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WORKING PAPER

Entrepreneurial Origin, Technological Knowledge and the Growth of Spin-off Companies

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ABSTRACT

We contribute to the literature on corporate spin-offs and university spin-offs by exploring how different characteristics in the technological knowledge base at start-up influence spin-off performance. We investigate how the technological knowledge characteristics endowed at start-up predict growth, taking into account whether the knowledge / technology is transferred from a corporation or university. We use a novel, hand-collected dataset involving 48 corporate and 73 university spin-offs, comprising the population of spin-offs in Flanders during 1991-2002. We find corporate spin-offs grow most if they start with a specific narrow-focused technology sufficiently distinct from the technical knowledge base of the parent company and which is tacit. University spin-offs benefit from a broad technology which is transferred to the spin-off. Novelty of the technical knowledge does not play a role in corporate spin-offs, but has a negative impact in university spin-offs unless universities have an experienced technology transfer office to support the spin-off.

KEY WORDS: technological knowledge, corporate spin-offs, university spin-off

INTRODUCTION

The technology transferred to spin-offs from universities or corporations at founding can be viewed as their main asset (Wright et al., 2007). Consequently, the factors related to the endowed technological knowledge are supposed to have an impact on the potential success of these companies after founding (Malerba and Orsinego, 1993). According to Malerba and Orsinego (1993), the technological environment in which a company is founded represents some of the most important economic properties of technologies and the characteristics of the learning processes involved in innovative activities. The technological environment can thus be characterized by the fundamentals of the knowledge characteristics underlying the technological regime, including the complexity, the tacitness and the level of pervasiveness or scope of the technological knowledge base.

We analyze to what extent these knowledge characteristics of the technology base impact spin-off company success. Spin-offs represent an important dimension of corporate entrepreneurship concerned with the creation of new businesses that emerge from established organizations (Phan et al., 2009), which have been under-researched (Narayanan et al., 2009). The heterogeneous nature of these spin-offs has been recognized in the corporate entrepreneurship literature. For instance, Parhankangas and Arenius (2003) examine variations in the nature of the resource dependence and complementarity relationships between corporate parents and spin-offs as a source of heterogeneity.

While researchers have recognized that start-up environment heterogeneity leads to performance differences (Franco and Filson, 2006), the main focus has been on the knowledge overlap between parent organization and corporate start-up and the way in which parent organizations support the spin-off of activities (Sapienza et al.,

2004). Surprisingly, few have looked at the influence of technological knowledge characteristics on spin-off performance, despite the fact that the technological knowledge base is a major determinant of potential success. One explanation might be that much prior research focuses on a single sector where variations in the technological knowledge base are essentially absent, such as e-commerce software (Buenstorf and Fornahl, 2009) and disk drives (Franco and Filson, 2006). A second reason might be that most prior spin-off research has also focused solely on corporate spin-offs (Parhankangas and Arenius, 2003), yet spin-offs from universities present a contrasting technological environment with different underlying technological knowledge characteristics. Researchers have yet to look at how the characteristics of the technological knowledge base in spin-offs from different technological environments impact spin-offs' success. Addressing this issue is important since it adds to understanding of the heterogeneity of new ventures in the corporate entrepreneurship and spin-off literatures. We take the spin-off company as the unit of analysis and focus specifically on the exploitation by spin-off companies of the technology based knowledge resulting from explorative activities undertaken at their parent companies or institutes. We define a corporate spin-off 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 of developing and marketing new products or services based upon a proprietary technology or skill" (Van de Velde, et al., 2006). In parallel, the high cost and expertise necessary for developing the discovery has encouraged universities to commercialize their knowledge by creating university spin-offs (Markman, Siegel and Wright, 2008; Rasmussen, Mosey and Wright, 2011; Sullivan and Marvel, 2011). We define a university spin-off 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 start the company while still affiliated with the university, and/or a core technology (or idea) that is transferred from the parent organization" (Steffenson et al., 1999).

Corporate and university spin-offs are a means to exploit technological knowledge based upon exploration activities that took place in a larger parent organization. As the goal and mission of universities and established corporations are quite different, we expect their explorative activities to have a different focus. This in turn translates into a difference in the kind of technological knowledge transferred to the spin-off. Marsili (2002) suggests that when knowledge originates from universities, it is likely more generic. Corporate and university spin-offs may have different knowledge and other resource bases which they can use to position themselves in their respective markets. Moreover, the institutional origin of the technological knowledge likely moderates the impact of the knowledge characteristics on the performance of the corporate start-up. Tacit knowledge for instance in an academic environment is different from tacit knowledge cumulated in corporations. We offer a first opportunity to observe how different forms of technological knowledge transferred to both corporate and university spin-offs impact their growth.

Our study contributes to prior literatures as follows. First, we add to the resource based literature by examining how organizations' technological knowledge resources impact performance. Our research attempts to provide further insights into how different forms of knowledge generate important sources of competitive advantage by theorizing and testing the role of technological based knowledge. Second, we also advance theoretical and empirical knowledge of the heterogeneity of spin-offs by focusing on the heterogeneity of the technology based knowledge

endowments transferred by the parent organization. to spin-off. Third, we also add to the corporate entrepreneurship literature by conceptualizing that the impact of the technological knowledge base spun-off from the parent organization differs according to the nature of the parental context. Specifically, we identify which different characteristics of the technological knowledge base spun-off has a positive impact on growth of corporate spin-offs and how this differs from the impact of the same knowledge characteristics on the potential growth of university spin-offs. Overall, we provide new insights that contribute to redressing the balance of corporate entrepreneurship research by focusing on the spin-off level of analysis rather than only the parental level (Narayanan et al., 2009). Taking into account the technological knowledge endowments provides a bridge between the parent and spin-off levels.

