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From Basic Research to Innovation: Entrepreneurial Intermediaries for Research Commercialization at Swedish 'Strong Research Environments'

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Abstract

The recent rise in university-industry partnerships has stimulated an important public policy debate degrading the theoretical rationale for government support for knowledge transfer/exchanges from higher education sector. This paper draws on a particular case study conducted at Lund University, which is the largest comprehensive research university in Sweden. We ask the role of fundamental research at the university and organizational responses to growing expectations with respect to its subsequent use and applications, particularly those of 'Centres of research excellence'. We identify new forms of intermediary organizations as 'brokers on the boundaries' which bridge the gap between everyday scientific activities of researchers, entrepreneurial activities of academics, and more centralized forms of strategic initiatives taken by an 'entrepreneurial university' as an organizational actor. The paper concludes by identifying organizational strategic choices and constraints, and implications for rapidly changing higher education and research policies in Sweden and beyond.

1. Introduction

University-industry collaboration, commercialization of research results and the protection of intellectual property emanating from universities have become major policy and research concerns in relation to the promotion of innovation and economic development (e.g. Geuna, 1999; Feldman & Bercovitz, 2006; McKelvey & Holmén, 2009). Thus recent rise in university-industry partnerships has stimulated an important public policy debate regarding the theoretical rationale for government support for knowledge transfer activities (Harman, 2005). Nevertheless, despite growing interest

[1] The authors acknowledge financial support from Vinnova to conduct the study in 2009, upon which this paper is based. The views expressed in this paper are solely those of authors.

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among academics and policy makers worldwide, there are a number of perceived gaps in the understanding of university-industry linkages (D'Este and Patel, 2007), appropriate incentive mechanisms and organizational forms, and the implications for research policy.

The starting point for this paper is an identified gap in the academic discourses and policy expectations concerning research excellence, commercialization of research, 'the entrepreneurial university' and 'academic entrepreneurship' on one hand, and the actual behaviour of individual scientists and the organizational forms it takes, on the other. In the field of higher education research, much has been written about the nature of the pressures for change in universities - both from the viewpoint of the internal organizational transformation and their changing role in society (Bok, 2003; Geiger and Sá, 2008; Slaughter and Leslie, 1997; Marginson and Considine, 2000; Etzkowitz, 2002). The term 'entrepreneurial university' (Clark, 1998; 2001) refers to such an organizational change of the university. An 'entrepreneurial university' can be defined as 'a university that has developed a comprehensive internal system for the commercialization and commodification of its knowledge', which includes 'not just structures such as liaison or technology transfer offices which bridge the gap between industry and the academy but also incentives for adjusting lines of study and the allocation of research budgets to the demand in the private and public sectors' (Jacob et al. 2003, p.1556).

The concepts such as 'university entrepreneurship' (see a review by Rothaermel et. al 2007) and 'academic entrepreneurship'(e.g. Shane 2004; Meyer, 2003) describe a wide range of activities in which individual academics may take, including formation of spin-off firms, patens and licensing, and sponsored research and other forms of 'relationship-based' university-industry links such as consulting(Perkmann and Welsh, 2007). Meyer (2003) points out that existing public support mechanisms encourage the development of a 'behavioural pattern' which can be characterized as 'entrepreneurial academics' rather than 'academic entrepreneurs'. Entrepreneurial academics are interested in looking for broader 'avenues in which they can pursue their research interests', not necessarily interested in setting up fast-growing university spin-off companies. It has been pointed out that the literature on university entrepreneurship tends to privilege economic over social ends in its approach, and most of empirical studies tend to be limited to the effect of 'distinct

subsystems' on economic knowledge transfer through engagement with industry (Vorley and Nells, 2008).

Tensions between the wide range of activities encompassed under the concept of academic entrepreneurship and the tendency to define entrepreneurial activity in narrow economic terms pose challenging questions to universities how to re-organize their orgnisational structures and institutional practices and to make strategic choices in order to support different forms of linkages fostered at different levels. In order to address these questions in a specific institutional context, this paper draws on a particular study conducted at Lund University, which is the largest comprehensive research university in Sweden. Lund University accommodates fourteen (out of forty across all of Swedish HEIs) 'strong research environments' funded by Linnaeus grants, recent prestigious national research grants in Sweden, awarded for 'excellent basic research'. This specific study is based on an intensive policy-oriented project conducted in early part of 2009. The aim of the study is to identify factors which enhance innovation activities from 'basic' research environments. Based on the interviews, existing gaps between knowledge from basic research and the market are identified. Our findings also highlight new forms of intermediary organizations, which bridge the gap between activities at an individual level, including everyday scientific activities of researchers as well as activities associated with 'academic entrepreneurship', and more centralized forms of strategic initiatives for commercialization of research taken by an 'entrepreneurial university' as an organizational actor.

