From the university environment to academic entrepreneurship

6th Inter-RENT Online Publication

Editor

Tõnis Mets

European Council for Small Business and Entrepreneurship (ECSB)

Published by
European Council for Small Business and Entrepreneurship
Turku, Finland, 2009

ISBN: 978-952-249-001-8 (online)

TABLE OF CONTENTS

Tracking entrepreneurship in the academic environment (editorial)

Tõnis Mets

The Inter - RENT Workshop 2009

Tradition of Inter-RENT Workshop and publication initiated by the Board of the ECSB and started in 2004 has widened post-conference publication options: besides the traditional Inter-RENT online publication professor David Smallbone is preparing RENT Anthology based on the selected 27 best papers of RENT Conference in Covilha, 2008. That is partly limiting the number of papers for pre-selection but is giving more chance to focus on some special topics to cover by current Inter-RENT Workshop online publication. Therefore the editor is grateful to the Board members for accepting the topic of relations between entrepreneurship and university environment. That permitted to dedicate the publication on the role of entrepreneurship domain in and around university: from knowledge production to knowledge and technology transfer and implementation by industry, from mono-disciplinary university model to trans-disciplinary entrepreneurial university, from entrepreneurship education targeted to university members for facilitating enterprise and creating entrepreneurial attitudes in society generally. All these university role-related processes are analyzed in University-Industry-Government framework in the context of entrepreneurial university.

The aim of the editorial introduction is to create general framework for the Workshop and chapters of its publication. That means to conceptualize the role of entrepreneurship in the processes mentioned above and shed light upon the aspects covered by the following chapters.

As during the last decade in the context of European Union (EU) Lisbon strategy (Raivio, 2008) universities have been considered the source of new knowledge for building up knowledge society: this creates new goals for universities. Besides teaching and research, serving society is becoming a coherent domain of the university. Transition towards fulfilling the third mission is called the second academic revolution (Etzkowitz, 2004) and active universities in that process are called entrepreneurial universities characterized with the University-Industry-Government (UIG) linkages as well with the special role of entrepreneurship domain in that framework (Figure 1).

Entrepreneurial university interlinks its three missions: education, research and serving society. Institutionally that has meant having in a university structure besides traditional

education and research functions, a technology transfer office (TTO) and active patenting of own research results by the university (Baldini, 2006).

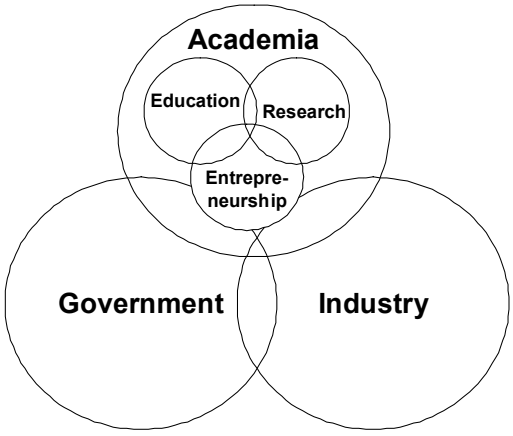


Figure 1. Main actors and domains of entrepreneurial university (Mets, 2009)

That means also creating entrepreneurial competencies and mindset among university members, active position to production and implementation of university knowledge for prosperity of society and entrepreneurial environment inside and around the university. Knowledge production and commercialization related processes are fulfilled in the different frameworks of UIG linkages as examined by the number of researchers, for example, in regional development (Etzkowitz, Klofsten, 2005), learning (Matley, Mitra, 2002), knowledge networks' (Carayannis, Alexander, 1999) and intellectual property (IP) system (Kelli, Pisuke, 2008) context.

Parties in UIG-relations can demonstrate different roles. Several analysis of technology transfer processes from a university to a firm or an entrepreneur and relevant environment (for example: Siegel et al, 2004; Hindle, Yencken, 2004; Howard, 2005) are treating different facets of the entrepreneurial university, even integrating partly them, but do not link these facets together into integral model, which should contain besides already well-known teaching and research functions also commercialization of research in entrepreneurial context. Suggested entrepreneurial model of UIG-linkages in Figure 1 is not functional enough for mapping patterns of main processes of university R&D commercialization, incl. the model how university is creating value from its own research. For that purposes the concept of business model, implemented before in companies' framework (for example: Chesbrough, Rosenbloom, 2002; Osterwalder, 2004), hereby for university is used (Figure 2).

General business model schema (Figure 2) does not present in details all possible trajectories of knowledge creation and functions of entrepreneurship domain in the university environment. But their location and functions in the general schema are corresponding to

mainstream of processes described in the Figure 1 and 2. There can be two different approaches to university business model:

- wider view to university as a creator of intellectual and social capital for and in society,
- narrower view to university optimizing commercialization of research as fund-rising function.

Although, other solutions could be located somewhere between them, which approach to prefer depends on the agreement between society and the university. Mainly we must mention that this is the question of governmental (societal) order, evaluation criteria and funding partly studied by Rasmussen and Gulbrandsen in Chapter 1 "A principal–agent perspective on government support programs to promote academic entrepreneurship: The case of Norway" of the current Inter-RENT Workshop publication.

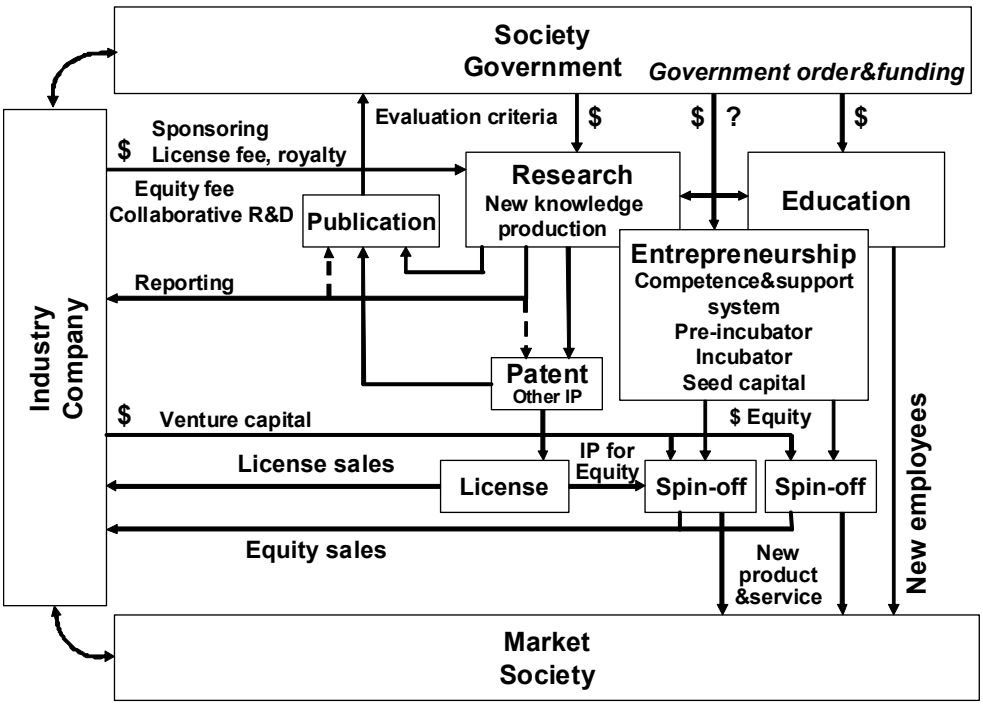


Figure 2. Business model of R&D commercialization for entrepreneurial university in the framework of University-Industry-Government (Mets, 2009)

Including entrepreneurship function into the university means also implementation of more active measures for technology transfer (TT) as mentioned above. Entrepreneurship domain in University knowledge transfer (KT) plays multiple roles:

- support of university spin-off processes,
- linking different disciplines into integral part of knowledge and technology transfer,
- shaping entrepreneurial attitudes among university personnel,

- via education creating entrepreneurial attitudes among students.

The first role has direct impact on TT and KT via spin-off companies. The second role creates better understanding and higher trans-disciplinary competence among academicians in different technological, legal, economic and social aspects of R&D and knowledge production mode 2 (about mode 2 see for example, Hessels, Lente, 2008) for commercialization. The third role has indirect impact influencing on orientation and selection by researchers thematic fields and goals for R&D and implementation of new ideas in real business or other fields of society in the future. The fourth role prepares the new generation of researchers as well business and technology players of the region – that means long-term impact on the entrepreneurship environment of the region and readiness for collaboration from all sides: academia (university), companies (industry) and region (government). In that way entrepreneurship training and education becomes a part of the entrepreneurial university model with long-term orientation. The role of entrepreneurship education at a Portuguese university assessed by Gerry, Marques and Nogueira is partly covering that topic in Chapter 2 “Graduates & Business Start-Ups: an assessment of entrepreneurial propensity in a Portuguese university”.

Not depending on institutional realization, knowledge transfer and entrepreneurship domain in current business model (Figure 2) have the following roles (Howard, 2005; Autio, 2007; Mets, 2009):

- Knowledge diffusion is covered mainly by scientific and popular publications, and standards, capacity building of university graduates – new employees for private and public sector carrying new knowledge to their jobs, life-long (post-graduate) training, but partly also via other (staff) public and personal communications, and (not protected as IP) new products and services launched by university spin-offs. That means also creation of social capital and sharing of knowledge via networks. The role of entrepreneurship domain is mainly educational: training university students and facilitating entrepreneurial culture within the region.
- Knowledge production means patenting new technology at first, and following publications, sales of licenses on patents and other protected IP to industrial partners. Partly this function is covered with investment of own IP into spin-off companies and financial involvement of venture capital. Entrepreneurship domain (support system) is mainly targeted to spin-off processes and entrepreneurial attitude and competencies of the academic personnel, incl. development of entrepreneurial environment, business incubation, consultancy and mentoring, seed and venture capital funding, etc.
- Knowledge relationship includes donation and corporate sponsoring of research projects and funding of chairs or scholarship, contracted teaching services, research and

consultancy, cooperative and collaborative research, business and research partnerships, incl. industry (trans-disciplinary) research centers and institutes, joint laboratories, facilities and ventures. Because of complexity of ownership IP becomes special issue in this relationship. The roles of entrepreneurship, besides these listed above, are strategic and management support functions on industry (trans-disciplinary) level, incl. linking business and IP strategies.

- Knowledge engagement comes from the third mission of university and means interaction between universities, industry (business) and government to solve complex problems before society. The need for that comes from non-linearity of innovation processes which need active collaboration of UIG partners in the field of strategic issues of knowledge-based economic development, incl. R&D and knowledge transfer policies and support measures on the state level. Complex domain of entrepreneurship can be implemented as facilitator of entrepreneurial competence and culture via education and creation of entrepreneurial environment transcending university boundaries.

The TT roles and relevant processes in UIG framework described above have intersections with each other. Chapter 3 “Managing intellectual property rights in academic spin-off ventures” by De Cleyn and Braet and Chapter 4 “Commercialisation strategies of research-based spin-offs: the case of companies that operate in the market for technologies” by Conceição, Fontes and Calapez are partly covering IP management and commercialization aspects in that framework. As knowledge engagement is a part of governmental policy, Chapter 1 besides introduction into UIG relations framework adds some valuable understanding how to implement government program supporting commercialization of university research and reaching higher involvement of university in economic development of society. In this meaning the authors of the following chapters have given a valuable contribution to opening of different aspects of entrepreneurship and entrepreneurial behavior in academic environment.

All these aspects are more widely analyzed on the example of South Africa in the concluding Inter-RENT seminar’s contribution in Chapter 5 “Towards an Academic Entrepreneurship Governance Framework for South African Higher Education” written by Grundling and Steynberg. Unfortunately, hereby it only remains to regret that nor selected five chapters of the current issue neither any other compilation of researches cannot cover full multifaceted character of academic entrepreneurship in the full variety of internal and external environment. That gives continuing challenge for entrepreneurship researchers to learn multidisciplinary processes of university mission in creating new value for society.

According to the editor’s opinion the main conclusion of the researchers seems to be agreed that only long-term goals create the integral position for entrepreneurship domain in the university context. This has become clearer that the emerging crises situation in economy

during the last year is affecting all partners in UIG framework and they cannot continue in former comfortable co-existence without radical comprehensive collaboration. It could be declared that entrepreneurship is critical success factor and catalyzer for efficiency growth of technology transfer via impact on the focus of R&D as well as for fostering spin-off processes at university. Finally that leads to more balanced approach in university development and its partnership with industry and region.

Corresponding Editor

Prof. Tõnis Mets, Ph.D, e-mail: Tonis.Mets@ut.ee

References

Autio, E. (2007). Entrepreneurship Teaching in the Öresund and Copenhagen Regions. Lyngby: Technical University of Denmark.

Baldini, N. (2006). University patenting and licensing activity: a review of the literature. *Research Evaluation*, 15 (3), 197-207.

Carayannis, E.G. and Alexander, J. (1999). Winning by co-opeting in strategic Government-University-Industry R&D partnership: the power of complex, dynamic knowledge networks. *Journal of Technology Transfer*, 24, 197-210.

Chesbrough, H. and Rosenbloom, R.S. (2002). The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. *Industrial and Corporate Change*, 11 (3), 529-555.

Etzkowitz, H. (2004). The evolution of the entrepreneurial university. *Int. J. Technology and Globalisation*, 1 (1), 64-77.

Etzkowitz, H., Klofsten, M. (2005). The innovating region: toward a theory of knowledge-based regional development. *R&D Management*, 35 (3), 243-255.

Hessels, L.K., Lente, H. (2008). Re-thinking new knowledge production: A literature review and research agenda. *Research Policy*, 37, 740-760.

Hindle, K., Yencken, J. (2004). Public research commercialization, entrepreneurship and new technology based firms: an integrated model. *Technovation*, 24, 793-803.

Howard, J. (2005). The emerging business of knowledge transfer: From diffusion to engagement in the delivery of economic outcomes from publicly funded research. – Paper presented at Triple helix Conference 5: The capitalization of knowledge, Turin, Italy, May.

Kelli, A., Pisuke, H. (2008). Intellectual property in an innovation-based economy. *Review of Central and East European Law*, 33, 223-238.

Matley, H., Mitra, J. (2002). Entrepreneurship and learning: the double act in the triple helix. *Entrepreneurship and Innovation*, February, 7-16.

Mets, T. (2009). Creating business model for commercialization of university research. *Management of Organizations: Systematic Research*, 51, 83-94.

Osterwalder, A. (2004). The business model ontology: a proposition in a design science approach. – Doctoral diss., Universite de Lusanne, Ecole des Hautes Etude Commerciales.

Raivio, K. (2008). Foreword. University Reform – A Prerequisite for success of knowledge-based economy. In: European Universities in Transition: Issues, Models and Cases, ed. C. Mazza, P. Quattrone, A. Riccaboni, F."Giorgio Cini". - Edward Elgar.

Siegel, D.S., Waldman, D.A., Atwater, L.E., Link, A.N. (2004). Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies. *Journal of Engineering and Technology Management*, 21, 115-142.

1. A principal–agent perspective on government support programs to promote academic entrepreneurship: the case of Norway

Einar Rasmussen* and Magnus Gulbrandsen**

***Bodø Graduate School of Business (Norway)**

****NIFU STEP (Norway)**

Abstract

Universities and other public research institutions are ever more active in commercialization of research. This development is partly stimulated by an increasing number of government support programs. Still, the role played by this new type of actor in the innovation system is not very well understood. This paper analyzes the development of the Norwegian government support program FORNY using principal-agent theory to analytically sharpen the distinction of roles and the way the relationship between the different actors are organized. The FORNY program serves to reduce the agency problems of adverse selection and moral hazard in the relation between the government and the actors who are involved in the commercialization of research. Key tasks include collecting and sharing information, engaging in long-term relationships with principals and agents, developing strategies and specific contractual relationships, taking higher risk than the often risk averse agents, and using multiple indicators. The program also plays an institutional role by reducing goal conflicts. This approach, however, requires a long term effort which is generally less visible for outside stakeholders, and it is under constant pressure from short term expectations.

Key words: Academic entrepreneurship, Agency theory, Government support program

Introduction

Academic entrepreneurship, or the creation of new ventures based on academic research, has become an important objective for policy makers and universities across Europe (Mustar et al., 2008). In many countries, special initiatives to support the commercialization of university research have been established (Callan, 2001; Rasmussen et al., 2008). Most European countries have one or several public support programs oriented at science-based entrepreneurship encompassing early-stage funding, training and cultural change activities, scholarships for academic entrepreneurs and more (Mosey et al., 2006; Rasmussen, 2008). The programs have become more sophisticated and specialized over time, and in many

countries there are several that partly or fully target commercialization of publicly funded research (Feldman et al., 2002; Wright et al., 2007). Using a broad definition, one survey identified 178 initiatives relevant for commercialization of research in Canada alone (Gault and McDaniel, 2004). Research to understand the support programs' operation has not followed this expansion.

The academic entrepreneurship literature has mainly looked at the spin-off firm and the university level of analysis (Nosella and Grimaldi, 2009; Rothaermel et al., 2007). An emerging stream of literature has also looked at support such as incubators (McAdam et al., 2006), science parks (Siegel et al., 2003), seed funding (Wright et al., 2006), and training programs (Mosey et al., 2006). The role of government policy makers has been less scrutinized, although several studies have looked at the impact of legislative changes like the US Bayh-Dole Act (Mowery et al., 2001; Shane, 2004). This paper analyzes government support programs for commercialization of research from universities and other public research organizations. These programs have been neglected in most studies of academic entrepreneurship and their role and operation are not well understood. The following research question will guide our study: *what is the role of specialized government programs to promote academic entrepreneurship and what sort of challenges do they face?*

Government support programs are usually organized as separate entities, with an important emphasis on monitoring, evaluation, and indicators. These programs aim to deal with the special challenges of commercialization of university inventions and other results from academic research. Such commercialization is usually characterized by high risk and high uncertainty, features which make a principal-agent framework appropriate (Eisenhardt, 1989).

A historical case study approach is adopted to analyze the Norwegian FORNY program, which has been in operation for 15 years. With an annual budget of close to NOK 150 million (about 28 million USD), it is the single most important public source of funding for science-based entrepreneurship in Norway. The program is managed by the Research Council of Norway, but it receives funding from several different ministries. FORNY allocates funding to TTOs, other commercialization support organizations, universities and other public research institutions, and directly to individual academic entrepreneurs and start-ups. This paper uses a principal-agent framework to analyze the different tensions in the strategic and operational decisions of a support program for early stage science-based entrepreneurship.

In the next section we review the existing literature related to the role of government support programs for the commercialization of research and outline a principal – agent framework to analyze their role. Next, we investigate how Norwegian policy-makers, represented by the FORNY program, have developed a specialized support structure for the commercialization of research in the period from 1994 to 2008. We discuss the role of this program in relation to other actors, the types of agency problems that have emerged, and ways to deal with these. Two approaches can be identified. One is to create structures that deal with the agency problems of moral hazard and adverse selection. The other is to reduce the inherent goal conflicts between the actors, thus reducing the agency problems. Finally, we discuss issues that do not fit into a principal-agent framework and provide implications for the organization of government programs to support academic entrepreneurship.

Government support programs

The government efforts to promote commercialization of publicly funded research have developed rapidly. This may be seen as a result of a gap between two policy areas. Programs to support university-industry collaboration and applied research are widely used and well established (Branscomb et al., 1999). This is also the case with programs to provide support for entrepreneurs and SMEs (Lundström and Stevenson, 2005) where many countries have increased the emphasis on support tailored for new technology-based firms (NTBFs) (Heydebreck et al., 2000; Lindström and Olofsson, 2001; Storey and Tether, 1998). Still, it is increasingly recognized that these two different types of support are not fully able to address all challenges associated with the commercialization of academic research. First, many studies have pointed at the early stage and embryonic nature of university technologies (Agrawal, 2006; Colyvas et al., 2002; Jensen and Thursby, 2001). Second, the entrepreneurial process may be inhibited by a lack of business experience and commercial skills among academics (Bird and Allen, 1989; Radosevich, 1995; Samsom and Gurdon, 1993; Vohora et al., 2004). Third, barriers related to the non-commercial academic environment and possible conflicts of interest with other university tasks have been frequently discussed in the literature (Anderson, 2001; Mustar et al., 2006).

The rationale for government intervention in commercialization of university research is debated, and conceptual frameworks are scarce. Salmenkaita and Salo (2002) outline four different policy rationales for government intervention in the commercialization of new technologies, with market failure and systemic failure as the two most common. This is sometimes expressed in terms such as a ‘finance gap’ and a ‘knowledge gap’ faced by university spin-off firms (Lockett et al. 2002).

European programs often seek to emulate the perceived US capacity for commercializing research results (Mustar et al., 2008). Many US universities and their TTOs take an active role in promoting research commercialization. National initiatives such as the SBIR program have contributed to fostering academic entrepreneurship (Toole and Czarnitzki, 2007). Although regional and multinational authorities (e.g. the European Union) are increasingly more involved in innovation policy issues, the policies to support academic entrepreneurship have generally been implemented at the national level (Mustar et al., 2008).

Government support to promote science-based entrepreneurship is usually delegated to separate programs, such as TULI in Finland (Salo et al., 2006), the NSERC Idea to Innovation (I2I) program in Canada (Rasmussen, 2008), and the University Challenge Funds in the UK (Wright et al., 2007). These programs are usually organized within a larger government body, such as a research council or development agency. The programs act on behalf of the government and typically provide funding to activities executed by agents such as research institutions, TTOs, or individual researchers. Delegation of activities and the relationship between the actors involved are the analytical domain of principal-agent or agency theory (Braun, 1993; Eisenhardt, 1989).

Principal-agent theory

The principal-agent framework helps to sharpen the distinction of roles between different actors and the way the relationship between them is organized (Eisenhardt, 1989). It has been used in prior studies of the relation between government and science (Braun, 2003; Van der Meulen, 1998), the role of technology transfer organizations (Guston, 1999), the role of intermediary agencies (Braun, 1993), the role of research programs (Shove, 2003), and the role of research councils (Van der Meulen, 2003).

Principal-agent theory depicts situations where one actor (the principal) hands over resources, often in a contractual relationship, to other actors (the agents) in order to reach goals that the principal cannot reach alone. An entrepreneurship support program like the Norwegian FORNY initiative or the other programs mentioned above can be viewed as principals in the relationship with entrepreneurs and local commercialization support units, but they can also be seen as agents of the ministries that fund them. They are therefore “intermediary” organizations (Jensen et al., 2003) doing “boundary work” (Guston, 1999) in a complex situation with multiple principals and multiple categories of agents. Specific contracts, strategic plans, and budget documents usually specify the rights and obligations of

the agents. It may be hypothesized that the intermediary position is multifaceted; the support program must adhere to the goals and rationales of its funding sources and balance this with the objectives of the entrepreneurs and other actors that it selects for support. At the same time, the program often has an explicit goal to influence the objectives of the actors receiving funds, e.g. to change academic culture towards more entrepreneurship.

Three sets of problems for an entrepreneurship support program may be discussed within a principal-agent framework (Guston, 1999; Van der Meulen, 1998). First, *goal conflicts* denote situations where the principal and the agents have conflicting or only partly overlapping goals. The government programs often aim for commercialization in the form of new firms and sale of licenses and often require that the researchers are involved in entrepreneurial projects. Academics, on the other hand, may desire autonomy and research funding that allow them to pursue the most interesting scientific problems. Some of them may even have goals of personal financial gain which could constitute a tension with respect to university goals and culture. In addition, some of the ministries that fund such programs have overarching goals related to regional development and the sustenance of specific sectors, which may or may not be in conflict with promoting academic entrepreneurship. Partial goal conflict is an assumption of agency theory (Eisenhardt, 1989).

Second, *adverse selection* refers to the problem of finding the appropriate agent for delegation. This often requires the principal to rely on the agents' own judgments or actions; commercialization often requires active disclosure, peer review of the technical quality and another type of expert review dealing with market/economic criteria of quality. A costly delegation and review process may be necessary, and it can sometimes be difficult to find evaluators without a close relationship to the agent. Thus, adverse selection refers to the misrepresentation of ability by the agent (Eisenhardt, 1989).

Third, *moral hazard* implies that the delegation gives the agent an incentive not only to carry out the required task, but also to act in unacceptable ways by not putting forth the agreed-upon effort. Blind trust is rarely an option, so monitoring activities, indicators, incentives, and sanctioning opportunities often become central.

In agency theory, the degree of information the principal can have about the agents' behavior is important. As proposed by Eisenhardt (1989), the agent is more likely to behave in the interest of the principal when the principal has information to verify the agents' behavior. A support program needs to develop mechanisms to find the appropriate agents and sanction lack of effort, thus reducing the problems of adverse selection and moral hazard. Further,

Eisenhardt proposes that the type of information the principal can obtain about the agents' behavior will influence the type of contract between the principal and agent. In the case where the principal cannot observe the agent's behavior due to adverse selection and moral hazard, information systems that can monitor the agents' behavior are positively related to behavior-based contracts and negatively related to outcome-based contracts. In other words, if a support program can verify that those who receive the support is both capable of performing the task and are putting forth the effort required, further incentives are not required. Alternatively, the contract can be related to the outcome of the agents' behavior, but also here the degree of information that can be obtained will influence the type of contract. Eisenhardt (1989) suggests that outcome uncertainty is positively related to behavior-based contracts and negatively related to outcome-based contracts. Moreover, the degree of task programmability, outcome measurability and the length of the agency relationship influence the type of contract chosen. The efficiency and use of indicators and monitoring exert much influence on how principal-agent relations are organized.

Method

In order to investigate the development and challenges of government programs for the commercialization of research, comprehensive data over a long period of time would be preferable. In many countries, these types of programs are rather young, operated by many agencies, and have undergone considerable organizational changes which make data collection difficult. The Norwegian FORNY program provides a unique opportunity to follow the development over time for several reasons. First, this program has been in continuous operation since 1994 without any larger re-organizations. This has made it possible for experiences to accumulate. Second, the program is responsible for all the government schemes in Norway directly related to the commercialization of publicly funded research. . Third, FORNY deals exclusively with commercialization of research in a fairly narrow sense. Fourth, the program has been a central actor in a period where significant changes have taken place regarding the commercialization of research at Norwegian institutions. FORNY has regularly been in contact with similar programs in other countries to learn from best practice (e.g. Rasmussen et al., 2006a). Thus, the FORNY program may be seen as an archetype or exemplar of a government program to promote science-based entrepreneurship. A final advantage of studying the FORNY program is the transparent operation and good data availability.

The empirical analysis is based on a large number of interviews, document studies and surveys collected as part of evaluations and scientific investigations of commercialization of

academic research in Norway conducted by the authors in 1994-2009. Key studies are summarized in Table 1. In addition, we have analyzed secondary data about the FORNY program, such as three comprehensive evaluations of the program (Bolkesjø and Vareide, 2004; Borlaug et al., 2009; Hervik et al., 1997), annual reports, newsletters, calls from funding schemes, and presentations at the FORNY user conference held twice a year. Most of these documents are available through FORNY's web page (www.rcn.no/forny).

Table 1: Data about commercialization of research in Norway collected by the authors

Year	Data	Goal/focus	Reference
1994-1995	Case study of six European universities; 43 interviews and documents	Comparative study of university policies for commercialization	(Gulbrandsen, 1995)
2000	Case study of commercialization activities at six European universities (two Norwegian); 100 interviews and documents	Comparative study of university initiatives to promote commercialization of research	(Rasmussen et al., 2006b; Waagø et al., 2001)
2002	Interviews with 30 academic entrepreneurs and support staff		(Gulbrandsen, 2003)
2003-2005	Case study of four university spin-offs, 49 interviews	Understanding of the start-up process in a university context	(Rasmussen, 2006)
2005-2006	Around 20 interviews, large survey and document analysis	Mapping of the commercialization support structure in Norway	(Gulbrandsen et al., 2006)
2007	Interview study of Norwegian support actors and policy makers	Assessment of the Norwegian support system for commercialization of research	(Rasmussen et al., 2007)
2008	Interview study and survey of universities and TTOs	Assessment of FORNY's infrastructure scheme	(Borlaug et al., 2008)
2009	Survey of universities, TTOs and FORNY's firm and license portfolio	Assessment of the FORNY program	(Borlaug et al., 2009)

The Norwegian context

Due to the low level of industry R&D expenditure and the low share of high technology firms in the economy, the Norwegian government considers it to be particularly important to foster the creation of new research-based firms. This is also deemed important for a transition from a dependency on finite oil and gas resources. Like in many other countries, the Norwegian policy makers have in recent years issued several legislative changes and spent considerable funds on initiatives to increase the commercialization of university research. Ownership to research results was moved from the individual researcher to the higher education institutions through legislative changes in 2003, a somewhat controversial change especially among professors already active in commercialization. Significant changes can also be seen at the university level where TTOs and other organizations have been established.

Norway has seven universities, around 30 state and private colleges, and close to 100 small and large research institutes. Competitive research funding can be obtained through the Research Council of Norway and some other actors like the regional health organizations and the various ministries. As in other countries, basic funding has decreased in all parts of the public science system, and the institutions are increasingly on the lookout for new sources of funding.

Evolution of FORNY

The FORNY program is currently the main support mechanism for commercialization of research in Norway, oriented at universities, colleges, research institutes, and university hospitals. However, research results are most often commercialized in direct partnerships between the public research institutions and industry or other partners. FORNY is oriented at research results that are *not* transferred through these collaborations. In addition to funding promising commercialization projects, FORNY is also a major source of funding for the support infrastructure such as science parks and TTOs. FORNY is operated by the Research Council of Norway and receives funding, presently around NOK 150 million annually, from five Norwegian ministries. The Ministry of Trade and Industry, the Ministry of Local Government and Regional Development, and the Ministry of Education and Research have been the primary sources of funding and can be regarded as the most important principals for FORNY.

The program was established as a project within the Research Council of Norway in 1995. The first strategy document pointed out that the program should "… contribute to innovation and through this value creation and employment in Norwegian industry. This will be achieved through strengthening the ability to commercialize research-based business ideas that emerge within the universities and research institutes" (Bolkesjø and Vareide, 2004). The strategy document outlined two target areas for the program; to establish an infrastructure to lower the barriers towards commercialization at the research institutions, and to professionalize the commercialization process aiming at increasing both the number and quality of commercialization concepts. Commercialization was seen to happen either through a license to an existing firm or through the start-up of a new firm.

Instead of targeting the researchers directly, FORNY used regional commercialization units connected to the major research institutions as agents to operate the program. Before the expansion in 2002, there were six commercialization units. In most cases these operators were often connected to science parks and jointly owned by the research institutions, public

agencies, and private firms. These companies specialized in supporting entrepreneurs from research into business. Their assistance included the evaluation of an idea and its commercialization prospects, IPR issues, adding competence, providing commercial networks, and access to financing. The commercialization units were awarded commercialization funds as an annual lump sum based on an application to the FORNY program and were free to decide what projects to support.

The early experiences revealed a need for a stronger involvement from the research institutions. The funds that were granted as one sum to the commercialization operator were split in two in 2000: the infrastructure funds where the research institution had to apply for a 50 percent cost covering of activities, and the project funds that still were awarded directly to the commercialization units.

The result metrics of the program were connected to three levels with specified outcomes. First, the inventors in the research groups: number of specific commercialization opportunities received and changes in attitudes and culture in the research departments. Second, the research institutions: number of specified business ideas and changes in the institutional culture, infrastructure, strategies, and priorities. Third, the commercialization units: total number of commercialization projects executed, the commercialization projects in relation to total public support, the value creation in the projects, and the ability to engage competence and funding from other actors and support providers.

From 2001, a rewritten program plan outlined a new main goal for FORNY: “to increase the value creation through commercializing knowledge-based business ideas with a high value creation potential”. The removal of the points about “Norway” and “Norwegian industry” may signify an increased emphasis on non-spin-off commercializations and on international collaboration in entrepreneurship.

The responsibility of the research institutions was further strengthened in 2004 when they were allowed to apply for project funding directly without going through the commercialization units. Still, the major research universities established technology transfer offices (TTOs). This was done to strengthen their position as IPR owners and to provide more freedom to choose partners in commercialization projects. The result was nevertheless a more complex system with an increased number of support actors competing for funding from the same sources. In 2008 the FORNY program provided financial support to 48 institutions, including 15 commercialization units/TTOs, 7 universities/university colleges, 18 R&D institutes, 5 university hospitals, and 13 state colleges.

In addition to the close ties with research institutions and commercialization units, FORNY has close coordination with other government agencies, in particular with the agency Innovation Norway, which has several schemes to support entrepreneurship. The FORNY supported ventures can also receive support from the R&D tax deduction scheme SkatteFUNN and other support schemes for industrial R&D.

Funding schemes

In recent years the FORNY program has operated four different funding schemes and one performance-based incentive scheme that all are aimed at increasing the commercialization of research from Norwegian R&D institutions. These schemes are summarized in Table 2.

Table 2: The schemes operated by the FORNY program

Scheme	Annual budget	Outcome measure	Description
Idea generation and development of infrastructure (Infrastructure funds)- Established in 2000	NOK 27.4 million in 2008.	Conferences and seminars (500 in 2008), seminar participants (15 000), potentially interesting research-based business ideas (672), and ideas actively pursued (273).	The research institutions can apply for infrastructure funds in order to include commercialization as a part of their strategies, to increase the awareness and knowledge about patenting and commercialization, and to simulate the search for commercialization opportunities. The FORNY funding can cover up to 50% of the total costs. The program can also support the establishment of TTOs at the universities, cooperation between TTOs and other commercialization units, alignment of policies and rules at research institutions, and part-funding of patenting costs.
Commercialization funds - Established in 1995	NOK 47.8 million in 2008.	Commercializations (70; 36 licenses and 34 start-ups in 2008).	The commercialization units receive a lump-sum grant based on applications. The potential for commercialization at the institutions and the prior performance is taken into consideration when the funding decision is made. Funding decisions for both infrastructure and commercialization funds are made internally in the FORNY secretariat. These funds can be used locally to cover up to 50% of the costs of specific commercialization projects up to licensing or firm establishment, but not for product development.
Proof of concept funds - Established in 2002	NOK 46.5 million in 2008.	No specific outcome metrics.	Grant awarded to specific projects to support technology development on the basis of panel evaluations of submitted applications. Application has to be submitted by a commercialization unit operator already receiving commercialization funds. 39 projects were supported in 2006. The funds aim to strengthen the projects and lead to more successful commercializations.
Leave of absence grant - Established in 2006	NOK 6.5 million in 2008.	No specific outcome metrics.	Grant to support researchers to commercialize an idea. Covers the cost of the employer for making 20 to 100 per cent of the researcher's position available to work on a commercialization project. Awarded to 16 projects in 2006.
Incentive funds	NOK 7.5 million in 2008.	Not relevant	Awarded to the commercialization units depending on their performance measured on several criteria. For start-ups, external interest in the project is measured as external equity funding, pilot customer or industry partner, or loans provided. Additional incentives for the estimated value creation potential of the venture. For licenses, incentives are connected to license income (up-front or the first 5 years) and whether the licensee covers patenting costs and development costs.

