental innovations to improve and strengthen their current product base. Universities typically create new knowledge that is grounded in scientific exploration and discoveries. The high cost and expertise necessary for developing this knowledge has encouraged universities to commercialize their knowledge by creating USOs (Franklin, Wright and Lockett, 2001; Lockett et al., 2005; Shane, 2004). In contrast, corporations create market oriented knowledge, which is often not appreciated by the business units (Chesbrough, 2003; Saxston, 2006). Because the business unit managers are not interested to develop this knowledge further into products that are of interest to the parent organisations, employees start up spin-offs to commercialise the results with or without support of the parent company. Parent organizations have different cultures, incentives and systems (Moray and Clarysse, 2005) that are passed on to the spin-offs, determining their technology strategy and growth. There is, therefore, a need to examine the importance of a spin-off’s origin on the technology endowment choice and the venture’s subsequent growth. Examining differences in the resource endowments of CSOs and USOs is central to enhance our understanding of the role of different institutional contexts. The resultant insights have important implications for the design of more fine-grained policy to stimulate spin-offs. Our central research question is, therefore:

RQ1: Do these resource endowments translate into differences in growth?

This study makes a number of contributions. First, we contribute to the spin-off literature. Specifically, we add to previous work on the role of institutional linkages (Mustar et al., 2006). Previous research has considered the effect of parental culture, routines and strategic choice. While previous research has also examined the role of the extent to which spin-offs are dependent on the parent organization for technology, consideration of the nature of technology has been limited to whether a formal or informal transfer of technology has occurred. We extend this literature by considering the scope and newness of the technology transferred in the context of spin-offs emerging from two types of institutional context. Second, we contribute to the literature relating to the determinants of the growth of new ventures. We go beyond the traditional literature that has focused on the demographic, educational, psychological and financial influences on growth to consider the extent to which the characteristics of technology inherited from the parent are important in explaining post start-up growth. Third, and more generally, we contribute to the organizational sociology literature and the institutional theory literature. Corporate and university spin-offs are unique among new ventures in that they originate from a larger parent institution. Organizational sociologists have long considered the effects of the transfer of resources and routines from old to new organizations (Phillips, 2002). They have attempted to establish a framework for understanding new organizations as the progeny of parent organizations. Models and metaphors from biological evolution are increasingly being used in the analysis of organizations (Aldrich 1999), business strategy (Barnett and Burgelman 1996), and industrial competition (Nelson 1995). Studies have posited that part of a parent organization's "blueprint" would carry over to the new organization through the experiences of the founders of the spin-off companies (Hannan and Freeman, 1986; Romanelli, 1991). Spin-offs inherit general technical and market-related knowledge from their parents that shape their nature at birth (Klepper and Sleeper, 2005). Yet, while past efforts have emphasized the source of progeny, few previous attempts have been made to assess empirically the consequences of transferring technology endowments from parent organizations to their progeny.

This paper unfolds along the following lines. First, we discuss the theoretical framework used to develop the hypotheses to be tested in the empirical part of the study. Next, we present the research methodology, followed by the research results. We make use of a novel, hand-collected dataset comprising CSOs and USOs in Flanders. Finally, we discuss the results as well as the theoretical contributions and limitations of the study.

ENTREPRENEURIAL ORIGIN

Researchers have suggested that entrepreneurial origin is an important source of resource differences, strategies, and performance (Knight, 1989; McGrath andMacMillan, 2000; Shrader and Simon, 1997). Routines and resources are transferred from old to new organizations through personnel migration (Aldrich and Pfeffer, 1976; Almeida and Kogut, 1999; Pfeffer and Leblebici, 1973). People leave corporations and universities to join or create CSOs and USOs. The organizational blueprints of these parent organizations can transfer across firm boundaries, in a manner analogous to the reproduction and transmission of biological genes (Winter, 1991). These transfers may include unique insights and decision rules to transform resources into action (Prahalad and Bettis, 1986), cognitive dimensions of competency (Fiol, 1991), and specific knowledge and information (Boeker, 1997). Since “what an organization knows at its birth will determine what it searches for, what it experiences, and how it interprets what it encounters” (Huber, 1991), one implication is that a spin-off’s capability accumulation may be linked to its inherited knowledge and that the agent of transfer may have an impact on the efficacy of transfer.

In the US, legislative initiatives such as the Bayh-Dole Act of 1980 helped to accelerate the rate of diffusion of new technologies from universities and federal laboratories to firms. Similarly, in European countries legislation was enacted to stimulate the commercialization of university-based research and technology. Licensing has traditionally been the dominant route for the commercialization of technology invented at universities and research institutes (Shane, 2004) but there has been increasing attention to spin-offs from universities (Siegel, Veugelers and Wright, 2008). Shane (2004) found that USOs tend to be established to exploit technologies that are radical, tacit, early stage and general-purpose. Radical technologies tend to provide the basis for the creation of university spin-offs, while incremental technologies are more likely to be licensed by established companies (Lowe, 2002). Research has shown that, when a university technology is at a very early stage of development, and so is ‘unproven’, it cannot be licensed easily to established firms. As a result, early stage inventions tend to lead to the formation of spin-offs (Doutriaux and Barker, 1995). USOs often need to overcome cultural obstacles since spin-off companies are often perceived to be diluting academic work and potentially risking the university’s reputation (Blair and Hitchens, 1998). University spin-offs generate several problems for the achievement of the traditional academic goals of the creation and dissemination of knowledge.

