

How can universities facilitate academic spin-offs?

An entrepreneurial competency perspective

Einar Rasmussen*
Professor
Nord University Business School
N-8049 Bodø
Norway
Tel: + 47 75 51 72 00
Fax: + 47 75 51 72 68
E-mail: einar.rasmussen@nord.no

Mike Wright
Professor
Centre for Management Buy-out Research
Imperial College Business School
Exhibition Road
London, SW7 2AZ
E-mail: mike.wright@imperial.ac.uk
And
University of Ghent, Ghent, Belgium

*Corresponding Author

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ABSTRACT

Some universities are successfully involved in creating and developing new high-growth technology businesses while others struggle to do so. Clearly, the characteristics of the university and its environment are important, but explain only part of this variation. We explore how universities can promote new research-based businesses by suggesting that the nature of the support supplied depends on the demands of the spin-off firms. Adopting a demand side perspective, we seek to understand the challenges faced by new technology businesses and hence identify how universities can assist their start-up and development. From the academic entrepreneurship literature, we derive how universities can supply support for the development of firm competencies either directly or indirectly. The paper nuances the common conception of a university as one uniform entity in relation to spin-offs, and assesses the literature including all levels within the university, from central university administration, TTO, department, research group, scientist, and students.

1 INTRODUCTION

It is well documented that universities can play an important role as seedbeds of new technology ventures, and the creation of new businesses on the basis of university research has become an important part of innovation policy in most countries (Wright et al. 2007). Despite high expectations and significant attention to the role of universities in creating high growth businesses, the results in many contexts appear disappointing (Harrison and Leitch 2010; Siegel and Wright 2015). Arguably, universities such as MIT and Stanford are seedbeds

of many high-growth ventures, while the majority of institutions have a track record comprising a very limited number of successful spin-off firms (Mustar et al. 2008). The reasons behind these variations are multifaceted, and a better understanding of how universities promote high-growth ventures is valuable in designing policies and infrastructure to promote academic entrepreneurship.

University spin-off ventures are sometimes narrowly defined as firms that exploit intellectual property or patented inventions generated from university research (Di Gregorio and Shane 2003). A large share of university spin-offs do not involve intellectual property formally disclosed to the university (Fini et al. 2010; Aldridge and Audretsch 2011). We assess the role that universities can play in the start-up and growth of technology firms and define university spin-offs as new ventures initiated within a university setting and based on technology derived from university research (Rasmussen and Borch 2010).

The qualities of the entrepreneurs are essential in explaining spin-off creation and success (Clarysse et al. 2011a). Moreover, the university context plays an important role, both in relation to the individuals starting university spin-offs and their ventures. Some university characteristics associated with spin-off firm formation are well established in the literature, such as intellectual eminence (Di Gregorio and Shane 2003), faculty quality (Powers and McDougall 2005), or scientific productivity (Van Looy et al. 2011). It is increasingly recognized that entrepreneurs and their ventures are imprinted by their founding environment (Beckman and Burton 2008; Bercovitz and Feldman 2008). Hence, it is clear that both the extent of venture creation and the type of ventures created are influenced by university-level factors.

What is less clear is *how* different university-level factors lead to the establishment and subsequent performance of science-based ventures. Understanding how university conditions influence spin-off creation and development provides a much more relevant basis

for deriving policy implications than just listing the characteristics of successful institutions. Most characteristics are difficult to change, at least in the short run, while it might be possible to compensate for disadvantages. For instance, star scientists are able to overcome both geographic distance to venture capitalists as well as the disadvantages of not being affiliated with a top research university when founding a new technology venture (Fuller and Rothaermel 2012).

Understanding how universities can promote the establishment and growth of spin-offs requires detailed knowledge about how these firms develop and the type of conditions and support that facilitate their success. Absent this knowledge risks a mismatch between the supply of support provided and the demand for support from the spin-off firm. We adopt an entrepreneurial competency perspective that is developed to understand how university spin-offs emerge (Rasmussen et al. 2011). By reviewing and building upon current evidence from the literature, we explore the following research question: how do different levels within the university contribute to the development of entrepreneurial competencies in spin-offs?