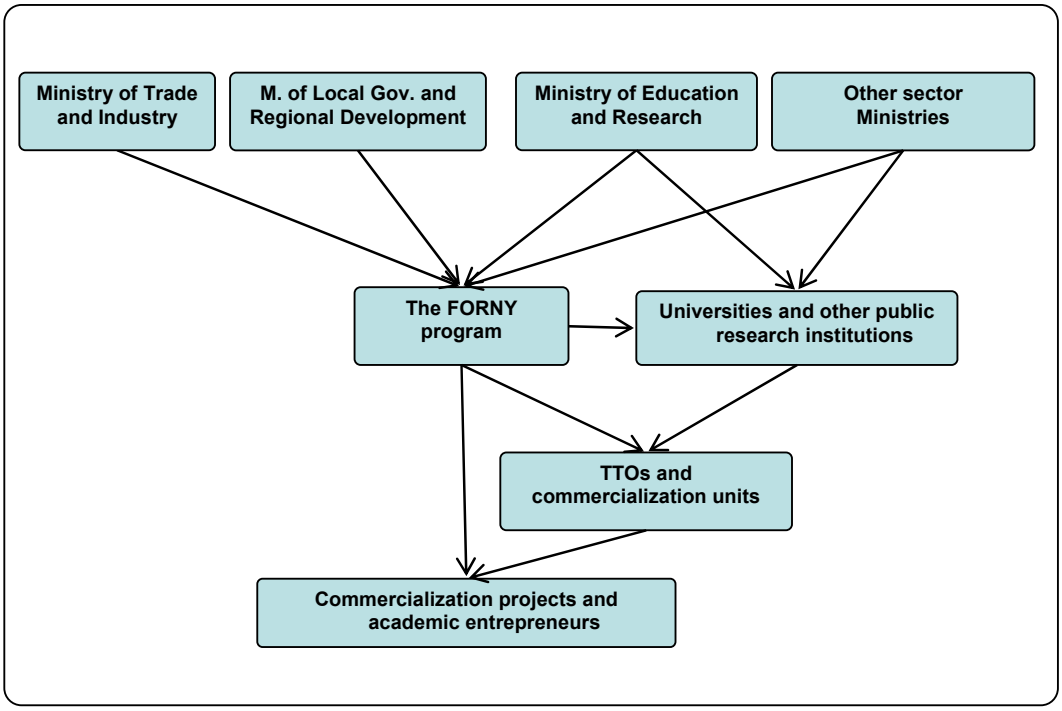
The annual grants during the period 1995-1999 were about NOK 30 million rising to NOK 90 million during 2003-2005 to NOK 145 million in 2008. In total, during the period 1995-2008 the program received about NOK 1 billion, equivalent to around 180 million USD.

The program secretariat maintains a database of all funded projects. This database is updated annually with financial information from the national company accounts register about all the start-up companies. An assessment of the project portfolio supported by FORNY grants from 1996 to 2007 (Borlaug et al., 2009) shows that 295 companies had started and 125 license agreements had been signed on the basis of technology developed in Norwegian research institutions. In 2008 about 200 of these firms still existed with a total turnover of about NOK 900 million and 700 employees. Most of these firms are small and only about five percent display patterns that make them likely to become high-growth firms.

Analysis of FORNY in a principal-agent framework

As mentioned, FORNY can be viewed as an agent of the Ministries that provide funding for the program's operation and as a principal for the actors that receive funding from it (TTOs, commercialization units, universities, and commercialization projects). Furthermore, the TTOs also act as both agents for the universities and the FORNY program, and principals for the commercialization projects they support. Thus, a rather complex picture of relationships emerges. Figure 1 illustrates the contractual relationships between the actors connected to the FORNY program.

Figure 1: The contractual relationships between actors connected to the FORNY program.



Each arrow represents a principal–agent relationship.

The relation between the FORNY program and its funding ministries varies considerably in terms of goal specificity and active involvement. A challenge in these relations is the difficulty of assessing the outcome of the commercialization support. For the ministries, the outcome should ideally be measured in the form of the additionality, i.e. the share of the outcome that would not have been achieved if the support did not exist. This is in practice impossible to measure accurately, so proxies have to be used. FORNY has been active here, probably to demonstrate its legitimacy to its funders. Vehicles of legitimacy have been the database showing the development of all projects supported by the program as well as frequent evaluations. FORNY has successfully been able to argue for significant increases in the funding from the Ministries over the years.

FORNY is also a principal for the organizations it funds. The infrastructural funds target the research institutions directly, the commercialization funds are awarded to the TTOs and commercialization units, while the proof of concept and the leave of absence grants are awarded directly to promote specific commercialization projects. Moreover, the agents of the FORNY program are also nested in principal agent relationships. The universities and other public research institutions often have ownership in the TTOs and commercialization units and sometimes also in the projects and spin-offs. The TTOs provide resources to the specific

projects that do not come from the FORNY program. These complex interrelations imply that there is ample room for goal conflicts and information asymmetry.

As a response to the challenges of incorporating multiple goals and dealing with agents at several levels, the FORNY program as outlined above has developed from the initial commercialization funds into four different funding schemes. As illustrated in Table 3, these schemes provide funding to three target groups leading to different implications for the principal-agent relationship.

Table 3: Analysis of the support schemes offered by the FORNY program

	Infrastructure funds	**Commercialization funds**	**Project funding (proof of concept/leave of absence)**
Goal	Institutional change and idea development	Early stage project development	Funding for early stage commercialization projects
Target area	Supports activities and infrastructure at the research institutions	Supports TTOs and commercialization units to develop commercialization projects	Supports specific commercialization projects
Goal conflict	Research institutions may have priorities differing from FORNY's	Similar goals, but agents may seek to maximize funding	Researchers may have other priorities, e.g. gaining extra R&D funding
Moral hazard	Risk that funds are used for general administrative functions replacing other funding sources	Risk that funds are used in a manner that does not correspond with the priorities of FORNY (i.e. research-based ideas)	Risk that funds are used to improve scientific and/or technological aspects and not commercial development
Adverse selection	Difficult to select the institutions having the highest potential and need for support	Difficult to select the TTOs and commercialization units that will deliver the best commercialization services	Difficult to select ideas and entrepreneurs that have the highest potential and need for support
Outcome uncertainty	High	Medium (actors have a portfolio of projects)	High for single projects
Outcome measurability	Very difficult	Time lag	Time lag
Risk aversion	High at the institutional level, especially at smaller institutions	Medium	High for single projects
Information systems	Activity based	Result based	Few
Monitoring	Behavior, based on activities and number of ideas	Outcome, based on number of projects and assessments of these	Milestones, selection of projects through expert review
Relation to agent	Long term	Long term	Short term (single grant), but TTO involvement required to reduce agency problems

The infrastructure funds can be seen as an investment to increase the future potential for commercialization of research by inducing changes in the research institutions. FORNY intends to change attitudes and behavior and generate extra efforts. There is a risk that the institutions have other priorities and seek to use these funds to replace their own funding of

existing efforts, although this seems to be a rather minor problem (Borlaug et al., 2008). The outcome of the infrastructure activity is extremely difficult to measure, thus FORNY have mainly relied on measures related to behavior and keeping a long term and close relationship to the institutions. This is in accordance with agency theory. Questions may nevertheless be asked about the assumption that attitudes among scientific staff can be changed in this manner and that this inevitably will lead to changes in behavior.

The commercialization funds are awarded to agents that share many of the same goals as FORNY related to developing new ventures and licenses with commercial success. The TTOs and commercialization units do, however, have their own agenda of sustaining their activity and generating revenue. Some of them are also obliged to serve a specific region or a specific university, regardless of the nature of the ideas. The FORNY funds are an important source of income for most of these agents, creating incentives to manipulate the criteria for gaining funding from FORNY.

The TTOs and commercialization units allocate much of their funding to specific projects, thus taking the role as principal towards the entrepreneurs and projects. Academics are motivated by doing research, although surveys show that many may have an additional motivation of use or commercialization, at least as long as it does not interfere with or hamper research opportunities (Etzkowitz 1998). It is likely that the ones who actively seek out TTOs through meetings, disclosures (which still seem fairly voluntary in the Norwegian system) and otherwise, want to succeed in commercialization just as much as the TTOs. The goal conflicts may therefore be small in this case or related to other aspects like the distribution of revenues.

In order to incentivize the commercialization units to “work hard” and have a strict commercial orientation, FORNY added a bonus scheme. In its original form, this scheme awarded a cash payment to the commercialization unit for each new firm established. This system was increasingly critiqued because some of the commercialization units seemed to be very eager to formally establish companies, even when the ideas were early stage or had low growth potential. The bonus system has been changed several times to avoid this type of moral hazard problems. In the present system, there are also incentives to collaborate with other TTOs. The bonus system, however, illustrates some of the challenges with incentive systems, especially when using proxies (e.g. number of firms) to reward long-term goals (e.g. value creation). The zero sum game between the TTOs probably also make it more difficult for them to develop particular expertise and a sharing of work, compared to a situation where

each research institution and/or region funds a unit specifically tailored to its strengths and weaknesses.

The project funding in the form of proof of concept and leave of absence grants is awarded to single projects. Because these projects have a one time relation to the FORNY program, the risk of moral hazard is large. As a quality check, it is still required that these projects are connected to a TTO or commercialization unit in order to receive the grant. These projects do, however, seek the same goal as FORNY. Although there is a risk that researchers find this funding interesting for other purposes than commercialization, the process of applying for these funds and the selection process makes it unlikely that researchers bother if they are not really interested. An assessment of these funds showed that 59 percent had materialized in the form of a spin-off or license within one to three years.

Goal conflicts

There are several possible goal conflicts in this system. The most recent formulation of the program's main objectives is as follows; FORNY will:

- Contribute to changed attitudes and behavior in the research institutions in order to make the search for commercialization opportunities an integrated and prioritized part of the research activity.
- Contribute to the establishment of professional organizations and systems for the commercialization of research at the research institutions.
- Contribute to make competent and relevant commercialization assistance available
- Contribute to research-based industry development across the country.
- Contribute to increased cooperation and learning among research institutions, entrepreneurs, investors, industry, and the government authorities.

As can be seen, the program has strengthened its emphasis on building a support structure for commercialization rather than getting more directly involved. All in all these goals probably express quite clearly the intents of the different ministries that support FORNY. One possible goal conflict is related to FORNY's goal of contributing to changed attitudes and behavior to make commercialization an integrated part of academic work. This goal is probably shared with the TTOs, some of the research institutions and some of the Ministry departments. Other Ministry departments and many of the higher education institutions, however, are likely to see commercialization as a secondary activity and to give it a far lower priority than research and teaching. Some universities and colleges spend a share of their infrastructure funds on student activities, which may be on the borderline of what FORNY

has intended. Several national surveys (Gulbrandsen et al. 2006) have furthermore shown that large parts of the research community are indifferent to the legislative changes in 2003 or are skeptical towards the increased emphasis on commercialization. In addition, FORNY's goal of establishing professional organizations and systems for commercialization of research at the research institutions may lead to a certain pressure to choose a "TTO model". From an initial start with many different systems for commercialization, more and more universities and colleges select to set up external technology transfer offices alone or in collaboration with other research institutions in the region. FORNY's goal of contributing to research-based industrial development "across the country" might point at some tensions related to a long-standing national debate about national research priorities, concentration of resources, and regional priorities. The last two FORNY goals of increased cooperation and competent commercialization assistance are less likely to create tensions.

The division of FORNY support in four specialized funding schemes is probably one way of reducing the goal conflicts. In this way, also the different ministries – the principals when we view FORNY as agent – can see clearly that the program works "for them", e.g. emphasizing regional development (favorable for the Ministry of Regional Development) and support to the higher education institutions directly (positive for the Ministry of Education and Research). FORNY's historical decision to work largely with the commercialization units, rather than directly with the research institutions, may also be seen as an attempt to dampen the goal conflicts. An intermediary structure is created that may be better placed to convince the universities and colleges about the importance of commercialization. The fact that the program works more and more directly with the research institutions and their TTOs could then be taken as a sign that especially the universities and colleges have embraced the third mission and expanded their tasks following the most recent legislation.

These possible goal conflicts point at both moral hazard and adverse selection issues. The adverse selection problem has mainly been delegated to intermediary agents like the TTOs and commercialization units. In recent years, FORNY has also taken an increased interest in the moral hazard problem, in particular related to the use of "infrastructure funds" by the technology transfer organizations. Worries that this has been little more than a "block grant" to the TTOs has led to the development of a new set of indicators and changed criteria for funding. We have seen that FORNY is not very satisfied with the behavior-based infrastructure funds. The relationship between principal and agents is probably not close enough to allow for a more informal assessment of behavior, and the tools of the infrastructure funds like meetings, conferences and student organizations for

entrepreneurship have to some extent become goals in their own right, which the program did not intend.

Overall, it seems like the FORNY program has relatively low levels of moral hazard problems because the agents share the same goal of creating commercial successes. The commercialization units and TTOs have partly overlapping goals with the FORNY program and the academics that receive support are those who actively seek to commercialize. That is, the part of the academic staff who are not interested or even against commercialization of research are not likely to receive funding from FORNY.

In a complicated structure where funding is awarded by means of a series of contracts (i.e. from ministry to FORNY to commercialization unit to commercialization project) there is a risk that the problems of moral hazard increases. The goals are interpreted and communicated at several levels and delegated by contracts. Each level adds administrative costs. Thus, FORNY have since 2002 awarded proof of concept funding directly to the projects themselves, and not through the block grants to the TTOs and commercialization units.

The outcome uncertainty is high at all levels, particularly at the project level where the outcome of each commercialization vary from nothing to highly successful. Given the large number of different organizational forms among their agents (limited companies, university administration units, research institute departments, university professional committees, foundations), we can assume that direct monitoring of behavior and results are difficult. Thus, the long term operation with annual funding based on applications and close contacts between FORNY and its agents through meetings, conferences, workshops, training programs, and international study trips are ways of controlling the behavior of the agents.

Discussion – The role of the FORNY program

The FORNY program operates at the intersection of several ministries and the actors involved in commercialization. Thus, the program becomes an agent of the government and a principal for the commercialization support organizations like TTOs. The needs and interest that the FORNY program formulates to its agents are on behalf of someone else. Likewise, the results that the program can show to its principals reflect the performance of others. Thus, FORNY serves as an intermediary body where its interests are defined in terms of the interests of both their principals and agents (see also Van der Meulen, 2003). This picture is complicated by the fact that the government as principal is represented by several ministries with only partly overlapping goals. Furthermore, the agents involved in commercialization are

also highly different with varying goals. As illustrated in Figure 1 and Table 3, FORNY supports three types of agents, the research institutions, the TTOs and commercialization units, and the commercialization projects.

From a principal-agent perspective, the FORNY program clearly serves a function of reducing the problems of adverse selection and moral hazard in the relation between the government and the actors directly involved in the commercialization of research. Another, and conceptually different function of the FORNY program, is the initiative to reduce the propensity for agency problems to occur by reducing the underlying goal conflicts. This approach may be regarded an institutional role because the aim is to change the institutional context in ways that reduce agency problems. We will discuss the experience with each of these approaches in turn.

Dealing with adverse selection and moral hazard

An important task for the FORNY program has been to collect information on both the behavior (activities) of the agents and the outcomes (results) of the program. This information is used to monitor the effort of the agents and provide incentives such as the bonus scheme. Due to high outcome uncertainty, the program only makes limited use of the quantitative information for decision making. FORNY engages in long-term relationships with the agents, such as research institutions and their TTOs and has developed an understanding of their operation that supplements the more quantitative information. Thus, FORNY is an example of how government support programs can reduce information asymmetry between actors in entrepreneurship and the government. By tailoring support to specific phases and activities in the entrepreneurship process, government programs can design evaluation and monitoring systems that are more appropriate for a highly heterogeneous research system. The FORNY case also shows the downside of such a system. It is fairly well suited to documenting poor organizational performance and less-than-satisfactory results, but less suited to revealing underlying flaws in preconditions and assumptions. Examples of the latter are unrealistic expectations to the potential for commercialization from public research and a too strong focus on results in the short and medium term. These aspects are not unique to Norway.

Reducing goal conflicts

Making institutional changes to reduce problems in the principal-agent relation is the other approach to promoting academic entrepreneurship. This typically involves efforts to reduce goal conflicts between the principal and agent. The situation in Norway has changed from

1994 until now. Commercialization of research has become a part of the strategies at most research institutions and the commercialization units have become more aligned with the goals of their parent institutions. The infrastructure funds from FORNY may have played a role in this respect by emphasizing long-term work with attitudes, culture, and support systems. Still, other things have likely had a greater influence, like the 2003 legislative changes in intellectual property rights and obligations for the higher education institutions.

Increasing funding has most often been followed by strengthened emphasis on collecting information about the results of academic entrepreneurship. The main use of FORNY's database and the frequent evaluations of the program seem to be oriented at legitimacy-building and as a tool for overcoming goal conflicts and tensions in the relationship between FORNY and the ministries that support it. By facilitating the exchange of information, government support programs can help reduce goal conflicts between ministries and academics. Thus, the FORNY program reduces goal conflicts by developing trust among the actors.

Another goal conflict between the government and the actors involved in commercialization of research is related to risk aversion. Commercialization involves high risk, and only a very small proportion of research-based new ventures or licenses generate significant revenues (Carlsson and Fridh, 2002). Research institutions, particularly smaller ones, are likely to be risk averse because of small chances to achieve a commercial success. The FORNY program supports a portfolio of projects and is likely to be risk neutral. It might be expected that research organizations with a track record of successful commercialization are less likely to be risk averse. Only a few larger research institutions belong to this category, notably US universities such as MIT and Stanford (Kenney and Goe, 2004; O'Shea et al., 2007). Thus, by supporting a portfolio of projects at the national level, government support programs can promote academic entrepreneurship among risk averse agents such as smaller and less experienced institutions.

Some goal conflicts can probably not be influenced to a great extent by the FORNY program and other intermediary actors like the research council and the innovation agency. The ministries that support these actors have, as mentioned, partly conflicting goals. Although FORNY has tried to balance e.g. emphasizing high technology spin-offs close to the major universities with regionally distributed support, this has been difficult in practice. Recent attempts at centralizing some of the commercialization support functions has led the Ministry of Regional Affairs to reduce their funding of the program, perhaps because the ministry sees

this as a moral hazard issue. FORNY may find its intermediary role simpler with fewer principals, although they will have less funding to allocate.

The limitations of agency theory

The principal-agent perspective provides a structured framework to analyze the challenges facing government programs to promote commercialization of research. Still, there are several issues that fall outside this framework. Entrepreneurial processes are not programmable; they involve uncertainty and high risk. Thus, the connection between behavior and outcome is unclear. This makes it difficult for the principal to separate moral hazard and adverse selection from risk and uncertainty, particularly for single projects and actors involved in a modest number of projects. In this situation, learning and experimentation with different approaches is preferable in order to develop better practice. The FORNY program provides funds for knowledge generating projects and facilitates learning through frequent seminars, workshops, and study programs. These collaborative activities are difficult to incorporate in the principal-agent framework.

In our discussion of the FORNY program from a principal-agent perspective, the role of other public support schemes is underplayed. The picture becomes much more complex if other government support programs to promote university-industry relations and entrepreneurship are included. These programs are supported by the same ministries and often support the same projects and spin-off firms as the FORNY program (Borlaug et al., 2009). Agency theory is not conceptually developed to handle parallel relationships between actors.

Lessons for the design of support programs for academic entrepreneurship

Since the start in 1994, the schemes and the organization of the FORNY program has evolved to become much more complex, which probably reflects the heterogeneity of Norwegian research institutions and the complexity of the task delegated to the FORNY program. As asserted by Wright et al. (2007), a common policy to stimulate spin-offs is a gross underestimation of reality, and more fine-grained initiatives are needed. By using a principal-agent framework to study the role of a government program, this paper contributes to a more nuanced picture of the challenges involved in promoting academic entrepreneurship.

Conclusion

This paper has analyzed the role of a government program to support the commercialization of university research using a principal-agent perspective. Our findings show that the

program takes an intermediary role between several Ministries acting as principals, and several stakeholders in the commercialization process (universities, TTOs, science parks, academics, entrepreneurs etc.) acting as agents. This might be described as serving a stabilizing function (Guston, 1999). Part of this intermediary role is to reduce agency problems arising between the government and the actors involved in the commercialization process. We identified two main approaches to reduce agency problems. One is to reduce the problems of adverse selection and moral hazard when distributing funding. Key tasks to achieve this is collecting and sharing information, stabilizing relationships between principals and agents through systematic meetings and exchange of experiences, developing strategies and specific contractual relationships, and using multiple indicators to monitor the outcome of the activity. The other is to reduce goal conflicts by inducing commercialization of research as a part of the activity within the academic institutions and building trust among the actors involved in the commercialization process. This approach, however, requires a long term effort which is generally less visible for outside stakeholders. It might be tempting for programs that need to prove quick results to not prioritize long-term activities to reduce goal conflicts. Thus, a major challenge for government support programs are related to the balance between the long term efforts needed to develop an infrastructure for commercialization of research and the short term need to show results from the resources invested.

Acknowledgements

We would like to thank an anonymous reviewer for valuable comments to an earlier version.

Emails of authors: Einar Rasmussen: einar.rasmussen@hibo.no, Magnus Gulbrandsen: magnus.gulbrandsen@nifustep.no

References

Agrawal, A. (2006). Engaging the inventor: Exploring licensing strategies for university inventions and the role of latent knowledge. *Strategic Management Journal, 27*(1), 63-79.

Anderson, M. S. (2001). The complex relations between the academy and industry - Views from the literature. *Journal of Higher Education, 72*(2), 226-246.

Bird, B. J., & Allen, D. N. (1989). Faculty entrepreneurship in research university environments. *Journal of Higher Education, 60*(5), 583-596.

Bolkesjø, T., & Vareide, K. (2004). *Evaluering av kommersialiseringsenhetene i FORNY-programmet*. Bø: Telemarksforsking.

Borlaug, S. B., Grünfeld, L., Gulbrandsen, M., Rasmussen, E., Rønning, L., Spilling, O. R., et al. (2009). *Between entrepreneurship and technology transfer: Evaluation of the FORNY programme*. Oslo: NIFU STEP.

Borlaug, S. B., Rasmussen, E., Spilling, O. R., & Gulbrandsen, M. (2008). *Evaluering av bruken av infrastrukturmidlene i FORNY-programmet*. Oslo: NIFU STEP.

Bozeman, B. (2000). Technology transfer and public policy: a review of research and theory. *Research Policy, 29*(4-5), 627-655.

Branscomb, L. M., Kodama, F., & Florida, R. L. (1999). *Industrializing knowledge : university-industry linkages in Japan and the United States*. Cambridge, Mass. ; London: MIT Press.

Braun, D. (1993). Who governs intermediary agencies? Principal-agent relations in research policy-making. *Journal of Public Policy, 13*(2), 135-162.

Braun, D. (2003). Lasting tentions in research policy-making -a delegation problem. *Science and Public Policy, 30*(5), 309-321.

Callan, B. (2001). Generating spin-offs: Evidence fro across the OECD. *STI Review, 26*.

Carlsson, B., & Fridh, A. C. (2002). Technology transfer in United States universities - A survey and statistical analysis. *Journal of Evolutionary Economics, 12*(1-2), 199-232.

Colyvas, J., Crow, M., Gelijns, A., Mazzoleni, R., Nelson, R. R., Rosenberg, N., et al. (2002). How do university inventions get into practice? *Management Science, 48*(1), 61-72.

Eisenhardt, K. M. (1989). Agency Theory - an Assessment and Review. *Academy of Management Review, 14*(1), 57-74.

Etzkowitz, H. (1998). The norms of entrepreneurial science: cognitive effects of the new university-industry linkages. *Research Policy*, 27:823-833.

Feldman, M. P., Link, A. N., & Siegel, D. S. (2002). *The economics of science and technology : an overview of initiatives to foster innovation, entrepreneurship, and economic growth*. Boston: Kluwer Academic Publishers.

Gault, F., & McDaniel, S. (2004). Summary: Joint Statistics Canada -University of Winsor Workshop on Intellectual Property Commercialization Indicators, Windsor. *Science, Innovation and Electronic Information Division working papers*(6), 38.

Gulbrandsen, M. (1995). *Universitetet og region -Samarbeid mellom universiteter og regionalt næringsliv i Norden* (No. 518). København: Nordisk ministerråd, TemaNord.

Gulbrandsen, M. (2003). *Kommersialisering av norsk universitesforskning -en intervjustudie*. Oslo: NIFU.

Gulbrandsen, M., Røste, R., & Kristiansen, T. E. (2006). Virkemidler for kommersialisering av forskningsresultater. Oslo: NIFU STEP, Report 40/2006.

Guston, D. H. (1999). Stabilizing the boundary between US politics and science: The role of the Office of Technology Transfer as a boundary organization. *Social Studies of Science, 29*(1), 87-111.

Hervik, A., Arnestad, M., & Wicksteed, B. (1997). *Evaluering av FORNY-programmet*. Molde: Møreforskning.

Heydebreck, P., Klofsten, M., & Maier, J. C. (2000). Innovation support for new technology-based firms: the Swedish Teknopol approach. *R & D Management, 30*(1), 89-100.

Jensen, R., & Thursby, M. (2001). Proofs and prototypes for sale: The licensing of university inventions. *American Economic Review, 91*(1), 240-259.

Jensen, R. A., Thursby, J. G., & Thursby, M. C. (2003). Disclosure and licensing of University inventions: 'The best we can do with the s**t we get to work with'. *International Journal of Industrial Organization, 21*(9), 1271-1300.

Kenney, M., & Goe, W. R. (2004). The role of social embeddedness in professional entrepreneurship: a comparison of electrical engineering and computer science at UC Berkley and Stanford. *Research Policy, 33*(5), 679-844.

Lindström, G., & Olofsson, C. (2001). Early stage financing of NTBFs: an analysis of contributions from support actors. *Venture Capital, 3*(2), 151-168.

Lockett, A., Murray, G., & Wright, M. (2002). Do UK venture capitalists still have a bias against investment in new technology firms. *Research Policy, 31*(6), 1009-1030.

Lundström, A., & Stevenson, L. (2005). *Entrepreneurship policy : theory and practice*. New York: Springer.

Martin, S., & Scott, J. T. (2000). The nature of innovation market failure and the design of public support for private innovation. *Research Policy, 29*(4-5), 437-447.

McAdam, M., Galbraith, B., McAdam, R., & Humphreys, P. (2006). Business Processes and Networks in University Incubators: A Review and Research Agendas. *Technology Analysis & Strategic Management, 18*(5), 451 - 472.

Mosey, S., Lockett, A., & Westhead, P. (2006). Creating network bridges for university technology transfer: The medici fellowship programme. *Technology Analysis & Strategic Management, 18*(1), 71-91.

Mowery, D. C., Nelson, R. R., Sampat, B. N., & Ziedonis, A. A. (2001). The growth of patenting and licensing by US universities: an assessment of the effects of the Bayh-Dole act of 1980. *Research Policy, 30*(1), 99-119.

Mustar, P., Renault, M., Colombo, M. G., Piva, E., Fontes, M., Lockett, A., et al. (2006). Conceptualizing the heterogeneity of research-based spin-offs: a multi dimensional taxonomy. *Research Policy, 35*(2), 289-308.

Mustar, P., Wright, M., & Clarysse, B. (2008). University spin-off firms: lessons from ten years of experience in Europe. *Science and Public Policy, 35*(2), 67-80.

Nosella, A., & Grimaldi, R. (2009). University-level mechanisms supporting the creation of new companies: an analysis of Italian academic spin-offs. *Technology Analysis and Strategic Management, 21*, 679-698.

O'Shea, R. P., Allen, T. J., Morse, K. P., O'Gorman, C., & Roche, F. (2007). Delineating the anatomy of an entrepreneurial university: the Massachusetts Institute of Technology experience. *R & D Management, 37*(1), 1-16.

Radosevich, R. (1995). A Model for entrepreneurial spin-offs from public technology sources. *International Journal of Technology Management, 10*(7-8), 879-893.

Rasmussen, E. (2006). *Facilitating university spin-off ventures - an entrepreneurship process perspective* (Vol. Dr. Oecon thesis). Bodø, Norway.

Rasmussen, E. (2008). Government instruments to support the commercialization of university research: Lessons from Canada. *Technovation, 28*(August), 506-517.

Rasmussen, E., Borch, O. J., & Sørheim, R. (2008). University entrepreneurship and government support schemes In A. Fayolle & P. Kyrö (Eds.), *The Dynamic between Entrepreneurship, Environment and Education*: Edward Elgar.

Rasmussen, E., Borch, O. J., Sørheim, R., & Gjellan, A. (2006a). *Government initiatives to support the commercialization of research - an international benchmarking study*: Bodø Graduate School of Business.

Rasmussen, E., Moen, Ø., & Gulbrandsen, M. (2006b). Initiatives to promote commercialization of university knowledge. *Technovation, 26*(4), 518-533.

Rasmussen, E., Sørheim, R., & Widding, L. Ø. (2007). *Gjennomgang av virkemidler for kommersialisering av forskningsresultater (Assessment of government supports schemes for the commercialization of research)* Bodø, Norway: Bodø Graduate School of Business.

Rothaermel, F. T., Agung, S. D., & Jiang, L. (2007). University entrepreneurship: a taxonomy of the literature. *Ind Corp Change, 16*(4), 691-791.

Salmenkaita, J.-P., & Salo, A. (2002). Rationales for government interventions in the commercialization of new technologies. *Technology Analysis & Strategic Management, 14*(2), 183-200.

Salo, A., Mild, P., & Pentikainen, T. (2006). Exploring causal relationships in an innovation program with Robust Portfolio Modeling. *Technological Forecasting and Social Change, 73*(8), 1028-1044.

Samsom, K. J., & Gurdon, M. A. (1993). University scientists as entrepreneurs -a special case of technology-transfer and high-tech venturing. *Technovation, 13*(2), 63-71.

Shane, S. (2004). Encouraging university entrepreneurship? The effect of the Bayh-Dole Act on university patenting in the United States. *Journal of Business Venturing, 19*(1), 127-151.

Shove, E. (2003). Principals, agents and research programmes. *Science and Public Policy, 30*(5), 371-381.

Siegel, D. S., Westhead, P., & Wright, M. (2003). Science Parks and the Performance of New Technology-Based Firms: A Review of Recent U.K. Evidence and an Agenda for Future Research. *Small Business Economics, 20*(2), 177-184.

Storey, D. J., & Tether, B. S. (1998). Public policy measures to support new technology-based firms in the European Union. *Research Policy, 26*(9), 1037-1057.

Toole, A. A., & Czarnitzki, D. (2007). Biomedical academic entrepreneurship through the SBIR program. *Journal of Economic Behavior & Organization, 63*(4), 716-738.

Van der Meulen, B. (1998). Science policies as principal-agent games - Institutionalization and path dependency in the relation between government and science. *Research Policy, 27*(4), 397-414.

Van der Meulen, B. (2003). New roles and strategies of a research counsil: intermediation of the principal-agent relationship. *Science and Public Policy, 30*(5), 323-336.

Vohora, A., Wright, M., & Lockett, A. (2004). Critical junctures in the development of university high-tech spinout companies. *Research Policy, 33*(1), 147-175.

Wright, M., Clarysse, B., Mustar, P., & Lockett, A. (2007). *Academic entrepreneurship in Europe*. Cheltenham: Edward Elgar.

Wright, M., Lockett, A., Clarysse, B., & Binks, M. (2006). University spin-out companies and venture capital. *Research Policy, 35*(4), 481-501.

Waagø, S. J., Rasmussen, E., Kvaal, T., Gulbrandsen, M., & Trondsen, E. (2001). *The role of the university in economic development -an analysis of six European universities of science and technology*. Trondheim: GREI - NTNU.

2. Graduates & business start-ups: an assessment of entrepreneurial propensity in a Portuguese university

Chris Gerry, Carla Susana Marques and Fernanda Nogueira

Department of Economics, Sociology and Management,
University of Trás-os-Montes e Alto Douro (Portugal)

Abstract

Much of the literature on the determinants of entrepreneurship focuses *either* on behavioural *or* contextual variables. The aim of the present research was to assess students' propensity to launch business start-ups on graduation, taking into account *both* of these sets of influences. The analysis presented here was based on a survey of 640 undergraduates at UTAD, a provincial Portuguese university, in which equal attention was paid to students' psychological attributes/competencies *and* the contextual factors influencing their predisposition for entrepreneurial initiatives. Particular emphasis was also given to students' perceptions of the value of higher education, and of their likely future employment paths. The paper concludes that, while gender and commitment to a specific profession were undermined students' entrepreneurial propensity, risk-acceptance and the nature of the academic training received enhanced it.

Key Words: entrepreneurship, entrepreneurial potential, business start-ups, university students.

Introduction

Entrepreneurship, particularly in relation to small and micro-enterprises, is frequently seen as a key vehicle for employment creation (Folster, 2000) an essential means of enhancing the innovation dynamic in the local, regional and national economies (Robbins et al., 2000). In this way, entrepreneurial initiatives contribute to the process of adaptive remodelling and restructuring of the contemporary business world, providing a constant stream of learning experiences and consequently underpinning development of a more sustainable type (Videira, 2001, quotes in Franco, 2007). While at a macro-level entrepreneurship is seen as being responsible for job-creation, innovation and the creation of wealth, at a more individual level, the development of enterprising behaviour has been characterised as one of the primary stimuli to the widening of career options, particularly among first-time labour market entrants (Reynolds et al., 1994).

In recent years, the rapid changes unleashed by a new phase of globalisation, combined with a deteriorating economic conjuncture – both in Portugal in particular as well as in the international economy in general, has shrunk recruitment and/or significantly altered employment conditions in many of the traditional types of employment that, in the past, absorbed most university students. Today, graduating students are more likely than before to see the possibility of establishing their own enterprises as a positive rather than residual career option (Kolvereid and Moen, 1997). However, both the extent of the propensity for students to do so and the opportunities for them to accumulate the necessary attributes and competencies would appear to be highly variable between countries and regions, as well as between courses of study.