Corporate spin-offs also originate from a larger parent organization, specifically established firms. Agarwal et al., (2004) state that established firms with abundant, but underexploited knowledge are especially fertile grounds for spin-off formation. Corporations may support the entrepreneurial actions taking place within their organization (Sharma and Chrisman, 1999; Covin and Miles, 1999). However, not all established firms are unwilling to support entrepreneurial initiatives. Therefore, other studies have looked at entrepreneurial spin-offs that are created by employees who wish to pursue business ideas that are not supported by the parent company (Agarwal et al., 2004).

Researchers have examined the organisational institutional context in which technology transfer activities take place. Clarysse et al (2007) found that the degree to which the technology is “formally” transferred from the parent organization to the USO has both a direct impact on the starting resources of the USO and on its later growth path. Bercovitz et al. (2000) looked at the effect of institutional structures and policies on patenting and licensing behaviour. Di Gregorio and Shane (2002) related institutional determinants to the spin out rate of (public) research organisations. These institutional determinants include characteristics relating to reward systems, entrepreneurial/academic culture, IP policies and the overall organisational structure of the research organisation. Previous research has suggested that knowledge overlap between the source and recipient affects the ease with which a technology is assimilated by a new organizational unit (Szulanski, 1996). In this paper, we extend previous research by looking at how the institutional context influences the technology transfer from parent organizations to corporate and university spin-offs.

RESOURCE ENDOWMENTS OF SPIN-OFF COMPANIES AND GROWTH

A number of scholars have examined the starting resource configurations of spin-off companies, drawing on the resource-based view of the firm (Penrose, 1959; Wernerfelt, 1984; Barney, 1991; Teece, Pisano and Shuen, 1997; Eisenhardt and Martin, 2000). Central to this perspective is the idea that firms differ in their resource positions, and that such resource heterogeneity is a source of performance differences across firms (Barney, 1991; Peteraf, 1993). Amit and Schoemaker (1993) define the firm's resources as stocks of available factors that are owned or controlled by the firm. The unique bundle of tangible and intangible resources comprising the firm enables it to conceive and implement strategies that improve efficiency and effectiveness (Wernerfelt, 1984; Barney, 1991). Firm competitive advantage is rooted in resources that are valuable and inimitable, and the firm's survival largely depends on how it creates new resources, develops existing ones, and protects its core competencies (Day and Wensley, 1988). Resources are converted into final products or services by using a wide range of other firm assets and bonding mechanisms such as technology, management information systems, incentive systems, trust between management and labour and more.

Previous research has examined the resource endowments of young high-tech companies such as spin-off companies. In an attempt to conceptualize the heterogeneity of these companies, Mustar et al., (2006) give an excellent overview of papers dealing with this subject. They distinguished papers that mainly focus on the resources of the firm as a differentiator and a predictor of competitive advantage. Among these resource-based studies, some authors emphasise the differences in social resources at start-up (Westhead and Storey, 1995; Shane and Stuart, 2002) as an explanatory factor, others focus mainly on the financial resources (Hellmann and Puri, 2000) or on the technological resources (Bower, 2003). Recently, Heirman and Clarysse (2004) and Druilhe and Garnsey (2004) have offered comprehensive views of different starting configurations including social, technological, financial and human resources. Another group of papers focuses rather on the relation between spin-offs and their parent organisation. Most of these studies analyse how decisions made by the parent institution might influence the starting configuration and business model of the spin-off (Radosevich, 1995; Roberts and Malone, 1996; Carayannis et al., 1998; Steffensen et al., 2000; Meyer, 2003; Clarysse et al., 2005; Moray and Clarysse, 2005; Westhead and Storey, 1995; Lindelof and Lofsten, 2004; Link and Scott, 2004). This research has considered the effect of parental culture, routines, the incubation context (e.g., Link and Scott, 2004) and the strategic choice of the parent in terms of whether a formal, proactive and supportive framework was in place to facilitate spin-offs (e.g., Radosevich, 1995). Prior research has also examined the role of the extent to which spin-offs are dependent on the parent organization for technology (e.g., Roberts, 1991), and whether a formal or informal transfer of technology has occurred (e.g., Moray and Clarysse, 2005; Clarysse et al., 2005). This literature has not, however, examined the heterogeneity of the technology transferred in terms of its scope and newness in the context of spin-offs emerging from two types of institutional context

THE TECHNOLOGY ENDOWMENTS OF SPIN-OFFS

Spin-offs are created to commercialize a new technology. The venture is spun off from that parent institution, implying that the parent institute makes the strategic choice not to commercialize further the technology itself. According to Itami and Numagami (1992), technology is the most fundamental of the core capabilities of a firm. The technology endowments spin-offs receive from their parent thus likely influences their ability to commercialize their new technology.

The literature considers the scope and newness of technology as relevant characteristics of technological resources. The scope of a technology refers to the choice between focusing on a platform technology or on a specific (product) technology. A platform technology is a technology built on a broad technology platform, which can serve as a base for several products and market applications (Meyer et al., 1997). A platform technology can lead to different products that are commercialized using different business models. It can also be an evolving system of separately developed pieces of technology that connect to an interrelated system (Gawer and Cusumano , 2002). In contrast, a product technology is a new technology embodied in a very specific product. The scope of a technology is also implicitly included in several strategic choices previously stated in the literature: the product line breadth (Zahra and Covin, 1993), the intensity of product upgrades (Zahra and Bogner, 1999) and the number of products introduced to the market.