By applying a firm level, or demand side, perspective, our paper contributes to the literature on university spin-off support. We show that different levels within the university may have more or less important roles in supporting the development of entrepreneurial competencies in spin-offs. Our paper provides a framework to assess how different levels within the university can help support spin-off creation both directly and by accessing competencies from external actors. Hence, we integrate the existing literature to provide a more holistic understanding on how the multifaceted university organization can support spin-off creation and growth.

The next section provides an overview of why universities engage in new venture creation and the challenges entailed. Section 3 takes the spin-off venture's perspective. Here, the entrepreneurial competency framework is outlined and the specific types of contributions

a university can offer at firm level are reviewed. The paper concludes by discussing how the competencies to promote new spin-off venture creation and development can be facilitated at different levels within universities.

2 UNIVERSITIES AND NEW VENTURE CREATION

Venture creation has gained substantial interest from policy makers and academics as an output from university research. Compared to other university outputs, the creation and support of new ventures remains a marginal activity. Education of skilled graduates, dissemination of research findings through publications, and a variety of different collaborations with existing firms are far more important outputs. However, a study of Canadian scientists in natural sciences and engineering that have received research grants found that 16.8% have attempted to create a spin-off (Landry et al. 2006) and a US study found similar numbers (Fini et al. 2010). Although these numbers are not representative of all academics and universities, they show that spin-off activity is potentially a significant output from universities.

2.1 Why should universities engage?

Proponents of university spin-offs adhere to two main arguments for why universities should prioritize new venture creation based on university knowledge. The first is related to the direct economic impact generated by new technology ventures, and can be referred to as the *economic growth* argument. In this view, new technology businesses are concrete examples that investments of public money in universities can lead to direct economic benefits in terms of new business activity at national and regional level. In other words, universities help make new jobs, tax income, and technology businesses that can compete internationally. Although

other university outputs such as education of skilled graduates and collaboration with existing industry is far more common, the impact on economic growth is more intuitively direct when thinking about spin-offs. The impact of a skilled graduate or a university as R&D partner is difficult to quantify, while the economic activity of a research-based new venture can be directly attributed to its origin in university research.

The second argument for promoting research-based ventures from universities is that these firms may act as a technology transfer mechanism that converts new scientific knowledge into application in society. Following this *technology transfer* argument, venture creation can be seen as a tool to facilitate the dissemination of university research. Hence, the impact is more indirect through spreading new technology to other firms and the society (Autio 1997). Inherent in this perspective is an understanding that research-based new ventures play a more important role in economic and technological progress than the average new venture. These firms generate economic spillovers as well as helping to resolve global challenges such as those related to climate and energy problems; to improving health, health care systems and welfare; to enhancing research-based professional practice; and to promoting knowledge-based trade and industry. In other words, even if many university spin-offs stay small, they can be seen as an important ‘lubricant’ in the innovation ecosystem that introduces and disseminates new science-based innovations.

There is no doubt that the potential benefits of creating research-based spin-offs are substantial, but disadvantages and alternatives need to be taken into account when assessing their role. Critics have claimed that a too heavy commercial orientation would endanger the university as independent knowledge producer and there have been examples of conflicts of interest (Blumenthal et al. 1997). However, most empirical research shows that entrepreneurial activities in universities are associated with higher scientific productivity and strengthen, rather than dilute, the universities’ core missions (Van Looy et al. 2011). It seems

that spin-off activity is positively related to measures of research productivity and quality (Colombo et al. 2010; Di Gregorio and Shane 2003). Worries that universities suffer from a brain drain because scientists spend time and effort on entrepreneurial activities have not been confirmed by empirical studies (Toole and Czarnitzki 2010).

Another key issue when assessing the benefits of science-based ventures is how the results compare to the resource inputs and alternative ways of commercializing or disseminating research results. The creation of research-based ventures is extremely resource demanding and large amounts of resources have been used by universities and other public support arrangements to promote such ventures. It has been questioned whether the amount of public financing has exceeded the value creation by these firms (Harrison and Leitch 2010). However, some studies estimating the economic impacts of research-based spin-offs over longer time periods show significant returns (Vincett 2010; Smith and Ho 2006).

2.2 Challenges for universities

Despite the potential benefits from promoting spin-offs and the strong attention from policy makers, it seems that many universities struggle to become effective supporters of spin-offs. Data from the US show that some universities are highly successful in creating new ventures based on research, while the majority of universities have modest numbers (O'Shea et al. 2005). In Europe, the number of firms created is growing, but these numbers are highly skewed in favour of few institutions (Wright et al. 2007). Many studies have tried to figure out why some universities perform better, but except for the clear pattern that historical success leads to future success, there seems to be no easy answer to this question.