Various studies, both in the USA, (e.g. Kourilsky and Walstad, 1998; Lüthje and Franke, 2003; Van Auken et al., 2006) and in Europe (e.g. Kolvereid and Moen, 1997; Gürul and Atson, 2006) have provided clear evidence of a general growth in people's propensity to create their own enterprises. Though there appears to be widespread agreement concerning the main factors at work when employed professionals opt to establish their own firms, it would be unwise and inappropriate to uncritically assume that these factors play exactly the same role in the case of recently-graduated university students. A number of recent studies (e.g. Lena and Wong, 2003; Franke and Luthje, 2004; Teixeira, 2007; Rodrigues et al, 2008) have attempted to gain a better understanding of precisely which variables may contribute most significantly to graduate business start-ups. In recent years, entrepreneurship among university students has been studied in a number of Portuguese higher education institutions, e.g. Raposo et al. (2008) in the University of Beira Interior and Teixeira (2007) in University of Porto. On the one hand, the research undertaken in the University of Beira Interior formed part of a wider comparative cross-border study of regions' capacity to retain graduates (either as employees or self-employed) after completing their studies; on the other hand, a key aspect of the University of Porto study was the attempt to determine whether students' choice of course influenced their employability in general (including the success of graduate start-ups). The research on which the present paper reports, while also attempting to understand the main determinants of student entrepreneurial propensity, was distinctive inasmuch as it not only attempted to identify the perceptions, personal attributes and competencies that most influence students' intensions to contemplating starting their own businesses, but also recognised the importance of contextual and environmental factors that might mould their perceptions and consequent decisions[1]. Thus the main aim of the research

[1] Generally, those who never been in full time employment will have insufficient experience of the 'external environment', and rather imperfect knowledge of the current conditions in the labour market. Furthermore, they will understandably be poorly informed regarding the pros and cons of self-employment, either because their (self-) interest has not yet been stimulated, and/or due to poor dissemination (by government and by universities) of the business start-up support programmes available.

was to assess the relative importance of individual attributes/competencies *and* contextual factors in determining students' propensity for business start-ups on graduation.

Following this introductory contextualisation, the authors provide a brief literature review, then describe the methodology adopted and the estimation model used in the data analysis, present the results considered most relevant to the aims of the paper, finishing with a summary of the main conclusions and their implications for policy and future research.

Student entrepreneurship potential: a brief review of the literature

Earlier contributions on the nature of entrepreneur (such as Cunningham and Lischeron, 1991) and, more recently Jason (2005), for example, have suggested the existence of a number of schools of thought regarding the specification of the entrepreneurial function and/or the essential nature of entrepreneurial behaviour.

Table 1 - The nature of the entrepreneur: main schools of thought

School of thought	Characterisation of the entrepreneur
'Great People'	*Innate capacity:* the entrepreneur is born with the potential to act intuitively, energetically, with confidence and determination.
Classical	*Entrepreneurial function:* the entrepreneur is anyone that shows evidence of functioning in an inventive, innovative and creative way.
Psychological/behavioural characteristics	*Psychological profile:* entrepreneurs have values and behavioural patterns that set them apart from the rest of society.
Management Schools	*The entrepreneur as organiser:* entrepreneurs are distinguished by their ability to identify opportunities, assess risks, plan the process, and manage the resources necessary for the successful conclusion of a business initiative.
	The entrepreneur as leader: the entrepreneur directs and motivates a team that has been established to achieve the specific aims of a business initiative.
	The intrapreneur applies the motivations and mind-set of an entrepreneur to management tasks inside the organisations in which they work.

Source: Adapted from Cunningham and Lischeron (1991).

The same authors further argue that the definition of the entrepreneur to be adopted will depend on the type of data to which the researcher gives the greatest emphasis, and on the particular aspect of entrepreneurship the study seeks to elucidate. Henderson and Robertson (1999) conclude that, more frequently than not, researchers tend to deploy a combination of behaviouralist, classical and managerialist assumptions regarding entrepreneurship, focusing both on key individual psychological characteristics (such as creativity, imagination, ambition and determination), and more technical organisational competences such as decision-making ability and resource-coordination capacity.

Adapting the definition of an entrepreneur proposed by Carland *et al* (1984, p. 358) we define 'potential entrepreneur' in this paper as "an individual [student] who [accepts the possibility

that he/she might] establish and manage a business for the principal purposes of profit and growth". It should be noted however, that for various reasons – ranging from the nature of the courses that students take, to the emergence of new entrepreneurial opportunities as a result of state withdrawal from direct provision of social goods/services – an increasing proportion of students may now be attracted to activities that could be more accurately described as "social entrepreneurship", in which the principal motivation would be provided by some combination of socially-beneficial, ethical or altruistic employment and a salary broadly in line with the skills developed during university study.

In much of the literature on entrepreneurial activities, there has been consistent interest in identifying the factors that lead an individual to become an entrepreneur (Kourilsky, 1980; Koh, 1996; Martínez *et al.,* 2007). According to several authors (e.g. Carland *et al.,* 1984; Hatten and Ruhland, 1995), the behavioural characteristics most commonly found in entrepreneurs include their propensity for innovation and their use of strategic management practices in their entrepreneurial initiatives. Additionally, the belief that entrepreneurs have distinctive psychological characteristics has a long tradition in entrepreneurship research (Gartner, 1988). Numerous studies have focused on personality traits that may be in some way connected to entrepreneurial behaviour through their influence over either the constitution of future entrepreneurial intentions and/or the reinforcement of established ones (Kennedy et al., 2003; Brice, 2004; Liñán-Alcalde and Rodríguez-Cohard, 2004; Barahona and Escudero, 2005; Asián, 2005; Li, 2006). Three groups of factors have been frequently used to measure entrepreneurial tendencies: (1) personal "demographic" characteristics; (2) personality traits (e.g. Robinson, 1987), and (3) contextual factors (e.g. Naffziger *et al.,* 1994):

(1) *Individual personal/demographic characteristics* such as those relating to gender, age, professional background, work experience, and educational status, regional origin, can be used to describe existing or potential entrepreneurs (Delmar and Davidsson, 2000). However, most of these variables appear to have little or no influence on a person's predisposition for entrepreneurship, nor can they be used as predictors of such a career or lifestyle choice (Robinson *et al*., 1991; Hatten and Ruhland, 1995).

(2) *Personality traits* such as achievement motivation, risk assumption/aversion, and attitudes regarding control and delegation provide a second focus for assessing entrepreneurial tendencies is to examine *personality traits*. Several psychological characteristics have been suggested as being good predictors of entrepreneurial

behaviour: (i) the need for self-achievement (e.g. McClelland, 1961); (ii) creativity and initiative (e.g. Hull *et al.* 1980); (iii) the propensity for risk-taking (e.g. Hirsrich and Peters, 1995); (iv) self-confidence and the "locus of control" (e.g. Brockhaus 1987); (v) desire for independence and autonomy (e.g. Collins and Moore, 1964; Hornaday and Aboud, 1971); (vi) motivation, energy and commitment; and (vii) persistence. Opinions differ as to which of these variables are the most important and precisely how to conceptualise and operationalise them: while Davidsson (1989) provided evidence of a relationship between the need for achievement and individual entrepreneurial behaviour, Robinson *et al.* (1991) stressed that self-esteem and innovative behaviour were more relevant to entrepreneurship than McClelland's classic self-achievement.

(3) *Contextual factors*. Authors such as Naffziger *et al.,* (1994), have argued that the decision to adopt an entrepreneurial lifestyle is neither made in the abstract nor in a vacuum, stressing the importance of the potential entrepreneur's perceptions regarding the environment in which this decision is taken, and in which patterns of entrepreneurial behaviour are concretely put into practice. Contextual influences commonly alluded to in the literature include factors such as: the cycle of boom and slump and associated changes in employment, inflation and exchange rates; paradigm shifts that alter the style and content of government economic policy and regulatory measures; alterations in the way in which firms organise their production and marketing in response to new competitive challenges; technological progress; and changing attitudes among consumers and the public in general. Clearly, all such factors may have a bearing not only on the individual's decision to become an entrepreneur, but also on his/her educational options, choice of profession, relocation/emigration, etc. While this approach focuses on the potential entrepreneur's perceptions of the main contextual factors that influence a firm's success, it also takes into account the interaction between a potential entrepreneur's socio-economic background, psychological make-up and his/her subjective appreciation of the influence of contextual factors (eg. Kruger and Brazeal, 1994; Wagner and Sternberg, 2004).

The theory that entrepreneurial behaviour is the simply the result of inherited competencies or that entrepreneurship is an innate characteristic of a minority of individuals no longer seems to have many followers (Rodrigues *et al,* 2008). While the mapping of potential entrepreneurs' psychological traits remains an important focus of attention, researchers have shown growing interest it trying to ascertain the extent to which psychological attributes conducive to entrepreneurial behaviour can be culturally acquired (Vesper, 1990) and/or

culturally moderated (Stephan et al., 2003). More recently, Li (2006) has proposed that the theory of *planned* behaviour provides a sound theoretical framework for understanding the origins of entrepreneurial intentions, emphasising that it is possible for people to *learn* to be entrepreneurs, mainly through the use of targeted educational approaches. Drawing on this perspective, it seems pertinent to analyse the contribution that education can make to the development of entrepreneurship by investigating the extent to which entrepreneurial propensity and intensions may be the result of factors that can be significantly altered through education, as Kolvereid and Moen (1997) have suggested.

In principal, few would disagree that it would benefit *all* students if, before completing their education, they were exposed to well-designed entrepreneurship-related inputs that stimulated independent, creative and critical thinking. Hatten and Ruhland (1995) and Teixeira (2007) argue that the early identification and systematic nurturing of students with entrepreneurial potential would yield positive results at both the individual and societal levels i.e. the emergence of more – and more successful – entrepreneurs. More concretely, the idea of becoming an entrepreneur may become more attractive to students because they see it as a viable way of combining income generation with a greater degree of independence than salaried employment provides (Martínez et al., 2007).

Though there has been a large number of studies of entrepreneurial propensity (e.g. Naffziger et al., 1994; Brandstätter, 1997), only a limited number of studies have focused on students' entrepreneurial intentions (e.g. Scott and Twomey, 1988; Oakey et al., 2002; Klapper and Léger-Jarniou, 2006). In general, the results of such studies indicate that it is males with a strong need for achievement, with evidence of creativity and leadership capacity, with a propensity for risk taking, and whose parents are or have been self-employed, that possess the key characteristics that increase the propensity to become an entrepreneur (e.g. Lena and Wong, 2003; Franke and Luthje, 2004; Teixeira. 2007; Raposo et al. 2008).

In summary, the approach adopted in the study reported on here reflects two key theoretical assumptions: (1) we would argue that demographic, psychological *and* contextual factors, both singly and in combination, play important roles in determining individuals' propensity to start their own businesses; and (2) we accept that not only students who are "well-endowed" in terms of the attitudinal prerequisites for entrepreneurial behaviour, but students in general, can benefit from entrepreneurially-oriented education.

Section 3 below details and describes the methodology adopted in the study and the type of data gathered. In Section 4, we assess which of the three groups of factors that theorists

have identified as likely determinants of entrepreneurial intention – demographic, psychological, and contextual – are the most relevant among the university students selected for study.

Methodology and related descriptive statistics

A questionnaire was designed, pre-tested and applied during the academic year 2006-2007. A sample was selected from a population of students who at the time were attending a first degree (undergraduate) course at the University of Trás-os-Montes e Alto Douro (UTAD), located in the interior north-east of Portugal. They were directly approached by the interviewers, who visited classrooms on the main and satellite university campuses. The sample covered a total of 640 students, distributed over 14 courses, constituting 9.5% of the total student population. The survey was conducted using a self-administered questionnaire.

The questionnaire contained 18 questions, which included specific demographic descriptors (such as gender, age, student status, and region of origin), as well as data on previous professional experience, academic performance, and the individual's social context. Students were presented with statements designed to measure the extent of their fears with regard to the possible creation of a business venture, asked to assess the key difficulties and obstacles they expected to encounter, and to identify factors associated with success in such an initiative. Respondents' attitudes were evaluated using a 5-point Likert scale. Entrepreneurial potential was directly assessed by asking students to indicate the intensity of their current *general* interest in creating their own business on graduation, and the extent to which they had taken *concrete* steps to turn that intention into what might be considered a "pre-start-up state of readiness". They were specifically asked what information they had collected, which training courses (if any) they had attended and which institutional contacts they had made in this regard[2].

After the data had been collected, it was analysed and interpreted using the statistical software package SPSS®. Table 2 summarises the main methodological characteristics of the study.

The sample consisted of 640 individuals who at that time were attending any of the courses provided by the University of Trás-os-Montes e Alto Douro.

[2] The vast majority of students had not received any specific training, nor had they collected pertinent information, nor established any institutional contacts (almost 89%), other than those associated with the course modules in entrepreneurship in which some of them were participating or had participated (11%). This result further underlines the importance of addressing the perceptions and skills associated with entrepreneurship (taught either as a specific module or across a wide range of key modules) in university (and, indeed, secondary) curricula.

Table 2 - Synthesis of Methodological Aspects

Time Basis	Cross-Section
Sampling Unit	Undergraduate students
Population	6047 individuals
Sample	640 individuals
Response Rate	9,5%
Sample Error	4,22%
Research Method	Self-administered questionnaire
Time Period	June 2006 – May 2007
Statistical Analysis	Bivariate, Multivariate – logistic regression

The demographic and geographic characteristics are shown in Table 3.

Table 3 - Characterisation of the sample

Sex	**%**	**Study Curricula**	**%**
Female	68,6	Economics & Business	30,4
Male	31,4	Other Social & Human Sciences	26,1
		Engineering	19,4
		Health Sciences	15,3
		Arts	8,8
Age		**Region of origin**	
Under 21	37,8	Trás-os-Montes e Alto Douro	8,0
21-24	48,1	Rest of Northern region	79,5
25-29	10,3	Rest of the country	11,9
30-39	2,8	No answer	0,6
Above 40	0,5		
No answer	0,5		
Student Status		**Sectoral employment preferences**	
Students	92,7	Private Sector	56,0
Worker-students	6,6	Public Sector	35,5
No answer	0,8	Non-profit sector	8,5

From the results of the questionnaire survey it was possible to conclude that the majority of students were female (68.6%), that a large majority of students interviewed (85.9%) were aged between 17 and 24 years of age and that the average age was 23 – a predictable outcome, given the typical age of initiating studies (18) and the average duration of their courses at the time (5 years, pre-Bologna). Almost all of those surveyed (95%) had always wanted to undertake university studies; almost the same proportion (94%) felt that a university education was a determinant factor in finding future employment in a profession that was to their liking, and a substantial number (84%) were registered for their first choice courses. Two thirds (67%) claimed that that their university corresponded in general terms to their expectations.

Nine out of ten (90%) saw their future life as consisting of the independent exercise of decision-making responsibilities in their chosen profession. Two thirds thought it likely that they would end up in salaried employment, i.e. working for some one else; put another way, only a third could conceive of a future in self-employment at the time of the survey. Just over half indicated a preference for employment in the private sector, while almost all of the remaining respondents referred to see their future as being in the public sector, with only a handful indicating interest in the non-profit sector[3]. Respondents were evenly divided over the extent to which university education provided students with an adequate preparation for becoming self-employed – 49% felt that it did, and 51% that it did not. Notwithstanding this result, almost two thirds (64%) of the students surveyed expressed a predisposition to establish their own enterprises. Of the 24% who indicated that they were *seriously* considering this possibility, a little over a quarter (28%) already had a clear idea of the type of business the would like to launch. The majority (60%) of those expressing the concrete desire to start their own business were female; in terms of their areas of study, 28% were students of economics and management, 26% from other social sciences and humanities, 22% from various engineering courses, 14% from arts courses and 10% were studying health sciences. These results were tested for differences in entrepreneurial orientation could be found between students attending different course; however, this variable proved to be statistically insignificant and consequently the remaining analysis was conducted without specific reference to the course attended. Furthermore, the results obtained were similar to those arrived at in the studies undertaken in other regions of Portugal[4] to which reference has already been made (Raposo et al., 2008, Teixeira, 2007), as Table 4 illustrates.

Table 4 - Intention to establish own enterprise on graduation

Do you intend to establish your own firm on graduation?	Beira Interior University (UBI)	University of Trás-os-Montes & Alto Douro (UTAD)	Porto University (UP)
Sample size	316	640	2.425
Yes	63.8%	23.8%	26.5%
No	35.9%	40.2%	73.6%
No response	0.4%	36.0%	–

Source: Adapted from Raposo et al., 2008, Teixeira, 2007.

Comparing these three regions of Portugal, we find that it is in Beira Interior University (UBI) that the largest proportion of respondents (63.8%) indicated a desire to establish their own

[3] In the study, students were asked in what type of organisation or sector they could see themselves working in on graduation. While the majority (in spite of the unfavourable economic conditions at the time) favoured the private sector (56%) in general and larger firms in particular (36,2%), and a substantial minority (35,5%) believed they might enter the public sector (despite the intense competition and restrictions on the sector's expansion), a relatively modest proportion (8,5%) identified the "third sector" as the preferred type of (salaried or self-) employment.

[4] The studies were undertaken in the University of Beira Interior (in the inland areas of the Central region of Portugal), and at the University of Porto (Portugal's second city, situated on coast of the Northern Region).

firms on graduation[5]. Both UTAD's and UP's students demonstrated a much lower willingness to establish their own businesses, the former having the lowest proportion of students with entrepreneurial plans (23.6%). Part of this discrepancy may be due to differences in the composition of the sample[6]: for example, at UBI the questionnaire targeted only final and penultimate year students, while at UTAD students from all years of study were surveyed.

Most studies focusing on student entrepreneurial propensities and intensions provide only a snapshot, whereas what is really required is a moving picture i.e. the results that only a longitudinal study can provide. In this sense, the differences noted above may disguise the fact that, on the one hand, even though first year students may show some general interest in establishing their own firms on graduation, many may not have had sufficient time to develop any really specific and concrete plans in this regard. On the other hand, those evincing little or no interest in their first year or two of study may radically alter their views and intensions, as a result of their overall educational experience, and/or due to some specific input into their undergraduate studies, and/or because of a shift in the conjuncture in which such intensions might or might not come to be realised.

Estimation model and results of the study

The major aim of this study was to assess which are the main determinants of student's entrepreneurial propensity. The nature of the data collected with regard to the dependent variable [Do you intend to create your own business? (1) Yes; (0) No] dictated the choice of the estimation model. Conventional estimation techniques (e.g. multiple regression analysis), in the context of a discrete dependent variable, are not a valid option. First of all, the assumptions needed for hypothesis testing in conventional regression analysis are necessarily violated – it is unreasonable to assume, for instance, that the distribution of errors is normal. Secondly, in multiple regression analysis, predicted values cannot be interpreted as probabilities – they are not constrained to fall in the interval between 0 and 1 (Hosmer and Lemeshow, 2000).

[5] Why are the results from UBI more impressive? Notwithstanding the decline in traditional industry and the consequent restructuring of investment and employment that the region has had to undertake over the last few decades, it now benefits from improved road connections not only with the Portuguese coast, but also with Spain's Extremadura region, with which it is generating significant business and institutional synergies. This – and the coastal origin of many more of its students – may go some way to explaining the marked predisposition for entrepreneurship among its students.

[6] The similarity of results for "metropolitan" Porto and "peripheral" Vila Real may be due to the influence of other factors. For example, *ceteris paribus*, do students in universities in big cities typically have lower propensities and intensions to create their own employment because, in such environments, competition is more intense, business initiatives riskier, and market niches scarcer? In contrast, do students at universities in relatively peripheral territories with a much less dense and dynamic business community tend to reject the idea of creating their own employment because they recognise the limitations on local self-employment in such localities? And if we compare the propensities and intensions of students from less entrepreneurially-developed regions studying in a metropolitan area, compared to those from large cities studying in more rural environments?

According to the literature (see Section 2) various sets of factors, such as students' demographic descriptors (gender, age, student status), their psychological traits (creativity, leadership, risk and capacity for self-assessment), and contextual factors (such as the type of profession/employment desired, extent of entrepreneurship training, extent of information on entrepreneurship support, nature of academic training) influence students' entrepreneurial propensities, the empirical assessment of which is based on the estimation of the following general logistic regression:

$$P(entrepreneur) = \frac{1}{1+e^{-z}}$$

Expressing the logistic model in probabilistic terms, we obtain the *logit* model:

$$\log\left(\frac{\text{Prob}(entrepreneur)}{\text{Prob}(Non-entrepreneur)}\right) = \beta_0 + \underbrace{\beta_1 \text{Gender} + \beta_2 \text{Age} + \beta_3 \text{Status}}_{\text{Student's demographic descriptors}} +$$

$$+ \underbrace{\beta_4 \text{Creativity} + \beta_5 \text{Leadership} + \beta_6 \text{Risk} + \beta_7 \text{capacity for self - assessment}}_{\text{psychological traits of students}}$$

$$+ \underbrace{\beta_8 \text{profession/employment desired} + \beta_9 \text{Extent of entrepreneurship training/information} + \beta_{10} \text{Academic training}}_{\text{Contextual factors}} + \varepsilon_{ii}$$

The logistic coefficient can be interpreted as the change in the log odds associated with a one-unit change in the independent variable. Thus *e* raised to the power β_i is the factor by which the odds change when the i^{th} independent variable increases by one unit. If β_i is positive, this factor will be greater than 1, which means that the odds are increased; if β_i is negative, the factor will be less than one, which means that the odds are decreased. When β_i is 0, the factor equals 1, which leaves the odds unchanged. In the case where the estimate of β_1 emerges as positive and significant for the conventional levels of statistical significance (that is, 1%, 5% or 10%), this means that, on average, all other factors being held constant, female students would have a higher (log) odds of entrepreneurial potential. The estimates of the β_s are given in Table 5 below.

Table 5 - Determinants of students' entrepreneurial propensity

	Estimates (β_s)
Individual characteristics	
(1) Gender (Fem=1)	-0,539**
(2) Age	0,060
(3) Student status (Normal=1)	0,513
Psychological characteristics	
(4) Creativity	0,089
(5) Leadership	-0,137

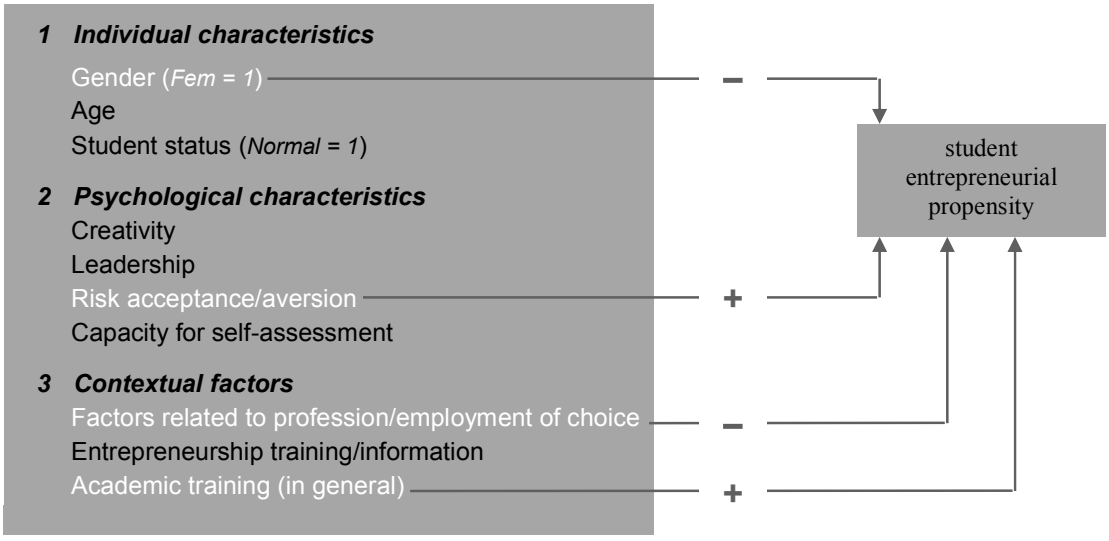
(6) Risk acceptance/aversion	0,303**
(7) Capacity for self-assessment	-0,017
Contextual factors	
(8) Factors related to profession/employment of choice	-0,862*
(9) Extent of entrepreneurship training/information	-0,031
(10) Academic training (in general)	0,437*
Constant	1,544
N	343
Entrepreneurs	119
Other	224
Goodness of fit statistics (correct %)	74,6
Hosmer and Lameshow test (p-value)	4,142 (0,720)

* Significant at 1%; ** significant at 5%.
Method: Forward Stepwise (Likelihood Ratio)

According to the results of the model used in the present research, females demonstrate a much lower propensity for entrepreneurship. This ties in with other studies (e.g. Martínez et al., 2007), that have indicated that "enterprising behaviour" (as conventionally defined) is found more commonly in males. Nevertheless, it contrasts, to a certain degree, with a study of African American students conducted by Ede *et al.* (1998), who found no difference between males and females in their attitudes toward entrepreneurship.

In the factorial analysis, psychologically-related factors, namely risk adversity/acceptance, leadership behaviour, creativity and capacity for self assessment; emerge as crucial for explaining students' entrepreneurial intentions (see Figure 1).

Figure 1 – Determinants of students' entrepreneurial propensity



The main difference between potential entrepreneurs and other students were observed with regard to attitudes towards risk, where the scores of those with an identifiable propensity to become entrepreneurs were much higher than those of the remaining students. Surprisingly, two of the contextual factors turn out to be relevant: desired future profession/employment and general academic training, as was also the case in the study by Martínez et al. (2007). Our interpretation of this result is as follows: on the one hand, those students with a clearly-defined commitment to a particular profession will (perhaps understandably) be less attracted to the self-employment option – though, traditionally, different professions have required a different mix of entrepreneurial attitudes, values and competencies; on the other hand, in opting for higher education – regardless of the "quantity" or "quality" of their personal or professional ambitions – students acquire and/or further develop attitudes, values and competencies that positively contribute to entrepreneurial success, should they decide to take that path on graduation.

Conclusions

In this paper, the entrepreneurial intentions of undergraduates in UTAD are examined along with their related factors. First, the entrepreneurial propensity of undergraduates attending universities located in the Portuguese Interior is reasonably high (around 24%) and, in broad terms[7], compares favourably with the findings of studies in other European countries (e.g. Germany, Austria).

More specifically, although it appears that a reasonable amount of students in Portugal would like to run their own businesses, their intentions are hindered by inadequate preparation, i.e. they recognize that both their practical business knowledge and entrepreneurial preparation are insufficient. Furthermore, one demographic factor (gender), one psychological trait (risk) and two contextual factors (students' declared profession of choice, and academic training) were found to significantly affect students' interest in and motivation for starting their own business. Taking these factors in turn, the following conclusions can be drawn:

(1) *With regard to gender.* Despite the predominance of female students in the sample, it is males that manifest greater propensity to establish their own businesses; this confirms the findings of many earlier studies (e.g., Asián, 2005; Teixeira, 2007; Raposo et al., 2008), but does not allow us to assess the subjective and objective elements that may constitute the "glass ceiling" faced by

[7] Studies undertaken elsewhere in Europe have tended to focus on single institutions, have had widely divergent sample sizes, and have achieved more or less comprehensive coverage both of the courses attended by students and their year of study. Obviously, this makes precise comparison difficult and risky. Until a pan-European survey instrument and methodology can be agreed and a comparative survey carried out, researchers will not be in a sufficiently strong position to confidently attribute high or low entrepreneurial intensions to a clearly defined set of variables.

potential women entrepreneurs. Consequently, while we may need to look more carefully at how women may be better equipped to benefit from the range of entrepreneurial initiatives on offer today, analysis should also try to take better account of how well current policies are designed in this regard.

(2) *With regard to risk.* It is no surprise that attitudes towards risk-taking constitute the most significant psychological factor, a result that again mirrors the conclusions of many previous studies (e.g. McClelland, 1961; Kourilsky, 1980; Brsndstätter, 1997; Barahona and Escudero, 2005; Teixeira, 2007; Raposo et al., 2008). While there is clearly a need to teach students how to more objectively assess all types of risk they may face in their professional lives, specific policy measures are required to mitigate unnecessary risk (in employment and in investment decisions, for example), and to institutionalise the sharing of risk in SME promotion (e.g. via the wider provision of micro credit, and the encouragement of unconventional business models and corporate formats).

(3) *With regard to the influence of the student's chosen professional path.* The pronounced negative influence of students' chosen professional paths may well be predominantly a question of context and culture: many students arrive at university with clearly established (though not necessarily realistic) ambitions with regard to the profession they wish to follow. For example, despite the contraction in public sector employment opportunities in recent years, this type of employment continues to be a popular and highly-favoured career choice; this suggests that slowly-changing cultural attitudes, as well as slowly-emerging improvements in the relevance of university training, still influence student decisions regarding self-employment and entrepreneurship. The inference would be that in order to overcome student resistance (or ignorance) with regard to self-employment and entrepreneurial behaviour, there is a need to extend entrepreneurship teaching to all courses, perhaps using a combination of both common and tailor-made components).

(4) *With regard to the value of academic training in genera*l: though only a half of the sample of UTAD students felt that the university was equipping them well for possible future self-employment, the results demonstrate that the experience of university training is, in itself, a factor that positively influences student propensity to seriously contemplate establishing their own enterprises, and to take concrete steps to turn their intensions into realities.

In conclusion, the findings of this study provide insights with practical implications for researchers, university educators and administrators, as well as government policy makers. Future studies need to be longitudinal, and need to focus on the *specific* effects of entrepreneurship training, rather than university education in general. On the question of policy, while the government (in general) and the Ministries most directly associated with education and training (in particular) clearly have a role to play in stimulating entrepreneurship – above all through higher education – it may well be that the *internal* policies and priorities of higher education institutions deserve a closer and more critical examination. Some institutions have adopted very specific measures with regard to entrepreneurship training, restricting it to students taking courses in economics and management; others have adopted a cross-cutting approach, introducing entrepreneurship modules in a wide range of undergraduate and postgraduate schemes of study[8]. Clearly more research is required if we are to assess the influence of specific educational inputs both on students' decisions to establish their own enterprises on graduation, and on the subsequent success and sustainability of such entrepreneurial initiatives.

E-mails of corresponding authors: Chris Gerry: cgerry@utad.pt and Carla Marques: smarques@utad.pt.

References

Asián, R. (2005). Measuring the Entrepreneurial Capacity of Business Men from Coria del Rio: Preceived Sel-eficacy [in Spanish: Medición de la Capacidad Emprendedora de los Empresarios de Coria del Rio: La Autoficacia Percibida]. Selected papers from the *XV Spanish-Portuguese Meeting of Scientific Management, Cities in Competition*, Seville.

Barahona, J. and Escudero, A. (2005). Is the Entrepreneur Born or Made? An analysis of Entrepreneurial Spirit Determinants [in Spanish:¿El Emprendedor Nace o se Hace? Un Análisis de los Determinantes del Espíritu Emprendedor]. Selected papers from the *XV Spanish-Portuguese Meeting of Scientific Management, Cities in Competition*, Seville.

Brandstätter, H. (1997). Becoming an entrepreneur – a question of personality structure?. *Journal of Economic Psychology*, 18: 157-177.

Brice, J. (2004). The Role of Personality Dimensions on the Formation of Entrepreneurial Intentions. *USASBE Small Business Advancent National Center*, University of Central Arkansas, USA.

Brockhaus, R.H. (1987). Entrepreneurial folklore. *Journal of Small Business Management*, 25(3) : 1-6.

Carland, J. W.; Hoy, F.; Boulton, W. R. and Carland, J. (1984). Differentiating entrepreneurs from small business owners: A conceptualization. *Academy of Management Review*, 9: 354-359.

Collins, O.F. and Moore, D.G. (1964). *The Entreprising Man*. East Lansang, Michigan: Michigan State University Press.

[8] Recent research (Gerry & Abreu 2007), suggests that, in UTAD at least, entrepreneurial propensity is far from being limited to economics and management graduates, and that therefore a more broad-based strategy of entrepreneurship training would be the appropriate response.

Cunningham, J.B. and Lischeron, J. (1991). Defining entrepreneurship. *Journal of Small Business Management*. 29: 45-61.

Davidsson, P. (1989). *Continued Entrepreneurship and Small Firm Growth*. Stockholm School of Economics, Stockholm, Sweden.

Delmar, F. and Davidsson, P. (2000). Where do they come from? Prevalence and characteristics of nascent entrepreneurs, Entrepreneurship & Regional Development, 12: 1–23.

Ede, Fred O., Panigrahi, Bhagaban, and Calcich, Stephen E., (1998). African American students' attitudes toward entrepreneurship. *Journal of Education for Business*, May/Jun98, 73(5).

Folster, S., (2000), "Do entrepreneurs Create Jobs?", *Small Business Economics* 14, 137-148.

Franco, M.J.B. (2007). Estudo do empreendedorismo ao nivel de aprendizagem individual: o papel do empreendedor. Ayola, J.C.C and Grupo de Investigación FEDRA (eds.). *Conocimiento, Innovación y Empreendedoris. Camino al Futuro*. Logroño: Universidad de La Rioja, 1307-1323.

Franke, N. and Lüthje, C. (2004). Entrepreneurial Intentions of Business Students: A Benchmarking Study. *International Journal of Innovation and Technology Management*, 1(3): 269-288.

Gerry, C. and Abreu, S. (2007) IncUTAD: incubadora de inovação, networking e competitividade. Narrativa da prática. Report submitted to the EU Equal Programme as part of the GLOCAL project, UTAD, Vila Real, 32-36.

Gorman G. (1997). Some Research Perspectives on Entrepreneurship Education, Enterprise Education and Education for Small Business Management: A Ten-Year Literature Review. *International Small Business Journal*, 15(3): 56-79.

Gürol, Y. and Atsan, N. (2006). Entrepreneurial characteristics amongst university students: some insights for enterprise education and training in Turkey. *Education and Training*, 48(1): 25-39.

Hatten, T. S. and Ruhland, S. K. (1995). Student attitude toward entrepreneurship as affected by participation in an SBI program. *Journal of Education for Business*, 70(4): 224-227.

Henderson, R. and Robertson, M. (1999). Who wants to be an entrepreneur? Young adult attitudes to entrepreneurship as a career. *Education & Training*, 41(4/5): 236-246.

Hisrich, R.D. and Peters, M.P. (1995). *Entrepreneurship: Starting, developing and managing a new enterprise*. 3ªEdition, Chicago et al., Irwin.

Hornaday, J.A and Aboud, J. (1971). Characteristics of Successful Entrepreneurs. *Personal Psycology*, Summer: 141-153.

Hosmer, D. and Lemeshow, S. (1989). *Applied Logistic Regression*. New York: John Wiley & Sons.