The newness of the technology refers to the degree to which the technology is innovative. A new technological innovation embodies a technology which is substantially different from and better than existing technologies (Chandy and Tellis, 2000; Tushman and Anderson, 1986). Technological innovation represents the intellectual or knowledge component of the technology, which is largely intangible. Schoonhoven et al. (1990) distinguish between (1) innovation achieved through the creation of new knowledge, and (2) innovation created by knowledge synthesis, in which existing knowledge is combined in unique ways to create a new product. Technological innovation can be defined as a technology new to a given organization or to a given industry (Tornatzky et al., 1983). We consider technological innovation only from the perspective of a given organization. The newness of a technology is also implicitly included in several strategic choices previously stated in the literature: the commodity-to-specialty products (Zahra and Covin, 1993), technological leadership (Narayanan, 2001), innovativeness (Zahra and Bogner, 1999) and pioneering (Zahra, 1996b). In the following paragraphs, we develop hypotheses on the relationship between these technology endowments and the growth of corporate and university spin-offs.

THE INFLUENCE OF TECHNOLOGY ENDOWMENTS ON THE POST-SPIN-OFF GROWTH OF CSOs AND USOs

Technology’s importance in determining success has been widely recognized in the literature (Zahra, 1996a). In numerous industries, companies have used their technologies to create an enduring competitive advantage by offering new products or utilizing new processes, revising the rules of competition, or redrawing their industry’s boundaries (Utterback, 1994). Technology as an endowment is important for new ventures’ market survival and financial success since poor technologies can undermine the success of ventures (McCann, 1991). Spin-offs can be created for very different purposes. USOs often come to the market as a result of a technology-push decision made by the university or public research organization (Wright et al., 2007), while CSOs tend to approach the market from a market-pull perspective, being either established by a parent perceiving a market need or set up by employees who do not receive the necessary support from the parent organization (Agarwal et al., 2004). These two different dynamics can lead to different endowments concerning the nature of the technology.

Scope of Technology

The scope of technology will influence the venture's growth (Grant, 1996). The breadth of a portfolio depends on the company's technology posture, risk orientation, environmental perceptions, financial resources and the capacity to manage the portfolio's complexity (Zahra, 1996a). A broad portfolio enables a company to pursue many market opportunities, reduces its vulnerability to rivals' technologies, and permits it to capitalize on the convergence of different technologies in creating new markets. A broad technology platform may encompass several promising applications, which can lead to a large number of products. However, a broad portfolio can tax the company's organization, resources and management. Intense product development and introductions require significant resource commitments, often resulting in an increase in employment, though without a guarantee of success. A broad scope of technology may imply that the attention of management is scattered over many products and potential product applications. This may make it more difficult to single out a few technologies and develop them into market-ready products.

Since spin-offs are created to commercialize a new technology, it is not always clear what the potential applications may be in the initial phase of developing the technology. Therefore, it might be more beneficial for spin-off companies to develop a broad portfolio since a broader scope of technology may heighten the chances of developing some successful applications. A broad scope of technologies, or platform technologies, provides a good basis for starting a spin-off company because it allows founders to change market applications if the first application that they pursue turns out to be a dead end (Tornatzky et al., 1995). This flexibility is important to the survival of new companies, which have no existing products to fall back on should an application for a new technology prove to be unviable. Second, a broad scope of technologies allows spin-offs to diversify risks and amortize their costs across different market applications, both of which are important to the establishment of successful new firms. It provides the new firm with potential market applications that are achievable at different points in time: some in the short term, others in the medium term, and still others in the long term (Nelson, 1991). This flexibility allows the founders of the spin-offs to match the pursuit of market applications to resource assembly over time and so better manage the firm creation process.

By their nature, universities are typically more focused on performing basic research, while companies execute more applied research (Shane, 2004). Basic research includes more fundamental research, which increases the chances of creating a broader scope of technology. Nelson (1991) found that university spin-offs tend to exploit general-purpose technologies, or basic inventions with broad applications in many fields of use. Universities have set up technology transfer offices to facilitate the commercialization of technologies invented within the research groups at the university. These technology transfer officers regard USOs as a means to generate income. Where the new technology is rather small and incremental in nature, the technology will likely be licensed to a company (Lockett, Siegel, Wright and Ensley, 2005). However, where the technology comprises a large technology platform, the technology transfer officers will have a preference to commercialize the technology through a USO. Three main reasons can be identified: 1) technology platforms may lead to many market applications, which can generate considerable revenues and make a spin-off more viable and sustainable through the development of follow-on products; 2) it is difficult to convince large corporations of the potential of early stage platform technologies as specific products may not be identifiable; and 3) technology transfer officers are generally less skilled in framing specific products, favouring a platform technology (Vohora, Wright and Lockett, 2004). Therefore:

> H1a: In the case of USOs, a broad scope of technology at start-up will be positively associated with post-spin-off growth.

CSOs are often started as a result of market-pull. Corporations see a market opportunity and develop the new technology in order to fulfill this market need. Due to their previous working experience in their parent firm, the employees of the CSOs have built up technological skills and knowledge. This will encourage them to focus on a more narrow scope of technology in order to address the identified market opportunity. Moreover, CSOs can also be created by employees who wish to pursue business ideas that are not supported by the parent company (Agarwal et al., 2004). Sometimes, the potential of the business idea is not large enough for the parent firm e.g. parent firms often demand that new products have the potential to become multi-million dollar products. However, this does not exclude the fact that the business idea or product, although smaller, may be very valuable. This also favors CSOs to focus on a narrow scope of technology. Therefore:

> H1b: In the case of CSOs, a broad scope of technology at start-up will be negatively associated with post-spin-off growth.

Newness of Technology

A high level of newness of technology may allow a spin-off to break the technological competences and power of established competitors and realize extreme growth. Being at the forefront of innovation may guarantee a longer term success (Tushman and Anderson, 1986). A high level of newness of technology can allow a company to fulfil a unique place in the technology and market needs of certain customers. Developing and introducing radically new products may be a proactive, aggressive attempt to push out the technological frontier in an industry (Kerin et al., 1992). However, developing radical technologies may be risky because it demands extensive investments in R&D, market development and customer education (Ali, 1994). Even where the company succeeds in bringing the technology to market, it is not certain that the company will be able to reap the fruits of their breakthrough technology.

