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A Knowledge-based Categorization of Research-based Spin-off Creation

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Abstract

In this paper we argue for the need of sector contextualization to achieve a better understanding of new venture activities aimed at commercializing university generated knowledge. From this perspective, we contend that an analysis of the creation of research-based spin-offs (RBSOs) must take place within a context of the specific knowledge base around which the new venture is formed. Two distinct knowledge bases are identified: analytical (science-based) knowledge and synthetic (engineering-based) knowledge. Propositions related to the processes governing the creation of RBSOs are developed, depending on whether the opportunity around which the new venture is formed has an analytical or a synthetic knowledge base. This means that we see the formation and early development of RBSOs as a historically determined heterogeneous trajectory, where differences in the underlying knowledge base may significantly affect the new venture creation process.

Keywords: Entrepreneurship, knowledge bases, new venture creation, researchbased spin-offs, university-generated knowledge

A knowledge-based categorization of research-based spin-off creation

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Summary

In this paper we argue for the need of sector contextualization to achieve a better understanding of new venture activities aimed at commercializing university generated knowledge. From this perspective, we contend that an analysis of the creation of research-based spin-offs (RBSOs) must take place within a context of the specific knowledge base around which the new venture is formed. Two distinct knowledge bases are identified: analytical (science-based) knowledge and synthetic (engineering-based) knowledge. Propositions related to the processes governing the creation of RBSOs are developed, depending on whether the opportunity around which the new venture is formed has an analytical or a synthetic knowledge base. This means that we see the formation and early development of RBSOs as a historically determined heterogeneous trajectory, where differences in the underlying knowledge base may significantly affect the new venture creation process.

Keywords: Entrepreneurship**;** knowledge bases; new venture creation**;** research-based spin-offs; university generated knowledge

1. Introduction

The contribution of university generated knowledge to economic development and growth in technological advanced economies has increased dramatically during the last decades (OECD, 2003). The most fast growing and wealth-creating industries, such as biotechnology, information technology, and telecommunications have for example gradually become more science-based. This has made policy makers interested in the role of universities as potential engines for innovation and job creation emphasizing their involvement in industrially relevant research and technology commercialization. Universities are hence increasingly shifting from their traditional role as educational providers and scientific knowledge creators, to a more complex 'entrepreneurial university model' that incorporates the additional role of knowledge commercialization

and active participation in the development of research-based spin-offs (RBSOs) in the local and regional economy (Etzkowitz et al., 2000).

The attention to the 'entrepreneurial university model' has generated a growing number of studies aimed at understanding the role of support structures and policies for the successful commercialization of university generated knowledge, both at the national level (Goldfarb and Henrekson, 2003) and at the university level (Meyer, 2003). In addition there has been a growing stream of studies focusing on the role of science parks and incubators in promoting or constraining the establishment and early development of research-based ventures (Siegel, Westhead, and Wright, 2003). However, despite the increased interest in RBSOs there is little theory informing the processes whereby these ventures emerge. Most studies take the established firm as the point of departure while leaving the organizing processes leading up to the formation of the new venture largely unexplored (Vohora, Wright and Lockett, 2004). The current theoretical knowledge of the creation of RBSOs - from initial perception of opportunity, through new venture idea development and resource acquisition to new venture team formation - consequently remain largely limited (Ndonzuau, Pirnay and Surlemont, 2002; Hindle and Yencken, 2004).

Entrepreneurship scholars have only recently initiated serious efforts to investigate the processes of creation before the venture is established as a competitive rent-generating new firm, for example by mapping the activities of individuals that are involved in starting up new ventures (e.g., Gartner et al., 2004). An important observation from this emerging stream of research has been that the new venture creation process is characterized by a large degree of heterogeneity. For example, in a recent study Delmar and Shane (2004) show that the sequence of organizing activities prior to the establishment of the new venture varies across different types of opportunities and that this can have implications for new venture performance. Moreover, Samuelsson (2004) in his dissertation found important distinctions in the new venture creation process depending on if the business opportunities around which new ventures are formed can be characterized as innovative or reproducing. The process of creating a business is hence

not “a well-worn route marched along again and again by identical entrepreneurs”, which speak against any universally valid one-size-fits-all model of new venture creation (Gartner, 1985:697). The new venture creation process can consequently be expected to vary depending on characteristics of the opportunity around which the new venture is formed.