Hull, D.L.; Bosley, J.J. and Udell, G.G. (1980). Renewing the Hunt for the Heffalump: Identifying Potencial Entrepreneurs by Personality Characteristics. *Journal of Small Business*. 18 (1): 1-18.

Jason, C. (2005). Toward a dynamic learning perspective of entrepreneurship. *Entrepreneurship: Theory and Practice*, 29(4): 373-397.

Kennedy, J.; Drennan, J.; Renfrow, P. and Watson, B. (2003). Situational Factors and Entrepreneurial Intentions. An paper for the *Small Enterprise Association of Australia and New Zealand, 16th Annual Conference*, Ballarat, 28 Setember – 1 October.

Klapper, R. and Léger-Jarniou, C. (2006). Entrepreneurial intension among French Grande École and university students: an application of Shapiro's model. *Industry and Higher Education*, April: 97-110.

Koh, H. C. (1996). Testing hypotheses of entrepreneurial characteristics: A study of Hong Kong MBA student. *Journal of Managerial Psychology*, 11 (3): 12-26.

Kolvereid, L. and Moen, Ø. (1997). Entrepreneurship among business graduates: does a major in entrepreneurship make a difference?. *Journal of European Industrial Training*, 21(4): 154.

Kourilsky, M. L. and Walstad, W. B. (1998). Entrepreneurship and female youth: Knowledge, attitudes, gender differences and educational practices. *Journal of Business Venturing*, 13: 77 - 88.

Kourilsky, M.L. (1980). Predictors of Entrepreneurship in a Simulated Economy. *Journal of Creative Behavior*, 14(3): 175-199.

Kruger, N.F. and Brazeal, D.V. (1994). Entrepreneurial Potential and Potential Entrepreneurs. *Entrepreneurship: Theory and Prectice*, 18(3): 91-104.

Lena, L. and Wong, P. K. (2003). Attitude towards entrepreneurship education and new venture creation. *Journal of Enterprising Culture*, 11 (4): 339-357.

Li, W (2006). Entrepreneurial Intention among International Students: Testing a Model of Entrepreneurial Intention. *USASBE Small Business Advancent National Center*, University of Central Arkansas.

Liñán-Alcalde, F. and Rodríguez-Cohard, J. (2004). Entrepreneurial Attitudes of Andalisian University Studentes. in http://ideas.repec.org/p/wiw/wiwrsa/ersa04p161.html, accessed in 20-01-07.

Lüthje, C. and Franke, N. (2003). The 'Making' of an Entrepreneur: Testing a Model of Entrepreneurial Intent among Engineering Students at MIT. *R&D Management*, 33: 2.

Martínez, D.; Mora, J-G and Vila, L. (2007). Entrepreneurs, the Self-employed and Employees amongst Young European Higher Education Graduates. *European Journal of Education*, 42(1).

McClelland, D.C. (1961). *The Achieving Society*. Van Nostrand, Princeton, NJ.

Naffziger, D.W.; Hornsby, J.S. and Kurtako, D.F. (1994). A proposed research model of entrepreneurial motivation. *Entrepreneurship Theory and Practice*, 18(3): 29-42.

Oakey, R.; Mukhtar, S-M and Kipling, M. (2002). Student perspectives on entrepreneurship: observations on their propensity for entrepreneurial behaviour. 2(4/5), 308-322.

Reynolds, P., Storey, D.J. and Westheadead, P. (1994). Cross-national comparisons of the variation in new firm formation rates. *Regional Studies*, 28: 443-456.

Robbins, D. K.; L. J. Pantuosco, D. F.; Parker and B. K. Fuller, (2000). An Empirical Assessment of the Contribution of Small Business Employment to U.S. State Economic Performance. *Small Business Economics*, 15: 293-302.

Robinson, P. B. (1987). Prediction of entrepreneurship based on attitude consistency model. Unpublished doctoral dissertation, Brigham Young University. Dissertation Abstracts International, 48, 2807B.

Robinson, P.B.; Stimpson, D.V.; Huefner, J.C. and Hunt, H.K. (1991). An Attitude Approach to the Prediction of Entrepreneurship. *Entrepreneurship Theory and Practice*, 15(4): 13-31.

Raposo, M.; Ferreira, J.; Paço, A.; Rodrigues and R.G (2008). Propensity to firm creation: empirical research using structural equations. *The International Entrepreneurship and Management Journal*, 4(4): 485-504.

Scott, M.G., and Twomey, D.F. (1988). The long-term supply of entrepreneurs: students' career aspirations in relation to entrepreneurship. *Journal of Small Business Management*: 5-13.

Stephan, U., Lukes, M., Pawlowska A. and Richter, P. G. (2003). Conditions for entrepreneurship in Germany, Czech Republic and Poland: is culture the crux? Paper presented at the *XI European Congress on Work & Organizational Psychology*, May 14-17, Lisbon.

Teixeira, A.A.C. (2007). Beyond economics and engineering: the hidden entrepreneurial potential. Mimeo, Faculdade de Economia, Universidade do Porto.

Van Auken, H.; Stephens, P.; Fry F. and Silva J. (2006). Role model influences on entrepreneurial intentions: A comparison between USA and Mexico. *Entrepreneurship Management*, 2: 325–336.

Vesper, K H. (1990). *New Ventures Strategies*. Prentice-Hall, Englewood Cliffs, New Jersey, 1990.

Wagner, J. and Sternberg, R. (2004). Star-up activities, individual characteristics and the regional milieu: Lessons for entrepreneurship support policies from German micro data. *Annals of Regional Science*, 38: 219-240.

3. Managing intellectual property rights in academic spin-off ventures

Sven H. De Cleyn[1,2], Johan Braet[1]

[1] University of Antwerp, Faculty of Applied Economics (Belgium)
[2] PhD Fellow of the Research Foundation Flanders (Aspirant FWO Vlaanderen) (Belgium)

Abstract

Although entrepreneurship literature has spent considerable attention to spin-off ventures arising from academia, few scholars have investigated the management of intellectual property rights (IPR) in these ventures. The aim of this study is to explore this matter through case study research in a limited number (17) of product-oriented academic spin-offs (ASOs). As the literature overview illustrates, relatively few authors have dealt in detail with IPR within the context of ASOs as central topic of their research. This study aims at overcoming this research gap by contributing to our understanding of the IPR issue in ASOs by investigating existing practice and identifying some major weaknesses in IPR activities.

Overall, the (preliminary) results of our case studies indicate that IPR management in ASOs seems open to significant improvements. Starting even prior to foundation, the intellectual property could be protected in a more comprehensive way, including other formal ways of protection than patents and avoiding too early dissemination of research results into the (academic) community. A possible explanation lies in the absence of legal expertise in the spin-off team.

***Key Words**: academic spin-off ventures; Intellectual Property Rights; patents; IPR management.*

Introduction

Research organisations and academic institutions have gradually become more involved in commercialisation of their research results (Carayannis et al., 1998; Ndonzuau et al., 2002). The direct deployment of economic activities – opposed to the indirect involvement as a result of diffusion through for example education or publications – by academic organisations occurs mainly in two modes: sale or licensing of intellectual property rights (IPR) to existing companies or creation of new ventures (Etzkowitz et al., 2001; Hindle and Yencken, 2004).

The focus of this study will entirely remain with these new ventures founded upon academic research results: academic spin-offs (ASOs).

The increased attention for commercialisation of academic research results appears both at the input and output of the process. The Bayh-Dole Act, passed in 1980 in the U.S., and similar legislation in Europe has lead to an increased patent activity in universities. The number of new patent applications filed by American universities has increased from 1,643 in 1991 over 3,261 in 1996 to double again in 2001 to 6,397 (AUTM, 1997). In 2001, the number of new patent applications almost doubled again to 11,622 (AUTM, 2007). Universities have thus increasingly become involved in efforts to legally and commercially protect their inventions and research results. Additionally, the staffing of U.S based technology transfer offices (TTOs) has increased significantly from 877 full-time equivalents (FTE) in 1997 to 1,831 FTEs in 2006 (AUTM, 2007).

The efforts at the input side are reflected at the output of the commercialisation process. The number of patents issued to American universities has more than doubled between 1979 and 1984, did so again between 1984 and 1989 and nearly doubled once more during the 1990s (Colyvas et al., 2002). Table 1 illustrates this sharp increase until 1999. After that year, the number of patents started to decline again (USPTO, 2007). A similar evolution can be observed concerning the formation of ASOs. Although no precise data are available prior to 1994, the upward trend is clearly illustrated in Table 1. The figures, both at the input and output side, clearly illustrate that the academic world has increasingly been involved in the process of creating economic value from their research results. For the European situation there is lack of clear and validated data on the subject.

Some authors (e.g. Colyvas et al., 2002) have indicated that the increasing patent activity at universities is not only the result of legislative initiatives, such as the Bayh-Dole Act, empowering academic organisations to patent their research results. The emergence of new technological fields, in particular biotechnology, has contributed significantly to the sharp increase of university patenting activities. Additionally, some court decisions in the same time period have forced patent offices to widen the range of patentable research results (Colyvas et al., 2002). Anyhow, evidence clearly demonstrates that academic organisations have gradually become more and more actively involved in the commercialisation process of their research results.

Although entrepreneurship literature has spent considerable attention to spin-off ventures arising from academia, several sub-aspects have not been elaborated in the existing

knowledge base. Few scholars have investigated the management of intellectual property rights (IPR) in these ventures. In an occasional effort to understand IPR management in an academic context, Young et al. (2008) have recently dealt with this issue in publicly funded R&D centres. The aim of this study is to explore IPR management through case study research in a limited number (17) of product-oriented academic spin-off ventures. A large part of the study is devoted to patents, as they make up one of the most important IPR elements involved in the knowledge transfer process. The goal is to understand how ASOs deal with their property rights (starting prior to founding) and which IPR-related activities can be subject to major improvements.

Table 1 – Number of U.S. patents granted to and number of academic spin-offs created by U.S. universities and colleges

Year	1969	1974	1979	1984	1989	1994	1999	2004	2005	2006
# patents	188	249	264	551	1,226	1,782	3,363	3,057	2,725	*n.a.*
# ASOs	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	241	344	462	628	553

Source: Mowery et al. (2001); USPTO (2007)

In order to clearly delimit the boundaries of the study, the central concepts of academic spin-off venture and IPR will first be defined. For the concept of academic spin-off, many related names have been used in literature. Within the context of this study, an academic spin-off is defined as (adapted from De Cleyn and Braet, 2007):

> *"An academic spin-off is [1] a new legal entity (company) [2] founded by one or more individuals seconded or transferred (sometimes part-time) from an academic parent company [3] to exploit some kind of knowledge [4] gained in the parent company and transferred to the new company*."

The parent organisation (academic parent) can then either be a university, university college or (publicly funded) research institution.

The second central concept concerns intellectual property rights. Within the limits of this paper, IPR includes patents, trademarks, copyrights and industrial design claims. Additionally, the usage of non-disclosure agreements (NDA) will be addressed shortly, although they do not fall under the umbrella of officially recognised intellectual property rights. Nevertheless, NDAs can be an essential tool to safeguard the effective protection provided by the other intellectual property rights.

The remainder of the paper is structured as follows. In the second section, literature on IPR within the context of academic spin-off ventures is discussed. Attention will be drawn on the research gap addressed by this study. Afterwards, the case study methodology applied in this exploratory research will be discussed in more detail. In the last section, the conclusions and implications following from this study will be addressed, together with limitations and lines for further research.

Contribution to the literature

Various scholar studies have addressed the IPR topic applying a different lens. Some authors have investigated patents and property rights as approximation for innovativeness or their influence on general business performance or profitability. In this context, studies differ in complexity. Some authors (e.g. Acs and Audretsch, 1989) use simple patent counts as indicator of innovative activity, while others (e.g. Trajtenberg, 1990) use patent counts weighted by citations or a combination of both indicators (e.g. Hagedoorn and Cloodt, 2003; Kleinknecht et al., 2002). As they serve as proxy of innovativeness at the input side of the innovation process, the use of patents cannot guarantee the creation of economic value through their application in new products, processes and services as output result.

Other scholars have discussed the IPR issue only indirectly, while addressing the development process of an ASO (e.g. Ndonzuau et al. 2002; Hindle and Yencken, 2004). Ndonzuau et al. (2002) have argued that 'natural' protection of inventions as a result of complex technological level and short time to market lead time, resulting in a high barrier to imitation, is often limited in ASOs. Therefore, artificial protection through intellectual property rights (e.g. patents and copyrights) is generally more appropriate (Lowe, 1993). As protection through IPR is technical and costly, Ndonzuau et al. (2002) pertinently remark that each case requires a thorough consideration on the appropriateness of formal protection. Through analysis of the models describing the evolution of academic spin-offs, it becomes clear that IPR management is seldom mentioned as important element for the development of ASOs. Vohora et al. (2004) have mentioned patents and other intellectual property rights as basis to underpin the establishment of the venture.

Similarly, Hindle and Yencken (2004) have discussed IPR as input for a new venture rather than as asset that needs further development and management. They see IPR as resource brought in the spin-off by the parent organisation, without indicating the need for further active development and exploitation of the IPR portfolio. In their article on a stage model of academic spin-off creation, Ndonzuau et al. (2002) stressed the importance of IPR protection

before foundation and the support parent organisations provide in this regard. However, none of the three studies has taken the management of a spin-off's IPR portfolio into account during the further development stages. We argue that, as is the case with for instance human and technical resources, the portfolio of intellectual property rights needs continuous attention and management during the entire lifetime of a venture to fully exploit its value and to unremittingly re-evaluate the usefulness of the individual IPR elements within the specific field(s) of application relevant to the spin-off.

Closer to the academic context, Colyvas et al. (2002) have discussed how university inventions get into practice, thereby stressing the role of IPR in this process. Especially in the U.S. it has become the norm in universities to consider patent protection if research results meet the criteria for patentability. As the results of the study of Colyvas et al. (2002) indicated, patents only play a major role in bringing inventions into practice if the invention is still in an embryonic phase. However, if the invention is "ready to use", companies more often adopt the invention without the explicit involvement of a patent or license. In a similar context, Steffensen et al. (1999) have argued that IPR can lead to conflicts between an academic spin-off and its parent organisation. As university technology transfer offices become routinised in transferring knowledge and the subsequent negotiation process (e.g. for licensing technologies), the disequilibrium between the experienced technology transfer office and the spin-off venture team can lead to a difficult and lengthy negotiation process (Steffensen et al., 1999). However, Steffensen et al. (1999) have found that in the majority of the cases, spin-offs receive more support than encountering conflicts with the parent organisation. Within the same context, Ganz-Brown (1999) argued that patents sometimes hinder the transfer of new technologies to the private sector. Especially in the case of "broad" inventions, patents block application of advanced scientific knowledge by other parties than the first mover (Ganz-Brown, 1999). For new technology platforms, competition on technology advance is therefore considered socially desirable over a single technological source (Ganz-Brown, 1999).

Additionally, some authors touch upon a major topic in the IPR issue in the academic context, namely the publishing attitude of academic researchers (Ndonzuau et al., 2002; Hindle and Yencken, 2004). Publications of research results prior to formal protection can jeopardise the commercial potential of an invention (especially in Europe where no grace period exists as in the US or Japan) , although the influence of publications on academic careers is much larger than the number of patents or jobs created (Heydebreck et al., 2000; Hindle and Yencken, 2004). Recent evidence however suggests that academic inventors (i.e. academic researchers engaged in patenting activity) publish significantly more than their

non-inventor colleagues working in the same research field (Van Looy et al., 2006). Patents might therefore not have any direct effect on academic careers; there is an indirect effect through a higher number of publications. On the other hand, commercialising research results has become an important and necessary source of incoming funds to finance expensive research activities (Hindle and Yencken, 2004). Publishing research results can hamper the commercialisation potential, especially if the publications are made prior to IPR filing.

During the literature review, we found only one article coming very close to the subject of our study. In their 2008 paper, Young et al. compared differences in IPR management practice between university-based and company-based publicly funded R&D centres. The results indicated a different IPR strategy and management approach. Company-based R&D centres, although publicly funded, were found to address IPR as primary source of competitive advantage, thereby restricting knowledge dissemination and technology transfer (Young et al., 2008). The situation is exactly the other way round in university-based R&D centres, where knowledge creation and dissemination is the primary objective (Young et al., 2008). This evidence might suggest that spin-off ventures arising from academia might develop a similar attitude (favouring knowledge creation and sharing over strategic IPR management as source of competitive advantage), as key team members have been or still are being employed in academia. As academic spin-off ventures, especially in their first years after foundation, most often operate close to their parent university, they might retain this attitude and thereby potentially endanger the economic value of the IPR or technology.

As the previous literature overview illustrates, relatively few authors have dealt in detail with IPR within the context of ASOs as central topic of their research. This study aims at overcoming this research gap by contributing to a small extent to our understanding of the property rights' issue in academic spin-off ventures by investigating existing practice and identifying some major weaknesses in ASO's IPR activities. This knowledge could enhance the effectiveness of technology transfer offices and incubators as service providers towards spin-offs in their pre-foundation and early development stages. Additionally, spin-offs might benefit from improved legal and commercial protection, better IPR management of core technologies and research results and a larger effective commercialisation output.

Methodology

Case study research has been opted for as methodology in this exploratory study. Especially within this exploratory setting, the case study approach has many benefits. As Flyvberg (2006, p. 221) describes "*the case study produces the type of context-dependent knowledge that research on learning shows to be necessary to allow people to develop from rule-based beginners to virtuoso-experts*." As academic knowledge on IPR management in academic spin-off ventures is scarcely out of the egg, in-depth case studies can help in understanding the dynamics within a single setting (Eisenhardt, 1989) and provides useful insights to build upon in follow-up studies. The main advantages of case-study research remain that a study object (IPR management in academic spin-offs) is studied within its real-life context (Yin, 1981). Using analytical generalisation (Yin, 1981), the information obtained through the case studies will be discussed and transferred to a more general level, leading to a wider applicability of the knowledge gained in our case studies.

The initial list of possible spin-off firms has been constructed with information from incubator websites and e-mail correspondence with incubators or technology transfer departments. In order to enable a comparative qualitative study between surviving and failed academic spin-off ventures, both active and inactive spin-offs have been included (respectively 13 and four). The pair wise comparison potentially offers stronger conclusions (Eisenhardt, 1989, p. 540). Additionally, as the case studies have been selected from five different Belgian universities instead of using a single university environment as setting, the likelihood of obtaining conclusions transferrable to other settings is increased (cfr. infra: analytical generalisation), while the use of multiple cases (17) offers additional benefits (cfr. Yin, 1984).

Each firm has been interviewed in one sitting of approximately 1.5 hours, in most cases by two interviewers to benefit from the advantages of multiple investigators (Eisenhardt, 1989, p. 538). All interviews with the main founder(s) of the academic spin-off were made in the period January 2004 – January 2006. These respondents were chosen because they were estimated to have a good overview of the current IPR management policy and activities of the ASO and the IPR activities prior to foundation. A reference set of questions has been developed to guide the interview, thereby leaving enough room for spontaneous answers, which gave a semi-structured nature to the interviews. Before each interview, the authors have gathered in-depth information on the company via different official sources (e.g. juridical databases, patent databases such as Espacenet) and company disclosures (website, press releases etc.), enabling thorough preparation and efficient interviews. Afterwards, the same

information sources have been used for reasons of data-triangulation (Eisenhardt, 1989, p. 538). Table 2 provides an overview of the main characteristics of each case.

Table 2 – Summary of the case studies

Spin-off	Year of foundation	Year of failure	Status	Industry sector	Patents	Future patents	Trademarks	Non-protected technologies	Publications prior to foundation	Prior valorisation	Number of NDAs
A	2001	-	Active	Pharmaceuticals	Yes	Yes	Yes	Yes	Yes	Yes	50-200
B	1997	-	Active	Telecom	No	No	Yes	Yes	Yes	Yes	2-5
C	1999	-	Active	Electronics	No	No	No	Yes	Yes	No	0
D	1996	-	Active	Biotechnology	Yes	Yes	No	Yes	No	No	10-50
E	2000	-	Active	Pharmaceuticals	Yes	Yes	Yes	Yes	Yes	No	5-10
F	2001	-	Active	Mechanics	Yes	No	No	Yes	Yes	No	0
G	2000	-	Active	Biotechnology	Yes	Yes	Yes	Yes	Yes	No	10-50
H	1999	-	Active	Biotechnology	Yes	Yes	Yes	Yes	Yes	No	50-200
I	1997	-	Active	Biotechnology	Yes	Yes	No	No	No	Yes	10-50
J	2000	-	Active	Pharmaceuticals	No	No	No	Yes	Yes	Yes	50-200
K	2001	-	Active	Food	Yes	Yes	No	No	Yes	No	10-50
L	2001	-	Active	Telecom	No	No	No	Yes	No	No	0
M	1998	2003	Inactive	Telecom	No	No	Yes	Yes	Yes	No	0
N	1998	2006	Inactive	Electronics	Yes	No	No	No	Yes	No	5-10
O	1983	2002	Inactive	Food	No	No	No	Yes	Yes	No	0
P	1980	1996	Inactive	Biotechnology	Yes	No	No	No	No	No	0
Q	1992	2000	Inactive	Electronics	Yes	No	No	No	Yes	No	50-200

Besides some general information, the main parameters investigated in this study are:

- The number of patents and patents in application.
- The number of current trademarks and intentions to obtain more in the future.
- The number of current design claims and intentions to obtain more in the future.
- The number of current copyrights and intentions to obtain more in the future.
- The number of non-protected technologies and reason(s) for non-protection through intellectual property rights.
- The number of publications made on the main research results prior to foundation of the spin-off and prior to patent filing.
- The number of prior valorisation initiatives on the same research results or technologies prior to foundation of the spin-off.
- The number of Non-Disclosure Agreements with external parties concerning confidential information of the spin-off.

Results and conclusions

The case studies yield interesting results, potentially bearing some far-reaching consequences. One of the most promising results relates to the IPR situation prior to spin-off foundation: 13 out of the 17 spin-offs have made publications on the research results prior to founding and patent filing. This situation, which could be declared by the publishing culture of many academic researchers (see e.g. Ndonzuau et al., 2002), makes up one of the major threats of the invention's commercialisation potential, as patent applications require novelty. New knowledge dissemination into the scientific community should be preceded by a thorough assessment of the invention's potential. Critical in this regard is the role of TTOs. Especially in the pre-foundation project stage (or even pre-project stage), the guidance and anticipative actions of technology transfer offices (such as information sessions, guidance through the IPR process etc.) might to a large extent influence the invention's commercialisation potential. Refraining from looking for early legal protection can jeopardise the commercial value of an invention from the spin-off or parent organisation point of view (as the temporary monopoly situation is lost) and deter potential investors.

One of the interviewees indicated that as researcher, he had no glue of the importance of protecting research results through legal mechanisms (such as patent filing). Even tough he was involved in his spin-off venture on an active basis, he still embraced the mindset of a researcher rather than that of an entrepreneur. This statement clearly illustrates [1] the tension between the academic reward system and the call for more commercialisation of academic research, as discussed earlier in this paper and [2] the critical role of TTOs in this process, and more precisely their role in raising the awareness of certain issues (e.g. protection of IPR) at specific moments in the commercialisation trajectories.

A second testimony illustrates the opposite story. One of the spin-offs active in the pharmaceutical industry was co-founded by the main inventor / academic researcher of the technology and a manager with many years of consultancy experience in the target industry (attracted by the researcher and TTO to fill in the management aspects of the start-up). The TTO was involved from early in the discovery process onwards, after the first preliminary results indicated a potential commercially interesting application. Additionally, the researcher was acquainted with the U.S. culture (where academic entrepreneurship has a longer history), as he had spent a couple of years in the United States to do part of his research. From the project phase onwards (pre-foundation), they first filed for patents and protected the intellectual property before publishing any research results. Additionally, the academic entrepreneur added that he only had published on non-core technological issues, in order further to strengthen their IPR position, as part of the critical knowledge was kept in-house through trade secrets.

The temporary postponement of publishing research results in academic journals does not necessarily encumber the researcher's academic career with a mortgage. Indeed, as prior research by Van Looy et al. (2006) indicated, inventing researchers (i.e. researchers involved in patenting activities) tend to publish more than their non-inventing colleagues in the long run. Therefore, short term benefits (faster publications) might not outweigh long term profit from an academic point of view. (Future) spin-off teams should therefore consider not to publish on their inventions prior to foundation of the venture, but to postpone the publication to seek legal protection first. Our results indicate that, within the narrow context of our research setting, ASOs and TTOs are still early on the learning curve in this regard.

Despite prior publications on research results, 11 ASOs in our sample have patents in their portfolio at foundation. Additionally, 7 intend and expect to obtain more patents in the (near) future, as a result of the ongoing research. These results indicate that the sample ventures have a strong research base to secure future innovations. Our sample cases indicate industry differences in this regard. It is not surprising to see that biotechnology or pharmaceutical companies all (except for one) have sought patent protection for their core technologies. In these industries, technologies are typically protected using patents as a mechanism to ensure (temporary) monopoly situations, in order to facilitate a potential return on investment.

Besides patents, companies have a range of other protection possibilities, of which the most common are trademarks, design claims and copyrights. Only two spin-offs without any patents have sought other ways to protect their business (in these cases through trademark protection). One of these two spin-offs worked with open source software as basic technology to develop their products. Therefore, patent protection is not feasible and the core knowledge (i.e. the way they combine and use the software tools) is tacit. In total, only six spin-offs have protected their products and/or services by using trademarks, while only four of these six expect to protect more by using trademarks in the future. Design claims and copyrights have not been found in any of the sample cases.

It could therefore be argued that academic spin-off ventures are insufficiently aware of protection possibilities. Especially in industry sectors where legal protection of intellectual property plays an important role, knowledge and assets (whether tangible or not) should be protected in all possible ways. As a minority of the academic spin-offs in our sample have sought other protection than through patents and many of them operate in high-tech industries where IPR plays a major role (e.g. biotech, pharmaceuticals etc.), the IPR management in ASOs can be described as rather inadequate. One entrepreneur attributed this situation to the (often) limited resource base of starting ventures. He indicated that,

although he was aware of the necessity to protect some core knowledge by patents and other IPR mechanisms, the lack of substantial capital lead to a situation were the venture had to make the trade-off to invest its scarce resources into IPR protection or product development. Especially in the early development, the development of new products is crucial to secure long-term revenues. Therefore, young high-tech ventures, if they are 'forced' to make the choice because of limited financial resources, often opt to invest their resources into product development rather than (expensive) patent protection, which does not guarantee any future revenue.

The prior observation is reinforced by the fact that 12 ASOs have non-protected technologies in their portfolio, which could at least partially be declared by the first observation of the study (publications prior to foundation). In two cases, money is the main reason for non-protection, while non-controllability of patent breach is an issue in another two. This might also relate to the first observation, which indicated that many researchers publish on their research results, even prior to patent filing. Additionally, there probably is a resource-effect. As Agrawal (2006) indicates, searching patent protection is costly from the inventor's perspective. The patent application procedure is complex and time consuming (Colyvas et al., 2002). Especially in the context of an (young) academic spin-off with a limited resource base, patent protection is restricted to its utmost minimum due to the high investment cost. An additional reason for not legally protecting an invention lies in the codifiability and complexity of new inventions (Agrawal, 2006). Often new inventions are the results of a series of projects and experiments. As in publications and patents only the last experiment is described in detail, a large amount of uncodified knowledge accompanies new technological inventions (Agrawal, 2006). In case of high degree of complexity and low degree of knowledge codification, legal protection is less needed or desired because a patent remains a public document describing a technology in detail. In some cases (the Coca-Cola recipe example is the most known) trade secrets can in some exceptional cases be very effective in preventing competitors from getting access to detailed information on a specific technology. One of the entrepreneurs took the risk of not-protecting the technology, because he first wanted to explore the value and usefulness of the technology development with some market feedback. Only in case the feedback would be positive, the entrepreneur considered to invest in patent protection of the new piece of technology (he already filed for three patents on other parts of the technology and research results). Anyhow, a trade secret can only serve as passive protection of knowledge or a technology. However, the risk of reverse engineering is too high in most industries, which makes that other ways of protecting (the active protection of formal IPR) an inventions – although only temporary – are the only means to avoid competition and realise a reasonable return on the investments made. In one case, the reason for non-protection was

due to the nature of the 'technology'. The spin-offs (which eventually failed) worked with living materials (animals), which can not be protected using the conventional (patent) methods.

Additionally, six academic spin-offs do not make use of non-disclosure agreements (NDAs). They often question its usefulness and strength (or lack thereof) in protecting the confidential nature of the knowledge and information disclosed. Two of the entrepreneurs admitted they were not familiar with NDAs and therefore were not keen on making use of them themselves. All information they disclose is inherently part of the public knowledge. From that moment on, it becomes available to any interested party to apply. At the other extreme, some ASOs who use NDAs have signed more than one hundred NDAs. One spin-off even requires a signed NDA by each of his clients. Although the use of NDAs is not widely discussed in literature, it can be argued that excessive use of this contract type nullifies its purpose, as the source of unlawful or careless use of the knowledge disclosed under NDA becomes very hard to trace. Both extremes thus have pernicious consequences for the venture. The leakage risk for confidential information increases with the number of disclosures.

An interesting observation concerns prior or alternative commercialisation initiatives. In four cases, the research results on which the ASO is based have earlier been commercialised through a different pathway. These findings provide an indication of the market potential of the inventions. Additionally, research results can be commercialised at a larger scale if other parties are allowed to use them. In 12 ASOs however, no outgoing licences are granted. In the other direction, relating to their freedom-to-operate, five spin-offs have obtained licences of third parties to develop their activities, while seven describe their dependency on third party licences as non-zero. This might indicate a conflicting situation, where spin-offs use protected technologies without having obtained licences to do so. Within the scope of this study, these aspects have not been investigated in more detail.

Overall, the (preliminary) results indicate that IPR management in academic spin-off ventures seems open to significant improvements. Starting even prior to foundation, the intellectual property could be protected in a more comprehensive way, including other formal ways of protection than patents and avoiding too early dissemination of research results into the (academic) community. As prior evidence suggests, researchers involved in patenting activities in the long run realise a higher publication output (Van Looy et al., 2006). Patents on academic research results are thus not necessarily substitutes with a negative impact on academic careers compared to academic publications, but should rather be seen as complementary. The role of technology transfers offices in this regard is crucial.

On the other hand, the reason behind thus relatively weak IPR management in academic spin-offs can be traced back to the experience and expertise of the spin-off team. In the vast majority of the spin-off teams under investigation, none of the key team members possessed any legal expertise or background. Some of the managers were familiar with contracts and NDAs through prior experience. Additionally, only one spin-off managed to fill in this gap by attracting a board member with legal expertise, although attracting a board member with legal expertise can be an 'easy' way to compensate for absence of this knowledge in the core team. This absence of legal expertise in the core venture team (management, founders) or the broader team (employees, board members) might therefore add to the weaker IPR management in academic spin-offs. Again, the technology transfer office could play a significant role in this regard by advising starting academic entrepreneurs to acquire legal expertise, whether in the core team or through other ways (e.g. as independent board member).

Implications

At different levels evidence is provided that academic spin-offs have rather weak IPR management policies, despite receiving support by the mother organisation. It seems that many improvements can be realised through education of academic researchers and future spin-off managers on IPR management. Especially in the pre-foundation period, efforts could result in better protection possibilities if patents would be allowed as substitute of publications. Prior evidence suggests that patenting activities do not necessarily jeopardise academic publications (see e.g. Van Looy et al., 2006). On the contrary, academic researchers involved in patent activities tend to publish more than their non-inventing colleagues (Van Looy et al., 2006). These results suggest that researchers should not be afraid to postpone dissemination of their research results in the academic community, thereby strengthening the IPR position of the academic spin-off. Additionally, different programs could be developed at the technology transfer office level to support ASOs more substantially in developing and managing their IPR portfolio. Patent (and other IPR) protection requires specialists and is costly, thus a thorough cost-benefit analysis, both quantitative and qualitative, should be performed to determine the appropriateness of the patenting investment. Inventive ways of dealing with the resource-effect should be developed. Additionally, more attention could (and should) be developed to other aspects of intellectual property protection. The results indicate insufficient development of trademark, copyright or industrial design protection. Furthermore, the academic spin-offs in our study have no clear vision on how to develop and manage their IPR portfolio into the future (except maybe for patents).

Limitations of the study

The study has several limitations. The most important relates to the statistical insignificant sample on which the observations have been based. As prior literature has indicated, the ability to draw general conclusions from case study research is rather limited (see e.g. Eisenhardt, 1989; Yin, 1981). The current observations have been obtained in a geographical setting (Belgium) in a limited number of cases. As large cultural differences exist in patenting behaviour, results might be significantly different in other settings. Therefore, the study should be replicated on a larger sample and in other geographical and cultural areas to validate the preliminary findings of this study.

Additionally, it might be important to evaluate the evolution of an ASO's IPR portfolio in a longer timeframe. The extent to which the currently observed IPR management practices in ASOs have a lasting impact on their performance and eventual changes in the IPR management policy during further development stages could not be investigated in the present short term study. The long term dynamics within the described context of academic spin-off ventures reveal the effects of early stage (IPR management) choices on long term performance.

Of equal importance, the consciousness-raising and support by technology transfer offices should be analysed to fully understand the IPR management of academic spin-offs. The policies and procedures applied by TTOs, starting in the pre-foundation period, can to a large extent determine the subsequent IPR position and policy of the spin-off. The present study has not taken into account which actions have been undertaken by TTOs (even before the spin-off creation decision has been taken) to protect intellectual property and develop an IPR management view for that specific project.

Future research

In the previous discussions on the results and the limitations of this study, some lines of future research have already been indentified. One of the most interesting lines is in a longitudinal study on the effect of the currently observed IPR policy in academic spin-offs on their future performance. In short term, the IPR management policy (or sometimes the absence thereof) in the current sample seems not to influence survival chances to a large extent. However, the effect on a longer term could not be detected properly within the setting of this short-term case study research. A longitudinal study on this subject could identify the long term IPR dynamics affecting spin-off performance.

Secondly, future research could address the issue of support offered by technology transfer offices to academic spin-offs on developing and managing an IPR portfolio. The decisions and actions undertaken by TTOs, even before the spin-off decision was taken, can influence the IPR position of the ASO. Future research could address the influence of TTO pre-foundation actions on the future spin-off IPR position.

Lastly, future research could address solutions to the resource-effect as described earlier. Studies could identify creative solutions (how spin-offs address the resource-effect problem) or investigate the effect of resource injections or specific support programs by TTOs, government agencies or policy changes aiming at improving the IPR position of academic spin-off ventures and helping them to overcome the resource barrier.

