The Influence of University Departments on the Evolution of Entrepreneurial Competencies in Spin-off Ventures

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The influence of the university department upon spin-off venture evolution is complex and dynamic. We examine how the university department context influences the spin-off process from the perspectives of both the spin-off venture and the department. By comparing the development of entrepreneurial competencies within spin-offs based in different departments at the same universities we observed significant differences in early venture performance. Small differences in initial departmental support from management and senior academics for gaining commercial experience and spending time exploring the commercial opportunity were seen to have a major impact upon the subsequent spin-off development path. Supported ventures gained momentum as the department helped develop entrepreneurial competencies and influenced how these competencies were developed from external actors outside the department. By contrast, a lack of departmental support for entrepreneurship severely constrained the evolution of spin-offs regardless of university level policies and practices. This emphasizes the need for a shift in focus from the well-studied university level to the relatively neglected department level to help explain institutional differences in university spin-off activity.

Keywords: Academic entrepreneurship; Entrepreneurial competencies; New venture evolution; University department; University spin-off

1. INTRODUCTION

New ventures do not emerge in a vacuum. Rather, activities pursued during the entrepreneurial process are shaped by the social and institutional environment. Yet how process and context interact to shape the outcome of entrepreneurial efforts remains largely unexplored (Aldrich and Martinez, 2001). In particular, insights are lacking regarding how the heterogeneous and multi-layered nature of context influences the process of new venture creation and development (Zahra and Wright, 2011). Gaining an understanding of these interactions can lead to the development of more fine-grained policies to support new ventures.

This issue is especially pertinent in the context of spin-offs from universities. The complex development paths and the many competencies needed to transform scientific findings into viable products and services from the traditionally non-commercial university context provide significant challenges (Vohora et al., 2004). Studies have highlighted that the impact of the institutional context upon the development of university spin-off ventures is particularly acute at the early stages (Jong, 2006; Kenney and Goe, 2004; Moray and Clarysse, 2005; Rasmussen and Borch, 2010). Support for university spin-offs varies significantly according to central university policies, variations in structures of technology transfer offices, and a wide diversity of contractual practices (Clarysse et al., 2005).

Prior studies have mainly used either the organization (university, technology transfer office (TTO), or incubator), the firm, or the individual level as the unit of analysis (Rothaermel et al., 2007). These studies have provided important insights concerning which factors in the university context are associated with spin-off creation and development, but the evidence on their impact upon spin-off performance is decidedly mixed (Grimaldi et al., 2011). This paper builds on an emerging research stream considering the influence of the university department level upon entrepreneurial activities. The seminal study by Louis et al.

(1989) showed that local group norms significantly influenced the entrepreneurial behaviour of faculty, while university policies and structures had comparatively little effect on their sample of life-scientists. Later studies assert that the level of entrepreneurial activity varies significantly between departments within the same university (Bercovitz and Feldman, 2008), and that the local environment can strongly influence faculty engagement in academic entrepreneurship (Kenney and Goe, 2004).

There is, however, a gap in our knowledge about *how* the university department level exerts influence during the spin-off firm creation process from the perspectives of both the spin-off venture and the department (Grimaldi et al., 2011).[1] A limited number of studies have provided evidence that national and university policy and the local environment all need to provide consistent support to maximize the likelihood of university spin off emergence (Brint, 2005; Clark, 1998; Louis et al., 1989). There remains a lack of clarity regarding how national and university policies are either reinforced or constrained by local practices. Two trends contribute to this complexity. First is the adoption by nations and universities of intellectual property policies to encourage university spin off formation (Wright et al., 2007). Second are changes in university governance that encourage the devolution of resource allocation authority for commercialization of research towards heads of departments within U.S. and European universities (Brint, 2005; Slaughter and Leslie, 1997).

An emerging stream of research suggests that a focus upon the department level will help unpick the relative influences of heads of department, allegiance to research disciplines and influence of local laboratory peers (Boardman and Corley, 2008; Perkmann et al., 2013). Yet there is a need for multi-level analysis that connects the spin-off firm level, and the academic entrepreneurs involved, with these department level influences. Addressing this gap holds important insights for research and policy concerning how to realize the commercial

[1] We define a department as an administrative unit within a university that relates to a particular subject discipline. Terminology may differ between contexts and in some cases departments may be grouped together into 'schools' of cognate disciplines.

potential of scientific research through spin-off ventures. Although there may be university level policies to support spin-offs, the organizational structure of universities (Ambos et al., 2008; Boardman and Bozeman, 2007; Clark, 1998) may create a schism between these policies and what actually happens on the ground. Efforts to induce changes are not likely to succeed unless accepted and practiced at the local level (Louis et al., 1989). We know from Bercovitz and Feldman's (2008) individual level analysis that department leadership and peers play important roles in evaluating performance, allocating slack resources (such as time), setting the social cues regarding the likelihood of invention disclosure and creating dissonance and symbolic compliance between individual behaviours and departmental norms. As spin-off firm creation is likely to be considerably more challenging and time-consuming than invention disclosure, and hence potentially more disruptive to the work of academics and departments, these factors may be expected to play important roles in facilitating or constraining spin-offs.

An important dimension of the challenges facing spin-offs is the development of the competencies to commercialize an invention. For example, the social capital needed to access the specific industry expertise necessary for commercialization may be more likely to reside at the department level than the university level. We therefore build on earlier work to examine how, having decided to participate in technology transfer specifically through creation of a spin-off, department level factors influence academic entrepreneurs in this process. We seek to address the following research question: *How does the university department context influence the process by which nascent university spin-offs develop the necessary competencies to overcome the initial phases of development?*

Through addressing this question, we propose that a focus on the evolution of entrepreneurial competencies (Helfat and Lieberman, 2002) may yield new insights on how the institutional context influences the genesis of the entrepreneurial process in university

spin-offs. Entrepreneurial competencies provide the ability to build a set of resources to effect new venture emergence (Danneels, 2002). Clearly such competencies are not fully formed at new venture creation but have to evolve to allow the venture to emerge and grow (Rasmussen et al., 2011).

We focus on the early stages of venture development because they are arguably the most influential in terms of the path upon which the venture evolves (Clarysse and Moray, 2004). Within this early stage we observe the evolution of competencies required to make the transition from academic research to the identification of a potential commercial opportunity and the establishment of an independent spin-off firm (Vohora et al., 2004). Studying the emergence of university spin-offs presents a methodological challenge due to the typically long timescales involved and their complex development paths (Shane, 2004). Thus, we followed the start-up processes longitudinally and use the credibility threshold (Vohora et al., 2004) as a proxy for successful venture establishment. The credibility threshold considers the initial equity investment by an external private investor. This provides a third party evaluation and is an indicator of the likely commercial viability of the opportunity (Lockett and Wright, 2005). We followed eight university spin-off venturing processes and compared the development paths of ventures that succeeded in gaining the credibility threshold with those who struggled or failed to do so.

Our study makes several contributions to the literature on academic entrepreneurship and institutional influences on the entrepreneurial process. First, we provide detailed insights into how the local context shapes the early development of spin-off ventures. Here, the university department context is shown to influence significantly how the new venture develops entrepreneurial competencies from within that department. Equally important, however, is the indirect influence of departmental support on how the new venture gains momentum in developing these competencies from external actors outside the department.

Thus, we show how relatively small differences in local context can influence whether the venturing process gains the momentum necessary to develop into a fledging new business.