THEORY AND HYPOTHESES

Exploration and Exploitation of Knowledge: Parent Organizations and Spin-offs

The notion of exploration and exploitation has emerged as an underlying theme in research on organizational learning and strategy (Vera and Crossan 2004), innovation (Rothaermel and Deeds 2004), and entrepreneurship (Shane and Venkataraman 2000). Exploration includes things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery, innovation (March, 1991). Exploitation includes refinement, choice, production, efficiency, selection, implementation, execution (March 1991). Some authors have adopted an evolutionary perspective on exploration and exploitation (Bierly et al., 2009). For example, Rothaermel and Deeds (2004) considered exploration and exploitation as a sequence in new product development. Nooteboom (2006) argues that while we can make a conceptual distinction between exploitation (practice) and exploration (invention), they build upon each other. Exploration arises from exploitation, and exploitation arises from

exploration. However, exploitation cannot take place without prior exploration (Rothaermel and Deeds, 2004). Thus, although spin-offs might still engage in explorative activities building upon the exploitative activities they have initiated, their main focus will be on exploiting knowledge generated at their parent organizations. This implies that the technological knowledge endowed to spin-offs at start-up largely determines their potential for success since exploiting this knowledge will be their main activity.

As firms and universities engage in explorative activities, they also need to find a way to exploit these assets and capabilities. If the exploitation of these activities is at risk of leading to tensions, an option is to create corporate or academic spin-offs. Corporate spin-offs are an answer to the desire to exploit new ideas created within the firm's network and an incentive to exploit accumulated knowledge through the rapid implementation of innovations.

Established firms are not the only organizations that perform explorative activities. The mission of universities is to create new knowledge grounded in scientific exploration and discoveries. Universities are important institutions for educating world-class technologists (Hsu et al., 2007), but are also an important source of knowledge spillovers (Zucker et al., 1998). Creation of an academic spin-off by a faculty member represents a particular innovation process through which innovative knowledge is first generated by academics, and then transferred to the marketplace in the form of a new company (Grandi and Grimaldi, 2005).

Endowments of Technological Knowledge

Technological knowledge refers to knowledge associated with products, technologies and/or processes (Burgers et al., 2008). The accumulation of technological knowledge not only permits more efficient utilization of related knowledge but also enables

organizations to better understand and evaluate the nature and commercial potential of technological advances (Cohen and Levinthal, 1990).

Klevorick et al (1995) describe three main sources of technological opportunities: scientific understanding; technological advances in other industries and positive feedbacks from technological advances in a previous period. We can assume that university spin-offs in general (but not exclusively) are based on technological opportunities which emerge from new scientific understandings, while corporate spin-offs in general target opportunities based on technological advances in other industries (Marsili, 2002). This does not mean that no corporate spin-offs emerge from new scientific understandings. Corporate spin-offs that emerge from large R&D departments in particular tend to be science driven. However, these forms of spin-offs, labeled new leg ventures or harvest ventures, are quite exceptional in the total population of corporate spin-offs (Hill, 2008).

The characteristics of the knowledge underlying the endowed technology can be categorized along three dimensions (Narayanan, 2001): scope/specificity, newness/cumulativeness and tacitness. Scope of the knowledge or technology implies the degree to which it is possible to use the same core knowledge/technology in different applications. As such, a broad scope allows broader diversification. The second characteristic of technology referred is its newness or cumulativeness (Marsili, 2002). Newness of the technology reflects the extent of the innovation's departure from existing technologies, products and practices (Bierly III et al., 2009). The third characteristic is the degree to which technology and the underlying knowledge is "tacit".

The literature on spin-offs adds one additional construct: "technology or knowledge relatedness" (Sapienza, Parhankangas and Autio, 2004). Related

technology based upon knowledge held in common between the parent organization and the spin-off is a factor which enhances the spin-off's ability to recognize valuable from irrelevant knowledge and thus increases the company's efficiency to focus on the valuable knowledge. At the same time, knowledge *not* held in common is a differentiating factor between the spin-off and the parent organization. Thus, some degree of overlap is considered to be optimal, while too little or too much is dysfunctional.

We examine the *scope, tacitness, newness* and *relatedness* as relevant characteristics of the technology endowments that spin-off companies receive and the knowledge overlap between spin-off and parent company. We suggest that the corporate and university organizational context will have different influences on how these different knowledge characteristics are exploited. Table I summarizes our model.

INSERT TABLE II ABOUT HERE

Scope of Technology. 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). In contrast, a product technology is a new technology embodied in a very specific product. The scope of technology will influence venture growth (Grant, 1996).

Exploration activities of universities are often concentrated around science. Some of these scientific activities can lead to the creation of technological knowledge which can subsequently be incorporated in products and services (Ahuja and Katila, 2004). This knowledge can then be exploited through creating a university spin-off. University spin-offs tend to exploit general-purpose technologies, or basic inventions with broad applications in many fields of use (Nelson, 1991). Exploiting a technology

platform 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. A broad scope of technology allows spin-offs to diversify risks and amortize their costs across different market applications. It provides the new firm with potential market applications that are exploitable at different points in time (Nelson, 1991).