Some argue that the growing interest among universities of pursuing commercial applications of research reflects a clear trend of an increasing number of 'entrepreneurial universities' playing an enhanced role in technological innovation (Etzkowitz et al. 2000;

Guerrero and Urbano 2012; Guerrero et al. 2014). Although some universities have succeeded in becoming more entrepreneurial, the development of commercial and entrepreneurial capabilities in universities is difficult. This is succinctly described by Ambos et al. (2008): *“At its heart, the challenge essentially involves taking an organization that is equipped for and accustomed to doing one thing (academic research) and at the same time asking it to build a capacity for doing something entirely different (commercialization of technologies and ideas). The extraordinary challenge here is that universities and their faculty are not simply required to switch from one (single-handed) activity to another, but to develop the simultaneous capacity for two activities (academic rigor and commercialization). Thus, tensions arise at the level of the organization as a whole as it strives to manage these two sets of activities at the same time, and also at the level of the individual who has to work out how to balance his or her time between competing demands “* (p1425).

Clearly, the university capability of promoting high-growth firms is multifaceted and involves many levels within the university (i.e. individual scientist, research group, department, central university, TTO, and other support infrastructure), as well as many external actors in industry and the public sector. Moreover, issues related to industry differences, the amounts of technological, human, financial, social and other resources, cultural differences, regional context, and so on will also influence whether and how universities can promote high-growth spin-offs. However, to identify a number of characteristics or factors associated with spin-off creation has limited value without a better understanding of why these relationships exist.

The following section will explore how universities can support entrepreneurial firms by taking the firm perspective, or demand side view. Analyzing this issue from the firm perspective enables the separation of university capabilities from other contextual factors to

help discover what priorities are available for policy makers seeking to harness universities to increase their spin-off activity.

3 THE DEVELOPMENT OF UNIVERSITY SPIN-OFF VENTURES

By definition, new ventures have no track record and need to assemble and develop a range of different input factors into an operating organization. A new organization needs to establish operating routines, secure affordable inputs from suppliers, and develop a customer base willing to pay for its products and services. This takes time and creates urgency given steep learning curves and an organization's limited resources. Stinchcombe (1965) noted that new organizations are imprinted with characteristics that fit the specific environment in which they were founded. Therefore the internal and external characteristics at founding have long term effects on the development, survival, and performance of new ventures (Ganco and Agarwal 2009).

Technology ventures created by academics are likely to inherit characteristics that differ from other technology firms (Colombo and Piva 2012). This is confirmed by several studies comparing university spin-offs with corporate spin-offs (Buenstorf 2007; Zahra et al. 2007; Ensley and Hmieleski 2005). These differences are partly related to the type of technology commercialized by the new firm and the resources endowed at start up (Clarysse et al. 2011b; Moray and Clarysse 2005). University spin-offs are often based on embryonic technologies developed in a university context with some distance to the market (Jensen and Thursby 2001). In contrast, corporate spin-offs usually commercialize technologies that are closer to market and benefit from the skills and competencies inherited from their parent organizations (Zahra et al. 2007). Moreover, there are also cultural differences between the academic environment and the business environment which means that firms originating in a

university have more limited access to the competencies needed to start and grow a business (Colombo and Piva 2012).

The many competencies needed to transform scientific findings from a traditionally non-commercial university context into viable products and services create specific problems for university spin-offs in overcoming the initial phases of development (Vohora et al. 2004). To analyze how the university context influence the venture creation and development process, a further examination of how a new venture is created within the university setting is warranted.

Entrepreneurship scholars have theorized on the properties that constitute the central aspects of emerging organizations (Brush et al. 2008; Katz and Gartner 1988). Developing a specific set of entrepreneurial competencies is central to initial venture success for university spin-offs (Rasmussen et al. 2011). Common to these perspectives is that firms engage in a continuous search for fit between the external context and internal resource conditions, rather than existing in a relatively “steady state” or “best” configuration (Autio et al. 2011). The transition from being a research activity in a university context to become a commercial venture in a business context creates particular challenges for university spin-offs (Zahra et al. 2007; Vohora et al. 2004). Hence, knowledge about new venture creation in other contexts may not be directly transferrable to university spin-offs.