Acknowledgements

The authors would like to express their gratitude to the interviewees (CEOs or founder(s) of the spin-offs) for their invaluable time and efforts. The authors also gratefully acknowledge the financial support of the Research Foundation – Flanders (FWO Vlaanderen) on behalf of Sven H. De Cleyn as PhD Fellow.

E-mail of corresponding author: Sven.decleyn@ua.ac.be

References

Acs, Z. J. & D. B. Audretsch (1989). Patents as measure of innovative activity. *Kyklos* 42 (2), 171-180.

Agrawal, A. (2006). Engaging the inventor: exploring licensing strategies for university inventions and the role of latent knowledge. *Strategic Management Journal* 27, 63-79.

AUTM (1997). *AUTM U.S. Licensing Activity Survey: FY 1996 – Survey Summary*. Deerfield, Illinois: The Association of University Technology Managers.

AUTM (2007). *AUTM U.S. Licensing Activity Survey: FY 2006 – Survey Summary*. Deerfield, Illinois: The Association of University Technology Managers.

Carayannis, E. G. & E. Rogers & K. Kurihara & M. Allbritton (1998). High technology spin-offs from government R&D laboratories and research universities. *Technovation* 18 (1), 1-11.

Colyvas, J. & M. Crow & A. Gelijns & R. Mazzoleni & R. R. Nelson & N. Rosenberg & B. N. Sampat (2002). How do university inventions get into practice? *Management Science* 48 (1), 61-72.

Debackere, K. (2000). Managing academic R&D as a business at K.U. Leuven: context, structure and process. *R&D Management* 30 (4), 323-328.

De Cleyn, S. & J. Braet (2007). *Research valorisation through spin-off ventures: Integration of existing concepts and typologies*. Research Paper 2007/008, University of Antwerp, Faculty of Applied Economics.

Eisenhardt, K. M. (1989). Building theories from case study research. *The Academy of Management Review* 14 (4), 532-550.

Etzkowitz, H. & P. Asplund & N. Nordman (2001). *Beyond Humboldt: Emergence of Academic Entrepreneurship in the U.S. and Sweden*. CERUM Working Paper, No. 27.

Flyvberg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry* 12 (2), 219-245.

Ganz-Brown, C. (1999). Patent policies to fine tune commercialization of government-sponsored university research. *Science and Public Policy* 26 (6), 403-414.

Goldfarb, B. & M. Henrekson (2003). Bottom-up versus top-down policies towards the commercialization of university intellectual property. *Research Policy* 32 (4), 639-658.

Hagedoorn, J. & M. Cloodt (2003). Measuring innovative performance: is there an advantage in using multiple indicators? *Research Policy* 32 (8), 1365-1379.

HEFCE (2003). *Higher education-business interaction survey*. HEFCE Publication, Paper No. 11.

Heydebreck, P. & M. Klofsten & J. C. Maier (2000). Innovation support for new technology-based firms: the Swedish Teknopol approach. *R&D Management* 30 (1), 89-100.

Hindle, K. & J. Yencken (2004). Public research commercialisation, entrepreneurship and new technology based firms: an integrated model. *Technovation* 24, 793-803.

Kleinknecht, A. & K. Van Montfort & E. Brouwer (2002). The non-trivial choice between innovation indicators. *Economics of Innovation and New Technology* 11 (2), 109-121.

Klofsten, M. (sine dato). *Training entrepreneurship at universities: a Scandinavian study*. Linköping, Sweden: Centre for Innovation and Entrepreneurship, Linköping University.

Lowe, J. (1993). Commercialization of university research: a policy perspective. *Technology Analysis and Strategic Management* 5 (1), 27–37.

Mowery, D. C. & R. R. Nelson & B. N. Sampat & A. A. Ziedonis (2001). The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole act of 1980. *Research Policy* 30, 99-119.

Ndonzuau, F. N. & F. Pirnay & B. Surlemont (2002). A stage model of academic spin-off creation. *Technovation* 22, 281-289.

Pirnay, F. & B. Surlemont & F. Nlemvo (2003). Toward a typology of university spin-offs. *Small Business Economics* 21, 355-369.

Steffensen, M. & E. M. Rogers & K. Speakman (1999). Spin-offs from research centers at a research university. *Journal of Business Venturing* 15, 93-111.

Trajtenberg, M. (1990). A penny for your quotes: patent citations and the value of innovations. *RAND journal of economics* 21(1), 172-197.

USPTO (2007). U.S. Colleges and Universities – Utility patent grants, Calendar years 1969-2005. Available online at http://www.uspto.gov/go/taf/univ/org_gr/all_univ_ag.htm. Last accessed on 12th September 2008.

Van Looy, B. & J. Callaert & K. Debackere (2006). Publication and patent behaviour of academic researchers: Conflicting, reinforcing or merely co-existing? *Research Policy* 35, 596-608.

Yin, R. K. (1981). The case study crisis: some answers. *Administrative Science Quarterly* 26 (1), 58-65.

Yin, R. K. (1984). *Case study research*. Beverly Hills, CA: Sage Publications.

Young, B. & N. Hewitt-Dundas & S. Roper (2008). Intellectual Property management in publicly funded R&D centres – A comparison of university-based and company-based research centres. *Technovation* 28, 473-484.

4. Commercialisation strategies of research-based spin-offs: the case of companies that operate in the market for technologies [9]

Oscarina Conceição[a)],Margarida Fontes[b)], Teresa Calapez[c)]

a)University of Minho & DINAMIA, Portugal
b) LNEG & DINAMIA, Portugal
c) ISCTE & DINAMIA, Portugal

Abstract

This paper addresses the role played by research-based spin-offs (RBSOs) in the transformation of scientific and technological knowledge in economic value, focusing on one potential source of heterogeneity in the performance of that role: the strategic decisions made by RBSOs regarding the mode of commercialisation of their technology. We discuss the conditions that can influence/constrain firms' ability to pursue with different strategic orientations, and advance some hypothesis regarding key factors that are likely to determine their strategic choices: nature of knowledge being exploited, appropriability conditions, location and degree of control upon critical non-technological assets, source institutional setting. Particular emphasis is put on one particular strategy: selling or licensing the technology (as opposed to embodying it into products or services), which is becoming increasingly widespread in some fields and which, we contend, RBSOs may be more prone to adopt, due to their specific characteristics. These hypotheses are tested on a group of 80 RBSOs from 6 European countries, using data collected specifically for this purpose, on the basis of questionnaire-based interviews.

This research adds to recent work on the determinants of the commercialisation strategy of technology-based SMEs, but by focusing on a particular group of companies - the RBSOs – we also take in consideration some distinctive characteristics of this group, which introduce some specificity in their innovative behaviour.

Key Words: *research-based entrepreneurship; commercialisation strategy; markets for technology; determinants of strategic choice*

[9] Support from the PICO project ("Academic entrepreneurship, from knowledge creation to knowledge diffusion", contract n° 028928) sponsored by the Sixth Framework Programme of the European Commission is gratefully acknowledged. The authors would also like to thank the other members of the PICO team for conducting data collection on RBSOs in their respective countries and an anonymous referee for his/her suggestions.

Introduction

Research-based spin-off companies (RBSOs) have recently become one focus of science, technology and innovation policies, being regarded as an instrument for the commercial exploitation of knowledge produced in public sector research organisations (Wright et al, 2007). However, contrary to what is often assumed by policy makers - and reflected in support policies - RBSOs are heterogeneous companies, created in a diversity of conditions and displaying a variety of behaviours (Mustar et al, 2006). Such variety has implications for the way these companies perform their role in the transformation of scientific and technological knowledge in economic value. Therefore, it is important to typify the heterogeneity that prevails among research-based spin-offs and to understand the reasons behind it and its impact upon these firms' innovative behaviour.

This paper is concerned with one potential source of heterogeneity – the commercialisation strategy adopted by the RBSO. We propose that the strategic decisions made by RBSOs regarding the mode of commercialisation of their technology have an impact upon the way they perform the knowledge production and transformation function, thus shaping their innovative activity. We advance a number of factors that are expected to influence RBSOs ability to adopt a given strategic orientation and formulate some hypotheses regarding them. These hypotheses are subsequently tested on a sample of European RBSOs.

Our research adds to recent work on the determinants of the commercialisation strategy of technology-based SMEs (Giuri and Luzzi, 2005; Hicks and Hedge, 2005; Novelli and Rao, 2007; Gans et al, 2002; Gambardella and Giarratana, 2007; Pries and Guild, 2007). However, the fact that our focus is on one particular type of technology-based company – the RBSO - requires us to take into consideration the specific characteristics of these companies, which are not addressed in other research and which are expected to introduce some variation in their behaviour. Hence, we contribute to a better understanding of the strategic behaviour of this category of firms.

Commercialisation strategies of RBSOs

RBSOs are defined as companies set-up to commercialise scientific and technological knowledge or technologies developed in an academic research setting (Mustar et al, 2006). This commercialisation process requires the new firms to make a key choice regarding the mode through which they will capture value from their knowledge assets. They may opt for engaging in the development of products or services based on that knowledge/technology; or

they may opt for selling or licensing the actual technology (Gans and Stern, 2003). To engage in the development of products or services and to bring them to the market, alone or in alliance with other firms, is the most typical strategy. However, the case of companies that specialise in the production and sale of intellectual property is becoming more frequent, particularly in some fields, as markets for technology develop (Chesbrough, 2006; Cesaroni and Giuri, 2005; Lichtenthaler, 2008).

Technological innovation, namely when it is based on substantially new technologies, is often associated with market and technological uncertainty (Freeman, 1982). Thus, the early choices made by RBSOs entrepreneurs are likely to be constrained by limited information, especially about markets, given the frequent lack of commercial background of the entrepreneurs (Ensley and Hmieleski, 2005). Therefore, these choices are not necessarily definitive. In fact, technological and/or market volatility may lead to changes in the competitive conditions (Druilhe and Garnsey, 2004) and subsequent learning processes may support more adequate decisions in the future (Costa et al, 2004). On the other hand, entrepreneurs may delay a final decision on the strategy to adopt, particularly when they are still completing the development of the technology, taking some time "prospecting", i.e. searching for and testing different application/market possibilities (Heirman and Clarysse, 2004). But firms will have at least an early "business orientation" which provides some strategic direction.

Even if firms' strategies may change through time, early choices are important because they can have an "imprinting effect" upon the company created (Stinchcombe, 1965; Eisenhardt and Schoonhoven, 1990). They influence the shaping of the new firm, since they have an impact upon decisions regarding resource mobilisation, competence development and search for relationships. They may also constrain its subsequent evolution, by reducing the margin for later choices: for instance, in some cases, deciding to license the technology may preclude its later use by the firm.

The decision on the commercialisation mode is, therefore, a major strategic decision for start-ups, that can be conducive to different modes of behaviour, concerning the organisation of firms' innovative activities, the outcome of these activities, as well as the way firms interact with their environment. For this reason it will inevitably lead to heterogeneity in terms of the functions played by RBSOs in the innovation system.

Specificities of RBSOs

When discussing the innovative behaviour of RBSOs we have to take into account that their genesis as companies created to exploit scientific and technological knowledge originating from academic research, endow them with some distinctive characteristics. These are

associated with the nature of the knowledge being exploited (Jong, 2006; Shane, 2001), the human and social capital of the entrepreneurs (Ensley and Hmieleski, 2005; Murray, 2004) and the institutional context from which they emerge (Clarysse et al, 2005; Di Gregorio and. Shane, 2003).

RBSOs exploit opportunities that originate from academic research and therefore they are more likely to apply scientific knowledge. The nature of this type of knowledge influences the conditions in which its exploitation takes place: it is potentially more novel, more easily codifiable, more generic (thus generating a wider set of opportunities), but also more distant from applications. RBSOs are created by entrepreneurial teams that typically involve at least some of the academic scientists or engineers who developed the technology. Thus scientific backgrounds, and therefore scientific and technological competences and networks, are likely to be prevalent, even if some teams add individuals with managerial experience. Finally, the fact that RBSOs originate from an academic, non-commercial environment, also have implications for the new firm. First, because such environment may have culturally shaped the individuals involved in the creation process. Second, because the parent organisation can exert (directly or indirectly) some influence upon the type of decisions made at start-up, while being less likely to provide support in the access to non-technical competences and resources.

These specific features are expected to shape the new organisation at three main levels: the nature of the technology being commercialised; the type of competences and resources possessed by the founders; the level and type of intervention of other actors, and thus contribute to influence their decision making process.

Market positioning: trading in technologies vs. products

RBSOs strategic decision on how to transform knowledge in economic value, also entails a decision on the type of market to target, in order to capture the value from that knowledge: so firms can opt for trading exclusively in the market for technologies, or chose to trade in the market for products[10] (Arora et al, 2001). The requirements for operating in each type of market are expected to be different (Gans and Stern, 2003) and thus, in order to explain the decision made by the RBSOs, it is necessary to understand the conditions that enable start-up firms to comply with these requirements. In the case of start-up companies originating from research organisations, technology and/or the technological knowledge possessed by

[10] Firms that engage in product development may still chose to sell/license (part of) their technologies, for various reasons (Lichtenthaler, 2008), although this option is less likely in resource constrained start-ups. These may nevertheless engage in some technology trade activities, while developing the core product (Kollmer and Dowling, 2004).

the entrepreneurs is the key asset. Thus a decision on the mode of commercialisation will necessarily entail an evaluation of the nature of this asset (Shane, 2001) and, similarly to other innovative start-ups, a number of decisions regarding the other types of assets and competences to acquire (build or access) in order to capture the value from that technology (Teece, 1986).

In this paper we will address this decision, focusing specifically on the option *to target or not target the market for technologies, as the firm main business.* Having in mind the above discussion about the importance of early decisions, but also about the potential for change in strategic orientation, we will consider: a) the conditions that lead entrepreneurs to adopt (or not) an early business orientation towards the market for technologies; and b) the conditions that are associated with operating in these markets as the main business, in later stages. We will also seek to understand whether and to what extent the early decision impacts upon firms' subsequent behaviour.

The focus on the companies that target the market for technologies – that is, markets where technology is traded in the form of intellectual property or other intangible forms rather than embodied in products or processes (Arora et al, 2001) – as opposed to those that do not address these markets, is based on a number of reasons. The option for trading in intellectual property assets as the main business (and not as a complementary or a transitory activity, while the core product or service is being developed) has been an exception, until recently (Teece, 2006). However this strategy is becoming more frequent and we witness an increase in the number of companies that opt for it (Chesbrough, 2006; Pries and Guild, 2007; Hicks and Hedge, 2005).

Some research has recently started to focus upon this phenomenon (Bekkers et al, 2006, Hicks and Hedge, 2005; Kollmer and Dowling, 2004). However, the conditions that are behind the emergence of these firms and that sustain their development are still relatively less understood, which makes them a relevant object of analysis. The particular case of RBSOs is even less understood: while some authors have described spin-offs business models that fit within the technology trade strategy (e.g. Stankiewicz, 1994; Druilhe and Garnsey, 2004), we only found one paper that specifically attempted to explain this type of commercialisation strategy (Pries and Guild, 2007). However, it is our contention that RBSOs, because of their specific characteristics, can be more prone to adopting this strategy. First because it will be "cognitively closer" to the founders' identity as researchers and to the cultural environment they originate from. Second, because the nature of the technology being exploited may favour this option, as we will explain below.

Thus we formulate the following research questions:

a) which factors influence RBSOs early business orientation towards technology markets?;
b) which factors influence RBSOs capacity to operate on technology markets as their main business?;
c) considering the potential "imprinting effect" of early decisions, how determinant is RBSOs early business orientation towards technology markets for RBSOs subsequent capacity to operate on technology markets as their main business?

Conceptual framework

Our approach to the factors that influence RBSOs decision on the commercialisation strategy combines insights from two theoretical sources: the economics of technological change and the strategic management of technology. Drawing on these two streams of literature we build a conceptual framework whose starting point is the notion that the main asset possessed by RBSOs is their knowledge/technology (Shane, 2001) and that, therefore, firms' decisions will be influenced by two types of factors: a) those related with the technology and the nature of knowledge underlying it (Malerba an Orsenigo, 1993); b) those related with conditions that enable firms to capture the value from their technology (Teece, 1986).

More specifically, we propose that the "technological imperatives" associated with the nature of the knowledge being exploited are likely to have a strong impact upon and thus condition/shape the strategic orientation pursued by the RBSO. But, since the capacity to profit from innovation requires going beyond the sole consideration of those imperatives, we also propose that the nature, location and mode of deployment of a set of non-technological competences and resources will equally influence the RBSOs' strategic orientation. In addition, we propose that some features of the public sector research environment from which RBSOs originate are also likely to influence the decision process, namely through their impact upon the above mentioned dimensions.

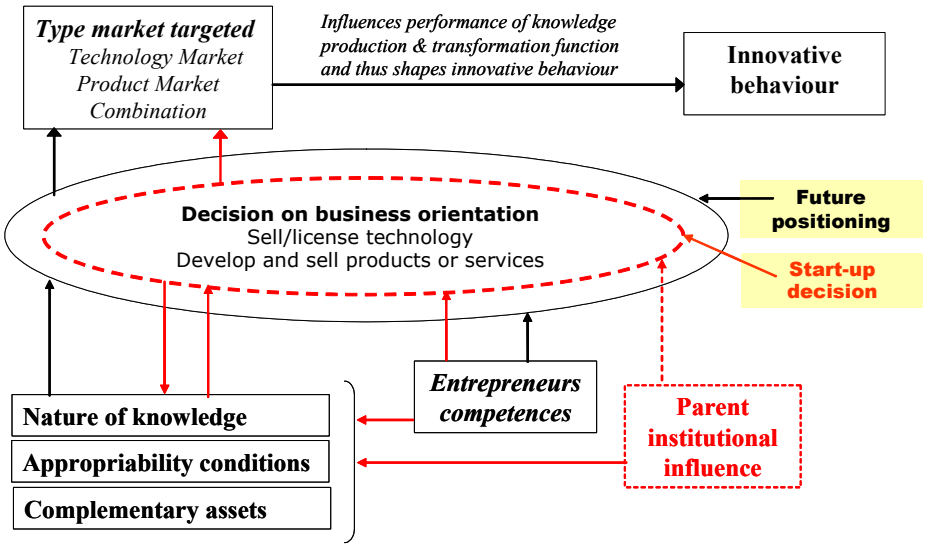
Thus, we advance the general hypothesis that RBSOs decision regarding commercialisation strategy is influenced by four types of factors:

1) nature of knowledge being exploited;
2) appropriability conditions, i.e. capacity to protect the technology;
3) location and control of critical non-technological assets, described in the literature as "complementary assets";

4) academic institutional setting of origin (particularly influential at the start-up stage), expressed through the direct or indirect influence of the parent organisation and through the impact of founders background upon the firm early competence base.

We also advance that these factors may impact differently upon the early decision to target a a given market and upon the ability to operate in that market (at a steady state) as the firm main business. Figure 1 depicts graphically this conceptual framework.

Figure 1 – RBSOs decisions on commercialisation strategy



In the next sections we present in detail the theoretical foundations of this framework and formulate more specific hypotheses regarding how these factors influence the commercialisation strategy of RBSOs, with particular emphasis on their influence on the key decision of whether or not targeting the market for technologies.

Evaluating the nature of the key asset: factors related with nature of knowledge

In order to address the impact of factors related with the technology being exploited and the nature of knowledge underlying it upon the commercialisation strategies of RBSOs**,** we draw on the economic theory of technological change and particularly on the approach introduced by the "technological regime" framework (Nelson and Winter, 1982; Malerba and Orsenigo, 1993). This approach is exactly concerned with the relationship between firms' behaviour – that is, strategies and forms of organisation - and the technological environment where these firms operate, which, it is argued, sets the boundaries of firms problem solving activities and establish the trajectories along which innovation can take place (Nelson and Winter, 1982).

Thus, the behaviour of a firm will be strongly shaped and constrained by the properties and dynamics of the knowledge underlying the technologies it develops/uses (Dosi, 1988).

Technological imperatives" and firm behaviour

Malerba and Orsenigo (1997), drawing upon Dosi (1988) description of the dimensions that characterise a technological regime, operationalise it as a combination of some fundamental properties of technologies: opportunity and appropriability conditions, degree of cumulativeness of technological knowledge and the characteristics of the knowledge base, which include: levels of pervasiveness/specificity, tacitness and complexity. Opportunity is defined as the ease of innovating for a given investment in search for new solutions; appropriability as the possibility to protect innovations from imitation; cumulativeness as the extent to which current innovative activities are based on knowledge and innovations developed in previous periods (Breschi et al, 2000). These properties provide an important analytical device that enables us to address the nature of the technologies being exploited by RBSOs.

Considering that RBSOs are new entrants exploring a new technology, we will assume, following Malerba and Orsenigo (1993), that they will be operating under *high opportunity* conditions. However, they may be confronted with different combinations regarding other properties, since cumulativeness and appropriability can be high or low.

High level of opportunity is generally considered an important incentive for innovation and thus potentially offers good prospects for new entrants, but the sources of technological opportunity differ (Klevorick et al, 1995) influencing the chances of these entrants (Marsili, 2002). Since RBSOs are created to exploit new technological opportunities derived from academic research, it is expected that scientific advances are their main source of technological opportunity as opposed to technological advances originating from the industry. Knowledge originating from outside the industry – as is the case of the one originating from academic research - is likely to be less specific to the industry and less cumulative. When this type of knowledge plays a more important role as source of opportunity, new firms tend to have an advantage (Winter 1984). Rather, when knowledge generated within the industry prevails, high opportunity may be associated with high cumulativeness, favouring exploitation by established firms (Marsili, 2002). In both cases, if appropriability is low, imitation by followers is a possibility and thus the strategy has to be coupled with alternative strategies of strengthening appropriability. However, these strategies may be beyond the reach of small entrants, to whom formal appropriation mechanisms are often the only effective means of protection (Hall, 2005).

Technologies characterised by high opportunity conditions are also sometimes characterised by high pervasiveness, i.e. the possibility of using the same core knowledge in a variety of applications (Malerba and Orsenigo, 1993). Since pervasive knowledge offer opportunities for diversification, through its application to diverse products and markets it can be advantageous for new entrants. This is particularly the case if cumulativeness is low. But in conditions of high pervasiveness, cumulativeness may not be a deterrent for new entrants, since diversified and specialist firms occupying different niches may co-exist, assuming different (and often complementary) strategic positionings in the same industry, as the cases of biotechnology and more recently nanotechnology amply document (Orsenigo et al, 2001; Zucker et al, 2007).

Thus, globally, conditions of high technological opportunity, particularly when associated with pervasiveness, high appropriability and low cumulativeness appear to be the most favourable for new small entrants exploring new technologies. Nevertheless, it is also possible for these new entrants to survive under other combinations of conditions, which still enable this type of generic strategy, but are more favourable to incumbents, thus requiring the new firm to find ways to co-exist with these.

The impact of the nature of technology upon the strategic decisions of technology intensive companies has been addressed by very few authors. Shane (2001) found that the exploration of more important (measured through the economic value of invention), more radical and broader inventions was more likely to be conducted through a new firm. Hicks and Hedge (2005) concluded that small patent-based based specialist suppliers that manage to survive and have long lasting success in the markets for technology, develop technology that is more general purpose, has a broader range of applications, has higher quality and is also more basic and closer to science. Similarly, Gambardella e Giarratana (2007), drawing on Bresnahan and Trajtenberg (1995) analysis of general-purpose technologies, concluded that the presence of those technologies favour technology trade, and thus that they are more likely to be licensed. Conversely, the generality of the technology can have a negative impact on new product development, because it makes it less suitable for specific application, and thus can be a deterrent for entering in product markets.

The impact of nature of knowledge on RBSOs strategic decisions

Despite the limited consideration given to the impact of the nature of knowledge upon the strategies of new technology intensive companies, the importance of this asset for RBSOs

led us to give particular attention to this issue in our research. On the basis of the discussion on technological imperatives and their impact on firms' behaviour, we will put forward some hypothesis regarding the influence of this specific factor upon RBSOs strategic decisions.

The above discussion suggests that more general purpose (or pervasive) technologies can provide firms with a "platform technology" that support a continuous stream of development. This can be critical for firms that intend to operate in the technology market (TM) in a sustained way. Moreover, more generic technologies also tend to be more distant from applications and thus to be more difficult / take longer to convert into products, thus being a constraint to operate in product markets (PM). Therefore:

Hip 1a: *RBSOs in TM are more likely to have pervasive technologies than RBSOs not in TM*

In addition, technologies with a greater component of new knowledge can be more valuable for potential acquirers and thus offer a competitive advantage in the TM. Given their novelty they also have a greater possibility of being patented, as well as to provide more valuable patents, which is equally important when operating in TM.

Hip 1b: *RBSOs in TM are more likely to have technologies that involve a greater component of new knowledge than RBSOs not in TM*

The impact of the parent organisation on the nature of knowledge should also be taken into consideration. New scientific knowledge – particularly the one associated with more basic research - tends to be generic in nature (Klevorick et al, 1995), enabling the opening up of a variety of search trajectories (Saviotti, 1998). Knowledge developed in the context of academic research is more likely to originate from basic science and is also more likely to be closer to the knowledge frontier. Thus RBSOs that exploit technologies largely developed in the academic context, are likely to have technologies that are more generic, more novel and more related with basic principles (and thus more distant from applications), as compared with RBSOs that exploit knowledge mostly conducted already in the firm, on the basis of founders' (tacit) knowledge. Therefore:

Hip 1c: *RBSOs in TM are more likely to start-up with technologies developed in the context of the parent research organisation and transferred to the new firm, than RBSOs not in TM.*

Finally, since RBSOs technological competences are largely embodied in the founders, the academic level/field of training and the type of technological experience and networks

possessed by them will also shape the technological knowledge present in the firm (Ensley and Hmieleski, 2005). Scientists differ in terms of degree of exposure to non-academic environments, but it can be argued that RBSOs that only have founders with academic R&D experience (as opposed to technological experience in industry) will be more likely to prefer to engage in R&D activities and build a technological portfolio, rather than to engage in the activities required to transform technology in products (Dasgupta and David, 1994).

Hip 1d: *RBSOs in TM are more likely to be created by founders whose technological backgrounds are exclusively academic, than RBSOs not in TM.*

Capturing value from the technologies: appropriability and complementary assets

Despite the critical importance of technology assets, the transformation of technologies into products and their commercialisation also requires the consideration of other aspects that are instrumental in enabling firms to capture the value from their technologies. This question has been addressed in greater detail by the strategic management of technology literature and particularly by the branch that focus of the markets for technology (e.g. Arora et al, 2001; Gans and Stern, 2003).

This literature draws a great deal on Teece (1986) seminal approach to the alternatives and also the hazards faced by firms in the introduction of their innovations in the market. The key dimensions of Teece analysis – the appropriability conditions and the nature, location and mode of deployment of a set of specialised non-technological competences and resources, that cannot be easily acquired in the market but are needed to capture rents from the innovation, or "complementary assets" – are retained as the basic analytical structure. Following Teece, the combination between these two factors is at the root of the most recent research on the conditions faced by young firms commercialising new technologies. However, these approaches move beyond Teece, by proposing that, in some conditions, it is possible for (small) innovating firms, to avoid the ownership of specialised assets and still capture rents from their innovations, due to the development of the markets for technology.

One important contribution of this stream of literature to our question, concerns exactly the impact that the development of markets for technologies had upon the alternatives open to small technology intensive companies, namely by creating a new division of inventive labour (Arora et al, 2001). Large technology advanced companies increasingly tend to focus on their core R&D competence and to acquire technology developed by other companies in less strategic areas, thus creating conditions for the emergence of firms specialised in research

and technology development that act as suppliers of intellectual property (Antonelli and Teubal, 2008, Chesbrough, 2006). These firms can opt for focusing on developing the technology and resort to licensing or other technology trade agreements to capture the value of their efforts, and thus avoid incurring in the costly development of manufacturing and commercialisation facilities and competences (Arora and Merges, 2004). However, this option also have hazards, particularly for small firms with low bargaining power in contracting and limited capacity to uphold expropriation threats by dominant companies. Thus, the choice for the more adequate strategy should always balance these hazards against the situation in the markets for downstream assets, since the conditions in these markets may lower the costs of the acquisition of some of them (Gans and Stern, 2003).

Research on commercialisation strategies of technology intensive firms

In contrast to what was remarked above regarding the nature of knowledge, the impact of appropriability conditions, and also, more recently, the combined impact of appropriability and complementary assets upon the commercialisation strategies of technology intensive firms has been extensively discussed by this literature.

Maybe the most comprehensive analysis was the one conducted by Gans and Stern (2003), who developed a conceptual framework to address the decision process of technology-based start-ups. They discuss the conditions in which new firms should compete directly in the product market with established firms; and those in which they should adopt a cooperative strategy, entering into agreements with established firms, that then become the channel through which the technology is commercialised to the product market. One key aspect of this approach is that it explicitly considers the possibility that established firms both control key complementary assets and have an incentive to appropriate the innovation, thus making alliances with them potentially more risky. The drivers behind the choice are, therefore, the capacity to preclude imitation by incumbents, and the extent to which incumbents own complementary assets that contribute to the value proposition of the technology. The authors discuss at length the conditions that favour cooperative and competitive strategies.

This issue has been empirically addressed by Gans et al (2002) and a few other authors (Giuri and Luzzi, 2005; Kollmer and Dowling, 2004; Novelli and Rao, 2007; Gambardella and Giarratana, 2007; Pries and Guild, 2007). These authors typically address the case of patent-based small firms and consider the range of strategic options open to them and the factors that influence their strategic behaviour. Their research puts some emphasis on identifying and delimiting a strategy that focuses on technology trade and on distinguishing it from

strategy(ies) focusing on product/service development. The distinguishing element between what can synthetically described as “technology market” and “product market” strategies is always whether the technology is sold as a disembodied good, or is incorporated into physical artefacts. But the way the strategies are defined depends on the way the various authors address the modes on which such incorporation takes place; and the relationship that the small supplier establishes with the buyers of the technology. In particular, the nature of the discussion on the role of specialised complementary assets depends on whether the authors focus exclusively on the in-house development of these assets, or also consider the possibility of establishing agreements with their owners. In our view this is a non negligible issue. In fact, Gans and Stern (2003) important insight about incumbents who have an incentive to expropriate the innovation, suggests that the *viability* of establishing such agreements in relatively advantageous conditions can be a key element in decisions on the commercialisation strategy.

Additional contributions come from the literature on technology licensing that discusses the conditions in which firms decide whether or not to license their technology, and how such licensing takes place. While most of this literature does not focus on start-up companies, firm size or age often emerges as an important dimension in the decision process. Strategies of small/young firms are found to be diverse from those of larger established firms: the former are more likely to license and tend to be more strongly influenced by the level of IP protection and the conditions in the market for downstream assets (Gambardella et al, 2007; Cohen et al, 2000; Arora and Merges, 2004; Arora and Fosfuri, 2003).

On the whole, these various streams of literature seem to converge in the conclusion that the appropriability regime and the access to complementary assets (under various forms) are key elements in firms decision concerning the modes of technology commercialisation and that small technology intensive firms – and especially start-ups – given their limited resources and reduced bargaining power, are particularly vulnerable to conditions at these levels.

They also suggest that, while the decision to concentrate on technology trade, avoiding the development of production/commercialisation assets, can be a favourable strategy to new entrants endowed with strong technological competences, this strategy has quite stringent requirements. These requirements concern both the characteristics of the technology (e.g. its novelty, uniqueness and the ability to make its advantages known to potential buyers) and the strength of the intellectual property protection. The strategy also has risks, mainly derived from engaging in contractual agreements with more powerful companies that may have an

incentive to appropriate the technology. Given these risks and requirements, technology intensive start-ups should consider carefully the circumstances surrounding the commercialisation process and the alternatives open to them.

Thus, in order to fully understand the conditions that influence the RBSOs decision process it is necessary to look in more detail into these aspects of the appropriability regime and access to complementary assets that are most relevant for this category of firms.

The impact of appropriability regime on RBSOs strategic decisions

The appropriability regime can be defined as the conditions concerning the protection of intellectual property assets against imitation, either through legal mechanisms (e.g., patents, copyright, formal non-disclosure agreements) or "natural" barriers to imitation, afforded by characteristics of the technology (tacitness, difficulty in reverse engineering) (Pisano and Teece, 2007). In general higher appropriability conditions would increase the likelihood that companies earn profits from their innovation. But, appropriability levels differ between sectors and the appropriability mechanisms that are available and effective also vary (Hurmelina-Laukkanen and Puumalainen, 2007). In the particular case of patents: despite a general increase in the level of patenting (Hall, 2005), their incidence and effectiveness are still largely confined to a few sectors, with alternative methods (secrecy, lead-time, fast progress down the learning curve) being extensively used in the other industries (Cohen et al. 2000; Arundel, 2001).

In this context, RBSOs configure a particular group of firms, since they are more likely to commercialise knowledge originating from scientific research. This type of knowledge is, in principle, more abstract and codified (Arora and Gambardella, 1994) making patenting easier. On the other hand, knowledge associated with new scientific discoveries can have a high tacit component, derived from its very novelty, which endows it with "natural excludability" (Zucker et al, 1998). This provides the firm with temporary protection against imitation, which is particularly important when formal mechanisms are not viable or are less effective.

While there is some debate about the means through which small technology intensive companies can protect their intellectual assets, there is more agreement in the literature about the case of small technology suppliers who wish to sell or license their technology. Legal protection, namely through patents, is regarded as indispensable (Arora and Merges, 2004; Gans et al, 2002), even if it is recognised that these firms may find it difficult to withstand cases of litigation. In fact, strong IP protection through patents, not only defends

the supplier from expropriation, but also facilitates technology trade. It guarantees ownership of the intellectual assets (therefore enabling their transfer to third parties) and reduces the asymmetry of information that characterise transactions in technology markets (Arrow, 1962) thus lowering transaction costs for both suppliers and buyers (Gambardella and Giarratana, 2007).