In this paper we will extend previous studies of knowledge-intensive entrepreneurship (e.g. Johannisson, 1998; Feldman, 2000; Madsen, Neergaard and Ulhøi, 2003) by focusing on new venture creation activities aimed at commercializing university generated knowledge. The aim of the paper is to develop propositions related to processes governing the creation of research-based spin-offs (RBSOs). As a starting point for our endeavor we acknowledge that entrepreneurial activities do not occur in a vacuum but is embedded in cultural and social contexts (Asheim and Coenen, 2005) and within webs of human networks that are both social and economic (Aldrich, 1999). To better understand the prerequisites for new venture creation in the context of university generated knowledge we therefore emphasize the need for sector contextualization (Pavitt, 1984). Following this argument, we contend that an analysis of RBSO creation must take place within a context of the specific knowledge base around which the new venture opportunity is formed (Autio, 1997). The paper adopts this challenge by making a conceptual distinction between new ventures created in different technological sectors, on account of their dominant knowledge base: analytical (science-based) or synthetic (engineering-based) (Laestadius, 1998; Asheim and Gertler, 2005).

A variety of definitions have been used in the literature for capturing the phenomenon of RBSOs, with labels such as ‘academic spin-offs’, ‘university-based start ups’, ‘research-based start ups’, ‘firms created by researchers’, etc (for an overview, see for example Pirnay et al., 2003: 357). For the purpose of this study, a RBSO is defined as a new company founded to exploit a piece of intellectual property created by faculty or staff in an academic institution (Shane, 2004:4). Our definition of RBSOs thus include ventures initiated by academic researchers where the goal is to exploit and commercialize research findings developed in a university (Klofsten et al., 1988; Olofsson and Wahlbin, 1993),

but exclude the efforts of researchers and teachers that start new ventures based on general knowledge rather than their own research.

This paper presents several contributions to existing literature and research on RBSOs. First, we explicitly focus on firm organizing processes rather than existing new ventures. A striking feature in studies of RBSOs is the tendency to focus on newly established rather than emerging organizations. Another common feature is that studies rarely open the 'black box' of economic value creation from university research (Ndonzuau et al., 2002). This means that great inferential leaps are made between input (results of research) to output (creation of economic value) without any attention to the intermediate processes and mechanisms that link the inputs to the outputs. Hence, only a very limited number of studies have explored the underlying processes governing the creation of RBSOs, and in this paper we provide an attempt in this direction. Second, and in line with Mustar et. al. (2006), we question the widespread tendency to view RBSOs as a largely undifferentiated outcome. Instead we are interested in how processes governing the creation of RBSOs may differ between cases. This, we hope, would help us to better understand the many facets of this multiheaded concept. Third, to achieve a better understanding of new venture activities aimed at commercializing university generated knowledge we explicitly acknowledge the need for sector contextualization (e.g. Pavitt, 1984; Autio, 1997). From this perspective, we contend that an analysis of the creation of RBSOs must take place within the context of the specific knowledge base around which the new venture is formed. Two major types of knowledge bases are identified to meet this need: synthetic and analytical (Laestadius, 1998; Asheim and Gertler, 2005). This categorization follows the epistemological distinction between two more or less independent and parallel forms of scientific knowledge production: natural science and engineering science (Laestadius, 2000). The distinction also closely resemble the findings in Autio (1997:268) where he identify 'science-based firms' that are relatively more active in transforming scientific knowledge into basic technologies and 'engineering-based firms' which are relatively more active into the application of specific technologies. Each of them represents a unique combination of attributes that are believed to determine relevant outcomes in the new venture creation process.

The rest of the paper proceeds as follows. The next section presents a literature review of relevant literature and research on the commercialization of university generated knowledge through the creation of RBSOs. This is followed by a section presenting two types of distinct knowledge bases identified in earlier studies. Thereafter we develop propositions related to the processes governing the creation of RBSOs, depending on whether the opportunity around which the new venture is formed has an analytical or a synthetic knowledge base. The paper ends with a concluding section, where implications and suggestions for future research are presented.

2. Commercializing university generated knowledge through the creation of RBSOs

Technological advanced economies can only compete by creating and exploiting knowledge that can give rise to new product and technology cycles. An increasing part of this knowledge is nowadays produced in publicly funded research, especially within universities (Shane, 2004). University generated knowledge is however not easily transferred to the private commercial sector (Harmon et al., 1997). The main carriers of university generated knowledge are academics directly involved in its actual production through research. To support the commercial uptake of university generated knowledge governments therefore pursue policies geared towards increasing entrepreneurial activities among academics (OECD, 2003).