As already noted, USOs tend to be founded to exploit technologies that are radical, tacit, early stage and general-purpose, which provide significant value to customers, represents major technical advances and have strong intellectual property protection. Several academic studies show that radical technologies tend to provide the basis for the creation of USOs, while incremental technologies are more likely to be licensed to established companies (Shane, 2004). Many university inventions lead to the formation of spin-offs because they are early stage technologies that are little more than ‘proof of concepts’ where the researcher discloses the invention to the university TTO. When a university technology is at a very early stage of development, and so is ‘unproven’, it cannot be licensed easily to established firms. As a result, early stage inventions tend to lead to the formation of spin-offs (Doutriaux and Barker, 1995; Vohora, Wright and Lockett, 2004). Roberts (1991) found that most USOs lack prototypes of their products at the time of spin-off even if they have achieved proof of principle in the laboratory. Radical new technologies usually take longer to develop than incremental technologies. A high level of newness of technology may therefore lead to longer development times and consequently to a lower short-term growth. Therefore:

> H2a: In the case of USOs, a high level of newness of technology will be negatively associated with post-spin-off growth.

CSOs are also created to commercialize a new technology. Due to their previous working experience, we might expect managers in CSOs to be more likely to engage in incremental technologies so as to get the products out as fast as possible in order to generate revenues. An incremental technology may allow the use of existing technological and production knowledge to transform the technology more rapidly into a market-ready product. Once products are on the market or a technology can be proven, revenues can be generated by selling the product or technology or by licensing the technology out. However, in the case of spin-offs that are often small entrants facing existing or new industries, a high level of newness may enhance growth by creating a period of monopoly where the ventures can position themselves. Pioneering can pre-empt the competition and strengthen the position of spin-offs. CSOs should pay attention to the level of newness of their technology, to protect themselves from competitors and their products from imitation. Therefore:

> H2b: In the case of CSOs, a high level of newness of technology will be positively associated with post-spin-off growth.

RESEARCH METHODOLOGY

Sample and data collection procedure

To test our hypotheses, we used the HITO database as a starting point to identify corporate and university spin-offs. This is a comprehensive database containing almost all research-based start-ups founded in Flanders between 1991 and 2002. Flanders is a small, export intensive economy located in the Northern part of

Belgium. Flanders is an emerging high tech region, experiencing a fast process of convergence between old and new technologies and thereby improving its competitive position (Cantwell and Iammarino, 2001). In this database, a research-based start-up is defined as a new venture that has its own R&D activities and develops and commercializes new products or services based upon a proprietary technology or skill. To construct the sample frame, we first identify the research-based start-ups among academic spin-outs, venture capital backed firms, and start-ups that received R&D subsidies. Next, we complement our sample with a random selection drawn from the entire population of companies that are active in high-tech and medium high-tech industries. In total, our sample comprises 205 firms founded in Flanders (Belgium). The HITO database contains three different subgroups: USO, CSOs, and independent start-ups. We use the CSOs and USOs identified in this database to address our research questions. The database comprises 48 CSOs and 73 USOs. To collect the data, all firms were visited by two researchers to conduct a personal interview with the founder or the different founding team members (Baron and Ensley, 2007). After the interview, the structured information was put into a database and the case history was written down in an interview report. The founders were targeted as key informants since, given the size and nature of the firms, they typically possess the most comprehensive information on the transfer of knowledge that has taken place between the parent firm and the spin-off (Kumar, Stern and Anderson, 1993).

Dependent Variables

Growth is a complex and multi-dimensional concept that is difficult to cover with any single measure (Delmar et al., 2003; Davidsson, et al., 2007). A number of indicators of venture performance have been found to be relevant, and have good inter-rater reliability, internal consistency and external validity (Chandler and Hanks, 1993). Several scholars have argued that traditional accounting-based indicators of profitability are inappropriate for young companies (Shane and Stuart, 2002). Newer high tech firms in particular may be loss-making since they are in the early stages of developing a market presence. Sales, on the other hand, are often a preferred measure of firm growth and financial performance of new ventures (Ardichvili et al., 1998; Hoy et al., 1992) because it is relatively accessible, it applies to (almost) all sorts of firms, and it is relatively insensitive to capital intensity and degree of integration (Delmar et al., 2003). Sales growth indicates the market acceptance of a venture’s products. Spin-offs that are able to grow their revenues at a faster rate in their early years are offering goods and services that customers quickly choose to buy (Chesbrough, 2003). These spin-offs are more likely to turn profitable sooner, to burn less cash and are more likely to achieve a profitable liquidity event (trade sale or IPO) for their investors (Bhide, 1992). Growth in sales has been used in several studies on CSOs (Parhankangas and Arenius, 2003; Sapienza et al., 2004; Agarwal et al., 2004; Zahra, 1996b). Sales growth was operationalized as total sales revenue in Euro in 2005, controlling for total sales revenue at founding. Due to the differences in age of the spin-offs, we standardized the growth measures.

The growth of spin-offs can also be measured on a non-financial basis. Growth in employees is a good indicator of the speed with which a new venture is able to grow (Chandler and Hanks, 1994). In the case of spin-offs, it is possible that assets and employment grow before any substantial sales and revenues are generated or profitability is obtained. Arguments have been offered for employment as a much more direct indicator of performance than sales (Brush et al., 2001; Delmar et al., 2003). In the high tech sector, growing employment may be associated with the development of legitimacy and value in the technology; venture capital -backed high tech firms may be floated on a stock market at considerable values before any sales have been generated (Davila, Foster and Gupta, 2003; Janney and Folta, 2003). Resource-based scholars value employment-based measures as a highly suitable indicator of firm growth. For example, Hanks et al. (1993) and Brüderl and Preisendörfer (2000) did not focus so much on financial measures of performance, but on exponential growth in employment. Employment growth was operationalized as employment in 2005, controlling for total employment at founding.