The above discussion enables us to put forward some hypotheses concerning the impact of appropriability conditions on RBSOs commercialisation strategies. First if all it suggests that legal protection through patents is critical for RBSOs operating in the markets for technology. However, because appropriability conditions in general and effectiveness of patents as protection mechanisms differ between industries, the prevailing appropriability regime will affect the existence of markets for technology and RBSOs ability to operate in these markets. Thus, entrepreneurs' perceptions about the appropriability conditions in the industry segment where they want to operate may influence the choice of commercialisation strategy. Therefore:

***Hip2a**: RBSOs in TM are more likely to operate in sectors where level of appropriability is (perceived as) higher than RBSOs not in TM.*

***Hip 2b:** RBSOs in TM are more likely to have their technology protected by patents than RBSOs not in TM.*

It is nevertheless relevant to consider that while patent protection can be a requirement for RBSOs operating in TM, it may also be important for firms developing new products and selling them in the PM, for protecting against imitation or for strategic reasons (Arora and Ceccagnoli, 2006). In fact, patents can also be used as basis for negotiation, either with other patent owners (cross-licensing) or with owners of other resources (e.g. financial or technological) to whom they signal the presence of knowledge assets and/or technological competence (Coriat et al, 2003; Rothaermel, 2002). So, the sole presence of patents may not necessarily differentiate between commercialisation strategies. But firms operating in PM also have more possibilities to resort to alternative protection mechanisms - which can be critical given small firms' frequent ability to enforce patent rights on products - and thus give relatively less importance to patents and/or attribute them different roles.

***Hip2c**: RBSOs in TM are more likely to attribute higher importance to patents as protection mechanisms (as compared with other mechanisms), than RBSOs not in TM.*

The impact of RBSOs origin on the appropriability conditions should also be taken in consideration. It can be argued that when the new firm is exploiting knowledge that was directly transferred from academic research, there is a greater possibility that its technology is patented. In fact, not only scientific knowledge is, in principle, easier to patent, but research organisations are putting a growing emphasis on IP protection (Wright et al, 2007). These patents are frequently transferred or licensed to the new firm, granting it strong IP protection from start-up. Given the information asymmetries that characterise markets for technologies, patents filed by a reputed parent can also have a function of quality endorsement of RBSOs (Lichtenthaler and Ernst, 2007). Thus the presence of parent patents can create favourable conditions for operating in TM. This option may be further encouraged by the nature of these patents. In fact, inventions originating from the university tend to be more fundamental and abstract and thus patents are often of an embryonic nature, still needing substantial development before commercial application (Thursby et al, 2001).Therefore:

Hip2d: *RBSOs in TM are more likely to start-up with technology protected by patents granted to the parent organisation, than RBSOs in PM*

The impact of complementary assets on RBSOs strategic decisions

New firms engaging in the transformation of their technology into marketable products or services will be confronted with the need to gain access (building or acquiring from others) a number of non-technological assets (physical assets or knowledge and skills) that are necessary to sell a complete product or service: such as manufacturing capacity; marketing, sales and distribution; regulatory knowledge (Teece, 1986). Access to these assets can be done in different ways: through acquisition in the market, through building in-house, or through alliances with the owner of the asset (Colombo et al, 2006; Gans and Stern, 2003; Shan, 1990). Those assets may be generic and supplied in the market in competitive conditions; or may be co-specialised to the innovation (Teece, 1986). The latter can be more difficult to gain access to: they may not be readily available in the market, since their owners may try to achieve control over them and may also be difficult to imitate, because they are built on the basis of a process of learning within the firm (Rothaermel and Hill, 2005; Pisano and Teece, 2007).

New entrants will thus face a choice: they can build the key complementary assets internally; they can try to gain access to them, through market transactions or through alliances; or else they can avoid engaging in downstream activities at all (Arora et al, 2001). This choice can be addressed at two levels: a) that of the objectives pursued by the firm, i.e. its founders may

or may not be willing to engage in a type of activity that requires downstream assets; b) that of the viability of gaining access to these assets in reasonably favourable conditions. These levels are not independent and it is their combined consideration that may contribute to explain RBSOs decisions.

Regarding the objectives, RBSOs origin and the nature of the knowledge they are exploiting can influence the founders' business approach. In some cases such knowledge can still be quite fundamental – e.g. concerned with basic principles or theoretical constructs – and thus still imprecise in terms of applications (Stankiewicz, 1994). Even if some applications are foreseen, extensive transformations may be required in order to accomplish them. This has both technological and managerial implications. In technological terms, it means that these RBSOs will be required, before all, to perform activities of knowledge transformation that locate them upstream in the value chain (Autio, 1997). The competences possessed by science-based teams are often more adjusted to this type of activity, which requires good scientific competences and a strong emphasis on research. Thus, they may be more prone to focus on the transformation of scientific knowledge into generic technologies (Autio, 1997), than on the transformation of these technologies into products, which will require building-up or gaining access to a much wider set of technical competences (Marsili, 2002). In addition, the commercialisation of technology intensive products require specialised managerial competences and resources (Costa et al, 2004) and the presence or fast development a diversified set of non-technological relationships (Colombo, et al, 2006). Globally, the conduction of the whole transformation of a technology (which can be very basic) into a marketable product will call for a diversity of investments in physical assets and competences that may be beyond the reach of a resource constrained start-up (Heirman and Clarysse, 2004; Colombo et al, 2006). Furthermore, an upstream positioning also creates better conditions for generating an output that can be patented and traded in technology markets. Thus, these firms will have less advantage (and possibly less interest) in engaging on the development of downstream complementary assets, thus having a greater incentive to operate in TMs. Therefore:

Hip 3a: *RBSOs are more likely to be in TM when they are exploiting basic knowledge and engaged in upstream transformation processes, and thus do not need to assess downstream complementary assets to commercialise their technologies*

The situation concerning access to key complementary resources and competences is also decisive for the decision process. Access can be problematic when new entrants are dealing with specialised assets under the control of existing firms. In some circumstances they may

be able to enter in vertical alliances with the owners of the needed assets, as when established, to whom RBSOS technologies/products are particularly interesting, assume part or all the manufacturing and/or commercialisation activities (Rothaermel, 2002; Colombo et al, 2006; Stuart et al, 2007). However, it may happen that key assets are controlled by firms that have an interest in appropriating the technology (Gans and Stern, 2003). In this case, the perception of a potential threat may act as a constrainer upon the establishment of that type of alliances, even if legal protection is guaranteed.

As we saw above, the literature that deals with firms' positioning relatively to complementary assets (e.g. Arora and Ceccagnoli, 2006; Pisano, 2006; Rothaermel and Hill, 2005; Gans and Stern, 2003) suggests that small technology intensive suppliers that do not possess such assets will have some advantages in commercialising the technology itself, providing that they fulfil the conditions to compete in technology markets. RBSOs may effectively choose that route, or may still wish to consider whether they have advantages in building some assets (Gans and Stern, 2003; Pisano, 2006)[11]. It can be argued that the decision will be influenced by RBSOs perceptions: of the importance of the assets for capturing the value from the technology; of the conditions for accessing the most critical ones and particularly of the level control upon them by existing firms; of the type of competences the firm can mobilise. But it is to be expected that, when key downstream assets such as manufacturing capacity; marketing competences, sales and distribution facilities, regulatory experience, are perceived as controlled by existing firms, RBSOs will have a greater incentive to operate exclusively in the TM. Therefore:

Hip 3b*: RBSOs are more likely to be in TM when downstream complementary assets perceived as key to capture the value from the technology are controlled by existing firms.*

The decision will also be influenced by the difficulty to build/acquire the assets, even if they are not controlled by incumbents. One basic element in this process are the competences possessed by the entrepreneurial team, or those it can mobilise through its networks (Elfring and Hulsink, 2003). Firms find it easier to build or gain access to assets in areas in which there is already previous knowledge (Colombo and Piva, 2008): RBSOs that often lack non-technological skills and networks, will need to undertake greater efforts in that area. While firms may subsequently recruit people with the additional competences, in early stages their knowledge base is largely composed of the competences of the founding team. Thus, RBSOs whose founders have no previous industrial experience and/or no management competences, may prefer to operate in the TM. Therefore:

[11] These authors suggest that in some conditions new entrants may be able to gain control upon the critical downstream assets: either because these are not controlled by incumbents and can be obtained through arm-length contracts, or because the assets necessary to effectively commercialise the innovation are themselves new.

***Hip 3c**: RBSOs are more likely to be in TM when they do not possess the skills/networks to develop downstream complementary assets or access them in favourable conditions.*

Empirical analysis

In this section we will test the hypotheses formulated above about the conditions that influence the commercialisation strategies of RBSOs, concentrating on the factors that are expected to influence the decision to target technology markets and the ability to operate in those markets.

Sample and data

The hypotheses are tested examining the strategies adopted by a group of 80 research based spin-offs firms (RBSOs) from six European countries (Belgium, France, Italy, Portugal, Slovenia and United Kingdom). The concept of spin-off adopted was the one defined in Mustar et al. (2006): new ventures created on the basis of formal or informal transfer of technology or knowledge generated by public research organisations.

The firms were selected from national databases on RBSOs, put together by the teams involved in the PICO project. The basic criteria used to build a first sample of firms, from which were selected the 80 cases, were age and growth orientation[12]. Considering the objectives of this research, it was decided to include only firms that were at least 5 years and no more that 15 years old, in order to guarantee that the RBSOs had achieved a reasonable level of development and defined a clear innovation strategy, but were not too distant from start-up, to limit the retrospective bias. Since it would not be possible identify firms denoting "growth-orientation" directly from a population, we defined the legal form as a proxy to it, assuming that growth companies are likely to wish to attract external financing and therefore also more likely to start up under (or adopt in the early years) a legal form – which varies between countries - that is flexible towards the capital/shareholder structure.

The final selection procedure also took into consideration the objectives of the research. Considering that commercialisation strategies can differ between sectors, the RBSOs were selected to show some heterogeneity in terms of industries. Heterogeneity was also sought in terms of type of activities performed, in order to encompass firms operating or willing to

[12] Given the objectives of this analysis, we were not interested in "life style companies", that is, companies (usually consulting) created as side-business by founders whose main occupation remains in the academic sphere. Rather we were looking for firms that "started up with an ambition to grow". But considering the age of firms and the nature of technologies being exploited, which may take some time to reach the market and start producing revenues, growth-orientation was judged to be more adequate than actual growth.

operate in product and in technology markets. In addition, there was also an attempt to include both firms with and without patents. As was pointed out above, recent work in commercialisation strategy focuses on companies that patented, while we were interested in looking at both groups and investigating also the role of patents in the strategic choice.

The empirical investigation is based on data collected for this purpose, as part of a questionnaire-based interview conducted in 2007. Data was obtained on firm's activity (early, current and expected in future), IP protection, origin of technology and source of technological opportunities, technological relationships with parent, presence/control of downstream complementary assets, background and competences of founders and management team and financial resources. Generic information on firm operation (employees and sales) was also collected.

The final sample included firms in Biotechnology (25 firms), Software and Multimedia (23), Instruments (15), Electronics and Components (10) and a residual category of Others[13] (7). About 25% of the firms were 10 years old or more, while about one half were between 5 and 7 years old. Regarding the activities performed, as measured by firms' main source of revenue at the time of the interview: 38.8% mentioned services, 30% products, 16.3% licenses and 15% did not have any revenue yet. Only about one half of the firms had already completed the development of the first product/ technology, so the firms' expectation regarding the main source of revenue *in the future* is also relevant to characterise them: 53.8% expected to have products, 27.5% licenses and 18.8% services. Thus 45% of the firms anticipated that the main source of revenue in the future would be different from the current one. Among these, 12 firms (33.3%) expected that change to involve having licenses as main source of revenue.

The majority of the firms mentioned that the technology was mostly developed at the parent organisation, being transferred (37.5%) or licensed (26.3%) to the new firm at start-up and only about 1/3 considered that it was mostly developed in-house. Several of the former had their technology protected by patents filed by the parent organisation (36.3%). Still regarding IP protection, about half of the firms had filed own patent applications. Combining the two sources, we conclude that 68.8% of the firms in the sample, had their technology protected by patents, either filed by the firm or by the parent organisation.

[13] Include: energy/sustainability, materials, cartographic systems, fine chemicals, sports equipment.

Description of the model

The data obtained from the questionnaire enabled us to build a number of variables that are used as multidimensional measures of the nature of the knowledge, appropriability and complementary assets, influence of parent organisation and founders' background.

Dependent variables

Since our goal was to investigate both the conditions that influence RBSOs early business orientation towards technology markets and RBSOs ability to operate in that market (at a steady state) as the firm main business we have defined two depend variables, one for each stage of analysis.

For the first stage we used as dependent variable "main business orientation at start-up" (*TechMarket). TechMarket* is a categorical variable, witch distinguishes between firms that chose "selling or licensing technology" as main business orientation at start-up and the firms that did not. This variable measures whether or not the firm decided to trade in the market for technologies at start-up. For each firm included in the sample, we collected data on its "business orientation at start up" and created a dummy variable *TechMar*ket, valued 1 if the company chose to be in market for technologies at start-up, 0 otherwise.

For the second stage we used as dependent variable a measure of RBSOs capacity to earn money from the market for technologies: have licensing as main source of revenue in the future *(RevMainLic). RevMainLic* is "expected source" instead of "present source", to have a measure that is equivalent in all firms, in order to address the presence of firms in different stages of development and, namely, the cases in which firms still do not have any revenue, or in which services are the only source of income while the technology is still being developed. Thus firms still in earlier stage of development are answering about a more stabilised situation, towards which they are working. We are aware that expectations may not be achieved, but since our main objective is, in fact, to understand which type of conditions influence firms efforts to earn money in technology markets, we assume that such efforts can be explained by factors that are at work when firms are striving towards this objective - whether or not have already attained it. *RevMainLic* is valued 1 if the main source of revenue expected in future is licenses, 0 otherwise.

Independent variables

Appropriability measures.

We measure appropriability in several distinct ways. First of all we used patent data to define several 0-1 variables, namely i) *AppIFamY_N* – presence of patents filed by the firm; *ParentPatent* – technology protected by a patent filed by the parent and iii) *TechProtPat* – technology protected by any type of patents. We also collected data on IP protection: i) *IPIndustry* – a seven-point scale, measuring the possibility and effectiveness of IP protection in the industry where they operate (perception of the level of appropriability in their industry); ii) *IPPatent* – a seven-point Likert-type scale measuring the firms' perception of the importance of patents as IP protection mechanisms; iii) *AppNoPat* – a meta-variable obtained by averaging the firms' perception of the importance of other protection mechanisms, besides patents: secrecy, confidentiality agreements, lead-time, moving down the learning curve (α-Cronbach 0,69). However, since we found that *IPPatent* was highly correlated (R=-0.593) with *IPIndustry* – suggesting that firms which attributed greater importance to patents as a protection mechanism also considered IP protection in their industry more possible and effective[14] – we decided to use the latter in our models.

Data on parent patents was measured at start-up and the IP regime in industry can be regarded as a longstanding feature, thus being independent from the moment when the question was asked, so these variables are relevant to assess the conditions at early and current stage. Variables based on data on firm patents and perceptions of protection mechanisms can only be used for the current stage, since they correspond to the activities conducted by the firm after start-up and thus cannot be regarded as potential determinants of early decision.

Nature of knowledge measures.

To measure the level of novelty of the technology we used *TechInnov_DK,* a seven-point Likert scale, measuring to which extent firms considered that new technological knowledge had to be created to develop the technology (Eisenhardt and Schoonhoven, 1990).

To measure the level of level of pervasiveness of the technology, we combined the scope of the technology (*TechBroadStart*) with the origin of technological opportunities (*TechOppBasSci*), since pervasiveness was presented in the literature as deriving from the

[14] This is consistent with literature on small technology suppliers IPR that suggest that for this type of firms patents are the most (and often the only) effective IP protection mechanisms (Hall, 2005).

generic nature of scientific knowledge. It was assumed that pervasiveness is higher when, simultaneously, the technology is broad and the importance of advances in academic research is high, which implies an interaction effect of those two variables.

The founder's technological competences were measured on the basis of data collected on the background of each founder at the time of firm creation: i) *FoundExpAcad* – a measure of the polyvalence of the team, obtained by summing up the number of founders with university education in technological/scientific fields, the number of founders with technical experience in academic research the number of founders with a PhD degree. Notice that each founder may be counted on several of those variables and ii) *FoundExpTechIndY_N* – a dummy variable valued 1 if at least one founder had previous technological experience in industry.

All these variables are based on data measured at the time of start-up, so they can be used in the analysis of early and current conditions.

Complementary assets measures.

Previous studies have used different proxies of complementary assets (CAs)[15], but only Gans et al. (2002), have asked directly the firms about their perceptions of the incumbent level of control upon key CAs. While entrepreneurs may not have complete understanding of the competitive environment and while their perceptions may not reflect the actual situation in what refers to the ownerships/control of downstream assets that are key to capture the value of their technology, it is their perceptions that influence decision making. Therefore we attempted to capture this dimension. We built on Gans et al. (2002) approach, but introduced a two step approach: first we asked firms to rank a set of assets in terms of their importance and then we ask them to rank the same assets regarding the level of control upon them.

To measure firm perceptions of importance of the different assets, each firm ranked, on a seven-point Likert scale, the importance of having access to competences/resources associated with 3 types of asset (manufacturing; marketing and advertising; sales and distribution channels[16]) in order to earn profits from the technology, product, service developed (variables: *CAImpMnf*, *CAImpMkt* and *CAImpSales* respectively).

[15] Examples of measures used: firm market share in a segment (Fosfuri, 2006); degree of interaction between R&D and production personal (Arora and Ceccagnoli, 2006); presence of production, marketing, sales facilities (Novelli and Rao, 2007). Gambardella and Giarratana (2007) use proxies specific for the software sector, based on firm trademarks (denoting the proportion of firm total fixed assets and firms total sales associated with software):

[16] Firms were also asked about regulatory assets, but this type of assets was found to be very specific to firms in certain industries and thus was not include in the analysis.

To measure firms' perception of level of incumbent control upon these same assets, each firm also ranked, on a seven- point Likert scale, the relative position of the RBSO and of other firms, regarding the degree of control upon each of these assets. The scale was designed to consider a set of possibilities that ranged:

- from complete control by the RBSO, that corresponds to its ownership of the assets (extreme left of scale);
- through situations where there is relative control of the RBSO – the balance of power is on the side of the RBSO, who can establish favourable or mutually favourable agreements with other companies to guarantee access (example: this is likely to happen with other small firms to whom the agreement is equally important for their business development);
- through the situation when the assets are freely available in the market at competitive prices (mid-point of scale);
- through situations where there is relative control by established firms – the balance of power is on the side of the established firm (usually large), who still establishes agreements with the RBSO, but given its financial capacity / market power have a dominant position and can make the rules;
- to complete control by established firms that own the assets themselves and can (and possibly do) effectively constrain access (extreme right of scale).

A reliability analysis upon the variables obtained from the questionnaire (level of control upon manufacturing, upon marketing and upon sales: *CACTRLMft, CACTRLMkt, CACTRLSales*) revealed a poor Cronbach alpha (0,54), that increased substantially when omitting the first one (0,72), suggesting the existence of two underlying dimensions, which was corroborated by a 2-dimensional PCA (principal components analysis) upon them. Consequently, a final measure was obtained on the basis of two variables: a) level of incumbent control upon manufacturing (*CACTRLMft*), directly obtained from the questionnaire; b) level incumbent control upon commercialisation assets (*CACTRLComm*), which corresponds to the mean of the variables relative to level of control upon marketing and to level of control upon sales.

Finally, to measure the control of incumbents upon assets that are key to capture the value from the technology – in other words, to assess whether the asset is simultaneously important and controlled by existing firms - we combined the 7-point likert-type variables measuring perception of importance (variables *CAImpMnf*, *CAImpMkt* and *CAImpSales)* and perception of control (variables *CACTRLMft, CACTRLMkt, CACTRLSales).* Assets that received a score of at least 5 on both control and importance are perceived simultaneously

as important and controlled by other firms. Following this rationale, a dummy variable was built for each complementary asset (*CA_Mnf*, *CA_Mkt, CA_Sales*) valued 1 if the asset is important and controlled by other firms.

To complement the data on perceptions on CA control, we have also attempted to assess whether the firm effectively owned a particular asset: manufacturing. We used employment as proxy to ownership of the asset and created a variable (*FTEProduction*) that computes the number of full time equivalent employees in the production function at the time of the interview[17].

With respect to the situation at start-up, we have used non-technological competences in the founder team as a proxy to firms' potential to build, acquire or gain access (through networks) to downstream complementary assets. Since academic entrepreneurs are described as having limited knowledge of the industry/market where they are entering, as well as limited competences and links in non-technological fields, this measure reflects the assumption that such knowledge, competences or networks are likely to increase with the presence of founders with previous industrial background. Thus, we used data collected on the background of entrepreneurs at the time of start-up to build a variable (*FoundPrevMgmtExp)* that computes the number founding entrepreneurs with previous managerial experience in industry.

Control variables

Considering that some industries are likely to be more favourable to the operation of markets for technologies, we collected data on current activities of each firms and its industrial classification and constructed five dummy variables according to the industrial segment in which the firm operates: *Soft_Mult* (=1 if industrial segment are software and multimedia); *Inst* (=1 if industrial segment are instruments); *Elect_comp* (=1 if industrial segment are electronics and components) and *Biotec* (=1 if industrial segment are biotechnology). Finally we considered *Age* as the number of years of the firm at the time of the interviews (2007). Since operation in technology markets is described as a relative recent phenomenon it is possible that this business orientation was more frequently chosen by younger firms.

[17] Novelli and Rao (2007) use the presence of in-house facilities as the indicator of control over CAs. By adopting only this measure, these authors exclude the possibility that firms can access and achieve some control upon these assets, through favourable contractual agreements. This possibility was considered in our question about control.

Empirical Results

To test our hypotheses we used a two step approach. First, we focused on the conditions that influence RBSOs early business orientation towards a technology market and defined one model (Model 1), whose dependent variable is the main business orientation at start-up (*TechMarket)* and whose independent variables are measures of:

- appropriability: perception of appropriability regime in industry (*IPIndustry*) and presence of a parent patent protecting the technology (*ParentPatent);*
- nature of knowledge: both direct measures such as novelty and pervasiveness of technology (*TechInnov_DK, TechBroadStart* TechOppBasSc*), and indirect such as strength of founders academic backgrounds (*FoundExpAcad*) and presence of founders with technical experience in industry (*FoundExpTechIndY_N).*
- ability to build complementary assets: proxyed by the strength of non-technological competences in founding team (*FoundPrevMgmtExp).*

Second we addressed the conditions associated with earning money from the market for technologies as the RBSO main business. We defined two models (Model 2 and Model 3), whose dependent variable is "licensing as main source of revenue in the future" *(RevMainLic),* and that included the early decision (Model 2) or its determinants (Model 3) as independent variables. For this purpose, in Model 2 we used as *independent variable* the early decision to operate in technology markets (*TechMarket*) and excluded from the model the variables identified in Model 1 as explanatory of that decision. Conversely, in Model 3 we tested whether factors that were determinant for the early decision remained important in later stages and thus included the variables identified in Model 1 as explanatory of that early decision, as *independent variables.*

In both models, we also included as independent variables, the measures of appropriability (*IPIndustry*) and nature of knowledge (*FoundExpAcad*) that were not found to have explanatory power for the early decision, and have also introduced new measures of appropriability and control over complementary assets that took in consideration the fact that the RBSO was already in operation.

In the case of appropriability, we included the perception of appropriability regime in industry (*IPIndustry*) in both models, but the measures used for presence of patents differed. In Model 2 we used *TechProtPat*, which combines own and parent patents, thus measuring whether the technology is protected by patents, regardless of their origin. In Model 3, parent patents

were included independently as one of the determinants of early decision, and thus we included a measure of own patents (*ApplFamY_N).*

In the case of nature of knowledge, Model 2 only included one (indirect) measure – strength of founders academic backgrounds (*FoundExpAcad)* – since all other variables were found in Model 1 to be determinants of early decision (thus being excluded from Model 2, according to the rationale described above). Conversely Model 3 included the whole set of variables measuring nature of knowledge, both direct measures such as novelty and pervasiveness of technology (*TechInnov_DK_inv, TechBroadStart* TechOppBasSc*), and indirect measures such as presence of founders with technical experience in industry (*FoundExpTechIndY_N)* and, once again, strength of founders academic backgrounds (*FoundExpAcad)*.

In the case of complementary assets, both Model 2 and Model 3 included the perceptions of control upon assets related with production and commercialisation (*CACTRLMft* and *CACTRLComm*) and employment in production activities as a measure of presence of the manufacturing assets (*FTEProduction*). In addition, in Model 3 we also included the measure of founders' previous non-technological experience (*FoundPrevMgmtExp*), which was found to be determinant in Model 1 (thus being excluded from Model 2).

We run the models, using logistic regression due to the dichotomous nature of the dependent variables[18]. Given the ordinal nature of some of the variables, results will be cautiously interpreted and mainly in terms of the qualitative, rather than quantitative impact.

Factors that determine early decision (Model 1)

In the case of Model 1, estimated odd ratios, reported in table 1, provide strong support for the hypothesis that the novelty of technology (*TechInnov_DK*) increases the odds of opting for operating in the technology market. However, we did not find support for the hypothesis regarding the impact of pervasiveness of the technology – at least measured as a combination of technology scope and importance of basic science. In fact in this case the estimated odd-ratio is below 1, which means a slight reduction on the odds of opting for operating in the technology market. Regarding the impact of founders' backgrounds on the nature of knowledge, our results show an inverse[19] and significant relationship between the founding team's previous technical experience in industry (*FounExpTechInd*) and the decision of operate in the technology market. However, the strength of academic

[18] The method used was backward stepwise LR
[19] As the proportionate change of odds (Exp b) is below 1.

backgrounds of founding team *(FoundExpAcad)* was not found to have any impact upon that decision. Thus, Hypothesis 1D was only partially supported. The results also show that the fact that technology was protected by patents filed by the parent increased the odds of opting for operating in the technology market. This result provides some support to the hypothesis that RBSOs starting-up with technologies developed in the context of the parent research organisation are more likely to opt for operating in the TM. It also provides some support to the hypothesis that protection by patents is important for the decision to operate in TM, even if at this early stage that protection is provided by a parent patent.
Regarding our proxy to the ability to build complementary assets, we found that, contrary to the expected, previous managerial experience in industry (*FoundPrevMgmtExp*) increases the odds of opting for operating in the technology market.

We also find an industry effect in our analysis: the results show that the odds of operating in the technology market increase significantly when the industry is biotechnology (*Biotec*), confirming that biotechnology firms are more likely to opt for operating in the technology market than those in other industries.

Table 1 – Model 1: Results of logistic regression

Variables	ParentPatent	TechBroadStart* TechOppBasSci	TechInnov_DK	FoundExpTechIndY_N	FoundPrevMgmtExp	Biotec	Constant
Exp (B)	5.629	0.942	2.101	0.111	2.892	6.641	0.17

All coefficients significant at the 0.05 level; R^2_N 0.504; valid N 73.

Factors that influence having TM as main business (Model 2 & Model 3)

Impact of the early decision upon future activity

Results from Model 2 suggest a significant impact of an early business orientation towards TM on the odds of having licenses as main source of revenues in the future. In the case of Model 3, in which the early decision is expressed through the variables that were found in Model 1 to be determinants of early business orientation towards TM, we find that only some determinants remain significant when we consider the firm subsequent orientation: presence of a parent patent (*ParentPatent)* and being in biotechnology industry (*Biotec)*. Rather, variables related with the nature of the knowledge (novelty or pervasiveness) or with founders background are not significant anymore.

Other factors associated with expectation of having licenses as main source of revenue

Model 2 and Model 3 also tested the impact of other factors, besides early decision or its determinants that were expected to be associated with the subsequent behaviour of the firm.

Table 2 – Model 2: Results of logistic regression

		IPIndustry	FoundExpAcad	CACTRLComm_nm	CACtrlMnf_nm	FTEProduction	AppNoPat	Age	TechMarket	Constant	R^2_N
Exp(B)	Model 2a	0.484**	0.779**			0.534*	1.632*	0.650*	22.109***	20.22	0.619
	Model 2b	0.515**	0.658**	2.001**	1.557*	0.399*	2.288**	0.527**	84.958***	0.759	0.714

* Sig <= 0.10; ** Sig <= 0.05; *** Sig <= 0.01, valid N 77.

Table 3 – Model 3: Results of logistic regression

Variables	ParentPatent	FoundExpAcad	Biotec	FTEProduction	Constant
Exp(B)	13.714***	0.798	30,049***	0.523**	0.253

* Sig <= 0.10; ** Sig <= 0.05; *** Sig <= 0.01, R^2_N 0.668, valid N 70.

In Model 2, we find that perceptions of high appropriability regime in industry (*IPIndustry)* increase the odds of having licenses as main source of revenues in the future, providing support for Hypothesis 2A. However, presence of patents (*ApplFamY_N*), per se, has no significant impact, confirming our suggestion that they may also be relevant for firms that operate in PM. The high correlation between IPIndustry and IPPatent, already mentioned above, suggests that firms that perceive a high level of appropriability in their industry also rate highly patents as protection mechanisms, thus providing also some support to Hypothesis 2C. But, contrary to our expectations, we find that perceptions of a high importance of non patent mechanisms (*AppNoPat*) also have a positive influence on licensing as future source of revenues. Thus, there is only partial support for the hypotheses on appropriability: perceptions of level of IP protection in industry are important, but presence of patents do not differentiate firms that expect to be in the TM as main business. In addition, these firms appear to rate more highly both patents and non-patent mechanisms as means of IP protection. Thus, the latter, instead of being less important to firms operating in TM, are possibly regarded as an additional means of reinforcing their capacity to protect their intellectual assets.

In the case of Model 3, neither perceptions of appropriability regime in industry, nor perceptions of importance of non-patent protection mechanisms, nor presence of patents filed by the firm, were found to be significant. However, in this model the presence of patent parent was tested separately and was found to have a strong impact upon the odds of having licenses as main source of revenue in the future. Given the formulation of the model, it was possible that the strong impact of the variable *ParentPatent* somewhat "shadowed" the impact of the variable *IPIndustry*, that measures the perceptions of appropriability in industry. Thus we tested for the association between these two variables. It was found that, effectively, there is a strong association between them, suggesting that there is a tendency for firms whose technology is protected by a parent filed by the parent to perceive appropriability in their industry to be higher[20].

Regarding the nature of knowledge, both models tested the strength of academic backgrounds of founding team *(FoundExpAcad).* It was significant in Model 2, but contrary to expected, it was found to decrease the odds of having licenses has the main future revenue. The other variables measuring the nature of knowledge, both directly (novelty and pervasiveness) and indirectly (impact of founders technical backgrounds in industry) were only included in Model 3, but they were not found to be significant[21].

In Model 2 and Model 3 we tested the two different measures of complementary assets (respectively in Models A and B)[22]. In Model 2B we found that a higher level of incumbent control upon manufacturing assets and upon commercial assets (*CACTRLMft* and *CACTRLComm*) increased the odds of having licenses as main source of revenues, providing support for Hypothesis 3B. However, in Model 2A we found no impact of the variable indicating whether the asset was simultaneously important and controlled by existing firms. In Model 3 (A or B), none of the measures of control upon CAs were found to be significant. Also in Model 3, no impact was found for the as proxy to ability to build CAs, measured through the presence of founders with previous management background.

However, in both Model 2 and 3 we found a significant and inverse relationship between the number of employees in production activities (*FTEProduction*), as an indicator of presence of manufacturing CAs, and the licenses as main source of revenues, confirming that firms with higher investment effort in production are less likely to operate in technology markets, and thus providing support for Hypothesis 3C. This is not unexpected, since it this investment is

[20] Ergo, with lower marks on *IPIndustry*; t-test, sig < 0.01, with sample means 4.1 and 2.3, for firms not protected and protected by parent patents, respectively.
[21] These variables were not considered in Model 2, given the assumptions of that model.
[22] In Model 2A and 3A we used the combined measure of importance of asset and incumbent control (*CACTRLMft* and *CACTRLComm)*; in Models 2B and 3B we used the measure of incumbent control upon assets *(CA_Mnf; CA_Mkt; CA_Sales*).

possibly the result of a decision: firms in PM are more likely to have already built some production capacity!

Finally the results of Model 2 show a negative impact of *Age* on the odds of having licenses as main source of revenues. This result leads to the conclusion that propensity to expect to operate in the technology market as the main business is higher among firms that were created more recently, supporting the idea that having TM as main business is a relatively recent phenomenon[23]. In addition, Model 3 show again strong influence of being in biotechnology industry on the odds of having licenses as main source of future revenue.

Discussion

The results obtained confirm that early choices have a strong impact on subsequent business orientation: an early decision to target technology markets increases the propensity to operate in this market in the future. However, they also suggest that the conditions that influence the early adoption of a commercialisation strategy are not necessarily the same that influence the subsequent ability to sustain that strategy, although some of them appear to remain relevant.

Regarding the conditions associated with adopting and with sustaining a technology market commercialisation strategy, the empirical research confirmed some of our expectations, but has also produced a few puzzling results. As expected, it was concluded that this strategy is more likely to be adopted when: the technology being exploited involves a greater component of new knowledge; that technology was already developed in the parent organisation and was protected by a parent patent; the firms are created by founders without previous technological experience in industry; the RBSO is in the biotechnology industry (these being also more likely to be the ones to operate in this market as their main business in the future). These results confirm the importance of a dimension often overlooked in research on commercialisation strategies: the nature of the knowledge being exploited (Nerkar and Shane, 2007). Some of these results also support the arguments about the parent technological influence, or more generally, about the relevance of RBSO features that are associated with their origin (Mustar et al, 2006). In particular, the impact of the presence of patents filed by the parent (which maintain their relevance for the continuity of the strategy), can be regarded as an indirect indicator of the significance of the technology

[23] It could be argued that operating in the TM is an early stage (thus temporary) strategy, and thus more likely to be adopted by *younger* firms. The nature of our dependent variable – that concerns expectations in terms of firms' main *business in the future* and not firms' *current business* - suggests our interpretation.

developed in the academic context, and also provide grounds for a possible intervention of the parent (as patent owner) on the decision about the commercialisation mode.

Another expected result was the finding that this strategy was more likely to be sustained when RBSOs operated in sectors where appropriability was perceived by the entrepreneurs as higher and when some key downstream complementary assets, related to production and commercialisation, were perceived as controlled by existing firms. These results are consistent with the extensive literature that presents the ability to protect the technology as indispensable to operate in technology markets (Arora and Merges, 2004). They are also consistent with recent research that brings complementary assets into the empirical analysis (Novelli and Rao, 2007; Gambardella and Giarratana, 2007), but refine it, by confirming Gans et al (2002) insight that it is *control* upon complementary assets – and not the *presence* of these assets in-house – that is the key element on start-ups' strategic decisions.