This paper aims to shed light on commercialization and knowledge transfer from basic research, and provide theoretical perspectives to the new 'boundary crossing' organizational forms emerging at such strong research environments. We provide a model to explain how such organizational forms may support 'needs-driven research' and 'research-inspired innovation' from basic research. Such processes can be identified by closely investigating individual's motives and institutional processes over time. In our empirical study, while limited in terms of timescale of the investigation, one of the questions we asked is why and how researchers at 'strong research environments' engage in academic entrepreneurship activities. We also aim to understand the organizational forms such individual entrepreneurship activities of academics take, and how individual entrepreneurship activities and organizational activities interact, and influence the nature of the research. Drawing on the empirical

investigation based on 25 semi-structured interviews, the paper contributes to conceptual discussions on the entrepreneurial university and academic entrepreneurship, with some particular policy implications for the future Swedish innovation and research policy and university organizations.

The rest of the paper is structured as follows. Following this Introduction, Section 2 provides the context of the study with current research and innovation policy trends in Sweden, and identifies the specificity of the Swedish context in regard to 'academic entrepreneurship' and 'research excellence'. Section 3 presents our conceptual framework to analyse 'strong research environments' at Lund University, namely, Linnaeus environments. Based on an overview of relevant literature drawing from research policy, higher education studies and innovation and entrepreneurship studies, 'a quadrant of university- industry linkages' is presented to show the interactions of knowledge between basic research and the market. Section 4 presents empirical cases from Lund University, illustrating 'entrepreneurial intermediaries' as new organizational forms which enable 'boundary spanning activity' between academia and industry. Section 5 concludes the paper with discussions based on our findings from the cases, identifying implications for the Swedish research policy, and further research issues.

2. Policy Contexts and Swedish Institutional Landscape of Academic Entrepreneurship and Strong Research Environments

2.1. Literature

Many of the literature concerning 'the entrepreneurial university' and 'academic entrepreneurship' tend to focus on both exogenous factors (e.g. socio-economic climates and industrial changes, legal frameworks) and endogenous factors including internal transformations within the university and other bottom-up organizational and management changes driven by changes in the IP regimes (Etzkowitz et al., 2008), for example. In order to explain the dynamics of organizational learning and knowledge management practices between university and industry, different factors have been identified (e.g. size and R&D of the firm, geographical distance, quality of research, incentive mechanisms) that influence the benefits from such interactions, and studies have been made at different levels of organizational analysis (D'Este and Patel, 2007; Feldman and Bercovitz, 2006). In

this section, in order to illustrate the characteristics of academic entrepreneurship activities in Swedish policy and institutional contexts, we will identify two main trends of recent policy and academic discourses and examine the Swedish cases in detail.

a) Commercialization and academic entrepreneurship

University involvement in technology transfer has become one of the most significant trends in higher education in the United States over the last two decades. The US research university system, as exemplified by the Massachusetts Institute of Technology (MIT) and Stanford, is taken as "a role model" for responsiveness to economic change and contribution to the creation of wealth by governments elsewhere in the world. It is generally accepted that an effective dissemination of knowledge between public knowledge institutions such as universities and the private sector depends on certain regulatory factors (*e.g.,* intellectual property rights (IPR) policy in the public sector) and on the existence and efficacy of mediating institutions. Nevertheless, only a small fraction of the flow of knowledge from universities to industry is mediated by formal licensing agreements involving university generated patents, while there are distinctive differences among sectors (Schartinger et al. 2002). There is also an increasing awareness that there has been a narrow focus on commercialization of university technologies, rather than other more economically important outputs of university research (Morey and Sampat, 2005). For example, there are a number of knowledge transfer channels which include consulting, collaborative research, patenting and licensing, recruiting graduates, co-supervision and publication (Perkmann and Walsh, 2007).

There have been an increasing number of studies which focus on technology transfer offices (TTOs) as units of analysis to examine the organizational transformation (Thursby and Thursby, 2002; Siegel et al. 2003; Jons-Evans et al., 1999). The widely observed recent policy direction in many countries to promote entrepreneurial activities by setting up formal mechanisms such as TTOs through 'international emulation of the Bayh-Dole Act' (Mowery and Sampat, 2004) may need to be tempered with more realistic expectations. Echoing recent findings from the US literature (c.f. Shane 2004), Japanese literature has begun to debate the suitability of the new system against the old 'informal' system of university – industry links (Woolgar, 2007; Walsh et al. 2008). In Europe, the economic impact of

institutional changes, such as adoption of organizational ownership of intellectual property rights (IPRs) to universities and formation of technology transfer offices, is far from definite (Geuna and Nesta, 2006). In view of the wide and different forms of linkages and interactions between university and industry which are increasingly recognized (e.g. Perkmann and Walsh, 2007), recent studies provide a more 'nuanced' view of the roles played by TTOs. For instance, Gill et al (2007) note that a centralized structure around a technology transfer office providing IP services to firms would be appropriate for the transfer of 'packaged' IP, and that more relational or 'people centred' links would be better supported by more decentralised arrangements.

b) Research excellence and relevance

In academic and policy discourses, there is a focus on *scientific research excellence,* and can be characterized as 'prioritisation' and 'concentration' of research in selected areas and institutions. These trends resonate with the wider transformation in research policy in many advanced economies. An increasing number of works have been conducted about institutional and organizational conditions about 'creative research environments' (Heinze et al 2007; Hollingworth, 2000), and many of the characteristics of such environments seem to explain certain features found in different types of 'strong research environments' found in Sweden (see next section).