Platform technologies allow companies to play a role in the market for technology (Gambardella et al., 2007). The market for technologies increases the effectiveness of strategies associated with specialization in the trade of technologies as opposed to products, creating opportunities for firms that adopt this specific positioning (Arora and Merges, 2004). This allows firms to opt to focus on developing the technology and to avoid incurring costly development of manufacturing and commercialization facilities (Fontes, Conceicao and Calapez, 2008). Since the academic entrepreneur is likely embedded in a technical community (Nahapiet and Ghoshal, 1998) and since markets for technology rely more on technical legitimacy than product market legitimacy (Gans and Stern, 2003), we expect that the academic entrepreneur will be more successful in growing a venture by employing a broad scope of technology to target the market for technology. Thus:

H1a: In the case of university spin-offs, a broad scope of technology at start-up will be positively associated with growth.

A broad product portfolio may also depress firm performance (Meyer and Roberts, 1986). A broad scope of technology can tax the company's resources and management as intense product development requires significant resource commitments, though without a guarantee of success (Zahra, 1996). 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. A narrow scope of technology on the other hand, may lead to focused exploitation. Therefore, it is important to determine the breadth of the product portfolio, based upon a careful examination of customers' needs and the company's resources, as having a large number of products is not always conducive to short-term profitability (Zahra, 1996).

Corporate spin-offs often understand the pressure of taking a technology quickly to the market based upon previous working experience within the parent (Zahra et al., 2007). A narrow scope of technology may lead to successful market introductions of specific products in a short time frame, allowing for successful exploitation of the knowledge gained through earlier exploration (Rothaermel and Deeds, 2004). By focusing on a few specific product applications, corporate spin-offs can quickly address customers' needs, thereby contributing to the corporate spin-off's growth (Bhide, 2000). As established firms often have embedded routines in exploiting technology in product markets, corporate spin-offs may build upon these skills. This may facilitate exploration of specific market opportunities and allow entering the market with a specific product which in turn can offer multiple opportunities (Gans and Stern, 2003). Corporate entrepreneurs may be able to develop competencies precisely because more established firms may be ineffective at organizing for and marketing new technological opportunities (Christensen, 1997). We expect corporate entrepreneurs will focus on a product technology to accelerate growth in the market for products. This means they can benefit most from a specific product technology which can find access to a product market rather than addressing a technology market. Therefore:

H1b: In the case of corporate spin-offs, a broad scope of technology at start-up will be negatively associated with growth.

Newness of Technology. Newness of technology reflects the extent of the innovation's departure from existing technologies, products and practices (Bierly et al., 2009). Technological innovation represents the intellectual or knowledge component of the technology, which is largely intangible. An innovation can be new to the individual adopter, to an organizational unit, to the entire organization, to the industry or sector, or to the whole world (Bierly III et al., 2009). We consider newness of the technology at the industry or sector level.

Being at the forefront of innovation can guarantee long term success (Tushman and Anderson, 1986) as a high level of newness of technology can allow a company to fulfill a unique place in the technology and market needs of certain customers. Many university inventions lead to spin-off formation because they are early stage technologies that are little more than 'proof of concept' where the researcher discloses the invention to the university technology transfer officer (Wright et al., 2007). Although a novel technology may facilitate entry into a market, it might mean that the spin-off faces a long time to market adoption of the products based upon this technology (Agarwal and Bayus, 2002). Many university inventions are very explorative in nature and at a very early stage of development.

A high level of newness of technology often implies that it will probably take time to develop the early stage, explorative technology on which the university spin-off is based into market-ready products and applications. A long development time will have a negative influence on company growth, since it takes a long time before the technology is being exploited in the market and starts generating revenues. In contrast, university spin-offs that are based upon technologies which are considered in

a university environment to be less novel, will probably start with products for which the market is ready, which in turn speeds up the adoption process for a specific company. Therefore:

H2a: In the case of university spin-offs, newness of the technology will be negatively associated with growth.

In their search for new market opportunities, companies often explore several technological trajectories. Some of these may lead to an enduring competitive advantage (Utterback, 1994). To exploit these technologies, corporate spin-offs are sometimes set up to create governance structures that allow rapid adaptation, which is particularly useful where new technical opportunities are being explored (Chesbrough, 2003). A high level of newness of technology may enhance growth of corporate spin-offs by creating a period of monopoly where the spin-off can position itself and protect its products from imitation (Zahra et al., 1995). Corporate spin-offs are often created to obtain the necessary freedom to commercialize some of the explorative activities of the parent as they are too different from its current mainstream activities. Their autonomy allows them to experiment with new ways to exploit the new knowledge. Again, this implies a high level of newness of the transferred knowledge which allows the corporate spin-off to differentiate its knowledge and products from the parent. Corporate spin-offs may target the product market by offering an integrated value proposition that allows it to fulfill a unique place in the market, hence enhancing company growth.

In contrast, when a corporate spin-off starts with a technology whose novelty component is low, one could wonder why the parent wants to spin-off that company. The spin-off might be a result of a restructuring activities where lower potential technological opportunities are spun off from the core. Therefore,

H2b: In the case of corporate spin-offs, newness of the technology will be positively associated with growth.