Second, our study explains how the local department level context strongly moderates the impact of university policies and practices on the spin-off process. Differences in managerial and senior academic support at a department level seem highly important for both the early and subsequent development paths of these ventures. This emphasizes the need for a shift in focus from the well-studied university level to the relatively neglected department level to explain institutional differences in university spin-off activity. Third, by investigating the development of three entrepreneurial competencies we contribute to a more fine-grained understanding of the relationship between local context and the earliest phases of spin-off creation and development. Each entrepreneurial competency develops differently and therefore policy to enhance venture development through local intervention is dependent upon both the type of competency needed and the new ventures' stage of development.

This article proceeds as follows. The next section presents a theoretical framework outlining three entrepreneurial competencies needed to establish university spin-off ventures and the likely influence of the institutional context on the evolution of these competencies. Section three explains the longitudinal study of eight university spin-off processes within two Norwegian and two UK universities. By examining spin off emergence in different national, university and departmental contexts we aim to unpick the relative influence of each level of policy and practice. The empirical findings are presented in the fourth section. Here we derive propositions regarding the effect of the institutional context upon gaining entrepreneurial competencies. In section five, a discussion of the findings and implications for further research and policy are provided.

2. THEORETICAL FRAMEWORK

The interaction between a spin-off venture and its host institution is complex and often dialectic. To enable a better understanding of how the institution influences the spin-off we integrate two theoretical perspectives. We propose that a focus upon entrepreneurial competencies is appropriate to better understand new venture emergence (Danneels, 2002). We choose competencies because they incorporate multiple levels of analysis and allow a focus upon the transition from individual actors towards firm level competencies. However, as this development does not occur in a vacuum, we incorporate the formative impact of the host institution both in terms of access to competencies and in the development (or not) of competencies over time (Klepper and Sleeper, 2005). An evolutionary perspective is therefore also adopted to capture the influence of historical routines (Nelson and Winter, 1982). This is particularly apposite as the development of entrepreneurial competencies within academic institutions represents a new development that often conflicts with traditional university policies and practices (Bercovitz and Feldman, 2008). For universities to encourage the development of entrepreneurial competencies requires the development of new routines and potentially the termination of old ones (Rasmussen and Borch, 2010). We therefore combine evolutionary theory and competency theory. To better understand how the university department may influence the emergence of spin-offs we first delineate the type of entrepreneurial competencies needed to develop such ventures.

2.1. Entrepreneurial competencies

The processes leading to the creation of new ventures are heterogeneous and many challenges need to be addressed. Academics are often highly dependent on others in their environment to supply the competencies needed to launch a new venture given the traditionally non-commercial environment in which they operate. Specific competencies have been linked to

research productivity (Henderson and Cockburn, 1994), competitive advantage (Man et al., 2002), and venture performance (Chandler and Jansen, 1992), but the competencies required to initiate and sustain the entrepreneurial process are less clearly defined.

Although many conceptualizations of entrepreneurial competencies can be made, key aspects concern the discovery and development of opportunities, the role of individual characteristics, and the acquisition of resources to exploit the opportunity (Bruyat and Julien, 2001; Stevenson and Jarillo, 1990). Thus, a distinct set of competencies related to opportunity identification and development, championing, and resource acquisition are required to succeed with new venture creation. Developing these competencies is a challenge for all nascent ventures, but for ventures emerging within the non-commercial university environment the need to develop such entrepreneurial competencies may be a significant constraint (Rasmussen and Borch, 2010). University spin-offs may eventually need to look outside the university to develop these competencies, but at an early stage the local department context may be highly influential (Bercovitz and Feldman, 2008; Jong, 2006; Kenney and Goe, 2004).

The first entrepreneurial competency is linked to the recognition of opportunities, a necessary element in the creation of new ventures (Shane, 2000). Building the competence to perform this activity is likely to have a significant impact upon the early development path of nascent spin-off ventures. The identification of entrepreneurial opportunities is a cognitive act, with different individuals playing different roles throughout the entrepreneurial process (Eckhardt and Shane, 2003). Moreover, technological resources are fungible (Penrose, 1959) and the resulting market application of technological inventions and knowledge is rarely clear from the outset (Gruber et al., 2008). As a result, business models are altered as entrepreneurs improve their knowledge about resources and potential opportunities (Chesbrough and Rosenbloom, 2002).

The second competency is related to the key role of human agency in entrepreneurship (Shane et al., 2003), and the need for someone to take a championing role in the venturing process (Gupta et al., 2006). Champions induce the commitment of others to the innovation by providing emotional meaning and energy (Howell and Higgins, 1990). University spin-offs may be championed by academics, external entrepreneurs, or a combination of both (Nicolaou and Birley, 2003). Moreover, university spin-off projects are often characterized by the dynamic interaction of different individuals with different competencies throughout the start-up process (Clarysse and Moray, 2004; Vanaelst et al., 2006).

The third key competency is the assembly and organization of resources to exploit the opportunity (Brush et al., 2001). Studies have found that financial capital, physical assets, technological resources, human capital, and organizational resources are important for new ventures. Intangible 'soft' resources are arguably more useful than tangible resources in the early stage of development (Lichtenstein and Brush, 2001). The resource acquisition process is, however, highly iterative and involves many different actors with the appropriate competencies. Given the traditionally non-commercial character of universities, there may be a notable variance in the availability of access to the resource acquisition competency (Ahuja and Katila, 2004).

2.2. The influence of university department context upon the evolution of competencies

The competencies outlined above are likely to evolve over time (Rasmussen et al., 2011). Idiosyncratic initial conditions can result in significant differences in innovation performance (Ahuja and Katila, 2004). Taking an evolutionary perspective yields new insights into how resource heterogeneity underpins venture performance differences (Henderson and Cockburn, 1994). For instance, Ahuja and Katila (2004) observed firms evolving radically different search behaviours due to small differences in initial opportunities and differences in how

firms capitalize upon new knowledge within novel scientific domains. University spin-offs may exhibit similar characteristics but for very different reasons. They face the opposite problem in that they have a potentially novel scientific breakthrough yet need to modify their search paths to identify potential commercial applications within which to embed that breakthrough (Shane, 2000). Relatively small differences in their initial search and resource acquisition behaviours could result in significant differences in their subsequent momentum and evolution (Miller and Friesen, 1980).

The entrepreneurship process of opportunity identification and development depends on the prior knowledge of the actors involved (Shane, 2000) and their ability to gather insights into potential application domains and customer needs (Dougherty, 1992). At the early stages of venture development we would expect the institutional context to have the most impact at the local level (Stuart and Podolny, 1996). Studies in the university context found that first-time inventors tend to co-invent with experienced peers or principal investigators (Colyvas and Powell, 2007), and faculty members' decisions to disclose new inventions are highly conditioned by the local work environment, through actively seeking compliance with the behaviour of department chairs (Bercovitz and Feldman, 2008). Hence local support from academic peers and heads of departments may be more impactful than institutional level support such as University management strategies and incentives. It appears that heads of department are more likely to support the commercialization efforts of scientists that have already demonstrated international research excellence (Murray, 2004). In turn, the behaviour of such 'star scientists' can be disproportionally influential upon peer researchers within the same department (Louis et al., 1989).

The decision of academics to become entrepreneurs, or champions, of new ventures has primarily been attributed to individual attributes (Clarysse et al., 2011), including their values and attitudes towards science and their social links to industry such as through family

entrepreneurs (Haeussler and Colyvas, 2011). Scientists' commercialisation and venture founding can also be related to the local environment with large variations seen at the department level (Stuart and Ding, 2006), group level norms and laboratory size (Haeussler and Colyvas, 2011). Since a critical mass of participating academics appears necessary for commercialisation, this is unlikely to be achievable purely at the laboratory level (Bercovitz and Feldman, 2008), emphasising the need to focus on the department level. However, the persistence of departmental routines and traditions may constrain the implementation of university level policies designed to encourage spin-offs (Boardman and Bozeman, 2007; Brint, 2005). Evidence appears to suggest that there is a positive relationship between the research quality of a department and commercialisation activities (but not engagement with industry) by academics and whether colleagues of the same rank are entrepreneurial (Perkmann, et al., 2013).