A popular route to commercialize university generated knowledge has been to promote the creation of new companies that exploit a piece of intellectual property created by faculty or staff in an academic institution. There are several reasons behind the popularity of this alternative. A major reason is that regional and national policymakers see new companies that are based on potentially valuable scientific discoveries as useful means to boost economic development (Olofsson and Wahlbin, 1993; Feldman, 2000). New companies that spin off from universities tend to locate near the parent university and their economic benefits (in terms of job creation and taxable wealth) thus tend to accrue locally while technology transfer to larger corporation means that benefits may be transferred out of the immediate region (Steffenson, Rogers and Speakman, 2000).

Another main reason underlying the promotion of new companies is that they offer incentives for a greater share of the wealth created eventually being returned to the original academic institution and academic researcher (Feldman et al., 2002). In a study of US and Canadian universities, Bray and Lee (2000) for example found that the average value of equity sold was more than 10 times higher than average annual income fees from a traditional license, and also significantly higher than the amount usually received from license issue fees. Furthermore, successful new ventures based on university generated knowledge may lead to enhanced faculty and university reputations, and may even provide employment for university graduates.

RBSOs are not a homogenous group of firms and previous studies have presented several ways of categorizing them (for an excellent recent review of previous studies, see Mustar et al., 2006). Some studies have primarily distinguished RBSOs according to the way they operate. Bullock (1983) for example identified two categories of RBSOs in this way: 'soft companies' which he referred to as technical consultants solving customized problems, and 'hard companies' which he referred to as selling standardized and relatively simplified products to a general market. Moreover, as the new ventures grow he assumes that soft companies subsequently develop into hard companies. In a later study, Stankiewicz (1994) classify RBSOs according to their operating mode, where he presented them as having either a 'consultant and R&D boutique oriented mode', a 'product oriented mode' or a 'technological asset oriented mode'. He argues that this typology is not mutually exclusive as firms can move between modes during their development. However, he also points out that each mode requires a different configuration in terms of technical skills, approach to management and financing, linkages to the academic knowledge base, and in the infrastructural support (Stankiewicz, 1994: 103).

Other studies have taken characteristics of RBSOs resources or knowledge base as the main point of departure. In a comparative study of new technology-based firms in Finland, UK and US, Autio (1997) link the niche markets of new technology-based ventures and the transformation of knowledge they undertake. He identify 'science-based

firms' that are relatively more active in transforming scientific knowledge into basic technologies, and 'engineering-based firms' which are relatively more active into the application of specific technologies. In another study of UK ventures, Druilhe and Garnsey (2004) identify five broad categories depending on the entrepreneur's relevant knowledge/experience and the resource requirements of the venture: 'research-based consultancy', 'development company', 'software', 'product-based company' and 'infrastructure creation'. Each category presents a different business model of how the business activities are resourced, how it creates value and how returns are to be realized. Moreover, they argue that as the business model of the new venture evolves the new venture may subsequently enter a different category of business activity. Finally, in a study of RBSOs in Flanders, Heirman and Clarysse (2004) develop a resource-based taxonomy and find four different starting configurations: 'venture capital start-ups', 'prospectors', 'product start-ups' and 'transitional start-ups'. Venture capital start-ups are found to be characterized by high market complexity and growth prospects. Prospectors are characterized by an unclearness of its product market at founding. Product start-ups mostly have an almost market ready product targeted at an international niche market, while transitional start-ups initially commercialize technical know how and tend to become product oriented later on.

Yet another way of distinguishing RBSOs has been depending on their relation with the university. In a UK study of RBSOs, Webster and Rapster (1997) differentiate four distinct types: 'independent firms', 'hybrid firms', 'shell firms' and 'virtual firms'. The independent firms have broken away from and with modest contact with the university. The hybrid firms are still located on the university and are dependent on administrative and financial support. The shell firms are sometimes (but not always) located within a wider university holding company and are designed primarily to pull in research income for a university department. Finally, the virtual firm brings together research staff from a number of academic sites, developing embryonic ideas for third parties who will take them to market. The relation with the university is also discussed in Franklin, Wright and Lockett (2001) who suggest differentiating between ventures where the researcher leaves the university from ventures where the researcher remains active as an academic

researcher, suggesting that the first group tends to be more successful. In a similar fashion, Nicolai and Birley (2003) present a typology based on the role and extent of involvement by the academic researcher where they distinguish between two alternatives: 'academic stasis´ where the researcher stays in the university and 'academic exodus' where the researcher leaves the university to concentrate on the new venture. In another recent study, Pirnay et al. (2003) review existing definitions of RBSOs and suggest a classification according to the status of individuals involved in the process (student or academic researcher) and the nature of the ventures activities (products or services). This classification result in four possible cases of RBSOs, where each case is argued to show different characteristics in terms of the business opportunity, the entrepreneur and required resources (Pirnay et al, 2003:363).