Tacitness of the Technology. The knowledge underlying skilful performance is largely tacit knowledge in that the performer is not fully aware of the details of the performance and finds it difficult to articulate a full account of those details (Nelson and Winter, 1982).

Tacit knowledge is often defined by its incommunicability as opposed to explicit knowledge, which is easily codified and translated (Nonaka and Takeuchi 1995). The degree of tacitness is a function of the extent to which knowledge is or can be codified and abstracted (Boisot 1995). Explicit knowledge is embedded in product and process technologies, patents, organizational processes, routines and rules (Nelson and Winter 1982).

In the context of university research, Arora and Gambardella (1994) argue that scientific knowledge is more explicit and codified and thus more easy to patent. Building upon this argument, Clarysse et al. (2007) have shown that patents are a basis for success and an indicator of early growth in university spin-off. Similarly, Haussler et al. (2009) show that patents are key for biotech spin-offs to find venture capital and get started. Spin-offs which can show a valuable patent find venture capital much faster. The recent professionalization of university technology transfer offices has led to an increase in quality of patents and an increase in financial support for the spin-offs based upon these patents. In contrast, if knowledge is tacit technology transfer offices at different universities might have difficulties to value the start-up and underestimate the potential of the technology (Wright et al., 2007). Therefore:

H3a: In the case of university spin-offs, tacitness of the technology will be negatively associated with growth.

Although tacit knowledge makes it more difficult for spin-offs to raise capital and gain legitimacy, this kind of knowledge is also hypothesized in the technology management literature to have major advantages over explicit, codifiable knowledge. Tacit knowledge implies that only those who have been involved in the development of the technology and exposed to the use of the relevant techniques possess the know-how necessary to replicate the technology and make use of it (Zucker et al., 1998). This "natural excludability" of the technology has two major implications. First, it means that the technology is less easy to copy and hence provides a competitive advantage to the company which is the first to commercialize it. Imitation will only happen after the technology is adopted in a major part of the market. Second, as knowledge is tacit, it becomes sticky so that the individuals who have initially developed the technology also have a major advantage to build commercial products upon this knowledge. Both arguments suggest a positive relation between the tacitness of knowledge and start-up performance to the extent that the knowledge can be immediately productized.

While universities have been focused on codifying knowledge to value the technology based on patents, corporations have a much more subtle patenting strategy making careful trade-offs between the different protection mechanisms at stake (Thumm, 2004). Thus the use of secrecy to guarantee a time to market advantage is much more appreciated in a corporate context than in the typical university environment. In contrast, when knowledge is explicit parent organizations tend to patent the technology and overvalue a license agreement with the potential corporate spin-off. In that case, growth will be difficult. Therefore:

H3b: In the case of corporate spin-offs, tacitness of the technology will be positively associated with growth.

Relatedness of the Technological Knowledge. Tacitness, pervasiveness and newness of the technology or knowledge base on which the spin-offs are founded reflect the main characteristics along which technologies have been defined in the technology literature (Malerba and Orsenigo, 1993). However, the knowledge based view of the firm suggests that young firms are in a race for accumulating distinctive firm-specific knowledge (Zahra et al., 2002). Parent organizations are therefore an external source of knowledge from which spin-offs can learn more efficiently than from other organization due to the historical link.

Dasgupta and David (1994) argue that different incentive systems in universities versus private companies tend to create totally different attitudes in these environments. Adopting knowledge and technology systems from universities is therefore not likely to help spin-offs to accelerate bringing new products to the market and outperforming potential competitors. If spin-offs overlap too much in their knowledge base with the research department they spin-off from, the learning argument made by Sapienza et al. (2004) that spin-offs can benefit from the routines of the parent might play in the opposite direction. In other words, the academic spin-offs might be too similar to the university department they spin-off from and be unable to identify or recognize the opportunities outside to build up a unique knowledge base. Therefore:

H4a: In the case of university spin-offs, relatedness of technological knowledge with the parent organization will be negatively associated with growth.

In a corporate spin-off context, Sapienza et al. (2004) argue that knowledge held in common is important for the firm's absorptive capacity and learning ability. The spin-off firm needs to develop filters which distinguish relevant from irrelevant knowledge. If a spin-off starts in the same domain as the parent, the knowledge is closely related and the founders of the spin-off will be able to use many of the parent organization's existing routines that are based upon experiential knowledge if the technology is closely related. Also technological choices are made more efficiently if knowledge can be transferred about similar technological choices which have been made in the past. This will allow the spin-off to cut development time and hence more readily realize a first mover advantage. Zahra et al. (2002) were the first to our knowledge to provide empirical support for the argument that faster technological learning is related to growth.

Sapienza et al. (2004) however argue that knowledge which is *not* held in common is also important for growth. A very high knowledge overlap between the corporate spin-off and the parent organization means that the spin-off is not able to differentiate enough from the parent organization and in a way becomes a competitor. So, if the relatedness of the technological knowledge base is too high, the corporate spin-off firm's growth will be limited. Hence:

> *H4b: In the case of corporate spin-offs, growth will be a curvilinear, inverted U-shaped function of technological knowledge relatedness between the spin-off and the parent.*

RESEARCH METHODOLOGY

Sample and data collection procedure

We used a unique dataset containing almost all research-based start-ups founded in Flanders during 1991-2002. Flanders is an emerging high tech region in Northern

Belgium experiencing a fast process of convergence between old and new technologies and thereby improving its competitive position (Cantwell and Iammarino, 2001). This context allows us to control for other environmental factors. A focused dataset also allows us to capture the whole population, thus avoiding the problem of low response rates. Focused datasets have been used in other studies. Hsu et al. (2007) surveyed a group of start-ups which had applied to participate in a semester-long educational program at MIT, while other researchers have focused on a particular region or country (e.g., Japan (Ito and Rose, 1994), Sweden (Lindholm, 1997) and Finland (Parhankangas and Arenius, 2003)).