The growth measure developed here captures both aspects of growth, namely sales growth and employment growth. The partial least square (PLS) technique used to test the hypotheses permits multiple measures of both dependent and independent variables (Birkinshaw et al., 1995), on condition that the reliability of individual items, the internal consistency between items and the discriminant validity between constructs is acceptable. Since this is the case for our dependent variable growth, both sales growth and employment growth are used to capture the construct growth. In their review of small firm growth studies, Davidsson et al., (2007) found that most researchers use employment and sales growth to measure growth.

Independent Variables

The *scope of technology* measures the extent to which the technology is being developed with the purpose of one specific technology or, in contrast, as a broad platform of technologies with many applications. This item was based on measures used by Meyer et al., (1997) and Heirman (2004). The scope of technology is measured at the time of founding. The measure is based on a five point Likert-scale ranging from 1 (specific product) to 5 (platform technology).

The *newness of technology* entails the innovativeness of the technology the spin-off would like to commercialize. Schoonhoven et al., (1990) make a distinction between innovation achieved through the creation of new knowledge and innovation created by knowledge synthesis, in which existing technological knowledge is combined or synthesized in unique ways to create a new product. The newness of technology is measured at the time of founding. The first question was designed to measure the extent to which new knowledge was created, using a Likert-scale from 1 (new technological knowledge) to 5 (existing technological knowledge). For the analysis, the scale was inverted to indicate increasing degrees of innovativeness. The second question was designed to measure the extent to which knowledge was combined in unique ways to synthesize information, using a Likert-scale ranging from 1 (no synthesis) to 5 (elaborate synthesis).

Control Variables

The age of the spin-off, size, start-up capital, uniqueness and relatedness were included as control variables. Age was measured as the number of months the spin-off had existed as an independent entity. A number of studies in the entrepreneurship literature have argued that high tech start-ups with larger founding teams also perform better (Feeser and Willard, 1990; Heirman and Clarysse, 2007). The size of the founding team is often an indicator of the heterogeneity of such a team so it is appropriate to control for this. The size of the spin-off was measured as the number of founders of the spin-off, following Roberts (1991). Next, we directly measure the start-up capital of the spin-off. Spin-offs that are able to attract more capital within the first years after legal foundation have also been argued to be more successful (Hellman and Puri, 2001; Lockett and Wright, 2005; Heirman and Clarysse, 2007). Further, we control for uniqueness of the technology, which captures the degree to which capable competitors can copy the technological developments of the spin-off. The uniqueness of the technology refers to the tacit character of the technology, e.g. if it is difficult or easy to transfer and codify the technological knowledge in a systematic way (Subramaniam and Venkatraman, 2001). We asked respondents to assess the statement "Our competitors could easily copy our products/services by investigating them (Zander and Kogut, 1995), using a seven point Likert-scale ranging from 1 (strongly disagree) to 7 (strongly agree). Finally, we control for the relatedness between spin-off and parent. We measured the technology transfer from the parent to the spin-off through three statements (Sapienza et al., 2004), using a seven point Likert-scale ranging from 1 (strongly disagree) to 7 (strongly agree). (e.g., the technological competencies are based upon the core technologies of the parent firm; the technological competencies complement those of the parent firm; and the developed technology is based upon the technological strengths of the parent firm.)

RESULTS

To test our hypotheses we used Partial Least Squares (PLS) analysis. The PLS technique is one of the structural equation modelling (SEM) techniques developed by Wold (1974) as an alternative to the LISREL program[4]. Generally, PLS results are presented in two stages. In the first stage, the researcher ensures that the measures used as operationalizations of the underlying constructs are both reliable and valid (assessment of the measurement model). Once convinced of the adequacy of the measurement model, the researcher can then proceed to interpret the resulting model coefficients (assessment of the structural model) (Birkinshaw et al., 1995). The acceptability of the measurement model used here was assessed by looking at the reliability of individual items, the internal consistency between items expected to measure the same construct, and the discriminant validity between constructs[5]. To

[4] PLS provides a clear advantage for two reasons: (1) it considers all path coefficients simultaneously to allow the analysis of direct, indirect, and spurious relationships; and (2) it estimates the individual item weightings in the context of the theoretical model rather than in isolation (Birkinshaw et al., 1995). PSL requires only that the basic assumptions of least-squares estimation are satisfied. The estimation is distribution-free, does not pose identification problems, can be used with small samples, and permits the same freedom with respect to measurement scales as ordinary regression (Cool et al., 1989). These advantages have encouraged PLS applications in an increasing number of fields, including economics, education, chemistry and marketing (Cool et al., 1989).

[5] All measures show an item reliability that is higher than the required 0.7. We checked convergent validity using Fornell and Larcker's (1981) internal consistency measure. It is similar to Cronbach's alpha (Barclay et al. 1995), and can be similarly interpreted. As shown in the "Fornell" column in

assess discriminant validity, Fornell and Larcker (1981) suggest the use of Average Variance Extracted (i.e. the average variance shared between a construct and its measures). This measure should be greater than the variance shared between the construct and other constructs in the model. This can be demonstrated in a correlation matrix which includes the correlations between different constructs in the lower left off-diagonal elements of the matrix, and the square roots of the average variance extracted values calculated for each of the constructs along the diagonal. For adequate discriminant validity, the diagonal elements should be significantly greater than the off-diagonal elements in the corresponding rows and columns. Table 1 demonstrates that this is the case for our constructs.