The above contributions all holds great merit for furthering our understanding of RBSOs. However, in this paper we are interested in the creation of RBSOs rather than their early development and growth. This means that we cannot take the new firm as the primary unit of analysis, simply as the organization is under emergence and does not yet exist (Gartner and Carter, 2003). Moreover, if one considers the commercialization of knowledge to be the core of RBSOs then it becomes important to acknowledge the different types of knowledge involved in this process (Autio, 1997). Hence, instead of taking the new firm as the primary unit of analysis we will focus on the *knowledge* on which the commercial opportunity is based and around which the emerging venture is formed. From this point of departure, we therefore ask to what extent the processes governing the creation of RBSOs can be expected to show different patterns dependent on its underlying knowledge base. This will be developed in the next section.

3. Knowledge bases

A basic assumption in this paper is that an analysis of the creation of RBSOs must take place within the context of the actual knowledge base around which the new venture is formed. Rather than seeing RBSOs as representing a single undifferentiated outcome driven by a universal process, we therefore posit that there may be different processes that give rise to distinct types of RBSOs depending on the type of *knowledge* from which

the commercial opportunity originate and around which the emerging venture is formed (Autio, 1997). By doing so, we acknowledge that different technological sectors may follow different paths of innovation (Pavitt, 1984). This means that we see the formation and early development of RBSOs as a historically determined heterogeneous trajectory where differences in the underlying knowledge base may significantly affect the new venture creation process.

For the purpose of this paper, we will distinguish between two types of knowledge bases identified in earlier research: analytical (science-based) and synthetic (engineering-based) (Laestadius, 1998; Asheim and Gertler, 2005; Asheim and Coenen, 2005). An analytical knowledge base refers to industries where scientific knowledge is highly important, and where knowledge creation is often based on cognitive and rational processes or abstract and formal models (Asheim and Gertler, 2005). The intellectual challenge is to understanding natural systems by discovery and application of natural laws where the knowledge often equals the product (Asheim and Coenen, 2005). Both basic and applied research is relevant activities as well as the systematic development of products and processes. Typical outputs are publications, licenses and patents. Examples of technological sectors that rely mainly on an analytical knowledge base include biotechnology, nanotechnology, information technology and genetics.

A synthetic knowledge base refers to industries where innovation takes place mainly through the application of knowledge or through recombination of existing knowledge in new ways (Asheim and Gertler, 2005). The innovation process is mainly oriented towards the efficiency and reliability of new solutions, or the practical utility and user-friendliness of products from the perspective of the customers. The intellectual challenge is geared towards constructing and running complex functional systems shaped as producable and useful artifacts (Asheim and Coenen, 2005). Overall, this leads to a more incremental way of innovation, dominated by the modification of existing products and processes. Typical outputs are patents, technical blueprints, and prototypes. Examples of technological sectors that rely mainly on a synthetic knowledge base include plant

engineering, food processing, telecommunications, and advanced industrial machinery and production systems.

Knowledge inputs are in the analytical knowledge base more often codified than in the synthetic knowledge base (Asheim and Coenen, 2005). However, this does not imply that tacit knowledge is irrelevant in the analytical knowledge base nor does it mean that there is no codified knowledge in the synthetic knowledge base. As pointed out by Asheim and Gertler (2005), there are always both tacit and codified knowledge involved and needed in processes of knowledge creation and innovation (se also Nonaka et al, 2000; Johnson and Lundvall, 2001). Hence, in both types of knowledge bases there is different mixes of tacit and codified knowledge, codification possibilities and limits, qualification and skills, as well as specific innovation challenges and pressures. In table 1, the analytical and synthetic knowledge bases are contrasted against each other.

Table 1 - The analytical and synthetic knowledge bases contrasted against each other

Analytical knowledge base	**Synthetic knowledge base**
Innovation by creation of new knowledge	Innovation by application or novel combination of existing knowledge
Importance of scientific knowledge, often based on deductive processes and formal models	Importance of applied, problem related knowledge, often trough inductive processes
Dominance of codified knowledge due to documentation of in patents and publications	Dominance of tacit knowledge due to more concrete know-how, craft and practical skill
More radical innovation/product innovations	Mainly incremental innovation/process innovations

Source: Asheim and Gertler (2005)

We acknowledge that the venture creation process in both knowledge bases will share similarities. They can for example both be considered as "technology developers" (Hellman and Puri, 2000) where academics play a leading role and revenues are far away. However, we posit that the specific processes governing the creation of RBSOs may vary depending on the specific knowledge base. This argument will be developed in the next section.