We first identified all research-based start-ups in Flanders. 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. We used four databases to identify these firms as no existing database contains a complete record of these firms: 1) lists of spin-off companies of public research organization and universities in Flanders, 2) the portfolio of venture capitalists active in early stage investments and located in Flanders, 3) a database a government agency that provides R&D subsidies to Flemish SMEs, and 4) a random sample drawn from the entire population of companies active in high-tech and medium high-tech sectors, this database is commercially available from Graydon.

Of the 1003 firms identified in this first step, a telephone screening was conducted and 247 met the definition of research-based start-up. Of these firms, 205 were interviewed in the first round of data collection in 2002-2003, from which we were able to identify 48 corporate spin-offs and 73 university spin-offs (representing respectively 23.4 % and 35.6% of the original sample). The remainder were

independent start-ups with no prior employment or relationship to established firms or research institutes and are excluded from our analyses.

All firms were visited by two researchers to conduct a personal interview with the founder or the different founding team members. 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). Additionally, archival data was collected to cross validate the information obtained through the spin-off companies. We checked secondary data sources such as web sites, brochures and press releases internal and external to the company. We extracted the financial data from the company's balance sheet available through the National Bank of Belgium. There was a near perfect correspondence between the information provided by the interviewees and the information we found in archival data sources.

In 2006, we updated the database by consulting BEL-FIRST to cross-check and update the information about growth in employees and revenues. BEL-FIRST is a financial database which contains detailed financial information (annual financial accounts) on more than 320,000 Belgian companies. As the dependent variables were measured in 2005, and the independent variables were measured at founding, the potential problem of endogeneity should be minimized.

Our response rate is much higher than the response rate mostly reported in entrepreneurship research. This is mainly because we conducted personal interviews with the founders/CEO and members of the management team at the premises of their firms, instead of using mail or telephone surveys. The responding firms were not

significantly different in size (measured as number of employees) or age from non-respondents, as indicated by Kolgomorov-Smirnov two-sample tests.

Dependent Variables

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 performance 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. Therefore, we focus on growth and not on other aspects of performance. Lopez Iturriaga and Martin Cruz (2008) provide evidence that suggests that spin-offs are one of the best strategies to promote entrepreneurship. A firm's growth is an aspect of entrepreneurship if it is achieved through the introduction of new products and services (Davidsson et al., 2007). As university and corporate spin-offs are created to develop and market new products and services based upon a proprietary technology or skill, examining their growth is of particular interest. Growth is a complex and multi-dimensional concept, difficult to cover with any single measure.

Sales are often a preferred measure of firm growth and financial performance of new ventures (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 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. These spin-offs are more likely to turn profitable sooner, to burn less cash and are more likely to achieve a profitable trade sale or IPO for their investors (Bhide,

1992). Sales growth has been used in several studies on corporate spin-offs (Parhankangas and Arenius, 2003; Sapienza et al., 2004. Sales growth was operationalized as total sales revenue in Euro in 2005, controlling for total sales revenue at founding.

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, 1993). In 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 (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). Resource-based scholars value employment-based measures as a highly suitable indicator of firm growth. Brüderl and Preisendörfer (2000) focused 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 and employment growth.

Independent Variables

The *scope of technology* measure was based on a five point Likert-scale ranging from 1 (specific product) to 5 (platform technology), referring to the choice of a company to focus on a specific technology or a technology platform (Meyer et al., 1997). The scope of technology is a single item measure that is measured at the time of founding.

The *newness of technology* refers to the extent of the innovation's departure from existing technologies, products and practices (Bierly et al., 2009). 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 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 at industry or sector level. 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). The newness of technology is measured at the time of founding (α=0.92).

The measure for the degree of *tacitness* was adapted from Zander and Kogut (1995). We use 7 items, each scored on a 1 to 7 scale. Question 1 dealt with the extent to which it is easy to document usage in manuals or reports. Question 2 concerns the ease of communication through written documents. Question 3 asks to what extent a manual can be made to describe the company's products/services. Question 4 investigates to what extent customers can learn how to use the company's products/services by studying a complete set of blueprints. Question 5 measures to what extent the product/services offered by the company are sophisticated. Question 6 investigates to what extent customers need training to understand the products/services offered by the company and finally, question 7 deals with the degree to which competitors can easily copy the company's product or services by investigating them (inter-item cronbach α=0.8352).

To capture *relatedness*, we use measures developed by Sapienza et al., (2004). Relatedness was measured with a seven-item scale using three statements 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 (α=0.93)[4].