3.1 Entrepreneurial competencies for university spin-off venture creation

To facilitate a more fine-grained discussion about how different actors may contribute to university spin-off venture evolution, we rely on the entrepreneurial competency framework (Rasmussen et al. 2011, 2014). This framework was developed from studying the early stages of university spin-off development and offers a theoretical basis to understand the heterogeneity of entrepreneurial competencies and the diversity among those who provide

them (Rasmussen et al. 2011). Simply stated, the entrepreneurial competencies are related to three core processes necessary to develop a new venture:

- 1) the need to develop a viable business opportunity (opportunity development competency),
- 2) the need for championing individuals that provide meaning and energy to the entrepreneurial process (championing competency), and
- 3) the need to access the resources necessary to develop the new venture (resource acquisition competency).

Using these three competencies provides an analytical framework that highlights how different actors can play different roles in the development of the venture. In what follows, the entrepreneurial competency framework is used to highlight the different challenges faced by new science-based ventures throughout their early development process and how the ventures can overcome these challenges. Identifying the sources and processes behind these entrepreneurial competencies helps unpick how the university can facilitate the creation and development of spin-off ventures.

3.1.1 Opportunity development competency

Any new venture is based on the exploitation of a business opportunity. For science-based firms this opportunity is usually based on new technological knowledge that potentially can be developed into highly innovative products or services. The creation of such opportunities is driven by scientific excellence (D'Este et al. 2012). However, technological innovations are fungible (Penrose 1959) and new inventions can lead to different market applications depending on the process through which they are commercialized (Shane 2000). University spin-offs often pursue several business models at the same time (Clausen and Rasmussen

2012). The market application of technological inventions and knowledge is rarely clear from the outset (Gruber et al. 2008) and the business models are modified as entrepreneurs gain more knowledge about resources and potential opportunities (Chesbrough and Rosenbloom 2002).

A key challenge for the initiation and development of university spin-offs is the ability to transform scientific knowledge into a commercial product or service that can be sold in the marketplace. This ability of seeing a potential business opportunity and develop it into a viable business is a cognitive act, with different individuals playing different roles throughout the entrepreneurial process (Eckhardt and Shane 2003). Initially, the perception of a business opportunity is related to the knowledge and experience of the individual scientist, and this ‘opportunity recognition capacity’ of academics has been found to be the most important explanation for scientist’s engagement in new ventures (Clarysse et al. 2011a).

At the individual scientist level, the likelihood of starting a spin-off company to commercialize research is much higher for faculty members that have received industrial support (Louis et al. 1989). Interestingly, work experience in the private sector is not necessarily significant, while joint research projects with private firms or having gained some corporate work experience after graduation is related to firm formation (Krabel and Mueller 2009; Wennberg et al. 2011). This indicates that the knowledge needed to establish a spin-off firm is developed in the interplay between academia and industry, rather than within one or the other sectors.

The network and experience of founders and managers of university spin-offs are likely to be more technologically oriented than market oriented. Hence, when exploring possible applications of the technology, university spin-offs may limit their search to familiar knowledge areas and consider only a few alternative uses (Zahra et al. 2007). Apparently, a broader and more informed consideration of alternative applications increases the chances of

developing a high performing business. This ability to seek improvements in the opportunity combined with the ability of altering the opportunity according to new insights can be seen as an opportunity development competency (Rasmussen et al. 2011).

This opportunity development competency is dependent on high technological expertise in combination with industry or market knowledge. While technological expertise is abundant within universities, commercial expertise is often in short supply. Hence, for university spin-offs that are initiated by academics, interaction with industry is often crucial to be able to conceive and modify a viable business concept based on scientific knowledge. There can be many sources of industry interaction and market knowledge that provides the competency of opportunity development. Although spin-off venture creation and industry collaboration can be seen as alternative ways of commercializing academic research, studies show that these activities are not substitutes but rather reinforce each other (Powers and McDougall 2005; Van Looy et al. 2011; Di Gregorio and Shane 2003). Spin-off ventures set up by scientists that work with industry or from research groups with extensive industry experience and networks seems better able integrate technological and market knowledge.