-----------INSERT table 1 here -----------

Having established the adequacy of the measurement model, we can proceed to interpret the resulting model coefficients (Birkinshaw et al., 1995). For each type of spin-off, two models were tested: a base model (including only control variables) and a full model (including control variables and the technology endowment variables).

-----------INSERT table 2 here -----------

-----------INSERT figure 1 here -----------

The base model in table 2 only includes the impact of the control variables on the spin-offs' growth. For the sample of CSOs, the control variables age, start-up capital and uniqueness have a strong and significant influence on growth ($p< 0.05$). Also in the sample of USOs, age and start-up capital have a strong and significant influence on growth ($p< 0.01$). Surprisingly, uniqueness is not significantly related to growth at conventional levels. For USOs, uniqueness does not seem to contribute to

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Table 3, all measures of reliability exceed 0.90, and thus are deemed to be reliable. Our constructs exceed the 0.70 guideline that Nunnally (1978) recommends. The traditional methodological complement to convergent validity is discriminant validity, which represents the extent to which measures of a given construct differ from measures of other constructs in the same model. In a PLS context, one criterion for adequate discriminant validity is that a construct should share more variance with its measures than it shares with other constructs in a given model. Details on the items and factor loadings are available from the authors.

growth. However, relatedness is strongly significantly and negatively related to growth ($p<0.01$). For USOs, size also contributes significantly to growth ($p< 0.05$) and relatedness has a significant, but negative influence on growth.

Next, we included the technology endowment variables in the full model. Both in the case of CSOs and USOs, the full model yields a higher explained variance of growth than the base model. The difference in R^2 values of the base and the full model allows us to examine the substantive impact of adding the technology endowment variables to the model. The effect size f^2 can be calculated as (R^2full – R^2excluded)/(1-R^2full). This indicator provides the substantive impact of adding the constructs. Cohen (1988) suggested 0.02, 0.15 and 0.35 as operational definitions of small, medium and large effect size respectively. The f^2 of the growth of CSOs is 0.057, while the f^2 of growth of USOs is 0.073. Thus, the technology endowment is shown to have a substantial effect on the growth of CSOs and USOs.

In hypothesis 1a, we predicted a positive and significant relationship between the scope of technology and growth for USOs. The hypothesis was strongly supported with a path coefficient of 0.2400 ($p<0.01$). In hypothesis 1b, we predicted a negative and significant relationship between the scope of technology and growth for CSOs. This hypothesis was supported with a path coefficient of -0.2530 at a significance level of 0.05. Hypothesis 2a predicted a negative and significant relationship between the newness of technology and growth for USOs. However, this hypothesis was not supported as the path coefficient is -0.0548 and not significant. We found a negative, but non-significant relationship between the newness of technology and growth for the sample of USOs. Hypothesis 2b predicted a positive and significant relationship between the newness of technology and growth for CSOs. This hypothesis was supported with a path coefficient of 0.1784 ($p<0.10$).

DISCUSSION

The effect of originating from a parent organization may influence the spin-off beyond formation, as the transfer of rules, routines, and procedures from parent to progeny organizations can both constrain and empower the spin-off (Brittain and Freeman, 1986; Romanelli, 1991). University (USOs) and corporate spin-offs (CSOs) follow a different trajectory before they are spun off and the motivation to create the spin-off often differs. The most straightforward way for a university to commercialize its technology is through licenses to existing companies (Shane, 2004). Several academic studies show that radical technologies tend to provide the basis for the creation of university spin-offs, while incremental technologies are more likely to be licensed by established companies. Most USOs are brought to the market under a regime of technology-push. Established firms are typically less involved in performing fundamental research. Therefore, CSOs are more likely to be created to commercialize incremental technologies. Moreover, CSOs are often created in response to a market opportunity.

Hypothesis 1a predicted a positive and significant relationship between the scope of technology and post-spin-off growth in the case of USOs, while hypothesis 1b predicted a negative and significant relationship between the scope of technology and post-spin-off growth in the case of CSOs. Both hypotheses were supported. The results did not support hypothesis 2a; we found a negative, but non-significant relationship between the newness of technology and post-spin-off growth for the sample of USOs. Looking at the results of the CSOs sample, we see that hypothesis 2b which predicted a positive and significant relationship between the newness of technology and post-spin-off growth is supported. An explanation may be found in the organizational origin of the spin-off companies.

Spin-offs inherit general technical knowledge from their parents that shapes their nature at birth (Klepper and Sleeper, 2005). Universities are often preoccupied by performing research that is on the leading edge of technology. When a USO is created, often the technology still needs considerable development time in order to turn it into a market-ready product (Wright, Clarysse, Mustar and Lockett, 2007). University inventions are typically quite embryonic and high risk (Shane, 2004). A strategy of a high level of newness of technology in combination with a radical technology may lead to long development times. Moreover, the market for this technology may not yet be ready or even exist. This may explain the negative relationship between the newness of technology and post-spin-off growth in the case of USOs.

Researchers working at universities often have little business experience. They frequently start developing specific products based on the technology without probing into the market needs. Later on, they sometimes come to the conclusion that the product is not well adjusted to the customer’s needs or that the market is not yet ready (Vohora et al., 2004). Therefore, in the case of USOs, it might be better to maintain a broader scope of technology and to develop several products at the same time. A broad platform of technology allows USOs to change market application in case the first application they pursue turns out to be a dead end (Tornatzky et al., 1995). Moreover, it heightens the chances that some products may be brought to market at several points in time (Nelson, 1991). This may explain the positive relationship between the scope of technology and post-spin-off growth in the case of USOs.