4. The creation of RBSOs

RBSOs do not form spontaneously. They take place in response to the actions and activities of enterprising individuals who decide that a certain technology or scientific discovery is worthy of exploitation through the creation of a new venture (Shane, 2004). The presence of a committed academic researcher or team of researcher is thus crucial for the venture to emerge (McQueen and Wallmark, 1984; Wright et al., 2004). The early stage of development and the tacitness of the knowledge that often underlies the invention mean that strong ties between the academic researcher and the emerging venture are necessary for successful development. That does not mean that the academic researcher must leave his or her position at the university, but they have to be enthusiastic about the process, helping raise capital etc (Shane, 2004).

In this section we will develop propositions related to the processes governing the creation of RBSOs. The dimensions we will cover are i) the role of the personal network for opportunity perception, ii) the process of initial venture idea development, iii) the primary source of early stage funding, and iv) new venture team formation. These organizing activities may occur over a long period of time and although presented sequentially below we acknowledge that the activities are iterative and cyclical in nature, and with considerable overlaps (Ndonzuau et al., 2002; Gartner and Carter, 2003; Klofsten, 2005).

4.1 The role of the personal network for business opportunity perception

A reason for individuals perceiving opportunities is because they have information that other people lack (Kirzner, 1973; Shane, 2000). Shane (2000) has for example found that prior knowledge of a particular market increases the likelihood of perceiving an opportunity in that market. The formation of a conjecture for a potential business opportunity is hence influenced by the possession of information or beliefs that lead an academic to think in a certain way about the possibility for capitalization of the knowledge that has been created. An important way people can get access to information about potential applications and markets is through their personal networks (Aldrich and Zimmer, 1986; Johannisson, 1998). Diverse social ties to a wide variety of people have

for example been found to increase the likelihood that an individual will gain access to the right complement of information necessary for discovering an opportunity (Aldrich, 1999; Singh et al., 1999). Moreover, also strong ties has been pointed out as potentially beneficial for successful opportunity discovery as they are trustworthy and provide people with information that recipients believe to be accurate. Consequently, networks and social relations affect the perception of business opportunities.

Weak network ties could favor the perception of business opportunities for academic researchers that mainly operate within analytically oriented research projects. Despite the importance of codifiable knowledge in analytically oriented research the circulation of new knowledge can still be expected to remain highly localized (Asheim and Coenen, 2005). A reason for this is because knowledge spillovers primarily occur within the established local networks of academics, often by word of mouth, well before formal results are published in widely accessible outlets (Nicolaou & Birley, 2000). Academics researchers moreover rarely have commercial networks and have relatively little contact with non-technical people (Clarysse and Moray, 2004). The existence of weak ties can in this setting play an important role as a bridging function to new information, knowledge and resources (Granovetter, 1973). Weak network ties could then help academics to receive positive recommendations and commercial evaluation at the right places, which in turn may favor the perception of business opportunities.

For academic researchers operating within synthetic oriented research the opposite may rather be the case. Synthetic knowledge creation is favored by interactive learning supported by strategic research alliances with industry (Asheim and Gertler, 2005). Here the greatest value for opportunity perception can be expected to be gained from closely or densely connected networks. Therefore, high-strength ties between cooperating parties make contacts more likely to share critical and confidential information (Nicolaou & Birley, 2000). Closeness, mutual trust, friendship and reciprocity are for example found to be positively related to the degree of learning in strategic alliances (Kale, Singh and Perlmutter, 2000). This would bind members of the network together by a level of trust

that leads to members of the team will help each other. Based on the above discussion, we can formulate the following propositions:

P1a: We expect the existence of weak network ties to be highly important for the perception of business opportunities among academic researchers operating within an analytical knowledge base.

P1b: We expect the existence of strong network ties to be highly important for the perception of business opportunities among academic researchers operating within a synthetic knowledge base.