In later stages of development, it is important that the spin-off venture does not lose its connection to the academic environment. The academic scientists can play a crucial role in connecting the entrepreneurial firm to scientific networks both within the laboratory or research group and more widely to the scientific community (Murray 2004).

To sum up, the following areas appear to be important for university spin-offs to succeed in developing their opportunity development competency:

- Industry and user connections integrated in the research activity.
- Active search for different possible applications of the technology being commercialized.

- Industry experience included in the founding team.
- Interaction with industry and users throughout the venture development process.
- Maintaining contact with the scientific community during the development of the new venture.

3.1.2 Championing competency

New ventures are started and developed by an entrepreneur or an entrepreneurial team that take a championing role in the venturing process (Gupta et al. 2006). The role of champions is to induce the commitment of others to the new venture by providing emotional meaning and energy (Howell and Higgins 1990). University spin-offs are usually championed by academics or by teams consisting of both academics and external entrepreneurs.

Entrepreneurial teams often change over time and university spin-offs often develop through dynamic interaction of different individuals with different competencies throughout the start-up process (Vanaelst et al. 2006; Clarysse and Moray 2004). It is often difficult to clearly separate the contributions of team members from other key supporters that promote the new venture. Hence, many persons both within and outside the university can play a championing role at some stage in the venturing process (Rasmussen et al. 2011).

The perceived viability of commercialization activity will influence the involvement and support of university scientists in spin-off venture creation. The professors' beliefs about the proper role of universities in the dissemination of knowledge has been identified as the most significant factor influencing their entrepreneurial behavior (Renault 2006). Studies indicate that the perceived viability to act entrepreneurial is to a high degree influenced by the local environment. Hence, scientists that are trained or currently work in an environment where entrepreneurial behavior is common are more likely to become entrepreneurs themselves (Bercovitz and Feldman 2008; Kenney and Goe 2004). However, if the current

local work environment is not active, potential entrepreneurs would be discouraged (Bercovitz and Feldman 2008).

The role of the local work environment is particularly important for university spin-offs because these firms are usually developed by teams where several persons play an active championing role (Vanaelst et al. 2006). Support from champions such as colleague scientists, university managers, TTO staff, and people in the external network of the university is often critical, particular in early stages (Rasmussen et al. 2011).

The lack of growth and financial success in many university spin-offs can be related to the motivations of the persons that started the venture. The individual motivation for academic entrepreneurs seems related to a variety of factors such as technology diffusion, technology development, financial gain, public service and peer motivations (Hayter 2011). The inherent tensions between the academic and the commercial values and norms seems to be a possible impediment for spin-off development (Gurdon and Samsom 2010; Ambos et al. 2008). These tensions are likely to be more keenly felt at lower levels in the university organization (Bienkowska and Klofsten 2012) and particularly at individual level (Ambos et al. 2008). However, it seems that scientists involved in commercial activities adopt a hybrid role identity that preserves the academic identity alongside their commercial role (Jain et al. 2009).

The use of external champions, or so called surrogate entrepreneurs, can lead to better performance among university spin-offs (Franklin et al. 2001; Radosevich 1995). The majority of university spin-offs are developed by teams and studies of team formation in these firms emphasize the importance of including persons with industry and entrepreneurial experience in the founding team (Clarysse and Moray 2004; Mosey and Wright 2007).

Empirical evidence shows that balanced teams with both academic and non-academic entrepreneurs show superior performance in terms of firm growth (Visintin and Pittino 2014).

To sum up, the following areas appear to be important for university spin-off to succeed in developing their championing competency:

- Entrepreneurial scientists that are motivated to grow the new venture.
- Support from colleagues and structures within the university.
- Structures and mechanisms that assist universities and scientists to preserve a hybrid role identity preserving both academic and commercial values.
- Include champions from outside the university to join the founding team.

3.1.3 Resource acquisition competency

Establishing a new venture requires access to resources such as financial capital, physical assets, technological resources, human capital, and organizational resources. Intangible ‘soft’ resources are more useful than tangible resources in the early stage of venture development (Lichtenstein and Brush 2001). Successful creation of a new venture is dependent on both the ability to assemble and organize resources (Brush et al. 2001). Hence, the cornerstone of the third entrepreneurial competency is the ability of resource leveraging that is needed to develop and integrate the internal and external resources necessary to establish and grow a spin-off venture.