Many studies have confirmed that academic founders contribute with important resources to university spin-offs through their experiences and networks (Knockaert et al., 2011; Mosey and Wright, 2007; Shane and Stuart, 2002). Still, major challenges for university spin-offs are in developing entrepreneurial teams with commercial experience (Ensley and Hmieleski, 2005) and in accessing other resources and capabilities (Zahra et al., 2007). It seems clear that the department level should have an important influence on many aspects of university spin-off creation, especially in the earliest stages of development. The literature, however, has mainly identified how individual academics' broad commercialisation activities are influenced by the department context, while the processes of department level influence on the spin-off firm itself have been neglected.

To explore the influence of departments on the evolution of the entrepreneurial competencies needed to develop spin-offs, we build on principal themes from the literature outlined above. These departmental themes concern the influence of departments on

commercialisation relating to external departmental links and networks with industry, and internal aspects relating to research quality, peer and senior colleagues' involvement with commercialisation, and departmental routines and group norms relating to the implementation of university level commercialisation policies.

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3. METHODOLOGY

3.1. Research design

A case study approach was chosen, guided by the evolutionary entrepreneurial competency framework outlined above (Suddaby, 2006). This approach gives a richer contextual insight and an in-depth understanding of processes that have been scarcely investigated in prior studies or within this context (Rothaermel et al., 2007). The literature reviewed above indicates that the university department context impacts access to competencies as the spin-off process evolves. Thus, a longitudinal approach that captures changes over time and reduces problems of retrospective biases is warranted (Pettigrew, 1990). Since the competencies we investigate are manifest in behaviours and actions, a longitudinal study of a limited number of cases was deemed appropriate (Eisenhardt, 1989). We therefore mapped the initiation and early development of eight university spin-offs.

3.2. Case selection

We adopted theoretical sampling (Eisenhardt, 1989) to distinguish between national, university and department level influences on the spin-off process. We sought spin-offs from departments without a historical legacy of spin-offs so that we could observe the development of new policies and practices. To examine the influence of department level factors we selected pairs of cases from two different departments within the same university, where some

departments had the explicit support of the head of department for spin off venture creation and others held at best an agnostic view. To help unpick the influence of department versus national policy, university policy and academic discipline effects we chose spin-off cases across a range of contexts that may impact competency access and development (Yin, 1989). Variation in external conditions helps isolate department level influence on the development of spin-offs and make more general observations compared to approaches such as a single university study. First, we selected universities from two national settings. In the UK (Universities C and D), commercialization of research has been high on the agenda since the 1990s and an infrastructure of TTOs is well established at most universities. British universities have been highly active in spin-off creation compared to other countries (Wright et al., 2007). By contrast, Norwegian universities (Universities A and B) have only recently become formally involved in spin-off formation. While previously belonging to the individual academic, IP ownership of academic research was only assigned to universities as recently as 2003. This led to the establishment of TTOs at Norwegian universities, increased awareness within the institutions, and increased public spending to facilitate commercialization of research.

Second, we selected two universities in each country; one older institution with a well-established commercialization infrastructure and tradition (Universities A and C) and one smaller with less comprehensive commercialization support (Universities B and D). As a result, our spin-off cases faced different levels of expertise in their university level environment, which potentially influence the role of the department.

Third, we included cases from biotechnology and engineering as there might be differences in the likely access to sources of competencies between these disciplines (Mosey and Wright, 2007). This allows us to base our conclusions on more varied and richer evidence than most previous studies which have relied on data from biotechnology and life sciences

(Bercovitz and Feldman, 2008; Colyvas, 2007; Jong, 2006; Jong, 2008; Louis et al., 1989; Stuart and Ding, 2006), for an exception, see Kenney and Goe (2004).

Prospective spin-off cases were identified in cooperation with well-informed individuals, notably TTOs, at each university. Ideally, all cases should be in an early phase when neither the product, the first customer, nor the funding are yet in place. To fit with the definition of a university spin-off, our selected cases had university research as the technological basis, and university researchers played key roles in their initiation and development. At the time of the study, only a few cases were identified that exhibited these characteristics. Permission to collect data was negotiated to ensure a rich source of data, and two cases within each university were included in the study.

Table 1 shows the central properties related to the background, characteristics, and developments paths of the selected cases. All cases had a history of soft funding support, such as proof of concept funding provided by government agencies. Therefore a third party had already made an informed judgment that each case was based upon technology with latent commercial potential. However, each case was also seeking significant financial and other external resources to sustain its development at the time of the study. Cases were therefore chosen to provide spin-offs with strong growth potential housed within different departments all facing the challenge of spinning-off their first venture.

INSERT TABLE 1 HERE

3.3. Data collection

Triangulation was incorporated through using several data sources to capture critical events prior to and during the development of the spin-offs. Secondary data from universities was collected through documentary sources such as strategy plans, annual reports, and web pages. Primary data from each university was collected through visits, conversations, and interviews.

The pairs of spin-off cases within the four universities emerged in the same time period and primary data from each case was collected by 85 personal interviews with 58 people throughout a 12-15 month period. People in various positions with direct involvement in the spin-off process within the spin-off firm and direct involvement in policies and practices to support spin-offs within the department and university were interviewed. These included: company founders and entrepreneurial team members, researchers, university managers, and people involved in commercialization support. Details of the respondents are shown in Table 2.

Following a narrative approach (Polkinghorne, 1988), the interviewers asked the informant to describe his or her involvement in and knowledge of the spin-off project from its inception to date, with a minimum of interruption by the interviewer. This approach enabled us to get closer to the actual events and to avoid personal views and theoretical perspectives influencing the data collection. Interviews were recorded and transcribed by two of the authors as part of the data analysis process. To avoid confirmatory biases, one of the authors was kept at a distance from the data gathering process (Doz, 1996).

For each firm, archival data, including financial reports, business plans, market analyses, and research documents, was obtained. In addition, relevant written documentation was collected both from informants and other sources like magazines, newspapers, and the internet. By combining the different sources of information and by collecting information over a period of time through repeated interviews with central people, an in-depth understanding of the research and spin-off process was obtained. For confidentiality reasons, the cases are anonymized. Confidentiality undertakings made access to data easier and facilitated rich and candid accounts from the informants about sensitive issues related to their working relationships with colleagues, partners, and the local work environment.

INSERT TABLE 2 HERE

3.4. Data analysis

The data provided both narrative accounts of the process (Pentland, 1999) and factual descriptions of context, actors, and events from a large number of sources. From the data we identified critical policies, practices, and events that influenced the acquisition and development of competencies. The interview transcripts and other material were read and reread as data were collected; emerging themes were refined as this process progressed and checked through the repeat interviews with the main players (Yin, 1989). Views of different respondents from each case were also compared by representing the entire start-up process of each firm in tabular form and as a narrative text.

The data analysis focused on the development of entrepreneurial competencies within the nascent spin-off ventures and the influence of the university context upon access and development of these competencies. To avoid conflation of the multiple levels of analysis, the strategy of retroduction was used (Leca and Naccache, 2006). Thus, as the analysis proceeded, the overarching logical frame shifted from exploring data, to refining theoretical models, and to empirical scrutiny of these models (Van de Ven and Poole, 2002). This was followed by a second-order analysis to develop propositions through analytical generalization (Yin, 1989), as presented in Section 4. This analysis was guided by the evolutionary competency framework developed above.