Policy initiatives to create and support 'strong research environments' by allocating long-term funding to a limited number of Centres of Excellence (COEs) in research at national level have been developed in a number of countries but the target, scale and scope of such policies vary. One type of such COE programmes, arguably based on linear 'science push' model (Power and Malmberg, 2008, p.237), are primarily concerned with the *academic aspects* of research and the aim is to create research milieus with sufficient intellectual power to be recognized as attractive by the international scientific community. These initiatives aim to concentrate resources for basic research in order 'to reinforce excellence and sustain world-class centres', 'to establish concentrations of researchers and resources that will pursue excellence in research and act as a linkage to international centres' or 'to identify and promote national key areas of excellence' (Power and Malmberg, 2008, p. 236). The research performed by these COEs may of course, even if they were selected on the bases of academic criteria, still be of interest to industry.

A second type of programme adds as an additional objective that the COE shall also be *attractive partners for industry and wider society*. Based on more 'interactive systems of innovation' model, overall, it is argued that university-industry links have the potential to 'accelerate technological diffusion, and establish new research agendas' (D'Este and Neely, 2008, p.310). There is also a perceived risk that scientific research shifts from basic to more applied topics and may lead to 'less academic freedom' (Behrens and Gray, 2001). The existing academic literature seems to suggest that the reasons why many university researchers engage with industry is diverse, and quite often the motive is to 'further their research rather than to exploit their knowledge' (D'Este and Perkmann, 2009; see also Owen-Smith and Powell, 2001). There are discussions on how these relationships affect fundamental research and how fundamental research could benefit from such relationships (Poyago-Theotoky et al. 2002; D'Este and Neely, 2008; Perkmann and Walsh, 2008). D'Este and Neely (2008, p.310), after Poyago-Theotoky et al. (2002), summarise the value of university-industry links to fundamental research as follows:

a) benefits from potential applications from fundamental research are perceived by collaborative partners (applications that otherwise would have gone unrealized);
b) tacit knowledge is satisfactorily transmitted through frequent and close interaction between university faculty and industrial scientists; and
c) complementary skills can be exploited to mutual advantage.

In the US context, Owen-Smith (2003) finds that there is convergence towards a 'hybrid system' linking scientific and technological success. The processes and organizational forms through which these benefits can be captured have to be empirically investigated.

2.2 Sweden – A Unique Case?

a) Commercialization and academic entrepreneurship

The case of a Swedish research and higher education system is unique for a few reasons and is worthwhile exploring from comparative perspectives (e.g. see Henrekson and Nelson, 2001; Goldfarb and Henrekson 2003 for comparison between Sweden and the US). Unlike many other European countries, Sweden has kept the law on the '*university teacher's exemption*' which allows university researchers (not the

universities as organisations) to retain to own full rights to their discoveries from their research results. The current IP regime in Sweden is a major factor which shapes university research commercialization and other academic entrepreneurship activities. Since scientists own the IP, irrespective of the funding source, they can transfer it to an independent company, hand it over to a university organization or use it as the basis for firm formation, as they see fit (Eztkovits et al., 2008). The researchers can receive support from publicly financed technology bridging foundations (TBS) and university holding companies on a voluntary basis. Thus, the university scholar has full discretion about the means of knowledge dissemination. In the case of patenting, the researcher receives the entire benefits emanating from the patent but has to bear all costs as well (Sellenthin, 2009).

Sweden has undergone major changes in its research policy during the 1990s, which was accelerated by recession and global industrial changes, and this was further accompanied by a new belief in universities as driving economic growth to foster 'knowledge-based entrepreneurship' (Etzkowitz et al. 2008; Benner and Sörlin, 2007; Jacob et al. 2003) . There are different interpretations of the level of academic entrepreneurship in Sweden. On one hand, it is argued that 'teachers' exemption' has encouraged many academics to explore opportunities in search of outside investment capital, and has encouraged a flurry of entrepreneurial activities, but it is also pointed out that academics seldom have the knowledge and resources to realize benefits from their formal ownership rights. On the contrary, Goldfarb and Henrekson (2003) argue that Swedish government's support for academic entrepreneurial activities has been ineffective due to a lack of incentives for academic researchers to become involved in commercialiastion activities while recent emergence of 'entrepreneurial culture' (Henrekson and Nelson, 2001)has been noted. In general, universities are in favour of the idea of abolishing teachers exemption, while individual researchers fears that spontaneous collaboration between universities and companies, as well as the formation of new firms would be hindered if the government abolished teachers' exemption and made universities responsible for patenting and commercialization of their research.