Among the puzzling results is the fact that, contrary to what has been proposed in the literature (e.g. Gans et al, 2002), the presence of patents (except parent ones) does not differentiate between RBSOs operating in technology and in product markets. However, this departure from other studies was not completely unexpected and may derive from the fact that the vast majority of them has focused exclusively on firms with patents, which was not the case here. Our result can be related to the fact that knowledge intensive firms operating in product markets may also require good IP protection (Arora and Ceccagnoli, 2006). Indeed, according to what was expected, the real difference between these firms and firms operating in technology markets is that the latter appeared to rate more highly patents as IP protection mechanisms and also to assign them different roles. What was relatively unexpected was the fact that non-patent protection mechanisms (such as secrecy, confidentiality agreements, lead-time) were more important for firms operating in technology markets, contrary to what we had hypothesised. A possible explanation is that, since IP protection is particularly critical for these firms and since patent protection is not always completely effective, they need to rely on a combination of mechanisms, which globally provide more efficient protection (Hurmelina-Laukkanen and Puumalainen, 2007). This is an interesting result that adds to our understanding of the behaviour of firms in technology markets.

However, the above conclusion regarding the non relevance of patent ownership for RBSOs strategic decision may need to be re-evaluated, if we consider two aspects. The first one is the continued impact of the patents filed by the parent organisation, which goes beyond the start-up decision. This impact may partly reflect the "political" influence of the parent in the

decision on the commercialisation mode (Moray and Clarysse, 2005). But it also reflects the importance of the IP protection offered by the patent that the RBSO inherits from the parent, which presumably defends the technology which drove the spin-off process. If we add the fact that several companies were still developing their technologies, and the fact that most of the firms that had already filed own patent applications were not yet granted these patents, we start devising a scenery that may be quite RBSO-specific: own patents may not have yet emerged in firms that are exploiting knowledge that is more science-based and thus further from application, thus requiring a more substantial transformation. Rather, at this stage, their technologies are protected by the patents that were filed by the parent. This situation may partly explain why own patents were not found to have a higher impact on these firms' decision and also why they rate so highly the importance of other protection mechanisms. If that is the case we cannot definitively conclude that patents are equally relevant for RBSOs that target technology markets and for those that target product markets.

A puzzling result was also obtained for the pervasiveness of the technology (that is, the capacity to generate a continuous stream of opportunities), which was found to decrease slightly the odds of operating in a technology market. This result may be related to the very nature of pervasive technologies, which enable a wide variety of applications, thus giving firms a large margin of strategic choice (Malerba and Orsenigo, 1993). Thus, we can speculate that knowledge intensive firms operating in product markets, namely those operating in fast changing markets, may have some advantages in exploiting pervasive technologies that enable them to develop a sequence of innovative products (Kim and Kogut, 1996). Also, contrary to our expectation, this strategic orientation was more likely to prevail when founders with non-technological backgrounds were present in the team. A possible explanation may be the intervention of external shareholders, who are often brought in at early stages in this type of firm and who tend to advocate the presence of these competences in the team (Hellman and Puri, 2002). Alternatively it is also possible that an entrepreneurial team who decides to engage in this type of business perceives its potential complexity and chooses to bring-in additional competences. In fact, while these RBSOs do not need to develop traditional marketing and commercialisation competences, they are nevertheless confronted with the need to sell their technology, which will involve identifying potential technology acquirers, capturing their interest, devising the most adequate technology selling strategies and conducting complex negotiation processes, frequently with more powerful companies (Arora et al, 2001). Thus, this finding is important, since it suggests a higher than expected degree of strategic awareness among teams willing to target the technology market and may require us to assess in more detail the type of competences that are added according to different business orientations.

The results obtained are still exploratory and based on a relatively small sample. One possible limitation of this analysis is that, from the statistical point of view, when using logistic regression, small samples may lead to unstable results, in the sense that the omission of a single observation could originate a quite different adjusted model. Because our objective is to take into consideration a combination of factors (measured in a multidimensional way), which we expect can provide a more comprehensive explanation of the phenomenon, it may be necessary to expand our sample, in order to increase the robustness of the results.

Conclusions

This paper addressed the commercialisation decisions of research-based spin-off firms, focusing on the case of companies that choose to target the market for technologies. Combining insights from two streams of literature - economics of technological change and strategic management of technology - we discussed the conditions that can influence firms' ability to pursue with this strategic orientation; and advanced some theory-driven hypothesis regarding the key factors that are likely to determine their choice: nature of knowledge, appropriability conditions, location and degree of control upon complementary assets and institutional setting of origin. Our analytical framework takes in consideration a combination of factors that tend to be addressed separately and the respective impacts; and also brings back into focus some aspects – namely those related with the nature of the knowledge being exploited – that are often overlooked.

The results of a first empirical test of these hypotheses on a sample of 80 European RBSOs provide some insights into the conditions that are associated with RBSOs decision to adopt a technology market commercialisation strategy, as well as with their capacity to maintain this strategic orientation beyond the early stages, assuming the operation in technology markets as the firm main business. Globally, they appear to provide a more effective explanation of the conditions that lead RBSOs to adopt an early business orientation towards technology markets (as compared with those that do not adopt that orientation); than of the conditions that influence RBSOs capacity to operate on technology markets as their main business (as compared with the ones that do not). In fact, even if early conditions appear to have some imprinting effect upon firms' subsequent behaviour, the set of factors that influence that behaviour and contribute to steer RBSOs subsequent orientation, are likely to increase in number and complexity as firms evolve (Vohora et al, 2004). However, our results confirm that combining factors related with the nature of knowledge, appropriability and access to

complementary assets it is possible to gain a better understanding of the RBSOs commercialisation strategies, than less comprehensive approaches.

This research contributes both conceptually and empirically for a better understanding of the factors that are behind the emergence and sustainability of a model of entrepreneurial behaviour, which is becoming increasingly frequent in science based fields - the company that opts for specialising in the production and sale of intellectual property, as opposed to pursuing with the development and market introduction of products or services based on it. Thus, it adds to the still incipient research on this model of behaviour and also to recent research on the determinants of the commercialisation strategy of small technology-intensive firms.

The research also led us to conclude that those factors encompass several features that are often associated with RBSOs (i.e. regarding characteristics of two of its main assets: the technology and the entrepreneur), suggesting a potentially higher propensity of RBSOs to operate under this model. Thus, by exploring this emerging strategic path and the behaviour of RBSOs that pursue it, this research has provided some conceptual and empirical insights into one of the less understood routes through which RBSOs perform their knowledge production and transformation function. It is our contention that firms adopting this model have specific functions in the innovative system, which is expressed on the nature of the transformation tasks they perform, on the outcomes of these tasks and on the knowledge articulation role they play throughout their interactions with knowledge partners, suppliers and clients (both private and public). It is therefore important, from a policy standpoint, to consider more attentively the RBSOs that adopt this type of business orientation. Against this background, the results of this research, although still preliminary, are politically relevant, since they call the attention to this specific model of RBSO behaviour and provide information on the conditions that favour its adoption and that make it viable.

References

Antonelli, C. and M. Teubal (2008). Knowledge-intensive property rights and the evolution of venture capitalism. *Journal of Institutional Economics*, 4:163-182.

Arora, A. and M. Ceccagnoli (2006). Patent Protection, Complementary Assets, and Firms' Incentives for Technology Licensing. *Management Science*, 52: 293-308.

Arora, A. and A. Fosfuri (2003). Licensing the Market for Technology. *Journal of Economic Behavior and Organization*, 52: 277-295.

Arora, A, Fosfuri, A and Gambardella, A (2001). Markets for technology and their implications for corporate strategies. *Industrial and Corporate Change*, 10: 419-451.

Arora, A. and A. Gambardella (1994). The Changing Technology of Technical Change: General and Abstract Knowledge and the Division of Innovative Labour. *Research Policy* 23: 523-532.

Arora, A. and R. Merges (2004). Specialized Supply Firms, Property Rights and Firm Boundaries. *Industrial and Corporate Change*, 13: 451-475.

Arrow, K (1962). Economic Welfare and Allocation of Resources for Inventions", in R. Nelson (ed.) The Rate and Direction of Inventive Activity, Princeton University Press.

Arundel, A. (2001). The relative effectiveness of patents and secrecy for appropriation. *Research Policy*, 30: 611-624.

Autio, M.(1997). New, Technology-based Firms in Innovation Networks Sympletic and Generative. *Research Policy*, 26: 263- 281.

Bekkers, R., V. Gilsing and M. van der Steen (2006). Determining Factors of the Effectiveness of IP-based Spin-offs: Comparing the Netherlands and the US. *Journal of Technology Transfer*, 31: 545 – 566.

Breschi, S, F. Malerba and L. Orsenigo (2000). Technological regimes and schumpeterian patterns of innovation. *Economic Journal*, 110: 388 - 410.

Bresnahan, T. and M. Trajtenberg (1995). General purpose technologies, engines of growth. *Journal of Econometrics*, 65: 83-108.

Cesaroni, F. and P.Giuri (2005) Intellectual property rights and market dynamics, LEM Working Paper Series, 2005/10. Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa.

Chesbrough, H. (2006). *Open Business Model: How to Thrive in the New Innovation Landscape*. Harvard Business School Press, Boston, MA

Clarysse, B., M. Wright, A. Lockett, E. Van de Velde and A. Vohora (2005). Spinning out new ventures: a typology of incubation strategies from European research institutions. *Journal of Business Venturing*, 20: 183–216.

Cohen, W.M, R.R. Nelson and J:P: Walsh (2000). Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not), National Bureau of Economic Research, WP No. 7522.

Colombo, M. and E. Piva (2008). Strengths and Weaknesses of Academic Startups A Conceptual Model, *IEEE Transactions On Engineering Management*, 55: 37-49.

Colombo, M., L. Grilli and E. Piva (2006). In search of complementary assets: The determinants of alliance formation of high-tech start-ups. *Research Policy*, 35:1166–1199.

Coriat, B., F. Orsi and O. Weinstein (2003). Does biotech reflect a new science-based innovation regime? *Industry and Innovation*, 10: 231 – 253.

Costa, C., M. Fontes and M. V. Heitor (2004). A methodological approach to the marketing process in the biotechnology-based. *Industrial Marketing Management*, 33: 403- 418.

Dasgupta, P. and P. David (1994). Toward a New Economics of Science, *Research Policy*, 23: 487-521.

Di Gregorio, D. and S. Shane (2003). Why do Some Universities generate More Startups than others? *Research Policy*, 32: 209–227.

Dosi, G.(1988). Sources, Procedures and Microeconomic Effects of Innovation, *Journal of Economic Literature*, 26: 120- 1171.

Druilhe C. and E. Garnsey (2004). Do academic spin-outs differ and does it matter? *Journal of Technology Transfer*, 29: 269-285.

Eisenhardt K. and K. Schoonhoven (1990). Organizational Growth: Linking Founding Team, Strategy, Environment, and Growth among U.S. Semiconductor Ventures, 1978–1988. *Administrative Science Quarterly*, 40: 84–110.

Elfring, T. and W. Hulsink (2003). Networks in Entrepreneurship: The Case of High-technology Firms. *Small Business Economics*, 21: 409- 422.

Ensley, M.D. and K.M. Hmieleski (2005). A comparative study of new venture top management team composition, dynamics and performance between university-based and independent start-ups. *Research Policy*, 34: 1091–1105.

Fosfuri, A. (2006). The Licensing Dilemma: Understanding the Determinants of Technology Licensing. *Strategic Management Journal*, 27: 1141-1158.

Freeman, C. (1982). *The Economics of Industrial Innovation*, 2nd Edition, London: Frances Pinter.

Gambardella, A., P. Giuri and A. Luzzi (2007). The Market for Patents in Europe. *Research Policy*, 36: 1163-1183.

Gambardella, A. and M. Giarratana (2007). General Technologies, Product-Market Fragmentation, and the Market for Technology: Evidence from the Software Security Industry, DRUID-DIME Winter Conference 2007, January 25-27, Aalborg.

Gans, J. and S. Stern (2003). The Product Market and the Market for "Ideas": Commercialisation Strategies for Technology Entrepreneurs. *Research Policy*, 32:333-350.

Gans, J., D.H. Hsu and S. Stern (2002) When Does Start-up Innovation Spur the Gale of Creative Destruction? *Rand Journal of Economics*, 33: 571-586.

Giuri and A. Luzzi (2005). Commercialisation Strategies of Technology based European SMEs: Markets for Technology vs. Markets for Products, LEM Papers Series 2005/08, Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy.

Hall, B.H. (2005). Exploring the patent explosion. *The Journal of Technology Transfer*, 30: 35-48.

Heirman, A. and B. Clarysse (2004). How and Why do Research-Based Start-Ups Differ at Founding? A Resource-Based Configurational Perspective. *Journal of Technology Transfer*, 29: 247 – 268.

Hellmann, T. and M. Puri. (2002). Venture capital and the professionalization of start-up firms: Empirical evidence. *Journal of Finance*, 57: 169–197.

Hicks, D. and D. Hedge (2005). Serial Innovators in the markets for technology. *Research Policy*, 34: 703-716.

Hurmelinna-Laukkanen*,* P and K. Puumalainen (2007). The nature and dynamics of appropriability – Strategies for appropriating returns on innovation", *R&D Management*, 37: 95- 112.

Jong, S. (2006). How organizational structures in science shape spin-off firms: the biochemistry departments of Berkeley, Stanford, and UCSF and the birth of the biotech industry. *Industrial and Corporate Change*, 15: 251-283.

Kim, D.J. and B. Kogut (1996). Technological Platforms and Diversification. *Organization Science*, 7(3):283-301.

Klevorick, A., R.C. Levin, R.R.Nelson and S.G.Winter (1995). On the Sources and Significance of Interindustry Differences in Technological Opportunities. *Research Policy*, 24: 185 - 205.

Kollmer, H. and M. Dowling (2004) Licensing as a Commercialization Strategy for New. Technology-Based Firms. *Research Policy*, 33: 1141-1151.

Leiponen, A. and I. Drejer (2007). What exactly are technological regimes? *Research Policy*; 36:1221-1238.

Lichtenthaler (2008). External technology commercialization projects: objectives, processes and a typology, *Technology Analysis & Strategic Management*, 20: 483-501.

Lichtenthaler, U., and H. Ernst (2007). Developing reputation to overcome the imperfections in the markets for knowledge. *Research Policy*, 36: 37-55.

Malerba, F. and L. Orsenigo (1993). Technological Regimes and Firm Behaviour. *Industrial and Corporate Change*, 2: 45- 71.

Malerba, F. and L. Orsenigo (1997). Technological Regimes and Sectoral Patterns of Innovative Activities. *Industrial and Corporate Change*, 6: 81- 117.

Marsili, O. (2002). Technological Regimes and Sources of Entrepreneurship. *Small Business Economics*, 19: 217- 231.

Moray, N. and B. Clarysse (2005). Institutional change and resource endowments to science-based entrepreneurial firms, *Research Policy*, 34: 1010–1027.

Murray, F. (2004). The role of academic inventors in entrepreneurial firms: sharing the laboratory life. *Research Policy*, 33: 643–659.

Mustar, P., M. Renault, M. Colombo, E. Piva, M. Fontes, A. Lockett, M. Wright, B. Clarysse and N. Moray (2006). Conceptualising the heterogeneity of research-based spin-offs: A multi-dimensional taxonomy. *Research Policy*, 35: 289 – 308.

Nelson, R. and S. Winter (1982). An evolutionary theory of economic change. Cambridge, Mass: Harvard University Press.

Nerkar, A..and S. Shane (2007). Determinants of invention commercialization: an empirical examination of academically sourced inventions. *Strategic Management Journal*, 28: 1155–1166.

Novelli, E. and R. Rao (2007). Complementary Assets and Market for Technology: An Empirical Study of Innovative SMEs, DRUID-DIME Winter Conference 2007, January 25-27, Aalborg.

Orsenigo, L., F. Pammolli and M. Riccaboni (2001). Technological Change and Network Dynamics. Lessons from the Pharmaceutical. *Research Policy*, 30: 485- 508.

Pisano, G.P., and D.J. Teece (2007) How to Capture Value from Innovation: Shaping Intellectual Property and Industry Architecture. *California Management Review*, 50: 278-296.

Pisano, G.P. (2006). Profiting from innovation and the intellectual property revolution. *Research Policy*, 35: 1122-1130

Pisano, G.P. (1991). The governance of innovation: Vertical integration and collaborative arrangements in the biotechnology industry. *Research Policy*, 20: 237–249.

Pries, F. and P. Guild (2007). Commercial exploitation of new technologies arising from university research: start-ups and markets for technology. *R&D Management,* 37: 319-328.

Rothaermel, F.T. and C. Hill (2005). Technological discontinuities and complementary assets: A longitudinal study of industry and firm performance. *Organization Science*, 16: 52-70.

Rothaermel, F.T. (2002). Technological discontinuities and interfirm cooperation: what determines a start-up's attractiveness as alliance partner? *IEEE Transactions on Engineering Management*, 49: 388–397.

Rothaermel, F.T. (2001). Complementary assets, strategic alliances, and the incumbent's advantage: an empirical study of industry and firm effects in the biopharmaceutical industry. *Research Policy*, 30: 1235–1251.

Saviotti, P.P. (1998). On the Dynamics of Appropriability of Tacit and of Codified Knowledge. *Research Policy*, 26: 843- 856.

Shan, W. (1990). An empirical analysis of organizational strategies by entrepreneurial high-technology firms. *Strategic Management Journal*, 11: 129-139.

Shane, S. (2001). Technology Opportunities and New Firm Creation. *Management Science*, 47:205-220.

Sine, W.D., S. Shane, and D. Di Gregorio (2003). The Halo effect and technology licensing: the influence of institutional prestige on the licensing of university inventions. *Management Science*, 49: 478–496.

Stankiewicz, R., 1994. University firms: spin-off companies from universities. S*cience & Public Policy*, 21: 99–107.

Stinchcombe, A.L. (1965). Social structure and organizations, *Handbook of Organizations*, J. March (ed.), Rand-McNally: Chicago, IL, 142-193.

Stuart, T.E., S.Z. Ozdemir and W.W. Ding (2007).Vertical alliance networks: The case of universit-biotechnology-pharmaceutical alliance chains. *Research Policy*, 36: 477- 498.

Teece, D.J. (2006). Reflections on "Profiting from Innovation". *Research Policy*, 35: 1131-1146.

Teece, D.J. (1986). Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy. *Research Policy*, 15: 285- 305.

Thursby, J., R. Jensen and M. Thursby (2001). Objectives, Characteristics and Outcomes of University Licensing: A Survey of Major U.S. Universities. *Journal of Technology Transfer*, 26: 59-72.

Vohora, A., M. Wright and A. Lockett (2004). Critical junctures in the growth in university high-tech spinout companies. *Research Policy*, 33: 147–175.

Winter, S. G. (1984). Schumpeterian competition in alternative technological regimes. *Journal of Economic Behavior and Organization*, 5: 287-320.

Wright, M., B. Clarysse, P. Mustar and A. Lockett (2007) *Academic Entrepreneurship in Europe* (Cheltenham: Edward Elgar).

Zucker, L., M. Darby and M. Brewer (1998). Intellectual Human Capital and The Birth of US Biotechnology Enterprises. *American Economic Review*, 88: 290- 306.

Zucker, L.G., M.R. Darby, J. Furner, R.C. Liu and H. Ma (2007). Minerva unbound: Knowledge stocks, knowledge flows and new knowledge production. *Research Policy*, 36: 850-863.

5. Towards an academic entrepreneurship governance framework for South African higher education

Jan P. Grundling and Lizl Steynberg

Centre for Entrepreneurship, Tshwane University of Technology (South Africa)

Abstract

Institutions of higher education are facing increasing market and financial pressures in an increasing competitive and global educational environment. The aim of this paper is to propose an academic entrepreneurship governance framework for institutions of higher education in South Africa to foster the upgrading of entrepreneurial competencies in staff and students whilst preserving the traditional academic competencies and the provision of unique entrepreneurial opportunities to perform entrepreneurial tasks according to their area of responsibility. The focus group research method was applied to draw upon respondent's attitudes, feelings, beliefs, experiences and reactions to academic entrepreneurship in the South African higher education landscape. The results of the paper is discussed against the following broad themes, including commonalities at institutions of higher education in South Africa, entrepreneurial and innovation achievements in higher education institutions of South Africa that specifically focus on technology transfer, patenting and licensing, direct cooperation by stakeholders in the governance of higher education institutions, research, development and innovation, and curriculum development. The paper concludes that the educational offering by institutions of higher education in South Africa is to be considered as commodities that could add value, nationally and internationally. However, the current academic entrepreneurship departure point is still relatively weak and the relative performance level is indeed modest as can be expected from a developing country in transition. Nevertheless, some positive signs were detected which indicated that higher education institutions in South Africa would be able to position them appropriately to respond to the marketplace demands.

Key Words: *academic entrepreneurship, governance framework, higher education institutions, South Africa, entrepreneurship*

Introduction

At present universities face considerable pressures to expand their undertakings to play a broader role in the competitive knowledge-based economy, as the responsibility of the

university in economic development has now taken a central stage among many higher education policy circles, in developed and developing countries alike. Knowledge is the key resource that forms the institutional basis of the post-industrial economy and society. It should be emphasized that it is institutions of higher education that give tangible expression to this argument by acting as catalysts for knowledge and research-driven economic growth as well as well-being enhancement. All this finds embodiment within a new techno-academic paradigm in which the academic knowledge base is center stage as a determinant of industrial change, economic growth and general well-being. Therefore, higher education institutions should not be viewed as a regional or national resource, but rather as a node in an increasingly seamless knowledge base, which has a progressively larger interface with the knowledge-driven global economy (Kinsella & McBrierty, 1997:246).

The focus of entrepreneurship and innovation education and research at institutions of higher education ipso facto implies a wish to enhance the quality of graduate and post-graduate business venturing prospects as well as business know-how in the normally pre-entrepreneurial stage. This should happen within a sense-making framework that integrates the research and education agenda for graduate entrepreneurship. Further, an entrepreneurship and innovation education and research approach should be followed that guide the content of the competitive landscape in which the prospective entrepreneur will function and not lag behind and thereby loses its relevance (Hannon, 2005). In the case of South Africa, the competitive landscape in which an academic entrepreneurship governance framework needs to be designed constantly need to account for two critical developments, namely global tendencies and secondly, the particularities of South African higher education. The latter include the demand for the massification of higher education participation, balancing traditional notions of academic freedom and autonomy with public accountability for financial expenditure and the contribution of higher education to the social economic imperatives of the country, as well as the challenge to create an integrated higher education system along the axes of race, gender, academic institutions and region (Reddy, 1998).

Of particular importance to entrepreneurial education lies the ability of institutions of higher education to shift and circulate information and technologies across academic faculties despite different academic disciplines, professional codes, and academic language that act as academic venture boundaries. These boundaries aggravate the need to integrate entrepreneurship education, research and innovation throughout higher education institutions, thus inhibiting the smooth functioning of academic entrepreneurship in institutions of higher education. A need therefore exists to overcome these barriers by

socially amalgamating the various faculties whereby entrepreneurial educators could play 'bridging roles' by acting as 'boundary spanners' between faculties and forming close cohesive networks through the whole institution. This will enable educators to link otherwise unconnected faculties to facilitate the development of unique knowledge and gain access to special knowledge and opportunities. This creates an advantage over the traditional structural design where educators were only part of a specific faculty cohesive group.

The key for higher education success therefore lies in its capacity to mobilize knowledge, and to use it to the full. However, this is dependent on a good governance framework. This paper is therefore structured to:

- Achieve the purpose of proposing an academic entrepreneurship governance framework for institutions of higher education in South Africa;
- Provide theoretical background for a governance framework;
- Describe the research methodology employed to explore what higher education institutions in South Africa do to support academic entrepreneurship;
- Report the findings of the focus group interviews and desktop research; and
- Propose a governance framework to manage academic entrepreneurship.

Purpose

The aim of this paper is to propose an academic entrepreneurship governance framework for institutions of higher education in South Africa to foster the upgrading of entrepreneurial competencies in staff and students, as well as for higher education institutions as a whole, whilst preserving the traditional academic competencies and the provision of unique entrepreneurial opportunities to perform entrepreneurial tasks according to their area of responsibility. The governance framework proposed, should adhere to the higher education policy framework promulgated in South Africa. Of particular importance, deducted from the higher education policy of South Africa, are:

- Higher education in South Africa is to be planned, governed and funded as a single coordinated system, comprising comprehensive universities, universities of technology and colleges;
- The growth of the private provision of higher education is encouraged as a complimentary facet of the system. However, a regulatory framework is needed to ensure that private institutions provide quality programmes that are sustainable; and
- A model of cooperative governance should have a pro-active approach, a constructive role in guiding government, and have an active participation by civil society to underpin the governance framework (Reddy, 1998).

The above requirements create a challenge to search for a governance framework able to answer three central research questions:

- Is it possible to develop a governance framework, generic in nature, that could be used by comprehensive universities, universities of technology and colleges?;
- Can an all inclusive governance framework be created that can be used both by private and public higher education institutions to ensure sustainable, quality programme offerings that are sufficiently market oriented?; and
- What features should the governance framework posses to ensure a cooperative nature between government and civil society?

Theoretical background

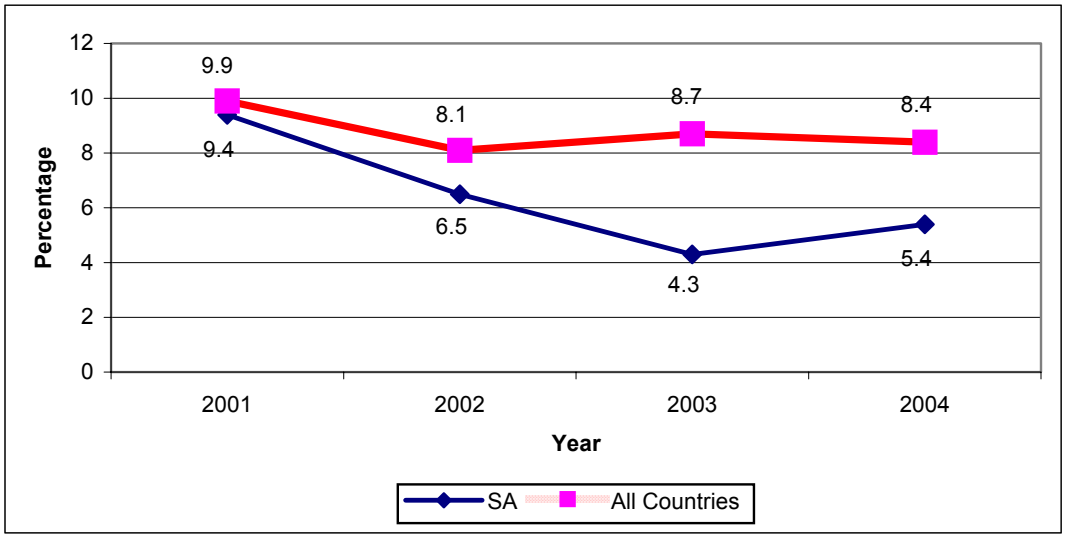
At present, a belief wave is flooding the world suggesting to higher education institutions an ever greater pressure to produce and transfer knowledge in order to aid and guide socio-economic changes and benefits locally, regionally and globally (Brawer, 1998). Globalisation in general, was the main driver leading to the emergence of the 'entrepreneurial' or 'market' university characterized by:

- The commodification of knowledge for commercial purposes and a shift to applied research;
- An increase in research and development funding by private sources;
- The establishment of new performance indicators for universities;
- Technology transfer through business-university partnerships; and
- *Changes in higher education governance and funding with greater corporate influence and a shift in the government's role in higher education from regulator to auditor (Subotzky, 1998).*

The above characteristics demanded a rethinking and restructuring of the higher education sector including amongst others better responsiveness to economic and social needs, greater accountability for resources allocated to higher education institutions, an ability to demonstrate measurable performance and returns on investment, and a research agenda directed towards maximizing profits rather than furthering academic and scientific frontiers (Subotzky, 1998). It can be argued that the recently narrow focus on becoming an entrepreneurial university in a sense endanger the core essence of higher education focusing on shifting the frontiers of knowledge through theoretical research and theory development. In the case of South Africa, the higher education sector is undergoing

extensive restructuring to position itself to meet the national requirements for skills development in the context of globalization, increase the absorption capacity of the formal economy from the low levels of 4% for new recruits, expand the participation of the black population in the entrepreneurial formal sector 11 times over the period of 20 years, and to increase the proportion of economic activity in the small business sector (Jesselyn & Mitchell, 2006). Still, the GEM report (2005:17) provided the following information about the Total Entrepreneurial Activity in South Africa compared to all other countries (Figure 1).

Figure 1 - Total entrepreneurial activity



Source: GEM, Global Entrepreneurial Monitor. 2005. South African Report.

Figure 1 provides evidence of year-to-year total entrepreneurial activity for all the countries involved in the GEM study. It is evident that the total entrepreneurial activity in South Africa is much more volatile, and also lower than the global average. This implies that it could be expected that entrepreneurship's role in business and innovation will also be lower than that of the global average.

A useful tool to determine whether a country is able to deal with the challenges of the new knowledge economy can be done according to the assessment methodology provided by the World Bank on five criteria, namely the Knowledge Economy Index, the economic incentive and institutional regime, innovation, education and information and communication technology. Table 1 revealed that in the SADC region, South Africa, Mauritius, Namibia, and Botswana are most prepared to deal with the challenges of the knowledge economy. However, it is a concern that a decline occurred in the contribution of education, and specifically higher education, to prepare South Africa to deal with the challenges of the knowledge economy (Kruss & Peterson, 2008:328).

Lui and Jiang (2001:186) correctly indicated that institutions of higher education's research behaviour are a function of the economic system which is determined by Government's policy and its fundamental ideology. In the National Plan for Higher Education of South Africa, greater effort is given to link government and business appropriations for universities to the quality of their performance in education and research (Adams, 2006). This in essence force higher education institutions to interact with industry to assist in meeting the needs of the national economy as these institutions are largely depended on money that could be gained from knowledge commercialization (Kroll & Liefner, 2007; Niewenhuizen & Kroon, 2002). Knowledge commercialization by institutions of higher education could occur in various ways. The White Paper on Education 1997; The Higher Education Act 1997; The National Plan for Higher Education 2001; and The New Funding Framework 2003 – offers a framework to higher education institutions to deal with national challenges in higher education and to formulate goals in terms of the (Roberts et al., 2006):

- National planning and policy priorities;
- Quantum of funds made available in the national educational budget; and
- Approved plans of individual higher education institutions.

Table 1 – SADC countries Knowledge Economy Index

Country	Knowledge Economy Index		Economy incentive & institutional regime		Innovation		Education		Information & communication technology	
	Recent	1995	Recent	1995	Recent	1995	Recent	1995	Recent	1995
South Africa	5.8	5.9	5.8	4.2	6.9	7.1	**5.0**	**5.8**	5.38	6.5
Mauritius	5.4	5.2	7.0	6.5	3.7	4.0	4.6	3.7	6.5	6.4
Namibia	4.2	4.3	7.1	5.3	3.3	4.0	2.6	3.7	3.92	4.1
Botswana	4.0	4.5	5.3	5.7	4.3	4.7	2.7	3.4	3.72	4.2
Swaziland	2.8	4.2	2.6	5.6	4.5	4.6	1.7	3.2	2.58	3.4
Zimbabwe	2.6	3.4	0.3	2.2	4.1	4.9	2.4	3.6	3.55	2.9
Lesotho	2.3	2.6	2.7	3.0	2.7	2.8	1.9	2.0	2.14	2.4
Tanzania	2.1	2.2	4.0	3.5	2.4	2.6	1.1	1.0	0.95	1.8
Mozambique	1.5	1.8	3.2	3.4	1.8	1.8	0.2	0.3	0.95	1.6
Angola	1.5	1.3	1.8	0.6	2.4	2.4	0.9	0.7	0.98	1.6
Madagascar	N/A	2.0	4.9	1.6	2.5	3.5	N/A	1.3	0.66	1.7
Malawi	N/A	2.3	2.7	3.9	2.1	2.7	N/A	0.9	0.41	1.5
Zambia	N/A	3.2	3.0	4.5	2.4	3.1	N/A	2.1	1.55	3.1

Source: Roberts, D.V., Gouws, S.M. and van der Merwe, A. 2006. Funding for Success in Higher Education: A Mechanism to Meet National Challenges.

The above framework acts as one of the steering mechanisms by which higher education institutions in South Africa are governed. The Funding Framework of 2003 offers excellent opportunities for entrepreneurial universities to (Roberts et al., 2006):

- Increase student participation by increasing enrolments as 56% of block grants from the government are allocated to input subsidies;
- Increase output funding by increasing graduate outputs or graduate output rate;
- Enlarge institutional factor grants by proportionally increasing the number of African and Coloured students who are considered to be disadvantaged students based on the previous Apartheid political system of South Africa;
- Ensuring that higher education institutions adhere to the desired 40:30:30 Full Time Equivalents (FTEs) in Humanities, Business and Commerce, and Science, Engineering and Technology; and
- Optimise desired proportions by taking into account the funding groups according to the Classification of Education Subject Matter (CESM) indicated by Table 2.

Over and above the funding formula, the South African government has embarked on a steady improvement of higher education via public accountability by means of the National Qualifications Framework (NQF) and the South African Qualifications Authority (SAQA). This system – a system of 'reward and punishment' – was created to establish rules for the assessment of the quality of program offerings at institutions and to ensure economic, social and political rationality thereof as a principal of legitimacy (Adams, 2006). The underlying principals clearly allows one to deduct that higher education programs are considered to be commodities in which students, society and businesses become rational choosers as consumers of these commodities.

Table 2 - Funding groups by Classification of Educational Subject Matter (CESM)

Funding Group	Ratio	CESM Categories
Group 1	1.0	Education, law, librarianship, psychology, social services, public administration.
Group 2	1.5	Business/commerce, communication, computer science, languages, philosophy/ religion, social sciences.
Group 3	2.5	Architecture/planning, engineering, home economics, industrial art, mathematical sciences, physical education.
Group 4	3.5	Agriculture, fine and performing arts, health sciences, life and physical sciences.

Source: Roberts, D.V., Gouws, S.M. and van der Merwe, A. 2006. Funding for Success in Higher Education: A Mechanism to Meet National Challenges.

Research methodology

Against the above background, the focus group approach and desktop research was employed to assist the researchers to explore what institutions of higher education in South Africa do to promote and support academic entrepreneurship. As an applied research method, the focus group were the most appropriate method to explore and discover, as well as to obtain an in-depth interpretation of academic entrepreneurship (Babbie & Mouton,

1998). Respondents were allowed to explain their thoughts and put them into the context of academic entrepreneurship related to their personal experiences. As a qualitative research method, the focus groups created a process of sharing and comparing among respondents their stance on academic entrepreneurship for which data was subsequently generated.