Established firms are less focused on performing research at the leading edge of the field. Mostly, their research activities are more short term focused and related to the customer and market needs. As a result, the founders of CSOs are often more experienced in addressing customer needs and may possess more business experience. Therefore, it might be beneficial for them to focus on a few specific products since they can position them better in the market. CSOs experience less the necessity to keep a broad scope of technologies. They seem to be capable of selecting the right market applications. Developing a broad scope of technology may only delay the CSO in getting its products on the market. This may explain the negative relationship between the scope of technology and post-spin-off growth in the case of CSOs. Abetti (2002) found that the best strategy for a CSO is to practice technological innovations that attack new market niches where the parent lacks core competencies or is uninterested. CSOs need to be able to differentiate themselves from their parent firm in order to succeed (Klepper and Sleeper, 2005). The similarities cannot remain too high. Therefore, a certain degree of newness of technology is required. This may explain the positive relationship between the newness of technology and post-spin-off growth for CSOs.

In all scenarios, age has a significant and positive relationship with performance. This result is in line with expectations. The older the spin-offs, the more time they have had to develop their technology, to identify customers, to bring their products on the market and consequently generate revenues. A spin-off's focus on technology commercialization is expected to increase as they approach adolescence. and start-up capital. Also start capital has a very strong and significant relationship with the performance of both USOs and CSOs. Uniqueness is positively and significant associated with performance in the case of CSOs, while it is not significant for USOs. If a CSO has a high level of uniqueness, this may imply that it will be difficult for the parent firm to copy the technology or to take it over. This will help the CSO to gain a competitive advantage versus its parent firm, especially if they are operating in the same market. For USOs, uniqueness compared to the parent is not so important, since the parent (university) does not have commercial interests or goals. The parent institution is not interested in copying the product coming out of the technology, since they are not commercially driven.

Relatedness is negatively and significant associated with the post-spin-off growth of USOs, while not significant for CSOs. The more the technology of the spin-off is related to the technology of its parent institute, the more difficult it will be for the spin-off to create its own identity. Moreover, if USOs are closely technology related to their parent institution, this may imply that the technology is early-stage, radical in nature and rather unproven. To bring this kind of technology to the market can take quite some time. This can explain the negative effect on the USOs' post-spin-off growth. This also explains the positive and significant effect of the start-up capital. Where a USO receives a large amount of start-up capital, it has more time to bridge the period between developing commercial products out of the technology and actually bringing them to the market (Vohora et al., 2004).

Our results indicate that it is opportune for CSOs to have a high level of newness of technology. This allows them to distinguish themselves from their parent firm. It is beneficial for them to have a rather narrow scope of technology. CSOs tend to be aware of the market needs and therefore it is more profitable for them to focus on a few technologies and to bring these to the market. USOs on the other hand, tend to profit more from a lower level of newness of technology and a broader scope of technology. This may be explained by the fact that USOs usually start with a more radical, leading edge technology. It often takes longer to transform a radical technology into a market ready product. Therefore, a large amount of start capital is necessary to bridge this period of time. USOs also need a broader scope of technology. Due to their limited market experience, their technological developments are less market oriented. A broader scope of technology heighten the chances that one of the technologies will be suited to be transformed more quickly into a product that addresses customer needs.

LIMITATIONS AND AREAS FOR FUTURE RESEARCH

As all studies, this one is not without limitations that provide opportunities for further research. First, although our study involved the population of USOs and

CSOs, it was limited to one geographical region namely Flanders. Our focus on this small geographic area allows us to reduce the influence of non-measured variance and culturally induced variation. The trade-off, however, is that one might question the external validity of this region and our findings. However, we have little reason to believe that the Flemish region would not be comparable to most emerging and developing high technology regions. This restricted the size of the sample studied and also the country institutional environment. The focus on Flanders includes some unique characteristics to the CSOs and USOs of our sample.

In the sample of CSOs, none of the CSOs were the result of an active corporate venturing policy of the parent company. All CSOs were set up in anticipation to a spotted opportunity. The reason for this is that there are almost no large established firms in Flanders that possess an active corporate venturing policy. In recent years, some established firms have started by creating a corporate venturing process, but in Flanders, no CSOs have been spun off yet. Established firms tend to keep their CSOs in this process for several years, before spinning them off. Therefore, it was not possible to examine the impact such an active corporate venturing process has on the technology strategy and performance of CSOs. This situation may be very different in case a sample of CSOs from the United States would be considered. In the US, several multinational firms have had an active corporate venturing process e.g. Xerox.

Also the USOs sample has some unique characteristics. In Belgium, people tend to go to university after graduating from high school. It is not the custom to first go to industry, start working for several years, and then come back to university to study. In contrast, only with rare exceptions do people come back from industry to start an education at the university. The same scenario is the case for doctoral students. Doctoral students tend to be hired a few months after graduating from university. This implies that most doctoral students do not possess any business experience while performing their PhD. Consequently, where these PhD students create a USO, they possess little business experience to transform their technologies into a market ready product. Again, this may be very different from the US context. In the US, it is not that strange to quit your job at the age of 40 and to start a PhD. This implies that these people may possess a considerable number of years of business experience. Further research could benefit from considering the distinctive characteristics of certain regions. This would create more insight into the impact of certain factors unique to the region of the companies on the results obtained in several studies. Moreover, the country institutional environment may vary in terms of incentives and feasibility of spinning-off. In some countries, the ownership of IP generated by universities is held by academics while in others it is held by the university, and restrictions on the ability of academics to create spin-offs may vary (Wright, et al., 2007). Further research might usefully explore the robustness of our findings by incorporating different institutional contexts.