Control Variables

We control for firm age, that is, number of years the spin-off had existed as an independent entity, because new ventures may perform differently at various stages of development (Mosakowski, 1993). As larger firms may be in a better position to attract new customers or to perform better (Heirman and Clarysse, 2007), we included the number of employees (including founders) of the spin-off to account for firm size. Spin-offs able to attract more capital within the first years after legal foundation have also been argued to be more successful (Lockett and Wright, 2005; Heirman and Clarysse, 2007). Therefore, we included the start-up capital of the spin-off as a control variable. We also controlled for the technological domain (industry) in which the companies' were founded. In line with Heirman and Clarysse (2007), we identified biotechnology, electronics, software and 'other' as relevant categories.

RESULTS

We undertook a multiple regression analysis[5] to test our results. The constructs "tacitness" and "scope" were calculated as summated scales. The variables show an

[4] We initially included technological domain as a control variable in the analyses, but left it out in further analyses as it is not significant. We did not include formality of the technology transfer as a control variable as less than 5 % of our sample experienced formal technology transfer.

[5] We also cross checked the stability of our results using Partial Least Squares. PLS is an extension of the multiple linear regression model, imposing the least restrictions of the various multivariate extensions of that approach. This flexibility allows it to be used when traditional multivariate methods are severely limited, such as when there are very few observations in comparison to the predictor variables (de Jong, 1993; Dijkstra, 1983).

inter-item reliability higher than the required 0.7. We checked convergent validity using Fornell and Larcker's (1981) internal consistency measure, which is similar to Cronbach's alpha (Barclay et al. 1995). All measures of reliability exceed 0.90, and thus are deemed to be reliable (Table II). Our constructs exceed the 0.70 guideline that Nunnally (1978) recommends.

INSERT TABLE II ABOUT HERE

For each type of spin-off, two models were tested: a base model and a full model.

INSERT TABLE III ABOUT HERE

The base model in table III only includes the impact of the control variables on the spin-offs' growth. Age has a strong and significant influence on growth in both the sample of university and corporate spin-offs. Only in the sample of university spin-offs, does start-up capital have a significant influence on growth ($p< 0.01$). It seems that in university spin-offs, a significant amount of start-up capital is needed to realize a specific growth ambition.

In the full model, we included the technological knowledge variables. Both in the case of corporate and university spin-offs, the full models yield a higher explained variance of growth than the base model. In hypothesis 1a, we predicted a positive and significant relationship between scope of technology and growth for university spin-offs. The hypothesis was strongly supported with a coefficient of 0.383 ($p<0.01$). In hypothesis 1b, we predicted a negative and significant relationship between the scope of technology and growth for corporate spin-offs. This hypothesis was weakly supported with a path coefficient of -0.19 ($p< 0.1$). Hypothesis 2a predicted a negative and significant relationship between the newness of technology and growth for university spin-offs. This hypothesis was supported, the coefficient is -0.20 ($p< 0.05$).

Hypothesis 2b predicted a positive and significant relationship between the newness of technology and growth for corporate spin-offs. This hypothesis was not supported either, with a coefficient of 0.17. Hypothesis 3a predicted a negative relation between knowledge tacitness and growth for the academic spin-offs, but this did not receive support (coefficient 0.011). Hypothesis 3b predicted a positive and significant relation between growth and tacitness for the corporate spin-offs and was supported (coefficient 0.22), with $p<0.05$. Hypothesis 4a suggests a negative relation between knowledge relatedness and growth in university spin-offs. This hypothesis is supported with $p<0.05$. Hypothesis 4b stipulates a curvilinear (inverse U-shaped) relation between relatedness and growth in corporate spin-offs. This hypothesis does not receive any support. However, there is a significant negative relation between relatedness and growth ($p< 0.05$). In summary, H1a and H1b (knowledge scope) are supported, Hypothesis 2a (technical novelty for academic spin-offs) is supported, H3b (tacitness for corporates) is supported and H4a (relatedness for academics) is supported.

DISCUSSION

Spin-offs have emerged as important and novel organizational forms that revitalize entrepreneurship by creating new ventures beyond the stereotypical independent start-up (Oakey, 1995). Spin-offs are a means to exploit knowledge based upon exploration activities that took place in a larger parent organization. Parent organizations often experience difficulties when they try to pursue both explorative and exploitative activities (March, 1991). Creating a spin-off company may help release the tension involved in simultaneous explorative and exploitative activities, especially if the market in which the activities are exploited is only vaguely related to core activities. Established firms are not the only parent organizations that are under increasing

pressure to commercialize their explorative activities. Universities also experience this pressure. University spin-offs have been created to exploit the technological knowledge developed within universities (Grandi and Grimaldi, 2005).

The importance of the technological knowledge which forms the basis for these companies has been widely recognized as a determinant of success (Zahra, 1996). Yet, little literature empirically tests how differences in technological knowledge impact performance, nor how knowledge source moderates certain relations. Our findings indicate that the source of knowledge matters in the case of knowledge scope and tacitness, but does not modify the impact of knowledge relatedness or newness. University spin-offs benefit from a broad technology to start from with multiple application possibilities. This might be because university spin-offs tend to have less market knowledge and thus have to experiment in the market to find the best opportunities (Vohora et al., 2004). Thus, they seem to benefit from a broader scope of technology at start-up, allowing them to change from one market application to the other if the initial application turns out to be a dead end. These results also support Gambardella and Giarratana (2007) who found that presence of a broad scope of technology allows operations in the market for technologies (licensing) to be combined with being active in the market for products. If the technology cannot be marketed by the spin-offs directly, it might be licensed to incumbents. This is opposite to corporate spin-offs. This may be because corporate spin-offs are founded by managers, who know the market better and thus tend to pursue a specific market opportunity with a given technological solution. Thus, maintaining a narrow scope of technology by focusing on a few products instead of a platform of technologies positively contributes to growth of corporate spin-offs. A narrow scope of technology allows the attention of the founders to be focused on a

few products and potential product applications. This facilitates singling out of a few products and their development into market-ready products, hence enabling growth. These findings support arguments that the best strategy for a corporate spin-off is to practice technological innovations that attack new market niches where the parent lacks core competencies or is uninterested. A specific product focus allows the corporate spin-off to produce goods and services based on the new explorative technology, targeting markets for products. This permits the spin-off to derive revenues primarily from product-related sources.