4. FINDINGS

Amongst the eight cases, we saw significant differences in venture development over the observation period. Within each university, one spin-off case succeeded in passing the

credibility threshold and one did not. The four cases of Alpha, Beta, Gamma, and Delta succeeded in gaining significant financial resources from private sector equity investors. The remaining cases did not reach this milestone, despite gaining public funding to sustain their nascent ventures. To obtain external financing was a desired goal for all cases, thus serving as a well-defined entrepreneurial event (Vanaelst et al., 2006). Like other small high-tech firms, university spin-offs have poor access to debt financing and therefore rely highly on equity to finance their growth (Carpenter and Petersen, 2002). Key characteristics of the spin-offs are summarized in Table 3.

INSERT TABLE 3 HERE

4.1. Competency Development

Several key differences in department level influence on competency development were identified between firms that gained external finance and those that did not. Rather than seeing variations between universities we saw differences between firms at the same university but based within different departments. Here, at the university level, there were similar supportive policies to encourage spin off formation. For example, they all had policies where academics were allowed to work on commercialization in addition to their academic duties for typically between 30 and 60 days per academic year. Crucially, such policies required the permission of the head of department and it is here that differences in performance emerged. Without the explicit support of the head of department, the provision of slack resources, a key enabler of commercialization, was effectively constrained at the department level. This is one of numerous examples of how university level policies were found to be moderated by department level influences. The following sections consider the three competency areas of opportunity identification and development, championing, and

resource acquisition. For each competency, we explore the role of the university department context in enabling or constraining their development in the spin-offs as summarized in Table 4.

INSERT TABLE 4 HERE

4.2. Opportunity identification and development competencies

Although the business opportunity was based on academic research, some form of market related knowledge was also needed to frame the initial business idea. The business concept was typically revised in an iterative process including several actors with both technological and market knowledge. More details and quotes highlighting the positive influence of department upon such competency acquisition and development are provided in Table 5.

INSERT TABLE 5 HERE

The four cases of Alpha, Beta, Gamma and Delta that gained credibility, exhibited certain commonalities related to how this competency was built over the period of study, and in the characteristics of the actors involved. The value of prior industrial experience within the department was important (Shane, 2000). For instance, the Beta founders had longstanding research collaboration with a pharmaceutical company and relied on informal support from colleagues at the department regarding how best to develop a commercial relationship. “[The founders] came to me and asked for advice for how to get away from ‘big-pharma’. As I have been working with large pharmaceutical companies, I could tell them how such companies used to operate” (University Professor, Beta).

However, going beyond previous insights relating to the importance of prior industrial experience, we find that industry experience within the department was necessary but not sufficient to develop the opportunity. Each academic team developed an increased understanding of the potential commercial viability of their technology through building a close working relationship with industry actors. To engage in this process typically required a change of recruitment practices within the department. For example, we saw a head of department and department manager change departmental policies to allow the employment of researchers from industry, as explained by the department manager of the Gamma case: "We bent the rules to spend university money on a consultancy contract for him (an industry based researcher) to work with the medics and prove the concept. If it hadn't worked we would have been in trouble, but it did…so we employed him in the department." Thus, the role of the department context included the direct provision of competency from internal sources, but also indirectly by influencing access to this competency from external sources, as outlined by Head of Department, Gamma. "We wanted to change the academics' attitude towards industry. Now we get new members of staff to shadow our academic entrepreneurs when they meet with our industry partners. They see how it works, … build their own relationships, and see the benefits for themselves."

The changing practices at department level were also evident in the Beta case, as explained by the Head of Department: "Initially we were doubtful of the relation with [Industry Partner] because we feared that they would withhold results and make it difficult to publish and keep up the academic production… Now the researchers are encouraged to have more contact with industry, but I think it will take time before the attitudes are changing… When it comes to Beta, some people at the institute are sceptical …but the general attitude is that people wants this to succeed. Many at the department have an interest in [this area of]

research and they know what Founder stands for as a researcher… We will stretch far at the Department to try to make this succeed."

By contrast, ventures that did not gain venture credibility were much slower at developing the latent value within their technologies. Two mechanisms constrained development of the opportunity. First, departments did not provide access to academics with prior industrial experience with whom inventors could explore the potential commercial applications of their technologies. This was particularly evident in Epsilon and Zeta where the original technology inventors did not have a position in the entrepreneurial team and the entrepreneurs spent little time in exploring different ways of applying the technology. This lack of opportunity development was questioned by one researcher behind the Zeta technology: "I'm not sure whether the current plan for commercial use of the [x] technology will be the final way of using it. There are many applications, which might be even smarter."

The second inhibitor was a lack of relationship building with industry actors. None of these four cases were able to establish a relationship with an industry partner or customer that actively helped frame the business concept. This was constrained by a somewhat hostile department attitude to working with industry as explained by the founder of Eta: "We are not encouraged to work with industry ... in fact quite the opposite ... it reduces the chances of our work getting published." This was reinforced by the Eta head of department who argued "I support work with industry but only if it will generate publications in the top journals." Thus, we propose that:

> *Proposition 1a: Spin-off ventures within university departments having a legacy of senior academic staff members interacting with industry are more likely to develop opportunity identification and development competency from within that department.*

Proposition 1b: Spin-off ventures within university departments that introduce recruitment and networking practices to develop a critical mass of industry networks are more likely to gain momentum in developing opportunity identification and development competency from external industry actors.

4.3. Championing Competencies

Considering championing competencies, over time, the function of champions changed from developing internal support and legitimacy within the university department to developing external support and legitimacy. Thus, academic researchers were important champions initially, while external individuals increasingly took championing roles later in the process. The departmental influence upon the development of the championing competency had several commonalities among the cases that gained venture credibility. Alpha, Beta, and Delta were all initially championed by teams of Professors and Heads of department were generally supportive of them spending time exploring the commercial potential of their research. Although one Head of department was sceptical about the practice of Professors starting spin-offs, he acknowledged their right to do so: "Alpha follows their goal, and has the full right to do that. The department would have benefited from another way of operating, but there is nothing wrong in what they are doing." Similarly, Gamma was initiated by an associate professor working in conjunction with a senior professor in another Department. These 'internal' champions were senior academics, well respected within their departments and more widely within their academic discipline, analogous to the 'star' scientists identified by Murray (2004). The commitment of these respected academics to become champions of the new ventures was partly conditioned by the viability of entrepreneurial activity at the university level that was reinforced by department level practices. One of the Alpha Professors, while noting that the university had signalled that it

was favourably disposed towards initiatives to create new ventures, also explained that: “For our project the department has been positive, and we have got leave of absence… There have been few problems for us but you are somewhat dependent on who is the Head of department at any time.” (Founder Alpha)

Cases Alpha through Delta all made use of public funding which was effectively distributed at the local level, as explained by the founder of Delta: “The most valuable money we got was the proof of concept funding. The Head (of department) suggested I go for it and it was so easy, one page of A4 and we had a post doc for six months… he built the prototype we showed to industry.”

These teams established strong ties with other researchers and managers within the department that helped provide legitimacy to their nascent ventures within the university. As the ventures became more formalized, the entrepreneurial teams added external team members possessing complementary expertise. The inclusion of new champions was facilitated by a supportive university environment. ”The relation with the university here has been very good” (New Chairman, Beta).