Recent new public policy initiatives have led to debates about whether commercialization and academic entrepreneurship are effective or not, within the Swedish context (Henrekson & Rosenberg, 2001; Granberg & Jacobsson, 2006; Magnusson et al. 2008). Swedish universities have been given 'a third task' along

with teaching and research roles in the Higher Education Act in 1997, whereby universities are expected to support economic and social development and play a greater role in explaining academic to the wider public. In addition, the last decade has witnessed the creation of many new university TTOs in Sweden, in the forms of university holding companies, and other regional technology transfer agents (Jacobs et al. 2003; Göktepe, 2008; Sellenthin, 2009). This has resulted in different routes for university inventors which include: patenting individually, patenting through TTOs (e.g. university, regional). In 2004, the government produced an innovation strategy entitled *Innovative Sweden: A strategy for growth*. According to this document, the future welfare of Sweden will depend on ‘‘strengthening and developing strong research and innovation environments that can interact with the surrounding society at international, national and regional levels and that can help to form competitive clusters and effective innovation systems’’ (Ministry of Industry, Employment and Communications, Ministry of Education 2004: 22 cited in Jacob 2006). In the autumn of 2008, the new *Research and Innovation Bill* reinforced the function of some of the university TTOs as regional technology transfer centres.

b) Research Excellence and Strategic Research

In the ongoing debate on Swedish science policy, a distinction is made between ‘needs-driven research’ and ‘curiosity-driven research’ (Granbert and Jacobsson, 2006). The former refers to research where ‘the nature of the problems dealt with is strongly influenced, or directed, by expressed needs of industry or other sectors of society’, whereas the latter refers to ‘research directed by intrascientific concerns’ (CF, 2003; Narvinger *et al*, 2004 cited in Granbert and Jacobsson, 2006). As shown in Table 1, historically, there are a number of funding mechanisms in Sweden which support mechanisms for ‘needs-driven’ industry oriented research excellence (e.g. Competence Centres, Vinnexcellence, SSF Strategic Research Centres). Traditionally, for many Swedish academics, interaction with firms occurred through their regular academic role (Benner, 2003). Over years, many large Swedish firms have forged strong connections with research at leading universities in Sweden, further supported by policies since the 1980s to create university-industry Competence Centres (under NUTEK, predecessor organization of Vinnova) and to finance projects with industrial partners. In recent years, the creation of ‘mission-oriented agencies’ (Benner and Sörlin, 2007) such as Vinnova (the Swedish Agency

for Innovation System) and the Foundation for Strategic Research (SSF) implies a sift towards more competition, concentration of resources, and rewarding 'strategic areas of research' as exemplified by the most recent government call for Strategic Research Areas in early 2009.[3] Vinnova's mission is to focus on funding for 'needs-driven research required by a competitive business and industrial sector and a flourishing society' (Vinnova, cited in Pålsson et al. 2009; see also Norgren et al. 2007).

In Sweden, while the current industry-linked COE programmes trace their roots to the late 1980s, the academically oriented COE programmes are recent phenomenon, only in 2006, with the beginning of Linnaeus grants.[4] Linnaeus grants started in 2006 as a first step in the Swedish Research Council (VR)'s new strategy of long-term financing of cutting-edge research groups in Sweden. This is the first academically oriented COE programmes in Sweden.

> *The aim of the Linnaeus Grants is to enhance support for research of the highest quality that can compete internationally. It also aims to encourage universities and colleges to prioritize research fields and to allocate funding for them. The geographical spread of the allocation of the funds was not taken into consideration.*[5]

The grant was awarded in competition with research groups representing all faculties and disciplines at all Swedish universities and colleges, and involves a ten-year financing of research. After the two rounds in 2006 and 2008, 40 Linnaeus environments have been selected.

Vinnova and VR are two organizations which seem to represent two contrasting funding missions in the Swedish research and innovation systems. VR principally funds basic academic research based on pure academic merits, while Vinnova's mission is to support 'needs-driven research' and enhance economic growth through innovation. Vinnova and VR jointly created the *Pilot Project 2009* programme in late 2008 to identify and support the mechanisms to enhance 'needs-driven research' and 'research-inspired innovation' which lead to commercialization of knowledge from excellent and basic 'strong research environments', exemplified

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[3] Swedish Research Council "Strategic Research Areas" http://www.vr.se/mainmenu/applyforgrants/callforproposals/closedgrants/strategicresearchareas.5.72e6b52e1211cd0bba880007247.html retrieved 8 June 2009

[4] Discussion with Lennart Stenberg about this point is acknowledged.

5 *Linnaeus Grants allocated 2006* available at: http://www.vr.se/mainmenu/fundinggranted/linnaeusgrants/linnaeusgrantsallocated2006.4.4b3ca0f810bf51c922780003302.html retrieved as of 24 March 2009

by recipients of the Linnaeus grants in 2006 and 2008, with the aim to create a future new innovation programme for basic research in Sweden. The thinking behind such a programme lies an intersection between 'linear model' and 'interactive model' of innovation (Power and Malmberg, 2008). Creating a policy initiative to support commercialization activities from 'basic' research environments funded by VR seems to be one of the series of 'entrepreneurial turns' (Jessop 1997) of the Swedish research policy over the last decade (see Jacob et al. 2003).