The creation of new business activity based on research is typically extremely resource demanding because of the needs for technological, market and organizational development, but also because university spin-offs tend to have long development paths. In addition to the resources needed to develop the technology and build the organization, new ventures need to build legitimacy in the relationship with all their operation partners (Delmar and Shane 2004;

Zimmerman and Zeitz 2002). This is particularly important for university spin-offs because they bring to market new innovations that are unfamiliar.

A key resource for university spin-offs in their early stages is the university scientists behind the technology being commercialized. Not surprisingly, many studies have confirmed that academics with access to more resources are more likely to form spin-offs. For instance, (Landry et al. 2006) conclude that: *“the likelihood of launching university spin-offs increases as the researchers have access to more financial resources from the NSERC operating grants and university–industry partnership grants programs, have more intellectual property assets, have knowledge assets in the fields of computer sciences and engineering rather than in the other natural sciences, have knowledge expertise in consulting, have higher social capital assets, have access to the resources of large research universities, have access to the resources of large laboratories, and have many years of experience in research.”*

In particular, academics’ social capital and networks has been emphasized as an important resource by several studies (Murray 2004; Nicolaou and Birley 2003). For instance, if the new venture founders have relationships with venture investors they are more likely to receive venture funding and are less likely to fail. (Shane and Stuart 2002).

In addition to the role of the academic scientists, the resource acquisition process is highly iterative and involves many different actors with the appropriate competencies. Most spin-off projects would not have access to many of the resources required, but those who succeed may be better at leveraging the resources they need. This may explain why successful spin-offs also emerge in resource deficit contexts (Clarysse et al. 2005). For example, university spin-offs located outside the venture capital intensive parts of the UK are through their entrepreneurs able to compensate for this disadvantage (Mueller et al. 2012).

Universities can clearly support their spin-offs through policies and direct support mechanisms. The literature on universities’ incubation models (Roberts and Malone 1996)

shows that differences in venture creation can be related to priorities regarding what type of ventures are supported by the university. For instance, a low selective model (Clarysse et al. 2005) will lead to a higher number of spin-offs than more resource intensive models, but the growth potential of these ventures might be modest.

Clearly, the university influence on firm development is highest at the earliest stages in the venturing process (Rasmussen 2011). Initially, the venture is formed within, or at least partly connected to, the university context and relies heavily on university resources. Moreover, decisions made at this early formative stage are likely to have a long lasting effect on the future development paths of the venture. Universities are often large and multifaceted organizations, and the factors influencing spin-off creation are often more pronounced at local department level, than at central university level (Kenney and Goe 2004; Bercovitz and Feldman 2008).

The university may also influence more developed firms, for instance as a collaboration partner. Universities producing high-quality scientific research have a beneficial impact on the growth of local high-tech start-ups, but only if these firms are able to detect, absorb, and use this knowledge (Colombo et al. 2010). Even for university spin-offs that have reached the stage of going public, an affiliation with a university enhances valuation, in particular when academics are present in the Top Management Team at the time of the initial public offering (Bonardo et al. 2011).

Universities and government support can offset some of the problems with scarce resources, particularly in the earliest stages of spin-off development, by providing funding and subsidized resources. Government support programmes typically provides different types of financial resources (Rasmussen and Sørheim 2012). Relying too much on public 'soft-money' can be a liability for these ventures because they do not develop their competency of accessing external resources.

To sum up, the following areas appear to be important for university spin-off to succeed in developing their resource leveraging competency:

- Access to resources from within the university:
 - time and physical resources in the university
 - advice from colleagues and research networks
 - networks with industry and investors
 - infrastructure such as advice and financing from TTO
- Access to resources from external actors:
 - team members with industry and entrepreneurial experience
 - government grants and ‘soft’ funding
 - external investors such as business angels and venture capital
 - industry partners and customers

4 HOW CAN UNIVERSITIES FACILITATE NEW VENTURE CREATION AND DEVELOPMENT

The above presentation of three types of competencies needed by new spin-off ventures provides a framework to understand how universities can facilitate the venture creation process. The factors leading to significant spin-off activity are highly inter-related (O'Shea et al. 2007) and studies concluding that single factors are leading to more spin-off activity should be interpreted with care. Spin-off activity is contingent on many factors at different levels within the university and many factors external to the university, where different types of support complement or substitute each other (Fini et al. 2011).