Each academic team was able to attract potential customers or development partners to champion their fledgling technologies. For example, Alpha emphasized the important role played by influential individuals in industry or other resource providers who made an exceptional effort to help the venturing project. Over the period of observation, stronger relationships were built where the academics and industrialists worked closely together and the industrialists became champions for the ventures within their practitioner communities. The credibility of the academics and their departments was key to their ability to build such relationships. “Being four professors with our research groups and total networks gives us an enormous impact” (Founder, Alpha). Departmental support was seen clearly to reinforce university level policies despite this type of venturing activity not being part of the formal job

description or part of the departmental appraisal process, as argued by the founder of Gamma: “The department worked hard to establish credibility with our industry partners. Technicians were allowed to work overtime, we were given priority in the labs… the Head of department did everything he could to make sure we delivered on time and kept our promises.”

In contrast, access to the championing competency was constrained for the nascent ventures that did not gain venture credibility. Despite university level policies to encourage spin-offs, the practices at department level were less supportive, or even hostile, as the Theta founder commented: “No one else in my department is doing this… it is perceived as a rebel or disloyal thing to do. I was given no advice and no one was interested.” Moreover, the commitment of the key academics was not as strong when compared to cases Alpha through Delta. The progress of Epsilon was hampered by unresolved issues in the relationship between the university and industry partners. According to a TTO manager, the department lacked the experience to handle this situation: “The department management tries to say as little as possible; that is the tradition in the university. There is no tradition to practice management in the sense that someone in a managerial role puts their head forward. One tries to find friendly solutions and steer away from conflicts. That might not be a bad strategy, but what happens in a situation when you cannot do that?”

The entrepreneurs in cases Epsilon through Zeta were typically less senior academics who were acting individually, such as the lecturer who founded Zeta: “I consider this my private project and do not talk about it to my colleagues at the university”. As a result, these academics received less internal support within the department and university. When questioned, the head of department was frank regarding their lack of support, “why should I allow them (founder Theta) time off to line their own pockets…..they need to increase their research income and then they can buy out their own time.”

The weak internal legitimacy also restricted access to external actors. Despite having links to industry, the academics were unable to build upon these links to gain external champions for their ventures. Thus, recruitment of new champions and team members to the spin-offs appears to be strongly influenced by the department. A supportive department environment encouraged championing and a hostile department environment restricted such behaviour. Although championing behaviour is connected to persons both within and outside the university, it seems that legitimacy within the host department generates momentum in the early phases of the spin-off venturing process. Thus we propose that:

Proposition 2a: Spin-off ventures within university departments where departmental managers apply university polices to provide academic time and proof of concept funding for entrepreneurship to academics with research credibility are more likely to develop championing competency from within that department.

Proposition 2b: Spin-off ventures within university departments with a number of senior academic internal champions engaging in venturing activity are more likely to gain momentum in developing championing competency from outside the university.

4.4. Resource acquisition competencies

The four successful ventures gained resources from a number of different actors (Table 3). The competence to leverage resources from those actors was gradually built as the ventures developed. Their departments typically provided tangible resources such as research time, laboratory space, equipment, consumables, and research support. For instance, despite his general scepticism, one Head of department arranged for generous support: “I have brought this up at Faculty level when [Founder Alpha] applied for sabbatical, that he had to get this,

otherwise it would be wrong, but it should be discussed how much help such a company should get from the [University]".

The two UK universities, C and D, had established university level practices to support spin-offs and had recruited experienced TTOs, but these were insufficient unless reinforced by departmental practices. Here Heads of department were provided with resources by the university but the allocation of those resources was at their discretion. Head of department Gamma explained how he allocates such resources, "I hedge my bets by spending all the money but making sure that academics are also likely to produce top notch research from their commercial work...then I can make sure that we get our share of the pot relative to other departments."

The departmental practice was equally important in the Norwegian cases, as explained by one of the Beta Founders: "A challenge is that we negotiate with the university, but it is the faculties and departments with their budgets that decide this. That has been the case because we want the university to speak with one voice, but we have to go to each faculty and department to give information and spend much time at all levels." As seen by the unsuccessful cases, a hostile organizational culture within the department may limit access to resources within the university and hamper the connection to other sources of competencies, as illustrated by the Eta Founder: "The feel of the place is dictated by the Head of department. He has a benign viewpoint. University policy is that spin-offs can have space for three years within the department to put down roots but that was never offered to me."

In addition to providing resources, a cumulative factor for the observed differences in performance was how the successful cases used the university department to their advantage to subsequently gain resources from external resource providers. A clear relationship with the university department and the TTO was seen as important in establishing credibility in relations with industry by the successful cases. "Some people find it strange that we are four

professors working in the company. ‘Is it allowed?’ Then it is very good to have our office in the university incubator. … Then people see that this is cleared with the university.” (Founder Alpha). In contrast, in those cases with less supportive departments such as Zeta, the founder kept a low profile within his department and used only informal contacts to gain access to resources. Epsilon struggled with unresolved issues in relation to the university department and the TTO regarding IPR, ownership, and the use of university personnel. Eta and Theta considered their ventures to be ‘renegade’ outfits best developed in a subversive manner.

The difference between resource acquisition at firms that gained venture credibility and those that did not was subtle yet significant. Epsilon, Zeta, Eta and Theta were able to make use of university facilities and build new ties to sources of public sector funding and potential customers. However, the rate of competency development at gaining resources from these actors was considerably less than for the successful firms. For Zeta, Eta, and Theta, they were limited in that the single academic founders did not receive much assistance from the university to build meaningful relationships with the requisite large number of actors, as illustrated by the Zeta Founder: “[The University] have no formal relationship to the project, but single individuals contribute with some marginal technical assistance.” Moreover, when departments provided support, this did not contribute to commercial development but was more research oriented, as explained by a TTO manager: “The [Department] got funding from the [University] to build a [Laboratory]. ... In this way the [University] could be a midwife and development partner, while Epsilon could take the role as commercialization partner. .... Regardless the outcome, it would be valuable (for the department) to develop expertise in the area.” Although all ventures gained public sector finance in the form of seed funding, this was not invested in recruiting team members with complementary expertise, but rather in recruiting academic researchers to conduct more testing. This ‘research focused’ behaviour was also manifest in their dealing with potential customers for their technologies, as

illustrated by the TTO manager who questioned Epsilon's strategy: "[The TTO is] a technology partner, not a market outlet. Epsilon is not a very tidy construction seen from a simple value chain way of thinking."

It appears that even if the university has potentially valuable resources, new ventures' access to these resources is partly dependent on appropriate structures to handle spin-off processes at the department level. The Beta founders devoted much energy to make arrangements with the departments and ultimately the university. The strong involvement by the university was seen as a positive signal by new team members and other resource providers. By contrast the founder of Eta wasted valuable time and effort trying to resolve ownership issues with the department. Also the CEO of Epsilon felt that unclear relations with the university hampered the progress of the project: "We will walk very many new paths together with the TTO to make agreements with employees and to point out roles and legal aspects that are not solved. …There is no doubt that this takes much time and is delaying Epsilon's progress."

It was apparent that an unclear relationship and lack of support from the parent organization provides a negative signal that makes external resource providers reluctant to engage in the new venture. We therefore propose that:

Proposition 3a: Spin-off ventures within university departments where departmental managers provide resources such as academic sabbaticals, laboratory space, technicians' time and consumables to support venture creation are more likely to develop resource acquisition competency from within that department.

Proposition 3b: Spin-off ventures within university departments where departmental managers apply university I.P. policies for spin-offs and create a credible position

among external resource providers are more likely to gain momentum in developing resource acquisition competency from external actors.

5. DISCUSSION

By contrasting the development paths of four spin-off cases that succeeded in overcoming the credibility threshold (Vohora et al., 2004) with four cases that struggled to do so, we have been able to observe how the university department context influences the early spin-off venture development process. While in line with prior studies (Kenney and Goe, 2004), our cases also suggest that the local department level was highly influential in the early development process of new ventures and acted as a moderator of general university support towards spin-offs. Our core contribution goes beyond these studies to specify how the local department level context influences the competency development process from the perspective of nascent university spin-off ventures. Specifically, we show that although there may be general university support, explicit departmental managerial support in terms of provision of slack time and tangible resources when combined with a critical mass of commercial interaction amongst star researchers provides a powerful enabler of university level policies for venture creation.