We expected a negative effect of newness of technology in relation to university spin-off's growth and a positive effect on corporate spin-off's growth, yet we found only support for hypothesis 2a. A possible explanation is that newness may lead to an inability to process and interpret the amount of information generated by excessive exploration, which then poses a challenge to the commercialization process (Gavetti and Levinthal, 2000). Agarwal and Bayus (2002) argued that high tech products based upon novel technologies take a long time to reach market. This might explain why the newness of technology does not contribute to the growth of corporate spin-offs.

As a further robustness test, we tested for a moderator effect between newness of technology and experience of the technology transfer office (TTO) in the sample of academic spin-offs.[6] We found a significant positive impact of the interaction term between TTO size and technological novelty ($p<0.01$) while novelty itself became slightly significant (with a negative impact) ($p< 0.1$). This result suggests that university spin-offs which start up with very novel technology only benefit if the TTO is experienced enough to support them.

[6] Due to space constraints, these results are not reported here but are available from the authors.

We found a negative and significant relationship ($p < 0.05$) between level of technological knowledge relatedness and growth for university spin-offs, as predicted by hypothesis 3a. We find the same negative and significant relation between knowledge relatedness and growth in corporate spin-offs. This underpins prior literature, which suggests that corporate spin-offs need to be able to differentiate themselves from their parent firm in order to succeed (Klepper and Sleeper, 2005). In exploiting the explorative technologies of their parent firm, it is important to create new resource combinations, which in turn can lead to new strategies. However, we do not find a curvilinear relation, which is in contrast to Sapienza et al.'s findings (2004). It may be that we focus here on technological knowledge, while Sapienza et al. also take organizational and market knowledge into account. These forms of knowledge might be more generic in nature and therefore easier to transpose into a different setting. Technological knowledge however might lead to competition if there is overlap with the parent institute.

Finally, we found that knowledge tacitness has a positive impact on growth of corporate spin-offs. This suggests that keeping something secret and, relatedly, having a company which is based upon knowledge susceptible of being kept secret has a larger impact on performance of a corporate spin-off than having a patentable technological knowledge base. Especially in corporate spin-offs, time to market seems to be a key source of competitive advantage. This is not so in university spin-offs, although the fact that technological knowledge can be codified and thus patented does not explain later growth of these companies. Further analysis did not show any curvilinear effect either.

Limitation and Areas for Future Research

Several promising opportunities exist to further extend research in this area. First, although our study involved the population of university and corporate spin-offs, it was limited to one geographical region. Our focus on this small geographic area allows us to reduce the influence of non-measured variance and culturally induced variation. We have little reason to believe that the Flemish region would not be comparable to most emerging and developing high technology regions in Europe (Clarysse, et al., 2005). However, active corporate spin-off policies in Flanders lag behind those in the US. As such, the corporate spin-offs in our sample were set up as a result of an identified opportunity rather than as a result of an active policy by the parent. Also, since in contrast to the US, Flemish doctoral students tend to go directly from undergraduate degrees to PhD studies, where PhD students create a university spin-off, they possess little business experience to transform their technologies into a market ready product. 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, 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.

Second, we focus on technology endowments at founding. It may be that the technological scope of university and corporate spin-offs change over time. University spin-offs may start with a technology platform, but once the market applications become more apparent, decide to focus on a few products. On the other

hand, university and corporate spin-offs may also develop more than one technology platform over time in order to maintain a competitive advantage. We were unable to obtain data on these changes but a longitudinal design, detailing the changes in scope of technology, is a potentially interesting avenue for further research.

Third, given our focus on the role of organizational endowments with regard to the exploitation of technological knowledge, we have not explicitly developed the role of social capital and networks provided by the parent organization or considered the nature of the relationship with the parent organization. The social capital embedded in the parent institute and transferred to the spin-offs can be a valuable resource, unique to each firm, largely invisible to competitors, and difficult for them to imitate, potentially contributing to spin-off growth (Stam & Elfring, 2008). This provides a further avenue for both qualitative and quantitative research. Analyses could consider whether corporations provide more business-related support to corporate spin-offs while universities provide their spin-offs with knowledge-related support. Further, consideration could be given to whether the parent organization maintains a significant equity stake in the spin-off and how this relates to the extent of support that the spin-off can rely on from the parent.

Fourth, we have not explicitly considered the nature of the providers of start-up capital. 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.

Implications for Practitioners and Policy Makers

Our findings have important implications for practitioners and policy makers. This study provides evidence for investors that a careful screening of the technological

knowledge base is important to assess the growth opportunities of the spin-off venture. In contrast to what many investors tend to believe, the “newness” or “novelty” of the technology on which the spin-off is based does not play a major role, on average. Depending on how well founders know the market they target, a platform technology will be more beneficial. The general observation is that if the market is not known, platform technologies offer more possibilities. However, if the market is known, they have a negative impact on growth because they might induce founder-managers to spread their scarce resources too thinly.