4.2 Initial venture idea development

While elements of potential opportunities may be "perceived" it should be emphasized that business opportunities leading to the creation of a new venture are made and not found (Ardichivili et al., 2003; Klofsten, 2005). Careful investigation of and sensitivity to information of locations, markets, sources of capital, ways to organize etc may help the academic researcher to begin develop a perceived opportunity into a venture idea (Ndonzuau et al., 2002). The venture idea here refers to the development of the conceived business concept (resource bundling, value chain positioning etc) that will be used to exploit the perceived business opportunity. The successful creation of a new venture follows a cyclical and iterative venture idea development process (Klofsten, 2005). How this process initially goes about when it comes to the creation of RBSOs is however largely unexplored.

Knowledge creation in the synthetic knowledge base is generally triggered by observable problems in industry. The opportunity develops in response to the need to solve specific problems in the interaction with industry partners (Asheim and Gertler, 2005). Trial and error is part of the inductive problem solving process and continued search for alternatives or refined solutions is triggered by failure or additional slack resources. It is hence more likely that the researcher or research team gradually sees the venture idea emerges and that they continue to refine it. This means that opportunities for profit

making within synthetic knowledge bases begin as simple concepts that over time become more elaborate as the new venture idea is developing. There is a notion – even if it is vague – of how to fulfill a market need, and a combination of research together with a good dialogue with clients and industrial partners makes the idea develop (see for example the case described in Klofsten, 2005:101). The initial idea development process can consequently be expected to closely resemble a "problemistic search" procedure (Cyert and March, 1963:121), where the initial research is motivated by an immediate problem and where the subsequent venture idea development is directed toward finding a satisfactory solution to that problem.

In the analytical knowledge base academic researchers does not generally wait to be activated by a perceived problem in industry. Rather, they develop technologies or make scientific discoveries without having any application in mind. However, once informed of its commercial potential the academic can be expected to start pursuing search for market niches, which may generate ideas for new products or services without much regard to market acceptance or commercial viability of the invention or new technology (see for example Wright, Vohora and Lockett, 2004:297). An academic researcher pursuing a perceived business opportunity based on an analytical knowledge base can hence be likely to continually look for potential business opportunities and conduct evaluations several times at different stages of development, which in turn may lead to both adjustments as well as recognition of additional opportunities. The initial idea development process may in this respect best be described as "opportunistic surveillance" (Thompson, 1967:151) where venture idea development is motivated by the search for a range of alternative commercial applications, and which does not therefore stop when a first problem solution has been found. Based on the above discussion, we can formulate the following propositions:

P2a: We expect initial venture idea development to be motivated by the development of solutions to a perceived problem among academic researchers operating within a synthetic knowledge base.

P2b: We expect initial venture idea development to be motivated by the search for alternative commercial applications among academic researchers operating within an analytical knowledge base.

4. 3 The new venture champion

The emerging venture requires access to differing inputs of skills, resources and entrepreneurial capacity according to its phase of development (Olofsson and Wahlbin, 1984; Klofsten et al., 1988; Vohora et al., 2002). This may come either by that the academic researchers further develop their own competencies or alternatively by bringing in an external (surrogate) entrepreneur to champion the new venture project (Radosevich, 1995; Franklin, Wright and Lockett, 2001). Experience has shown that researchers without entrepreneurship training and experience, while competent as initial technology champions, often is not well suited to the founder role needed to drive the new venture forward (Daniels and Hofer, 1993; Clarysse and Moray, 2004). This means that even if an academic researcher initially takes the role as the new venture champion, over time he or she most often will be replaced by an externally recruited CEO. However, empirical evidence suggests that there are differences among academic researchers concerning their involvement also in the very early stages of RBSO development. Either they want to be highly involved by championing the start up process themselves, or they want to stay out of it as largely passive shareholders or as members of the scientific advisory board and thus keeping their main jobs as academics (Nicolaou & Birley, 2003; Clarysse and Moray, 2004).

An external entrepreneur can generally be expected to be in charge of the start up process for new venture ideas originating from analytical knowledge bases. It is for example clear that academic researchers in science in general have inadequate commercial awareness and limited experience in how to go about the process (Vohora et al., 2001). Faculty with little or no previous experience of collaborative activity with industry has for example been found to be more concerned or worried about the seriousness of conflict of interest or divided organizational loyalty in commercialization activities (Campbell and Slaughter, 1995). Olofsson and Wahlbin (1984) even found reluctance among academic

researchers to have their interests in new venture activities too widely noted in the university, even if the information was publicly available. This means that academic researchers in settings which do not traditionally favor university-industry collaboration may seek to retain their university position, limiting his or her involvement to a directorship or membership of the scientific advisory board. Moreover, as academic researchers in science come from a different world representing different incentive structures, rules and organizational cultures compared to business there may also be a potential clash of value systems that most of them want to avoid (Bird, Hayward and Allen, 1993). Adding to this, the dominance of codified knowledge in analytical oriented research (Asheim and Coenen, 2005) should moreover make it easier for external (surrogate) entrepreneurs to step in while keeping the original research team involved on the scientific advisory board. This implies that an external entrepreneur can be expected to become in charge of championing the new venture project.