Through a more fine-grained analysis of the institutional environment, we delineated for the first time how the department level impacts the early development of three entrepreneurial competencies. In addition to enabling access to and development of internal sources of competencies we observed that the university departments also influenced access to competencies from external sources. While gaining support and resources internally within the university was important initially in the venturing process, gaining competencies from external sources gradually became more significant to achieve momentum in the development of the new ventures.

The opportunity identification and development competency was strongly connected to the ability to interact with industry and commercial actors. The initial establishment of such working relationships was, however, likely to be influenced by the industry experience and networks of the academic entrepreneurs and their colleagues and managers at department level. Thus, initial conditions within the university department may influence the development path of the nascent ventures. Firms originating in departments having broad industry networks outside the organizational boundary of the university were able to make a more effective and rapid transition from the academic to the commercial setting and exhibited a more commercially oriented development path. This finding adds nuance to the conclusions of Perkmann et al. (2013) regarding department support for academic engagement with industry, since it appears that a legacy and departmental managerial support for a critical mass of industry engagement among leading researchers is necessary to enable recognition of the most promising commercial paths for new technologies from that department (Boardman and Bozeman, 2007).

The championing competency was more readily available within departments when heads of department and managers were supportive of entrepreneurial activity and the academic teams could build on the supportive environment to engage champions from outside the university environment. Thus, a hostile department environment not only discourages academics from engaging in spin-off activity, but may also constrain the further development of these ventures by making external champions reluctant to invest their time and energy in the venture. The early development of spin-offs appears dependent on changes in team composition reflecting the specific challenges throughout the process (Vanaelst et al., 2006). Our successful cases exhibited a more dynamic and diverse team development path compared to those that struggled.

The resource acquisition competency involved gaining trust from actors within and outside the university that possessed valuable resources. Here we observed that access to university resources was often dependent on the department level as a gatekeeper, simply because this is the level where the strain on resources is most keenly felt and resource allocations are made (Boardman and Bozeman, 2007; Brint, 2005). Moreover, entrepreneurial teams that successfully managed to gather external resources and momentum made use of their parent university organization to legitimize their reliability to a much higher degree than those ventures struggling to acquire resources. This finding extends the argument that inter-organizational endorsements (Stuart et al., 1999) positively affect the ability of new ventures to acquire resources by adding the importance of the internal layer. All our cases faced the same challenge of getting access to resources due to a lack of track record that resource providers could use to judge the quality of the nascent venture. In the very early stage of developing a university spin-off venture, the university department of origin is one of the few signalling mechanisms for external actors to assess the quality of the venture. Thus, for equally viable venturing opportunities, a departmental environment providing the endorsement needed for resource providers to support the venture can release the momentum that differentiates between successful and unsuccessful cases. This extends the evolutionary argument of Ahuja and Katila (2004) in that idiosyncratic differences in resource endowments and problems faced have significant impacts upon subsequent innovative performance by showing how the local department context may be a source of such differences. The initial development of nascent ventures may be hampered by the lack of power in relation to external stakeholders. With explicit departmental support, the spin-off may be able to overcome some of these liabilities of newness by being able to access resources on better terms and conditions (IPR, funding, alliance partners, etc.). Even small contributions from the university

department at this early stage may give momentum to the venture that has a significant impact on later performance.

By observing how different competencies evolved as the spin-offs developed, we were able to differentiate between the university and the department level. Universities could provide resources to spin-off ventures and facilitate the resource acquisition competency most effectively when reinforced by departmental management (Rasmussen and Borch, 2010). The university level, however, played a more indirect role in the opportunity identification and development and the championing competencies compared to the department level. In the often loosely coupled university setting (Weick, 1976), initiatives to facilitate spin-offs at university-level are not likely to be efficient unless accepted at department level. Different departments have very distinct legacies and moving to new trajectories will only happen slowly as heads of department and administrators adjust to new values and incentives (Moray and Clarysse, 2005). This problem is often exacerbated by a lack of clear university decision-processes and line responsibilities in the implementation of academic entrepreneurship (Wright et al., 2009) and scepticism among some science-based departments about the expertise of TTOs (Mosey and Wright, 2007).

The development of the three types of competencies and the influence of the department level is summarized in Table 6.

INSERT TABLE 6 HERE

5.1. Implications for policy

Our analysis suggests a number of implications for policy. Since departmental management appear to act as gatekeepers between the university and departmental faculty, universities seeking to promote academic entrepreneurship need to ensure the provision of sufficient support and consistent policy signals that reconcile research and academic entrepreneurship

targets. Our findings also suggest that departments seeking to develop academic entrepreneurship successfully can introduce a number of policies including the facilitation of role models undertaking both high level research and academic entrepreneurship who can act as mentors for less experienced faculty.

Our study examines university spin-offs, but this is only one of the channels by which university technologies can be commercialized (Rasmussen et al., 2006). Formal technology transfer through licensing and different forms of academic engagement with existing industry are more widespread than spin-offs and may be more aligned with traditional academic activities (Perkmann et al., 2013). The opportunity identification and development competency may be conducive to many types of commercialization activities, while the championing and resource acquisition competencies may be more specific to spin-off creation. As a result, the influence of the department upon the development (or constraint) of opportunity identification competence should be as keenly felt for activities such as licensing. By contrast it seems that championing and resource acquisition competencies may be more specific to spin-off creation and therefore the influence of the department in these areas would be less critical. The opportunity identification and development competency may therefore need to be developed to enable recognition of whether the best route to commercialising technology may be through licensing rather than a spin-off. Department level influences and expectations regarding individual academics and the extent and nature of commercialisation expectations may play an important role in shaping the focus of the development of these competencies.

Successful academic entrepreneurship emanating from departments appears to be linked to the development of departmental credibility with industry. Departments could consider the introduction of advisory boards that include senior relevant industry leaders. Recruitment policies could also consider the introduction of industry experience criteria alongside

academic research criteria. Such policies would help to introduce faculty with relevant human and social capital in order to facilitate academic entrepreneurship and to appoint heads of departments who are supportive of academic entrepreneurship. The development of such expertise in departments may also play a role in helping to focus on the most appropriate modes of commercialisation of technology and hence the nature of competencies that are developed. Department level sabbatical schemes could also be introduced. At a national level, there may be a case to encourage academics seeking to become involved in entrepreneurship to move to departments at other universities where this is promoted. Further at a national level, as some heads of department may show more allegiance to their subject than their university, governments may seek to influence scientific disciplinary organizations either directly or through research funding bodies to promote academic entrepreneurship. At a local level the value of slack resources for the early exploration of the commercial potential of research appears crucial but unless supported by department management will remain less effective. Policy initiatives that provide such resources, such as proof of concept funds managed at a local level and with a relatively low administrative overhead appear to show a disproportionate impact on subsequent spin-off activity.

5.2. Limitations and implications for further research

Empirical study of the initial evolution of new ventures is challenging because attempts that fail at an early stage are hard to identify. However, our focus here is on evolution post start-up and we were able to identify cases that failed to achieve the credibility phase. Whether our findings could be generalized outside the academic entrepreneurship context warrants further research, for example in institutional settings where several actors are involved in developing complex projects with an uncertain outcome, such as new product development processes involving several organizations (or units) and processes of corporate entrepreneurship.