A study of MIT pointed to a combination of factors behind the university's success in spin-off creation, such as MIT's science and engineering resource base; the quality of

research faculty; supporting organizational mechanisms and policies such as MIT's Technology Licensing Office; and the culture within MIT faculty that encourages entrepreneurship (O'Shea et al. 2007). Although some of the elements leading to more spin-offs are clear, the theoretical understanding of how the university actually contribute to the new venture is limited.

Attempts have been made to develop more holistic frameworks to understand how universities can promote new businesses. Prior frameworks typically take the university as the unit of analysis and study successful environments for spin-off creation (Brunitz et al. 2008; van Burg et al. 2008; O'Shea et al. 2007). In contrast, this paper has outlined an entrepreneurial competency perspective taking the firm's perspective. This perspective is useful to understand how universities contribute to and impede the creation and development of new ventures. More importantly, this perspective can provide advice for less as well as more successful universities on how they can support spin-off creation and development. Table 1 summarizes the definition, purpose, and key mechanisms of the three entrepreneurial competencies described above.

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The entrepreneurial competency perspective points at the importance of opportunity development, championing, and resource acquisition by engaging both the internal university environment and external actors. Providing such an environment may, however, be a challenging task for many universities because it requires different capabilities than the traditional tasks of teaching and research. Moreover, universities are complex and heterogeneous organizations where decisions and activities at many levels can influence outcomes such as spin-offs. Most studies considering initiatives and policies for spin-offs

view universities as a ‘black-box’ with a uniform approach to spin-offs. However, there are significant differences in how spin-offs are promoted at different levels within universities (Rasmussen et al. 2014; Bienkowska and Klofsten 2012). Arguably, the creation of a spin-off venture is an inherently uncertain endeavor that easily can be ignored among other activities and demands in the university. A supportive attitude at central university level or high priority of the university’s TTO is not likely to create many spin-offs unless this activity is prioritized at all levels within the university (Rasmussen and Borch 2010).

In what follows, we discuss how different levels within the university relate to spin-off activity and can promote or inhibit competency development in spin-offs. Table 2 provides a framework to analyze the links between these different levels and the promotion of entrepreneurial competencies in spin-off ventures.

First, the central university level is responsible for policies and infrastructure, and will typically have an indirect relation to each spin-off firm. Hence, the central university level is likely to exert an influence on spin-off activity in a long-term perspective by managing the lower levels in the organization. Prioritizing research excellence may lead to the creation of entrepreneurial opportunities in the future, but universities also need to make sure that the entrepreneurial competencies to develop these opportunities are available.

Second, most universities have established TTOs with an aim to increase the commercialization of university research. TTOs are mainly dealing with formal spin-offs based on university owned intellectual property. TTOs may play an important role in gaining access to initial resources such as government soft funding and early stage investors. However, the extent to which TTOs are able to assist spin-offs in growing beyond their initial creation, is debatable (Mosey and Wright 2007).

Third, the department level is arguably closer to where the spin-off activity takes place and controls important resources for the entrepreneurship process. Initiatives and incentives

provided by the central level often require active priorities at the department level to be effective, which is not always the case (Rasmussen et al. 2014). Different disciplines may show greater allegiance to their academic ‘tribe’ than to the university and heads of department may vary in their stance regarding academic entrepreneurship. On the other hand, experienced academic entrepreneurs in a department may play an important mentoring role (Mosey and Wright 2007).

Fourth, most research is conducted in the context of a research group or lab. This local work environment is important for spin-off creation (Clarysse et al. 2011a) both in terms of developing viable entrepreneurial opportunities and stimulating academics to support and pursue such opportunities. Similar to departments, the stance of the lead professor may greatly influence the nature of encouragement and support for academic entrepreneurship. Research groups and labs may, however, be more constrained in terms of their life-cycle than departments. Spin-offs may on one hand be a means of generating income to continue the research or on the other hand a distraction from core activities. Research has largely ignored this level of universities.

Fifth, it is clear that individual level factors is the most important determinant of whether academics engage in new business creation (Clarysse et al. 2011a). Scientific excellence and industry experience is important for the creation of business opportunities, and prior entrepreneurial experience and external networks important for exploiting the opportunity. Given the variety of competencies needed to develop a spin-off firm, diversified teams appear well suited for this task.