On the other hand, for new venture ideas based on synthetic knowledge one of the original academic researchers can instead generally be expected to be in charge and champion the project. Faculties are for example more favorably disposed to personal involvement in commercialization activities in settings where industrial contract research is encouraged (Cambell and Slaughter, 1995; Rahm, 1995). For example, McQueen and Wallmark (1984) in their study of a Swedish technical university did not find any conflict between academic performance and activities aimed at commercializing academic knowledge. Lee (1996) moreover reports that faculty members in engineering and applied sciences are among the strongest supporters for commercialization activities such as start up assistance and equity investments. The dominance of tacit knowledge and the often established alliances with industry partners in analytical knowledge bases (Asheim and Coenen, 2005) may furthermore require a closer contact with the original research team during the development of the new venture. This implies that the researcher can be expected to be the initial venture champion, something which is also partly illustrated in Clarysse and Moray (2004) where the leader of the initial research project of developing a core technology platform (datacasting) evolves into the CEO position and become in

charge of championing the new venture project. Based on the above discussion, we can formulate the following propositions:

P3a: We expect an external (surrogate) entrepreneur to become in charge of championing the new venture project for venture ideas originating from an analytical knowledge base.

P3b: We expect one of the original academic researchers to become in charge of championing the new venture project for ventures ideas originating from a synthetic knowledge base.

4.4 Preferred source of early stage external funding

Academics face considerable challenges in meeting the need for early stage financing for their ventures (Klofsten et al., 1988; Carlsson, 2002; Baum and Silverman, 2004). New technological developments and potential breakthrough innovations are linked to scientific knowledge and intellectual property (IP) that is difficult for others to value (Lindström and Olofsson, 2001). Academics moreover often lack tangible assets that may be used as collateral. In addition, their potential new venture ideas are largely untested in markets, have little or no track record, and are subject to high obsolescence rates. For example, most inventions do not reach the market, and of those who do only less than half of them become at least a moderate success (Åsterbo, 2003).

Academics are often required to go through several rounds of raising capital before they can start reaping any economic returns on their technology or scientific discovery. Studies for example show that academic entrepreneurs provide the first financial resources needed to initiate new venture projects from their own personal savings and micro investments from family and friends (Cooper, 1986; Moore, 1994). However, over time the successful commercialization of an innovation or technological development require additional resources for continued R&D, marketing, production and overall management. This means that the importance of private savings gradually decreases in favor of external sources of capital (Klofsten et al., 1999; Shane, 2004). As such, the ability to turn the venture idea into an established competitive rent-generating new

venture is largely dependent on the extent it is possible to attract the interest and resources from potential external partners in the new venture creation process (Ndonzuau et al., 2002).

One solution is to seek additional support from venture capitalists (VCs), for example a private investor or a VC firm. VCs can be especially important since they often develop deep industry and technology specific competencies in a narrow field so that they can add value to their investments. Both private investors and VC firms also make contributions in similar areas for developing early stage projects, with an advisory/sounding board role being most important (Ehrlich et al, 1995). VCs have also been found to pursue firms with more radical and ambitious product and process innovations (Hellman and Puri, 2000). This mode of financing is thus much in favor of opportunities based on an analytical knowledge base, where the aim is to promote new economic activity and which require close and systemic industry-university cooperation and interaction in the context of science parks and incubators (Asheim and Coenen, 2005).

Another solution is by collaborating with an industrial partner that can assist with important complementary resources, something which often result in an equity joint venture. This alternative is more likely if the research team have an already established collaboration with industry on a research project (Wright et al., 2004). The equity joint venture is a new venture that is jointly owned by the university and the industrial partner into which technology is assigned or licensed. The industry partner may in this respect contribute with significant amounts of resources to the new venture, including finance to develop products for markets as well as facilities in which the new venture can operate in a commercial environment (Wright et al., 2004; Dushnitsky and Lenox, 2005). This mode of financing is thus much in favor of a synthetic knowledge base, where the aim is to strengthen and support localized learning of an existing industrial specialization and to promote historical technological trajectories based on “sticky” knowledge (Asheim and Coenen, 2005). Based on the above discussion, we can formulate the following propositions:

P4a: We expect venture ideas originating from an analytical knowledge base to be more inclined to seek venture capital as the main source of early stage external funding.