The spin-offs' ability to transform their discoveries (e.g. innovative technology) into products depends on their prior experiences. The corporate or university parent may transfer valuable experience, routines and procedures to their progeny spin-offs (Moray & Clarysse, 2005). Therefore, it might be interesting to consider any benefits that might arise from technological links with the parent. Also the experience of the parent institution in creating spin-offs may impact the configuration of technology and other resources that are spun-off, and which may influence growth. Another limitation is that, while we have incorporated financial resources in terms of start-up capital, we have not explicitly considered the nature of the providers of start-up capital. For example, different types of venture capital provider may have different kinds of expertise that enable them to support the growth of spin-offs (Knockaert, Lockett, Clarysse and Wright, 2006). Further research could explore the role of different financiers.

Nevertheless, our findings have implications for practitioners and policy makers. Our evidence that different configurations of technology are associated with growth patterns in CSOs and USOs, suggests a need for practitioners and policymakers to develop different kinds of expertise among these two types of spin-offs. For USOs, the importance of broader and more radical technologies suggests an initial focus on building value rather revenue streams. Scientific inventions that are narrower in scope may be less appropriate for the creation of USOs, but instead may be more suitable for licensing. Universities thus need to develop mechanisms and capabilities that enable them to sort scientific inventions into those that are suitable for licensing and those which can be developed as USOs. These capabilities need to include both a research base of sufficient calibre to generate new technology and the skills to shape it into new products. Further in-depth research may be needed to examine the different processes by which CSOs and USOs create growth opportunities from the different endowed technologies to refine support in this area. The time scales likely to be involved in the development of products from university inventions emphasizes the need for longer term support mechanisms with significant capabilities to create value (Clarysse et al., 2005). The importance of the amount of start capital emphasises the need for policy support to ensure the availability of such capital for early stage firms. However, given the expected differences in achieving growth resulting from the different configurations of technology between CSOs and USOs, there may be a need to differentiate policy in terms of the timing of financial support and the accompanying expertise of finance providers.

CONCLUSIONS

Researchers have suggested that entrepreneurial origin is an important source of resource differences, strategies, and performance (Knight, 1989; McGrath &MacMillan, 2000; Shrader & Simon, 1997). The resource inheritance of spin-offs can be traced directly to their parents, who provide them with distinctive, but limited, knowledge (Klepper & Sleeper, 2005). In this paper, we examine the influence of technology endowments on the post-spin-off growth of CSOs and USOs. Using a novel, hand-collected dataset of 48 corporate and 73 university spin-offs, comprising the whole population of such spin-offs in Flanders over the period 1991-2002, we have analysed the scope and newness of the endowed technology as a predictor of post-spin-off growth. Our results indicate that it is opportune for CSOs to have a high level of newness of technology. This allows them to distinguish themselves from their parent firm. It is beneficial for them to have a rather narrow scope of technology. CSOs tend to be aware of the market needs and therefore it is more interesting for them to focus on a few technologies and to bring these to the market. USOs on the other hand, tend to profit more from a lower level of newness of technology and a broader scope of technology. This may be explained by the fact that USOs usually start with a more radical, leading edge technology. It often takes longer to transform a radical technology into a market ready product. Therefore, a large amount of start capital is necessary to bridge this period of time. USOs also need a broader scope of technology. Due to their limited market experience, their technological developments are less market oriented. A broader scope of technology heighten the chances that one of the technologies will be suited to be transformed more quickly into a product that addresses customer needs. These findings extend previous work by highlighting the heterogeneity of institutional effects on spin-off firms. In doing so, we also show that it is not so much the amount of technology endowment that is important but rather its nature. The same choice of technology endowments may have a different impact on the spin-offs' growth, since spin-offs start with different knowledge inheritance.

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Table 1. Construct-level measurement statistics and correlation of constructs

CONSTRUCT	Fornell*	Scope of technology	Newness of technology	Growth	Age	Size	Start-up capital	Uniqueness	Relatedness
Scope of technology	1	**1****							
Newness of technology	0.9207	0.5129	**0.9236**						
Growth	0.9267	-0.037	0.1581	**0.9292**					
Age	1	-0.074	0.015	0.2915	**1**				
Size	1	0.1888	0.2139	0.1238	-0.0051	**1**			
Start-up capital	1	0.0779	0.1261	0.0100	-0.1595	-0.1884	**1**		
Uniqueness	1	0.5305	0.4616	0.1439	0.2311	0.0242	-0.1511	**1**	
Relatedness	0.9334	0.2650	0.3429	-0.0670	0.1358	-0.0879	0.2518	0.5776	**0.9082**

* We checked convergent validity using Fornell and Larcker's (1981) internal consistency measure (as shown in the "Fornell" column). It is similar to Cronbach's alpha (Barclay et al. 1995), and can be similarly interpreted.

**Diagonal elements in bold are square roots of average variance extracted (Hulland, 1999)

Table 2. PLS path analysis results (standardized beta coefficients)

	CSOs		USOs	
	Base model	Full model	Base model	Full model
Age	0.3012***	0.2689***	0.2368***	0.1986***
Size	0.1320	0.1363	0.1902**	0.1716*
Start-up capital	0.1998**	0.2205**	0.5781***	0.5961***
Uniqueness	0.2765**	0.3681***	0.0670	0.0243
Relatedness	-0.3001	-0.3538	-0.3079***	-0.3094***
Scope		-0.2530**		0.2400***
Newness		0.1784*		-0.0548
R^2	0.1671	0.2117	0.4740	0.5099

Path coefficients (t-values) * p< 0.10, ** p< 0.05, *** p< 0.01

Figure 1: research model