Most recently, the Government bill on research and innovation 2008 proposed increased support for 'strategic research areas'.[6] 24 research areas were considered 'strategic' for Swedish competitiveness and growth. Swedish Research Council (VR), Swedish Council for Working Life and Social Research (FAS), Swedish Research Council for Environment, Agricultural Sciences, and Spatial Planning (Formas), Swedish Energy Agency (Energimyndigheten), and Vinnova were commissioned to 'organize, review and recommend' the allocation of funds to Swedish universities in 20 of these research areas. The aim of the grants is to 'create research of the highest international standard and the goal is for the strategic research area to become one of the most important and high profile areas for the Higher Education Institution'. The Government used three criteria in prioritising the strategic areas.Strategic initiatives should address:

- research that, in the long term, has the prerequisites to be of the highest international quality,
- research that can contribute towards fulfilling major needs and solving important problems in society,
- research in areas that have a connection to the Swedish business sector.

The model upon whih the new 'strategic researhc areas' are based on seems to be a new type of COEs in Sweden, where both aademic excellence, industrial excellence and future soietal needs are to be met. Lund University came out best in the competition and it is proposed that they should receive SEK 715 m during a five-year period in order to build up 'world-leading research' within nine strategic areas. The questions remains as to the effects of these public policy instruments, how they

[6] http://www.vinnova.se/In-English/Activities/Strategic-Research-Areas/ access 24 September 2009 http://www.vr.se/mainmenu/pressandnews/newsarchive/news2009/recommendationsforthefundingofstrategicresearchareasnowcomplete.5.3b26f940121ecde8aa480006516.html access 24 September 2009

affect the nature of research and the relationships between university research and industry and other sectors in society.

The current Swedish research funding landscape can be summarized as below.

Table 1 Research Funding landscape in Sweden

Funding bodies		COEs	Interactive/hybrid model
VR	*Academic COEs*	**Linnaeus Environments (2006; 2008)**	***Vinnova/VR Pilot Study*** for future 'Innovation programme for basic research' (2009)
Vinnova (NUTEK)	*Industry Oriented COEs*	Vinnexcellence Centres; Industrial excellence Centres; Berzelii Centres; (1980s-)	
SSF		SSF Strategic Research Centres	
VR, Vinnova FAS, FORMAS, Energimyndigheten			**Strategic Research Areas (2008 -)**

3. Conceptual Framework for University-Industry Links and Entrepreneurial Intermediaries

There is a tendency to separate between 'basic (or fundamental)/curiosity-driven research' and 'applied research/needs-driven research', as if these two types of research are distinctive. Stokes (1997) analysed the tension between 'understanding' and 'use' in science, and identified the importance of 'use-inspired basic research' citing as a model case the fundamental yet use-inspired studies by Pasteur in the late nineteenth century. For example, research intensive firms using technology based on 'Pasteur' disciplines, such as pharmatheutical companies, are likely to benefit from regularl interactions with basic academic research, as this is where 'the interest of both parties are best aligned' (Perkmann and Walsh, 2008).

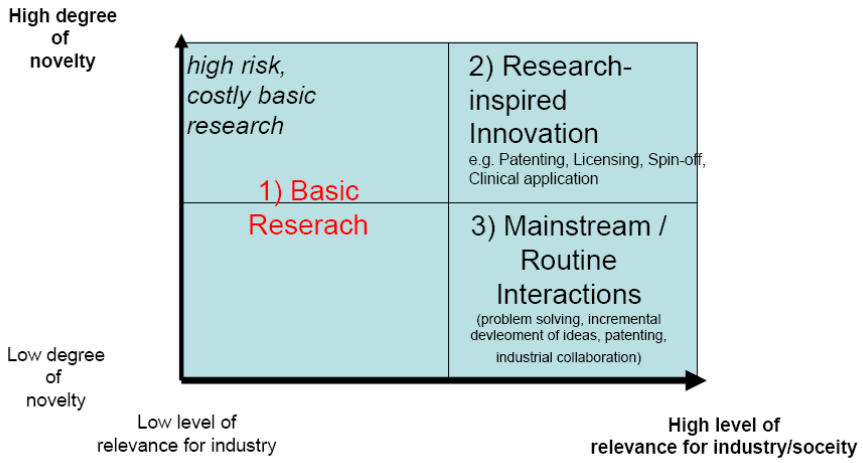
Figure 1 Pasterur's Quadrant

Basic and Applied research

Quest for fundamental understanding?	**Yes**	Pure basic research (**Bohr**)	Use-inspired basic research (**Pasteur**)
	No	--	Pure applied research (**Edison**)
		No	**Yes**
		Considerations of use?	