While our study comprised the early venture start-up process, future studies should explore which competences are exclusive to the start-up process and which are important for the further operation and development of the new firm. These questions are important because while external actors may contribute with temporary competences, it is important that the more enduring competences are built within the new firm. As our cases reveal, there is a trade-off between the degree of competency acquisition and development internally in the venture and the use of external competencies.

This study has also keyed into the theoretical gap concerning how the initial resources for a new venture are assembled and exploited (Greene et al., 1999). Little is known about the type of competencies provided by industry experience and networks and how these competencies are accessed by entrepreneurs in academic institutions. Our detailed analysis shed light on the impact of different levels within the university institutions, indicating that the department level has been underexplored in previous research.

Although different technology transfer mechanisms seem to facilitate rather than substitute each other (Van Looy et al., 2011), an interesting extension of our study would be to explore whether the department level mechanisms conducive to (restrictive of) spin-offs also promote (constrain) other forms of university technology transfer. For example, further research could examine to what extent do these mechanisms differ between departments that are world leaders in research versus those that have a lower research reputation. In a similar vein, empirical work could be conducted to consider to what extent the effects of these mechanisms differ between different scientific disciplines.

6. CONCLUSION

This study is a novel attempt to reveal how the university department context influences competency development during the initial phases of university spin-off venture formation.

As such we extend university entrepreneurship research by taking the entrepreneurs' perspective to explore why the department level exerts influence on spin-off creation and how this unfolds over time. Some of our spin-off cases developed valuable entrepreneurial competencies and gained momentum while others became increasingly isolated. The department level context influenced the development of competencies, both directly from within that department but also indirectly from external actors. Small differences in the local department environment relating to the access to commercial partners, legitimacy of venturing to the department management and availability of venturing and commercial experience had a disproportionate effect upon subsequent venture development. Our findings suggest that the local environment where the spin-off process is initiated appears to significantly influence the development path of nascent ventures. As a result, to better understand the creation and development of technology-based new ventures more attention upon competency development at the department level within universities is justified.

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Table 1: Central properties of the spin-off cases

Case (University)	Alpha (A; NO)	Beta (B; NO)	Gamma (C; UK)	Delta (D; UK)	Epsilon (A)	Zeta (B)	Eta (C)	Theta (D)
Initial founder(s)	Four professors	Two professors	Senior lecturer and post doc	Two Professors	Industry-university joint venture	Researcher; based on another professors' work	Senior lecturer	Lecturer
Entrepreneurial team	Four professors, consultant and lawyer	Two professors and two consultants	Senior lecturer, post doc, and consultant	Two professors and industry post doc	Hired CEO	Researcher	Senior lecturer	Lecturer
University ownership	No	Yes	Yes	Yes	Yes	No	No	Yes
Connection to Departments	Two departments	Two departments and the university hospital	One department	One department	One rather independent research group within department	Technology from one department, Zeta founded by researcher at another university	One department	One department
Head of department view of venture creation	Supportive to Alpha, despite general scepticism	Positive, but have to deal with strain on resources	Positive	Positive	Positive, but not proactive	Department not involved	Hostile	Agnostic
Department's legacy and attitude to venturing	One department had spin-off legacy and were positive. The other department saw this as novel	None of the departments had prior spin-off experience, but both were positive	No spin-off legacy but strong industry research links. Department supportive of spin-off	No spin-off legacy but significant contract research income Department supportive	Strong industry orientation within this group, but few spin-offs	No spin-off legacy. Researcher did not want to involve the department in spin-off and left	Department incentives focussed upon research income	Department incentives focussed upon research
Premises	University incubator	University incubator	City incubator	University incubator	University incubator	None	University	University
University level spin-off legacy and support	Many spin-offs. Entrepreneurship Center (1980s), Science park incubator (1990s), University on-campus incubator and TTO (2000s)	Few spin-offs. Science park incubator and TTO (2000s)	Many spin-offs. TTO (1980s). Entrepreneurship Center, Science park incubator, and University on-campus incubator	Many spin-offs. TTO, Entrepreneurship Center, Science park incubator, andUniversity on-campus incubator (2000s)	Same as Alpha	Same as Beta	Same as Gamma	Same as Delta

			(1990s).					
Field of research	Engineering	Biomedical	Biomedical	Engineering	Engineering	Engineering	Engineering	Biomedical
Product	Software	Medicine	Medical device	Electro-mechanical	Electro-mechanical	Electro-mechanical	Mechanical	Medicine

Table 2: Persons interviewed

	Alpha (Univ. A)	**Beta (B)**	**Gamma (C)**	**Delta (D)**	**Epsilon (A)**	**Zeta (B)**	**Eta (C)**	**Theta (D)**
Founders	Professor #1 (4**) Professor #2 (2) Professor #3 (2) Professor #4 (2)	Professor 1 (3) Professor 2 (1)	Senior lecturer (4) Post doc (4)	Professor #1 (2) Professor #2 (2)	Professor (1)	Founder (2)	Lecturer (3)	Lecturer (3)
Team members	Business developer (3) Lawyer (1)	Bus. developer (1) Bus. developer (1) Admin. support (1)	Researcher (1)	Post doc (2)	CEO (2)	N/A		
Board members	Same as founders	First chairman (1) New chairman (1)	Chairman (1) Finance Dir. (1)	Same as founders	CEO Industry partner (1)	N/A		
University management	Department manager (1)	University manager (1) Department manager #1 (1) Department manager #2 (1) Dean (1)	Head of Department (1) Department manager (1)	Head of Department (1) Department manager (1)	Professor (1)		Head of Department (1) Department manager (1)	Head of Department (1) Department manager (1)
Support actors	TTO CEO (1) TTO Business developer (1)	CEO science park (1) Univ. adm. #1 (1) Univ. adm. #2 (1)	TTO (1)	TTO (1)	TTO (2) CEO TTO (1)	Science park (2) Technology owner (1) Inventor (1)	TTO (2)	Business Angel (2)
Others		Informal advisor (1)		Development partner (1)	Student (1)			
Total # of interviews*	16	16	14	10	9	6	7	7
University visits	6	4	7	6	6	4	7	6
Secondary sources	Company presentations Business plan Press articles Student thesis	Company presentations Business plan Press articles	Company presentations Business plans Press articles	Company presentations Business plans Press articles	Company presentations Business plans Press articles Student thesis	Company presentations Memos Research articles	Company presentations Business plans	Company presentations Business plans

*The total number of interviews is less than the sum of persons interviewed because some interviews were done with more than one person and some persons have more than one position. **Number of interviews with this person.