P4b: We expect venture ideas originating from a synthetic knowledge base to be more inclined to seek industrial partners as the main source of early stage external funding.

5. Discussion

The growing attention to RBSOs as a commercialization channel for university generated knowledge has led to a growing interest into the process whereby these ventures emerge and develop (Ndonzuau et al., 2002). Governments are for example devoting increasing amounts of money to universities with the goal of turning them into engines of economic growth through spin off activity (Shane, 2004). But even if universities are capable of generating valuable scientific and technological knowledge they typically lack enough resources and capabilities to successfully commercialize the new knowledge in a new company. The resource needs include a whole new range of competencies ranging from intellectual protection to the identification or even creation of a market (Hindle and Yencken, 2004). These needs often extend beyond the traditional skills and experience of research teams and administrators and also require an exceptional level of commitment in and around universities (Klofsten et al., 1988). It also calls for the development of analytical tools and models that will open the 'black box' of economic value creation from university research in order to better identify and understand the underlying processes governing the creation of RBSOs (Ndonzuau, et al., 2002).

It is widely acknowledged that different technological sectors follow different paths of innovation (Pavitt, 1984; Autio, 1997; Asheim and Coenen, 2005). There are however relatively few studies that compare entrepreneurial activities aimed at commercializing university generated knowledge across scientific disciplines and technological sectors. In this paper we have suggested that an analysis of the creation of RBSOs must take place within a context of the specific knowledge base around which the new venture is formed. Two distinct knowledge bases were identified for this purpose: analytical (science-based) knowledge and synthetic (engineering-based) knowledge (Laestadius, 1998; Asheim and

Gertler, 2005). These have been found to require different mixes of tacit and codified knowledge, and also imply different qualification of competencies and skills and contrasting challenges and pressures for innovation (Asheim and Coenen, 2005), something that may have important implications for conditions and progress in the early development of RBSOs.

In the paper we propose that challenges and obstacles encountered in the evolution of an initial idea from a non-commercial research environment is different in different types of RBSOs. More concretely, we suggest that the processes governing the i) initial perception of the entrepreneurial opportunity, ii) early development of the venture opportunity, iii) the choice of new venture champion, and iv) the preferred source of early stage external funding, depending on whether the opportunity around which the new venture is formed has an analytical or a synthetic knowledge base. Table 2 below summarizes our discussion.

Table 2 - Knowledge bases and the process of RBSO creation

	Analytical knowledge base	**Synthetic knowledge base**
Initial perception of opportunity	Weak network ties highly important	Strong network ties highly important
Early development of venture opportunity	Motivated by search for commercial opportunity	Motivated by developing solution to perceived problem
New venture champion	Surrogate entrepreneur most likely to champion the project	Research team most likely to champion the project
Preferred source of early stage external funding	More inclined to seek finance from venture capitalist	More inclined to seek finance from industrial partner

It should be emphasized that the classification of industrial knowledge bases refers to a conceptually derived interrelated set of ideal types and they should hence be treated as such. They are intended to provide an abstract model so that deviation from the extreme can be noted and explained (Doty and Glick, 1994). This also means that actual observations may be more or less similar to an ideal type, but should not be automatically associated to any one of them. In empirical settings hybrid cases may - and often do -

exist. Hence, the categorization and the propositions developed thereof that have been presented in this paper are theoretical statements that should be subject to rigorous empirical testing. However, on a conceptual level, we believe it is of great merit to keep them separated, and we argue that this type of categorization can develop our collective understanding of new venture creation activities aimed at commercializing university generated knowledge.

6. Conclusions

We have in this paper focused on entrepreneurial activities aimed at commercializing university generated knowledge. We have argued for the need of sector contextualization (Pavitt, 1984) by emphasizing that an analysis of the creation of RBSOs must take place within the context of the specific knowledge base around which the new venture opportunity is formed (Autio, 1997). From this perspective the paper has presented several avenues for future research in this direction. For example, the propositions developed in this paper are novel suggestions that should be subject to future empirical testing. A better knowledge of the processes governing the creation and formation of RBSOs can hopefully save time and expenses for universities and research teams by informing them of challenges and obstacles that often is encountered, hopefully preventing them from pursuing unproductive lines of inquiry. Given the early stage of our collective understanding of the processes governing the creation of RBSOs we hope that the ideas and arguments put forth in this paper may stimulate others to join in our efforts.

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