In order to analyse 14 Linnaeus centres at Lund University, we needed to identify the dynamic relationships between actors who conduct basic research and the users of the knowledge, and the diverse channels through which knowledge from basic research are transformed into 'innovation'. Inspired by the quadrant frameworks developed by Stokes (1997) and works on 'creative research environments' by Heinze et al. (2007), the authors developed *a quadrant of university-industry links* (Figure 1). The quadrant *basic research* exemplifies a type of research that has a high degree of novelty, and the main aim of this type of research is to push the research frontier forward. Many Linnaeus environments are considered to be placed in this quadrant. This type of research can be costly and may have high level of uncertainty, while some of the research outcomes may be pumping new ideas into industry/society. Basic research is generic in character and often it is difficult to foresee the outcome of the basic research process, while the 'needs-driven' research tends to respond to a pre-defined problem. Basic research also can be 'needs-driven' aiming to answer universal and global problems. This type of research can be costly and may have high level of uncertainty, while some of the research outcomes may be directly pumping new ideas into industry/society.

Figure 2 Quadrant of university-industry interactions



In a schematic way, the possible routes for academic entrepreneurship from 1) basic research at 'strong research environments' seem to consist of a mixture of two types of activities: 2) 'knowledge-based entrepreneurship' and 'research- inspired (radical) innovation', which may be through spin-off firms, or in the forms of patents and licensing; and 3) conventional 'relationship-based' university-industry collaboration, through 'use-inspired' basic research and 'needs-driven research' (e.g. consultancy, problem-solving) leading to 'incremental innovation' processes.

Based on the conceptual framework developed as 'quadrant of university-industry links', the empirical questions to be asked in this study are as follows: in what ways individual scientists at Linnaeus environments make links with industry, and what organizational forms the interaction takes, and how that influences the nature of research activities? Such activity involves 'communication of knowledge across boundaries within and external to an organisation' (Youtie and Shapira, 2008, p.1190). Some Linnaeus environments have a number of constant routes to interact with industry such as industry funded collaborative research, collaboration with former PhD students working in industrial R&D, and PhD placements in industry. These routes provide space for developing 'needs-driven' research by building a loop of trust and scientific credibility between academia and industry. These interactions can translate 'basic research' into 'mainstream' academic-industry collaboration,

identifying the ‘needs’ of industrial partners, based on incremental development of ideas, while, this kind of interaction would require highest level of science.

The present paper aims to identify factors which enhance such ‘creation and accumulation’ of boundary spanning roles, especially those intermediaries which connects knowledge arising from ‘fundamental research’ to commercial arena. Youtie and Shapira (2008) focus on the creation and accumulation of ‘boundary-spanning activity’ that mediates different functions as key to enhance the role of university in innovation processes. Authors increasingly identify the creation and accumulation of ‘boundary spanning roles’ (Youtie and Shapira, 2008), played by either individuals or by organisations, that bridge the gap between research knowledge and commercialization opportunities. For instance, academic “star scientists” can serve as boundary spanners (Zucker and Darby, 1996). The ‘boundary crossing organisations’ (Guston 2001; Hellström and Jacob, 2003) address knowledge exchange problems by acting as ‘brokers on the boundaries’ (Fisher and Atkison-Grosjean, 2002). Youtie and Shapira show that ‘a variety of boundary-spanning organizational forms’ enhance ‘both formal and tacit knowledge generation and exchange processes, with key mediation and brokerage roles played by organizations within or associated with the university’ (2008, p.1195). A question then arises as to how such ‘boundary-spanning activities’ come into existence and what shape they take under what conditions.

The role of boundary organizations, intermediaries and brokers have been previously studied, including individuals who act as ‘boundary-spanners’ (Burt, 1992). Boundary spanning activities may take place through ‘creating new communication methods and tools, and garnering participation from representatives on different sides of a boundary, or developing expertise in delegated areas’ (Youtie and Shapira, 2008, p.1191). What are the conditions for such boundary spanning activities to take place? It is argued that, the ability of organizations to change depends on the willingness of individuals to adopt supportive norms, routines and behaviors (Whelan-Berry et al. 2003 cited from Bercovitz and Feldman, 2008). Bercovitz and Feldman (2008, p.69) argue that variation in organizational response to external pressure can be understood through ‘intra-organizational dynamics and the actions of individuals in context’. They find that only under certain conditions, for example, presence of local entrepreneurial norms, academics engage in ‘substantial entrepreneurial behaviour’ as

opposed to ‘superficial compliance’. The following sections present our empirical findings in a particular institutional setting of Lund University in Sweden.

4. Empirical Findings

4.1. Research Setting and Methodology

As already stated, Lund University received fourteen Linnaeus grants, the largest number of Linnaeus grants in Sweden. The research groups included in the study have all received Linnaeus Grants from the Research Council in Sweden, either in 2006 or in 2008. Drawing on the empirical investigation based on 25 semi-structured interviews, the paper contributes to conceptual discussions on the entrepreneurial university and academic entrepreneurship, with some particular policy implications for the future Swedish innovation and research policy and university organisations.