Table 3: Role of key actors in the early development of the spin-off projects

Case (University)	Alpha (A)	Beta (B)	Gamma (C)	Delta (D)	Epsilon (A)	Zeta (B)	Eta (C)	Theta (D)
Source of initial idea	Industry need	Basic university research	Basic university research	Basic university research	Industry partner	University research	Basic university research	Basic university research
Source of basic technology and competence	University research and industry experience	Industry sponsored university research	University research	University research	University research and prior spin-off company	University research	University research	University research
Major performer of technology development	Founders	Founders and university research group	Founders and postdoc	Founder and postdoc	University	Founder	Founder	Founder
Other performers of technology development	Industrial partners	Additional research partners	Research partners	Industry partners	Prior spin-off from same university group	Technology inventor at university	Founder	Founder
Major role in market development	Founding team (professors and external members)	Founders and new management	Founders and new management team	Founders and industry partner	Interaction between CEO, professors, and industry partners	Founder assisted by science park advisor	Founder	Founder and Business Angel (as consultant not investor)
First commitment for funding	Public sources (2003)	University (2003)	Public sources (2002)	Public sources (2002)	University (2003)	Public sources (2003)	Public sources (2004)	Public sources (2004)
Additional funding sources	Industrial investor	Seed-funding and private investors	Private Equity	Industry	Public sources	N/A	License income	N/A
Number of employees 2006	17	12	8	10	0	0	0	0

Table 4: Contrasting the evolution of competencies in successful and unsuccessful university spin-offs

	Opportunity identification and development	**Championing**	**Resource acquisition**
Successful cases			
Alpha	Idea based on professor's industry experience. Entrepreneurial team works intensely to modify the business concept and iterates with several industry partners.	Entrepreneurial team intentionally composed by professors specialized in different technologies and businesspeople. Team able to gain external persons to champion the Alpha case.	Draw heavily on department resources in initial phases, such as leave of absence. Used the university connection to leverage external resources.
Beta	Idea based on collaboration with industry. Founders actively iterating with colleagues, support actors and industry network to modify business concept. Strengthened management team with industry experts that further modified the business opportunity.	Professors actively championing the new venture with backing from university management. Recruited new management team members that strongly believed in the venture.	Gained significant resources from the university in early phases, such as funding and use of laboratories. Got assistance from support infrastructure (Science park) to leverage additional resources.
Gamma	Idea based on application of new measurement method in medical devices. Benefit seen by medical academics not appreciated by medical practitioners until researcher recruited to develop and test to practitioner specifications.	Senior lecturer championed within department and gained head and managers support to recruit industrial researcher. Medical practitioners championed within medical community to allow testing.	Head of department allowed use of test equipment in lab for commercial testing. Test data used to help attract surrogate entrepreneur that wrote business plan and secured VC funding.
Delta	Idea based on novel cooling technology adapted for air-condition units. Idea motivated by reduction of CO2 but sold to industry by researcher as method of lowering running costs.	The two professors had significant credibility with the head of department for research outputs. This allowed recruitment of researcher and led to industrial champions once cost savings were demonstrated.	Initial testing in department and soft funding for patent protection led to commercial deal with industrial partners. They financed scale up, testing and co-developed new product range incorporating the new technology.
Unsuccessful cases			
Epsilon	Epsilon is constructed as a technology development company and do not enter a relationship with a customer or business partner that can help identify a proper business concept.	Conflicts regarding other university industry collaborations make university inventors less committed and the CEO leave.	University set up laboratory suited for Epsilon's research needs at department. Negotiations to settle ownership and IPR issues with university were not completed.
Zeta	The founder focused on testing the technology without considering alternative applications and did not discuss the idea with colleagues at department.	Technology inventors positive, but not operationally involved in the venture. Founder kept a low profile with the idea and did not gain enthusiasm from	Founder gained access to resources for specific tasks through personal acquaintances, but did not formalize the relationship with the department or

	Managed to get in contact with industry partners, but did not enter an operating relationship that could provide feedback on the technology and business concept.	colleagues and industry partners to support the venture's development.	university.
Eta	Idea based on new functionality for sports equipment. Patent filed from own research income and despite commercial interest idea constrained by lack of founder time due to teaching and research commitments in department.	Founder approached by senior professors in department interested in financial income only. Industrial partners initially interested in research collaboration but pushed for license deal due to lack of added value from department.	Founder gained initial university soft funding for proof of concept but continued to work alone, Applied for fellowship to buy out of teaching but head of department failed to endorse application. Signed licensing deal after protracted discussions.
Theta	Idea based on novel medical testing system for improving drug discovery. Initially worked with pharmacy academics as target customers but found access to pharmaceutical firms difficult.	Founder championed amongst peer academic community but conflicted with department as gained no research income. Attracted business angel to write business plan for public funds but angel lost interest due to lack of department support.	Gained soft funding from university and paid business angel to write business plan and gained more public funding. Money used to demonstrate equipment to other academics and generate test data that was not persuasive to industry partners.

Table 5: Department level influence on the evolution of competencies in university spin-offs.

	Opportunity identification and development	**Championing**	**Resource acquisition**
Examples and quotes of department level influence on how the new venture develops competencies from within the department	The Alpha professors' broad network in industry played a crucial role in obtaining resources. "Both [Professor] and I had prior knowledge and contacts in [industry partner] that were used. The alliance with [industry partner] has created a 'domino effect' related to other customers." (Founder Alpha) In Gamma, the department management changed their recruitment policies to allow an industrial researcher to be employed within the department, the value of that appointment is explained by the founder "I knew one of my old post docs was working within industry so I rang him up and asked if he could give us some advice. He became interested and joined us, initially as a consultant, to help convince the medics that what we had was useful."	The prevailing attitude at the Department had strong impact on the Professors' decision to start Alpha. "The prevailing attitude [ten years ago] was that it would be a personal defeat to fail and little credit to gain from trying." (Founder). "I have not heard a single distorted word. All students finds this exciting and interesting, the same with our colleagues." (Founder Alpha) When we started the project with [Industry partner] …this was not always perceived positive among our colleagues. This is a maturation process, but there are still some critical voices. Because we have published quite a lot, graduated many students, and been a cooperation partner in research, the attitude to our work has gradually become more positive. (Founder Beta)	The university departments of Beta provided ample support, but this was not straightforward according to the Dean of School: "Beta is a special case because they are in the university and take up resources such as laboratories. This might lead to frictions. It might be that the persons involved in such companies do not fully participate at the other activity at the Department … So the main conclusion from me as Dean is that this is very positive but there can be complications at department level." At Delta, the department provided funding for patent filing and showcased the testing facilities to potential partners as explained by the dept manager "it was great to get companies in and show them our kit, they asked loads of questions and we got new testing business straight away"
Examples and quotes of department level influence on how the new venture develops competencies from external actors outside the department	"The department really supported us. They helped build the case for a consultant, sorted out the contract and gave him an office, … he felt welcome. Because they had done it before we knew who to speak to and they sorted it out, that wouldn't have happened five years ago" (Founder, Gamma).	"My impression is that the university has shown great goodwill in order to help the project further. **…** I was involved in discussions about the process, about funding, about who could contribute to the company, and in that process the entrepreneurs asked me if I could be chairman of the board." (New Chairman, later CEO, Beta)	"I think it can be a positive signal in this phase that the university is so much involved. … The university has shown great goodwill and been more enthusiastic than could be expected. They probably realize that this is a very exciting project that is worth to put a stake at. The same judgment as we have done." (New management team members Beta)

Table 6: Framework for department influence on competency development

Elements	**Opportunity identification and development competency**	**Championing competency**	**Resource acquisition competency**
Main source of competency	Iteration between entrepreneurial team and industry partners	The academic inventors and individuals in their network	Gaining trust from actors within and outside the university that possess valuable resources
Nature of competency	Related to iteration with actors having technology and market knowledge	Related to human agency	Related to accumulating resources to build the new venture
Direct influence of the department level context on the evolution of entrepreneurial competencies in spin-offs	Provide research setting with industry experience that promote the recognition and development of entrepreneurial opportunities	Provide a context with slack resources and legitimacy of venturing activity that influence whether internal champions decide to engage in the venture	Provide support for university policies that increases the availability of resources from the department to the new venture such as academic sabbaticals, laboratory space, technician time and consumables.
Indirect influence of the department level context on the evolution of entrepreneurial competencies in spin-offs	Provide access to diversified set of industry contacts that helps developing entrepreneurial opportunities such as through introduction of new recruitment and networking practices by management.	Provide a context with slack resources by application of university policies to provide academic time and proof of concept funding thereby increasing the legitimacy of venturing activity and attracting internal champions to engage in the venture	Endorse and support university I.P. policies and provide a credible position that helps the new venture obtain resources from external resource providers