Finally, students constitute an important resource within universities and are typically considered among the most important channels of knowledge transfer to industry. Although students have a low profile in the academic entrepreneurship literature, they can contribute to spin-off development for instance through theses and projects related to the spin-off and as

founding team members or early employees. Moreover, the alumni often represent a strong industry network that can be drawn upon by universities and their academic entrepreneurs.

In sum, the central university management plays a more indirect role, while the lower-levels in the university are in more direct interaction with the spin-off. Hence, lower levels appear crucial in promoting the entrepreneurial competencies of spin-offs, but their role differs depending on the type of competency considered.

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5 CONCLUSIONS

This paper has built on key findings from the academic entrepreneurship literature and adopted an entrepreneurial competency perspective to outline how universities can promote the creation and development of spin-off firms. It is evident that spin-off creation is an activity strongly integrated with other university activities. The entrepreneurial competency framework provides a demand side, that is spin-off firm. perspective on how universities could be supportive. Characteristics of supportive university environments have often been studied, while less is known about how universities in general can develop their ability to generate successful spin-offs. This paper discussed how all levels within the university can facilitate spin-off firm creation and development. By using the entrepreneurship competency framework, we show that the role played by the different university levels were dependent on the type of competency considered. While the individual academic plays a key role in supporting the development of all three entrepreneurial competencies, other levels may play more or less important roles depending on the competency considered. The central university management and students seems to play a more indirect role in spin-off support.

Assessing how universities can assist high-growth technology ventures is challenging because of large variations in the types of new ventures, the type of universities, and the contexts they operate within. Hence, there is clearly room for more research that integrates the firm's and the university's perspective. If spin-off creation is to be a successful endeavour at more than a few universities, more knowledge is needed on how this activity could become integrated and mutually beneficial to the activities at all levels within the university. Moreover, a better understanding is warranted on how universities can handle and nurture the relationships to external actors that provide crucial input to competency development in spin-offs.

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Table 1: Development of entrepreneurial competencies in university spin-off firms.

	Opportunity development competency	Championing competency	Resource acquisition competency
Definition of entrepreneurial competency	The ability to discover opportunities based on scientific research and to further refine these opportunities into a viable business concept.	The ability to identify with the venture and to convince others to contribute to its development.	The ability to develop and integrate the internal and external resources needed to develop the venture.
What is the main purpose of this competency?	Related to iteration with actors having technology and market knowledge	Related to human agency and motivation	Related to accumulating resources to build the new venture
What is the main mechanism for developing the competency in early stages?	Iteration between entrepreneurial team and industry partners	Involvement of the academic inventors and individuals in their network	Gaining trust from actors within and outside the university that possess valuable resources

Table 2: How different university levels can promote entrepreneurial competency development in spin-offs

University level	Opportunity development competency	Championing competency	Resource acquisition competency
Central university management	Indirect role: Prioritize scientific excellence and collaboration with users and industry	Indirect role: Have clear policies for how to handle commercial issues and professional support infrastructure internally at university.	Indirect role: Make spin-off creation a priority for both internal resources and in relation to the university's external stakeholders.
TTO	Indirect role: Provide arenas for active search for (alternative) applications of technology. Provide access to diversified set of industry contacts.	Indirect role: Add on external members to founding teams.	Key role: Gain access to external funding and other resources to support spin-off ventures from public and private sources.
Department	Indirect role: Make the search for commercial opportunities a part of the research activity.	Key role: Make spin-off creation a viable activity for academics to engage in (e.g. promotion criteria). Make operational space for academics to pursue spin-off projects. Actively manage conflicts of interest. Create arenas to bring in team members with industry experience.	Indirect role: Make available resources to the new venture such as academic sabbaticals, laboratory space, technician time and consumables. Help the new venture obtain resources from external resource providers
Lab/research group	Key role: Involve external industry and investors early in the research process.	Key role: Develop relationships with experienced entrepreneurs and industry people that can become champions for new spin-off ventures.	Indirect role: Share networks with external resource holders
Individual researcher	Key role: Scientific excellence and industrial experience	Key role: Prior entrepreneurial experience and industrial experience	Key role: Network within industry and among investors.
Student/alumni	Indirect role: Use commercialization cases	Indirect role: Students and alumni can join founding teams of spin-offs	Indirect role: Alumni network to resource providers