Initial data collection was conducted through documentary analysis including Annual reports of the Linnaeus environments, Linnaeus grant applications, and the evaluation of the 2006 environments obtained from VR. In total our empirical material consists of 21 semi-structured interviews (14 Coordinators and 7 Principal Investigators) at Linnaeus environments, conducted during spring 2009. We conducted further 4 interviews with the university senior managers and technology transfer officers. There are central organizations that support academic entrepreneurship activities at the University and the university has a technology transfer office, LU Innovation, and also a holding company called LUAB.

The Linnaeus Coordinators and PIs received standardized interview questions in advance. Each interview lasted about 50 -75 minutes. Our scope of the interview questions was deliberately broad, in order to include different research areas (e.g. from nano tech to demography), different disciplinary practices and approaches (very basic research to applied practices). Interview questions focused on the identification of existing collaboration between research groups and collaboration with external actors (e.g. commercialisation and knowledge transfer activities; dissemination activities, joint projects), and routes of dissemination and application of their research. The following generic research questions were examined throughout our interview processes:

- *What are the incentives for academics to work with industry and engage with public, especially those who are funded to work on 'fundamental'/'basic' excellent research?*
- *What is 'needs-driven research' and 'research-inspired innovation' ?*
  In what ways can the university and funders support such activities?

By interviewing some of the University senior management and administrators, we identified some of the organizational contexts and strategies of the University in terms of its research and innovation. There seem to be several reasons why Lund University was so successful in receiving so many Linnaeus grants, and one of the reasons is said to be the institutional strategic selection and support mechanisms throughout the application process. The University senior management took a proactive approach to strategically select and support applications for the Linnaeus grants in collaboration with faculty deans and the grant applicants. The process is described as 'a combination of bottom-up and top-down approach'.[7]

Our analysis consists of mapping the different perceptions and practices of 'needs-driven research' and 'research-inspired innovation', strategies and goals of research and knowledge exchanges from "strong research environments" exemplified by recipients of the Linnaeus grants. The interview results illustrate the Linnaeus grant's various *impacts* on society and each environment's strategies for diffusion of knowledge, commercialisation and knowledge exchanges (see Wigren et al. forthcoming). We also identified *constraints* and *opportunities* perceived by Linnaeus Coordinators and PIs in terms of commercialization of research and technology, dissemination of their research results, and new channels of knowledge exchanges. Informal discussions proved to be very helpful in order to identify the perceptions of 'needs-driven research', 'research-inspired innovation', strategies and goals of research and knowledge exchanges.

4.2 Findings from Interviews

The areas of research encompassed by the 14 Linnaeus environments at Lund University are wide ranging. Most of the environments are cross-disciplinary in nature, and many of them prefer to call themselves 'interdisciplinary' emphasizing inter-

[7] <Interview comments>

linkages between disciplines, while some think themselves as 'multi-disciplinary' as they work from their own disciplinary bases whilst collaborating with other disciplines.

2006

- **Interdisciplinary laser spectroscopy at the Lund Laser Centre, LLC**
- **Nanoscience and Quantum Engineering, NanoQE**
- **Lund University Diabetes Centre, LUDC**
- **Neuronanoscience Research Center, NRC**
- **Hemato-Linné**
- **Organizing Molecular Matter , OMM**
- **The Centre for Economic Demography, CED**
- **Centre for Innovation, Research and Competence in the Learning Economy, CIRCLE**

2008

- **Basal Ganglia Disorders Linnaeus Consortium**, **Bagadilico**
- **Lund Center for Control of Complex Engineering Systems, LCCC**
- **Snail and Swift: Evolution and Ecology of Animal Mobility. A centre for Animal Movement Research at Lund University**
- **Thinking in Time: Cognition, Communication and learning**
- **Lund University Centre of Excellence for integration of social and natural dimensions of sustainability, Lucid**
- **Lund Centre for studies of Carbon Cycle and Climate Interaction, LUCCI**

With a closer look at the research activities of each environment and especially, their interactions with industry and society, there seems to be common areas of convergence, surrounding broadly on the themes of *health*, *energy* and *environment*. We identified a number of 'commercialisation' routes and different forms of organizing innovation activities, especially in the following three areas.

Engineering/physics/chemistry – **LCCC, LLC, NanoQE, NRC, OMM**

Medial/clinical – **LUDC, Hemato-Linné, Bagadilico**, **NRC**

Environmental - **Snail and Swift, LUCCI, Lucid**

All the Linnaeus environments are selected based on the quality of the research, not on any industrial or social impact of the research. [8] However, close examination of the activities of each centre reveals that there are a variety of industrial and social interactions taking place at most of the Linnaeus Centres. Individual senior researchers at the Linnaeus environments seem to have developed a number of different routes to make their 'Basic research' to 'Research-inspired Innovation'. This is done, for example, by interacting closely with their own spin-off firms, which provides opportunities for 'needs-driven/user-driven basic research' activities to be available in more applied contexts. However, given the wide range of areas of

[8] To a limited extent, dissemination of research and innovation was part of the evaluation process as found in the appendix of the Linnaeus application.

Linnaeus environments, it is obvious that what is meant by 'innovation', 'commercialization', 'knowledge transfer', 'relevance' and 'impact' differs hugely in each environment (even within each environment).