A first two-day workshop was arranged and attended by 25 delegates representing five universities in South Africa. A representative from each university was given an opportunity to inform the delegates about the existing initiatives undertaken at the respective universities to promote and support academic entrepreneurship. After the presentations the delegates were divided into five focus groups to discuss, interpret and deduct implications for academic entrepreneurship. A second one-day workshop was arranged focusing on what universities in South Africa could do to become more entrepreneurial. During this workshop nine presentations were made, based upon secondary and primary research conducted by the researchers. By means of a brainstorming technique and using a funnel data reduction approach a framework was developed that could act as an 'inner-compass' able to provide general direction for the building of academic entrepreneurship in the midst of greater public control and greater demands from the experienced social order in South Africa. Between Workshop 1 and Workshop 2 the researchers conducted desktop research to evaluate achievements of higher education institutions in South Africa in the field of academic entrepreneurship.

Findings

The findings obtained are presented below.

Commonalities at institutions of higher education in South Africa

The first common feature identified was that at pre-graduate level Small Business Management and Entrepreneurial Skills as subjects were presented. The content of the two respective subjects also showed surprising similarities between the various institutions of higher education. A general consensus prevailed amongst respondents that the foundation of both subjects built to heavily on general management theories. A need exist to explore in more depth the distinct features between Small Business Management and Entrepreneurial Skills. Further, most of the respondents felt insecure on whether institutions of higher education in South Africa are focusing their entrepreneurial efforts on the right things. This feeling was caused by the fact that most institutions were still in the start-up phases and early growth phases of creating Centres for Entrepreneurship and Entrepreneurial Academic

Departments. It is therefore crucial that institutions of higher education in South Africa continue to meet on a regular basis to discuss issues of common interest in the field of academic entrepreneurship.

Secondly, it was synthesised that the academic community consists of many individuals in different kinds of roles. There are undergraduate, postgraduate, teachers and researchers, professional and administrative staff (including managers). When entrepreneurial behaviour in the academic community is to be stimulated, then special programmes and curricula for each of these groups have to be developed and implemented. For each of the groups the programmes ought to have different objectives, but all have one objective in common – the creation of awareness for entrepreneurship. Everybody in the academic community should show entrepreneurial behaviour to promote an integrated entrepreneurial climate in all institutions of higher education in South Africa. The target groups should be sensitised as follows:

- *Students* should be offered the opportunity to test the *feasibility* of their business ideas, both the technical (constructing the prototype or 'protoservice' or demo version) and the market feasibility (who and where are the clients, how to reach them and their opinion and requirements regarding the product or service). At postgraduate level students may even be offered the opportunity to execute activities related to the *preparation* of a business;
- *Teachers and researchers* are another group. They have the task of stimulating students to consider entrepreneurship as a career option and provide opportunities to students to discover if being an entrepreneur suits them. This will contribute to the awareness creation process; to allow a student making positive choices in a supportive environment during the feasibility and preparation stages; and
- The *professional and administrative staff* (including managers) is the third group identified. The task of both groups is to support the primary processes (teaching and research) at the institutions. This means that they must also be able and willing to support and facilitate the entrepreneurial behaviour in the academic community.

Most universities in South Africa have introduced institutes similar to 'Centers for Entrepreneurship' or are in the process of introducing it. It was foreseen that the staff composition in these centers would over time represent an interdisciplinary and multidisciplinary composition. It was also acknowledged that potential important sources of competitive advantage for a Center of Excellence are firstly, its networks, secondly, access

to knowledge bases residing in its geographical location and thirdly, the ability to combine disciplinary, inter-disciplinary and trans-disciplinary knowledge to explore new entrepreneurial issues, research, innovations and configurations.

Entrepreneurial and innovation achievements in higher education institutions of South Africa

Kruss and Peterson (2008) indicated that two distinct categories of universities exist in South Africa namely those with a small number of new forms of network, collaboration, incentivised and commercialised interaction with industry versus the old and historically advantaged universities possessing strong interaction with industries. The latter universities do have a sound scientific and technology research base and are able to respond to the challenges of the present. These universities can therefore more easily respond to economic opportunities than the previously disadvantaged universities.

In this section particular attention will be focused on the achievements of higher education institutions in South Africa in the areas of technological transfer, patenting and licensing, cooperation with important stakeholders, research and innovation, and curriculum development as important indicators of the status of the entrepreneurial university in South Africa. This section is based upon the desktop research.

Technological transfer

The innovations and technologies provided by institutions of higher education are normally for sale at an 'embryonic' stage. Being at this early stage, the future value of the technology is extremely uncertain (Elfenbein, 2005). Nevertheless, as a partner in the supply chain, it fulfils a critical role in the entrepreneurial and innovation system to the level of being part of the 'centre of gravity' in the innovation system.

Further, for any institution of higher education, patenting and innovation may represent a significant expense prohibiting many institutions to proceed with the process unless transaction partners have not already been identified and a firm is willing to buy into the innovation. It is therefore not surprising that Elfenbein (2005) was able to synthesize that institutions of higher education rarely are able to commercialise new technologies themselves due to limited incentives and capabilities available and therefore there is also little incentive to withhold the most valuable technologies for internal development. This is also the case in South African higher education institutions.

Patenting and licensing

Spinelli and Timmons (2003) considered a patent as an exclusive right granted for an invention, which is a product or a process that provides a new way of doing something, or offers a new technical solution to a problem. Patents are one of various options for securing intellectual property and are considered as one of the major pillars for the protection of especially technological intellectual property. In the case of research done by public research institutions including higher education institutions in South Africa, the Patent Fund, administrated by the South African National Research Foundation may cover up to 50% of all patenting costs (MRC Innovation Centre, 2006).

In the past patents has been a sure solution for many innovations over the years to protect ideas until commercialisation or industrialization realises. These innovations were primarily confined to in-house Research and Development (R&D) in what is now known as Closed Innovation (CI) systems. It was believed that innovation could best be cultivated in a closed orchestrated system that could form an effective barrier to imitation and entry from other businesses (Hurmelinna, et al., 2005).

Today, according to Hurmelinna, et al. (2005) businesses with limited research capabilities – as in the case of a large proportion of businesses in South Africa - that are able to extract new ideas from the innovative market, may create significant competitive advantages. This realisation led to a new approach where business innovations are often developed and commercialised in the open market. The change in approach labelled 'Open innovation' creates new opportunities to higher education institutions in South Africa to become involved in the national innovation process at a higher level as this system is characterized by shared intellectual property and the decision to apply the system depends solely on the management structures of the institutions involved.

Not only is the new approach beneficial to institutions of higher education, but also to businesses in general as Stowsky (2004) found that major business benefits could be derived from an open innovation strategy - of which the World Wide Web is but one example – if organized along the lines of:

- *Aiming at general technology development,*
- *Allowing all to participate in the development process; and*
- *Allowing the free flow of information between developing participants.*

The protection of intellectual property requires however of all institutions of higher education to develop sound intellectual property rights policies that allows for shared proportional benefits and risk-taking. The latter is currently a rather conscientious issue as most of the

higher education institutions in South Africa are governmental funded and is therefore very cautious to undertake risk-taking ventures. It is therefore not surprising that patent registration by higher education institutions in South Africa is still on a fairly low level.

Direct cooperation by stakeholders in governance of higher education institutions

Section 31 of the South African Higher Education Act stipulates that all higher education institutions must have an Institutional Forum with representatives of management, Council, Senate, academic and non-academic staff as well as students to identify problems, mediate interests and to advice relevant structures and by so-doing install co-operative governance in higher education (Adams, 2006).

Higher education institutions are also encouraged to engage industry and enterprises. By this direct involvement and engagement with industry and enterprises, institutions of higher education in South Africa are based on the belief that the central mission of universities is to advance and transmit knowledge. This approach according to Imenda (2006) is a clear break from the classical higher education approach of maintaining a community of scholars and an intellectual community engaging critically with the conventional wisdom of the day, towards an approach of fulfilling the gratification values of the marketplace which are governed by market-forces. Within this notion, 'entrepreneurship' becomes a necessity for all institutions of higher education in South Africa.

Consequently, although still at a relatively marginal level, business and industry in South Africa has become one of the main sponsors of research in many of the higher education institutions in South Africa for purposes of advancing commercial interests and to meet the growing needs of a society in transition. This implies that a fundamental criterion for academic entrepreneurial higher education institution in South Africa can be identified: 'Developing knowledge for practical ends'. If this criterion holds true then the following underlying principles apply for institutions of higher education in South Africa:

- To meet practical ends, a variety of interdisciplinary programmes need to be developed based on the recognition of emerging problems and opportunities;
- Staff, undergraduate and post-graduate students need to be connected with emerging research and speculative ideas;
- Adopt a more liberal educational approach with the sole aim of empowering individuals, to meet the demands of today and the future;
- As institutions of higher education in South Africa becomes more inserted in society and industry, knowledge transfer will have to become more performative and less enlightened

in nature and will be valued and prized accordingly primarily by the consumer of the knowledge; and

- Marketization of knowledge will signify higher education in service of the market rooted in shared and negotiated interest and building of its own type of 'academic capitalism'.

Research, development and innovation

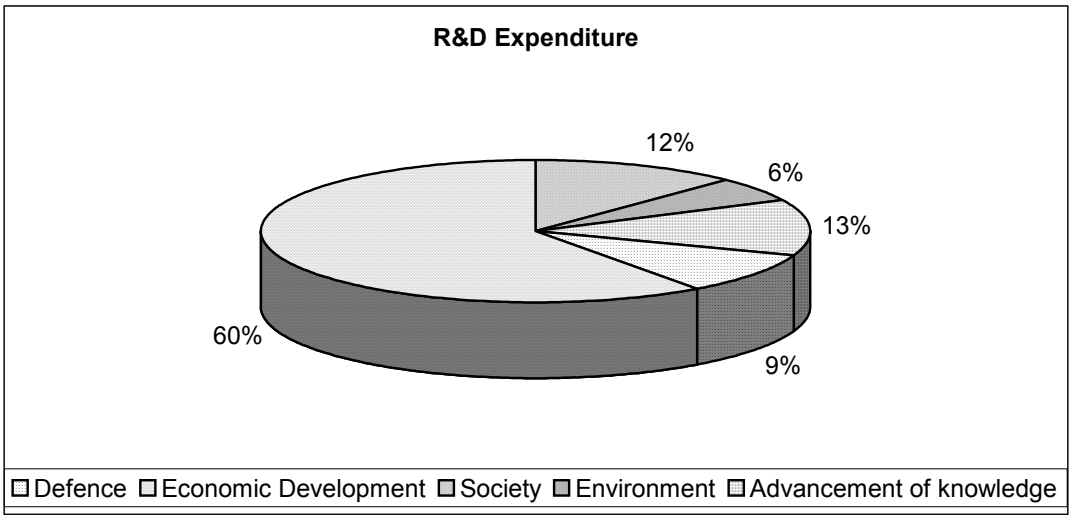
Promoting Research, Development and Innovation (RDI) at South African higher education institutions is based upon a framework of measurables founded on two dimensions namely the development of and performance in research focus areas and secondly, facilitating the continuation, enlargement and building of intellectually engaging communities of research practice. In this regard Christiansen and Slammert (2006) are of the opinion that the latter constitutes the biggest challenge due to the low participation rates especially across racial and gender groups in South Africa. Christiansen and Slammert (2006) also indicated that real expenditure available for researchers in higher education institutions in South Africa has stagnated for the past decade resulting in a shift towards more consultancy research-based activities. However, despite this fact, institutions of higher education in South Africa lag far behind their international counterparts to mobilize sufficient resources to enable strong research networks, regular visiting researchers or visits to other institutions on a large scale.

An aspect of concern is the low level of company spin-offs created by higher education institutions as a result of R&D activities. One explanation could be that traditionally higher education institutions were primarily involved in the start-up creation phases of entrepreneurship. This is more often than not the most turbulent phase in the whole entrepreneurial process as firstly, little is known about successful forms of action in the initial phases and secondly, the longitudinal character of venture creation is not fully understood by those involved in the process.

Another possible reason could be the allotted small proportion of funding of Gross Expenditure on R&D (GERD) in relation to the Gross Domestic Product (GDP) of South Africa. This proportion provides a good indication of the future competitiveness and wealth of a country as R&D spending is considered essential for making the transition to a knowledge-based economy as well as for improving production technologies and stimulating growth (Sajeva, et al., 2005). Whilst the aim of the South African Government is to spend at least 1% of its GDP on R&D this objective has never been reached since 1983. With a median of 0.76 and currently at 0.806 GERD:GDP, little emphasis is given to R&D activities. Further, of the R10.1 billion available for R&D, only 13% is spend on the advancement of knowledge; whilst the majority of money (60%) is spend on economic development (Figure

2). This indicates that too little is invested on human capital, which is considered a critical element for a successful knowledge based economy.

Figure 2 - R&D expenditure by socio-economic objective, 2001/2002



Source: Kaplan, D. 2005. Technology and the Growth of Manufactured Exports: Assessing South Africa's Performance and Policy.

An important consideration in determining the capability of South Africa higher education institutions to transform R&D activities into commercial application, demands an analysis of human capital availability in the scientific community. The South African Department of Arts, Culture, Science and Technology (2002) has made a comparison between four countries, South Korea, Malaysia, South Africa and Australia regarding the development of human capital as expressed by number of researchers per 1000 of the population (Table 3). Although performing better than Malaysia on this component, South Africa is performing weak on the broadening of research literacy in the general population. Another disturbing fact is that South Africa has an aging research workforce. The South African Department of Arts, Culture, Science and Technology also indicated that the number of science, engineering and technology (SET) practitioners, will vary between 7 and 11 per 1000 of the population in the years 2002 to 2012 and an university throughput in SET of only 2.7% to 3% during the same time frame is expected. The latter figures compare extremely unfavourable with SET graduate throughput in some of the European countries like the United Kingdom (19.5% - 21.0%), Turkey (5.2% - no available data), Switzerland (7.0% - 7.7%), Sweden (13.3% - 13.9%), Spain (12% - 12.6%), Slovenia (8.7% - 9.0%), Portugal (7.4% - 8.2%), Poland (8.3% - 9.0%), Norway (7.7% - 9.3%) and the Netherlands (6.6% - 7.3%) for the same period.

Table 3 - Researchers per 1000 of population

Researchers per 1000 of Population	
Australia	*4.843*
South Africa	*0.71*
Malaysia	*0.3*
South Korea	*2.771*

Source: South African Department of Arts, Culture, Science and Technology. 2002. South Africa's National R&D Strategy: The Changing Face of R&D within South African Public Sector Research.

Curriculum development

According to Frederick and McIlroy (1999), in the new economy, technology and knowledge production on which it is based, have become an intrinsic part of the economy as well as the third factor of production in leading economies. As a result, it may be envisaged that education and research in institutions of higher education will need to support the complete technology development process, which also include the process of innovation.

If it is accepted that South Africa's success, globally and nationally, is partially determined by an innovative economy, then the statement by Zourek (2006:3) *"… we need education systems which value the application of knowledge outside the walls of their institutions and we need curricula and courses that encourage citizens to be open to innovation, to be supportive of innovation, and to have the courage to innovate themselves"* becomes valid and relevant. In this regard the higher education framework in South Africa gives recognition to the importance of promoting knowledge transfer between public research organizations and higher education institutions.

In its broadest sense, entrepreneurial higher education orientations, as part of the technical aim of education, could be considered as an integral part of the supply side of the innovation and entrepreneurial system (IES) of a country by delivering human resources with adequate qualifications, research outputs as well as technologies to support the effective functioning of the economy (Elfenbein, 2005). When the level of innovations by means of registered patents is analysed and discovering that it is well below 1% of the aggregated budgets allocated to higher education institutions in South Africa, it becomes questionable whether the curricula content prepares or support students sufficiently to become innovative and entrepreneurial.

Proposed governance framework to manage academic entrepreneurship

Two critical issues will be highlighted namely boundary-spanning governance and the development of a morphogenesis to evaluate progress.

Boundary-spanning governance

Firstly, with regards to the governance of entrepreneurship education at higher education institutions it is proposed that it should be managed by an 'inter-faculty-inter-industry committee' (boundary-spanning leadership is provided) in order to achieve a greater measure of integration (common building blocks are created) in terms of generic entrepreneurial skills requirements that cross over academic disciplines, whilst simultaneously making provision for the unique disciplinary requirements and needs of specific disciplines. This implies a shift away from the traditional independent faculty approach (functional myopia) which lacks commonly shared interests that is adopted by most universities and substituting it for a new re-configured structure able to create entrepreneurial value through a holistic, yet focused approach (integrated birds eye view) among various faculties. This largely represents the antithesis of the traditional academic governance approach followed at the majority of institutions of higher education. However, it is considered necessary, as it is able to strike out higher potential for entrepreneurship and innovation directions through the whole academic supply chain. In essence a virtual horizontal department – operating on the basis of value chains - is created, without necessarily increasing the staff operational cost to the institution. Creating a virtual horizontal department will ensure that all employees (lecturing staff) interpret the market signals better, and ensure that customer and entrepreneurial concerns become known to all faculties, regardless of their function in the institution leading to a better customer focus. By establishing an inter-faculty-inter-industry committee, opportunity is created for healthy and critical curriculum content debate (knowledge interaction), whilst module developers become better informed on borderline subjects and aspects. Even more essential is the protection that will be provided to ensure that the disciplinary, inter-disciplinary and trans-disciplinary entrepreneurship field of study is not vulnerable to the 'tactic of isolation' by claiming academic ownership in one faculty.

Secondly, entrepreneurship and innovation cannot flourish within institutional isolation. Cross-fertilisation of national and international academic and industry business networks is required not only to build leading edge relevant curriculum content, but also to keep up to date with the dynamics in the field. In this regard it would be important to create entrepreneurial knowledge champions in each of the faculties, whilst still operating under the academic guidance of an Entrepreneurial Center of Excellence that could coordinate all activities and ensure proper co-operation between faculties. In essence, the Entrepreneurial Center of Excellence's focus is to orchestrate the entrepreneurial functions in all the faculties.

This will further ensure that the 'big divide' in entrepreneurial education between faculties is largely eliminated. With regard to its functions within the institution the Entrepreneurial Center of Excellence's role could be to:

- Establish an operating and repertoire-building entrepreneurship and innovation education framework and technique approach applying to real-time methodologies;
- Facilitate new entrepreneurial and innovation horizons for the institution through the diffusion of new information, the establishment of dialogue processes, and the exploration of new required dynamic capabilities;
- Build entrepreneurial talent for intellectual entrepreneurship leadership; and
- Establish bonding entrepreneurial networks that form the nucleus of the core of the university's entrepreneurial value system through web-connectivity, conferences and seminars, mobilising critical mass of people for innovation and the management of Memorandums of Understanding.

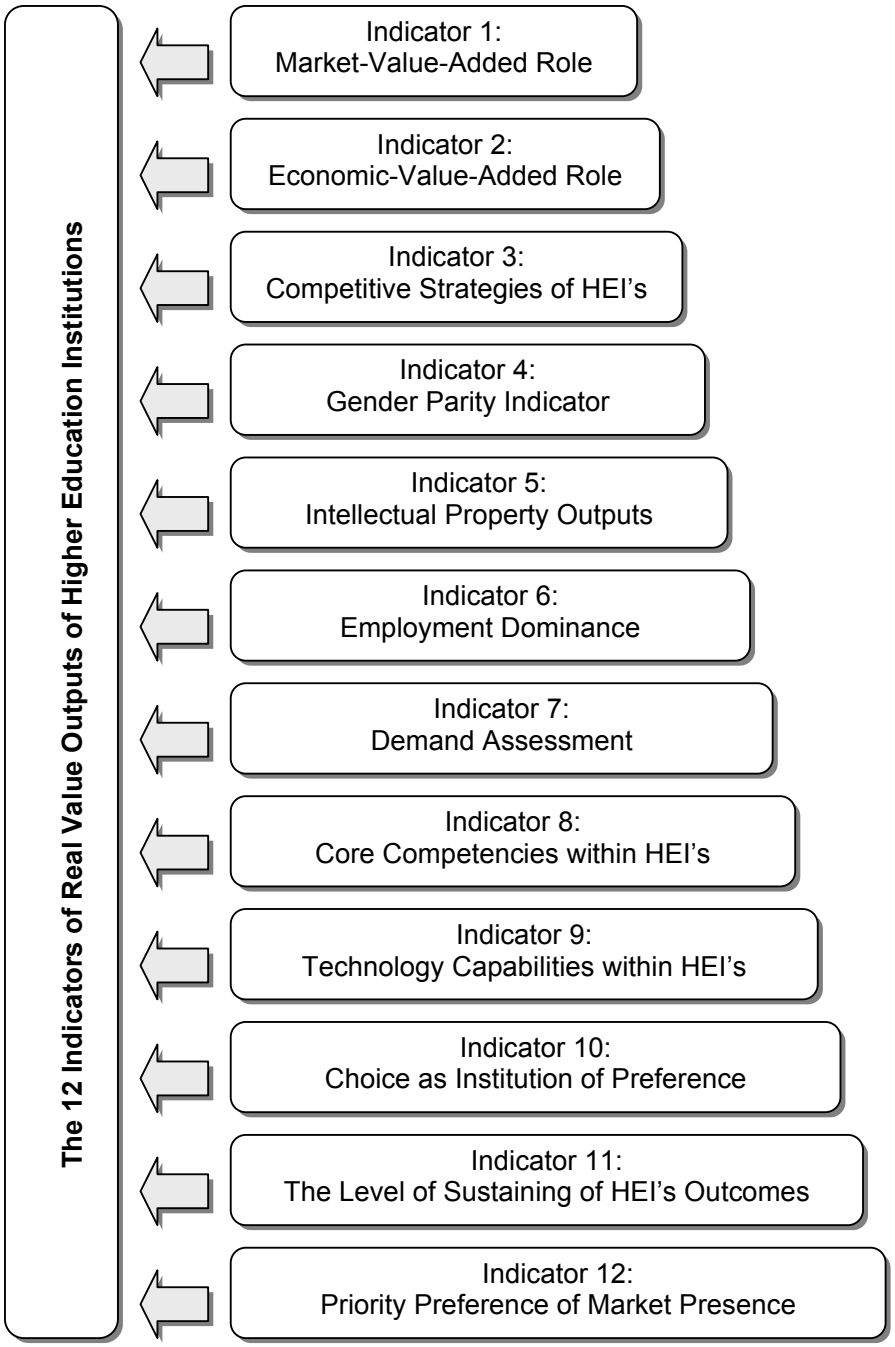
The development of a morphogenesis to evaluate progress

Sustainable social capital development is amongst others achieved by means of the real value outputs provided by Higher Education Institutions (HEI). For the purpose of this paper real value outputs, and therefore the relevance of HEI's, refer in general to the specific goals and purposes of the higher educational system in South Africa and specifically to the:

- Market competitive advantages created for individuals and groups through the education, research and community development initiatives of co-operative Higher Education Institutions (HEI);
- Perceived and real market value of higher education, research and community development initiatives of co-operative HEIs;
- Knowledge capabilities that exist within co-operative HEIs;
- Market attractiveness of the co-operative HEIs; and
- The relative weight given to Market Presence versus Consumption Potential at the Co-operative HEIs.

The degree to which Higher Education Institutions achieve these goals can be measured with the aid of indicators. Through the establishment of the 12 indicators within a three dimensional model (education, research and community development) the development and learning needs of youth and adults could be managed to continuously optimise equitable gender access to and appropriate learning, research and community development initiatives (Figure 3).

Figure 3 - The 12 indicators of real value outputs of higher education institutions



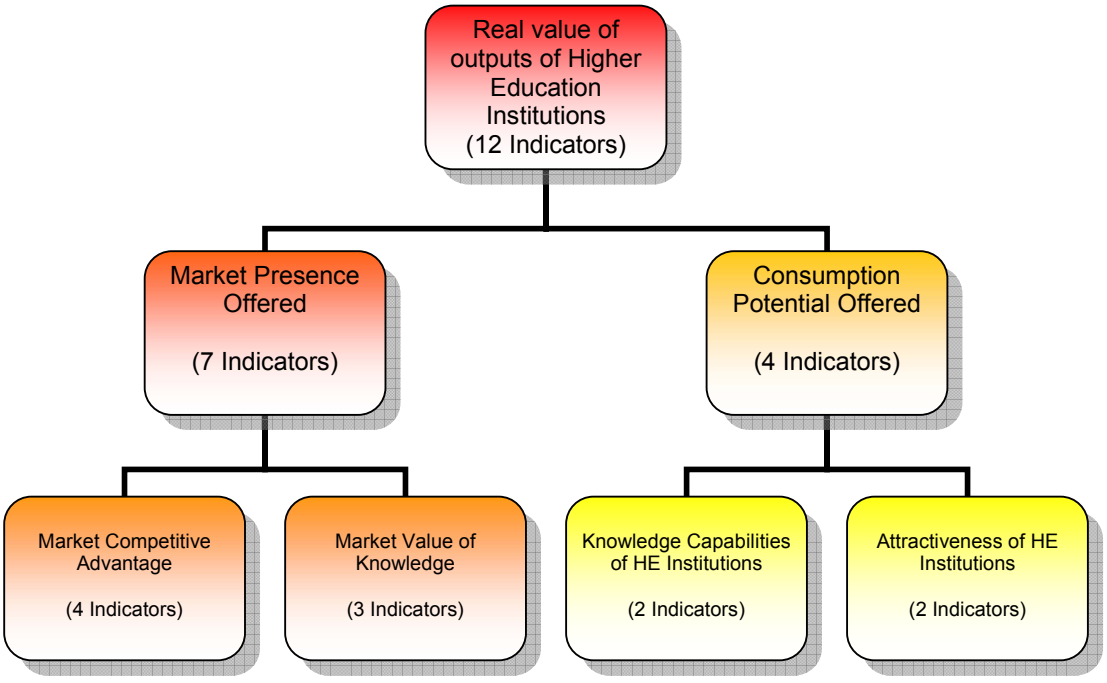
Source: Grundling, J.P. 2006. A Heuristic Sustainable Social Capital Development Model through Supra-National Co-Operative Higher Education.

The three dimensions under investigation are the educational offerings, research initiatives and community projects institutions of higher education are or intend to engage in. Optimisation of the three dimensional co-operative educational framework could be done based upon a play-off between two critical decision variables namely (Figure 4):

- The social capital presence that are offered by institutions of higher education engaged in the three dimensions (education, research and community development initiatives); and
- The consumption potential of institutions of higher education to contribute to social capital development.

For the purpose of this paper social capital presence refer to the extend to which education, research and community initiatives of higher education institutions contribute to enhance the market competitiveness and commercial value of knowledge of those individuals and groups effected by the initiatives. The consumption potential on the other hand refers to the capabilities of higher education institutions to offer market competitive education, research and community development initiatives and to be considered an attractive service provider. Co-operative higher education initiatives refer to potential joint initiatives that could be undertaken by the participating higher education institutions to enhance sustainable social capital development in the respective countries through the pooling of resources and expertise.

Figure 4 - Value of higher education institutions output to social capital development



Source: Grundling, J.P. 2006. A Heuristic Sustainable Social Capital Development Model through Supra-National Co-Operative Higher Education.

Lifelong availability and accessibility of higher education to all beyond the traditional age groups 18- to 22 year old students

This requirement can only be fulfilled in the presence of:

- Provision of an optimal range and choice of entry and exit points within the institutional system in order to create enough flexibility to address the specific needs and aspirations of an individual and society at large;
- Safeguarding the traditional roles of the university i.e. teaching and scholarship, sustaining academic disciplines and transferring knowledge but also to fulfil its role as a vehicle for economic growth through the creation and application of knowledge to activities such as innovation, creativity and entrepreneurship; and
- If generous financial support can be obtained from various sectors in society to keep pace with growing demands that outpaced support received from the government.

Conclusion

Institutions of higher education are increasingly being regarded as the main source of knowledge creation, growth and dissemination for socio-economic development. The biggest challenge for institutions of higher education therefore remains to recognize opportunities in the environment and transfer it into value-added activities that would create a 'carrying capability' for higher education institutions to meet current and future demands, whilst accommodating factors of system change and transformation in all spheres of life over time. Doing this, will ensure the development of a national entrepreneurial cultural accumulation process on which future generations in higher education could build.

It can be deducted that universities in South Africa are beginning to display an emerging trend of entrepreneurialism explicitly driven by financial imperatives facing higher education and a greater emphasis on applied research funded privately. There is also a greater emphasis to create teaching and research expertise and capacity in science and technology.

This paper furthermore emphasised the need to create governance mechanisms that could properly address the disciplinary, interdisciplinary and trans-disciplinary nature of entrepreneurial education in higher education institutions. It proposed the establishment of a joint-responsibility structure able to span the entrepreneurial holes in institutions of higher education whilst receiving guidance from a centrally Center of Excellence that could coordinate all entrepreneurial education and ensure cooperation by all academic faculties. A general framework was introduced to act as inner-compass in the discourse of promoting

academic entrepreneurship. Implementation of these proposals could be done at minimum cost to an institution of higher education.

It is envisaged that the outputs of the research and development, following a research focus area approach, will extend the boundaries of business and technology innovations by making information and knowledge useful. It can be concluded that the offering by institutions of higher education in South Africa are to be considered as commodities that could add value, nationally and internationally. However, the current academic entrepreneurship departure point is still relatively weak and the relative performance level is indeed modest as can be expected from a developing country in transition. Conversely, some positive signs were detected which indicated that higher education institutions in South Africa would be able to position them appropriately to respond to the marketplace demands.

Lastly, the survival and prosperity of institutions of higher education in South Africa depends largely on their motivation and ability to establish close working and funding relationships with private and governmental institutions not only to enhance the relevancy of curriculum content and to focus on research and innovation, but also to contribute to the required social and economic transformations that needs to take place.

References

Adams, F. (2006), Managerialism and Higher Education Governance: Implications for South African Universities? *South African Journal of Higher Education* 20(1):3-14.

Babbie, E. and Mouton, J. (1998), The Practice of Social Research. New York: Oxford University Press.

Brawer, B. (1998), Academic Entrepreneurship in Higher Education, http://www.celcee.edu/publications/digest/Dig98-3.html

Christiansen, I.M. and Slammert, L. (2006), A Multi-Faceted Approach to Research Development (II): Supporting Communities of Practice. *South African Journal of Higher Education* 20(1):15-28.

Elfenbein, D.W. (2005), Publications, Patents, and the Market for University Inventions. St.Louis: Washington University.

Frederick, H.H. and McIlory, D. (1999), New Zealand and its Competitors in the Knowledge Economy. *Telematics and Informatics* 16:177-217.

GEM, Global Entrepreneurship Monitor. (2005), South African Report, http://www.gsb.uct.ac.za/ gsbwebb/userfiles/GEM2005.pdf

Grundling, J.P. (2006), A Heuristic Sustainable Social Capital Development Model through Supra-National Co-Operative Higher Education. Workshop Theme: Innovation in Higher Education. 28 July. Windhoek, Namibia: Polytechnic of Namibia.

Hannon, P.D. (2005), Graduate Entrepreneurship in the UK: Defining a Research and Education Policy Framework. 1-3 November, pp. 1-16 in 28th ISBE Conference on Illuminating Entrepreneurship. Blackpool, United Kingdom.

Huremelinna, P.; Kylaheiko,K. and Jauhiainen,T. (2005), The Janus Face of the Appropriability Regime in the Protection of Innovations: Theoretical Re-Appraisal and Empirical Analysis. *Tecnovation*.

Imenda, S.N. (2006), Knowledge Production as a Function of the Individual Institution's Idea of a University. *South African Journal of Higher Education* 20(2):245-260.

Jesselyn, M. and Mitchell, B. (2006), Entrepreneurship Education in South Africa: A Nationwide Survey. *Education and Training* 48(5):348-359.

Kaplan, D. (2005), Technology and the Growth of Manufactured Exports: Assessing South Africa's Performance and Policy. Paper presented at DRUID Summer Conference on Industrial Dynamics, Innovation and Development, Elsinore, Denmark.

Kinsella, R. and McBrierty, V. (1997), Campus Companies and the Emerging Techno-Academic Paradigm: The Irish Experience. *Technovation* 17(5):245-251.

Kroll, H. and Liefner, I. (2007), Spin-off Enterprises as a Means of Technology Commercialization in a Transforming Economy – Evidence from Three Universities in China, http://wwwsciencedirect.com/science?_ob=ArticleURL&_udi=B6V8B-4P2J30V-1&_us

Kruss, G. and Peterson, I. (2008), University-Firm Interaction in the Region. Pp. 304-393 in Towards a Common Future: Higher Education in the SADC Region – Research findings from Four SARUA Studies, edited by P. Kotecha. Johannesburg: Southern African Regional Universities Association.

Liu, H. and Jiang, Y. (2001), Technology Transfer from Higher Education Institutions to Industry in China: Nature and Implications. *Technovation* 21:175-188.

MRC Innovation Centre. (2006), Section H: Funding for Commercialisation of Research, http://innovation.mrc.ac.za/section.htm

Niewenhuizen, C. and Kroon, J. (2002), Identification of Entrepreneurial Success Factors to Determine the Content of Entrepreneurial Subjects. *South African Journal of Education* 22(1):24-27.

Reddy, J. (1998), Transforming Higher Education. Pp. 64-69 in Education Africa Forum, edited by H.P. Africa; J.C. Hubert; A. Miller and T. Moja, T. Pinegowrie: Juta.

Roberts, D.V.; Gouws, S.M. and Van der Merwe, A. (2006), Funding for Success in Higher Education: A Mechanism to Meet National Challenges. *South African Journal of Higher Education* 20(2):219-231.

Sajeva, M.; Gatelli, D.; Tarantola, S. and Hollanders, H. (2005), Methodology Report on European Innovation Scoreboard 2005. *European Trend Chart on Innovation* 1:146.

South African Department of Arts, Culture, Science and Technology (2002), South Africa's National R&D Strategy: The Changing Face of R&D within South African Public Sector Research. Pretoria: Government Printers.

Spinelli, S. and Timmons, J.A. (2003), New Venture Creation. Singapore: McGraw Hill.

Stowsky, J. (2004), Secrets to Shield or Share? New Dilemmas for Military R&D Policy in the Digital Age. *Research Policy* 33:257-269.

Subotzky, G. (1998), Forging Partnerships to Meet Global Competitiveness and Reconstructive Development. Pp. 70-73 in Education Africa Forum, edited by H.P. Africa; J.C. Hubert; A. Miller and T. Moja, T. Pinegowrie: Juta.

Zourek, H. (2006), We cannot Afford not to Deliver on Innovation. *European Innovation* November: 3.