Universities thus need to develop mechanisms and capabilities that enable them to sort scientific inventions into those suitable for licensing and those which can be developed as university spin-offs. These capabilities need to include both a research base of sufficient caliber to generate new technology and the skills to shape it into new products. The time scales likely involved in development of products and services from university inventions emphasizes the need for longer term support mechanisms with significant capabilities to create value (Clarysse et al., 2005). This in turn points to the importance of start-up capital, which emphasizes the need for policy support to ensure the availability of such capital for early stage firms (Wright et al., 2006). As corporate and university spin-offs realize growth based upon different technology endowments, there is a need to differentiate policy in terms of the timing of financial support and the accompanying expertise of finance providers.

In most countries, policy makers have implemented different support schemes for university spin-offs ranging from support for export, facilitating access to financial means to subsidies for technological development. However, few schemes for corporate entrepreneurship currently exist. Therefore, as corporate spin-offs clearly demonstrate growth, policy makers could stimulate awareness at (large) companies of

corporate entrepreneurship and support corporate venture capital. This will help to create value out of technologies that often remain on the shelf in absence of corporate venturing activities.

CONCLUSION

Recognition of the heterogeneous nature of spin-offs has been made in prior research. But the role of the technological knowledge base in explaining differences in spin-off growth has been neglected. Moreover, technological knowledge and its impact on performance might be different between spin-offs that emerge from different environmental contexts. We address this gap and find that technological knowledge base at start-up is important in explaining subsequent performance differences of both university and corporate spin-offs. While newness of technology does not appear to have a significant impact upon subsequent growth of corporate spin-offs, it has a linear and negative impact on university spin-off growth. Only when the university hosts an experienced TTO, do university spin-offs benefit from starting with a novel technology. The direction of the effect of the scope of technology is in significantly opposite directions for university and corporate spin-offs. Broad purpose technologies benefit university spin-offs while a narrow technology focus suits corporate spin-offs best. Tacitness of technology has a significant positive effect on growth for corporations, but has no impact in a university setting. Finally, knowledge relatedness has a significant negative impact on growth for both corporate and university spin-offs. These findings provide novel insights that the composition of the technological knowledge base and the way it impacts the success of spin-off companies varies depending upon the institutional environment from which spin-offs emerge. As such, the study adds to understanding of the heterogeneity of corporate entrepreneurship at the spin-off venture level.

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Table I: Hypothesized relationships between the independent variables and Venture Growth by Type of Spin-Off

Independent variable	University Spin-offs	Corporate Spin-offs
Scope	H1a: (+)	H1b: (1)
Newness	H2a: (-)	H2b: (+)
Tacitness	H3a: (-)	H3b: (+)
Relatedness	H4a: (-)	H4b: (^)

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

CONSTRUCT	Fornell* (similar to Cronbach alpha)	Scope of technology	Newness of technology	Growth	Age	Size	Start-up capital	Tacitness	Related ness
Scope of technology	1	**1****							
Newness of technology	0.92	0.51	**0.92**						
Growth	0.93	-0.04	0.16	**0.93**					
Age	1	-0.07	0.02	0.29	**1**				
Size	1	0.19	0.21	0.12	-0.01	**1**			
Start-up capital	1	0.08	0.13	0.01	-0.16	-0.19	**1**		
Tacitness	1	0.53	0.46	0.14	0.23	0.02	-0.15	**1**	
Relatedness	0.93	0.27	0.34	-0.07	0.14	-0.09	0.25	0.58	**0.91**

* 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 III. Model Results

	University Spin-offs N= 72		Corporate Spin-offs N= 49		All N=121
	Base model	Full model	Base model	Full model	
Age	0.26***	0.22 ***	0.27 ***	0.26***	0.25***
	(0.08)	(0.08)	(0.09)	(0.09)	(0.08)
#employees	0.08	0.10	0.08	0.05	0.06
	(0.13)	(0.13)	(0.14)	(0.14)	(0.14)
Start-up capital	0.37 ***	0.36***	-0.07	0.03	0.02
	(0.14)	(0.14)	(0.12)	(0.12)	(0.13)
Biotech	0.05	0.01	0.32***	0.38***	0.36***
	(0.14)	(0.14)	(0.09)	(0.09)	(0.11)
Electronics	0.10	0.09	0.04	0.03	0.03
	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)
Software	-0.11	-0.15	-0.08	-0.17	-0.14
	(0.15)	(0.15)	(0.14)	(0.14)	(0.14)
Tacitness		-0.11		0.22*	0.24**
		(0.11)		(0.12)	(0.12)
Relatedness		-0.16*		-0.39***	-0.44***
		(0.1)		(0.13)	(0.12)
$(\text{Relatedness})^2$					0.08
					(0.12)
Scope		0.38***		-0.19*	-0.18*
		(0.12)		(0.11)	(0.11)
Newness		-0.20*		0.17	0.17
		(0.11)		(0.12)	(0.11)
Adjusted R^2	0.11	0.17	0.11	0.18	0.16

Significance levels: * p< 0.10, ** p< 0.05, *** p< 0.01 (two-tailed significance)