Knowledge transfer and commercialization take place through a variety of channels at different stages of research, not just at the end of research through research outcomes, but throughout the *whole* research processes. One of the interviewees pointed out that the availability of funding that allows an uncertain and risk-taking research is lower in Sweden compared to some other countries such as the USA. [9] In several interviews, special support needs were expressed in the early 'risky' phase of commercialization.

We would like to highlight some of the emerging mechanisms which act as *intermediaries* between internal (basic research/academic excellence) and external (industry and societal relevance) activities, bridging the gap between basic research and the market. We have identified two distinctive forms of interactions between university research and industry, drawing on the Quadrant of University-industry linkages:

A) *Mainstream/routine interactions* with industry and businesses: forms of interactions can be informal (both tacit and codified) in nature, sharing research knowledge and consultation, and other 'routine' interactions (e.g. sharing facilities, instruments, contract research, academic consulting). Mainly incremental problem solving.

B) *Research inspired Innovation* – new product development, sometimes through patenting and spin-offs. Innovation with a destructive nature.

For example, QuNano, a spin-off firm from *Nanoscience and Quantum Engineering* Linnaeus environment, is an exemplar of a *platform* for '*Research-inspired Innovations'*. It serves as an interface between the research unit and industry, and it acts as an intellectual property management and commercialization body of the academic research for wider industry interactions. There are also mechanisms being developed that connect 'basic research' to market opportunities by creating '*Mainstream/routine interactions*' with industry, through a specialized spin-off firm

[9] In the US, for example, the NIH Director's Pioneer Awards was established to encourage scientists to tackle major challenges in biomedical research using innovative approaches that have a high risk of failure but also the potential to produce monumental change.

acting as mediator between the research environment and the market in the form of consultancy. Colloidal Resource is an exemplar, a spin-off company set up by two former PhD graduates from Chemistry Department of Lund University. Colloidal Resource is a service company, finding commercial opportunities within the university and linking to external markets. Colloidal Resource now works with OMM, Linnaeus environment at Chemistry Department. Colloidal Resource and a scientist from OMM created and co-own a holding company called CR Development, and run a project "OncoPulse", with an aim of making a new technology available for diagnosing cancer.

'Research-inspired innovations' deriving from basic research at the university can be considered as a result of 'science' push. Researchers at an excellent research environment initially see an opportunity in the future research results in the academic field, driven by 'intrascience' needs. It is difficult for those outside the academia to have 'a demand' for such a research without knowing the research or without knowing the ways in which the technology or the finding can be applied. In some cases, however, a star scientist at excellence research environments act as an academic entrepreneur, and he or she moves between the scientific world and industry as 'a broker on the boundary'. A scientist can identify needs from industry and translate those needs directly into research in the forms of 'needs-driven research', which may lead to research-inspired innovation and/or 'mainstream/routine interactions'. Those scientists are typical 'boundary spanners' or 'knowledge mediators'. 'Research-inspired innovation' is an iterative process, sometime even creating '*innovation-inspired research*'. These processes are sometimes enhanced through patenting and spin-offs whereby knowledge then is made available widely for commercial application.

As already mentioned, Lund University has a technology transfer office, LU Innovation, and also a holding company called LUAB for financial support for university spin-off firms. It is interesting to note that our interview results show that in general, university researchers have varying degrees of interactions with LU Innovation and other innovation support organizations locally available in Lund. In many cases, the extent of interactions with LU Innovation seems to be rather limited. Many of the interviewees pointed out that the current system is very confusing and complicated with too many actors providing different innovation service provisions,

while the University is in the process of developing clearer innovation strategies. One of the ways for LU Innovation to reach larger number of researchers at Lund University would be through collaborating with such intermediaries. For instance, QuNano has worked closely with LU Innovation and LUAB.

When commercialization structures are available close to the daily scientific activities, sometimes through spin-off firms from the research environments, as the cases of QuNano and CR Development show, it is easier for researchers to make use of those intermediary organisations, which exist as 'brokers on the boundaries' closer to their scientific arena, compared to cooperating with central commercialization support unit, that are more distanced from their daily research activities. Another Linnaeus environment is creating an intermediary body for commercialization with support from public funding. The sustainability of these organizations is a critical issue when public support comes to an end. Further analysis of the nature, resources and organizational strategies of these intermediary bodies and investigation of their linkages to the research environment, the market, industrial partners and the university central unit needs to be conducted.

5. Conclusions and Discussions

There is a general acceptance that university entrepreneurship is the product of a wide variety of variables, including both exogenous factors (e.g. socio-economic climates and industrial changes, legal frameworks) and endogenous factors including internal transformations within the university and other bottom-up organizational and management changes. However, empirical studies tend to focus on one group of variables or determinants of university entrepreneurship – for instance, intellectual property regimes or the strategies of TTOs – in isolation from others and few attempt is made to bring together these diverse literatures into a coherent theory of organisational transformation and adaptation at the university (Volley and Nells, 2008).

Based on the conceptual discussions and the framework of 'quadrant of university-industry linkages', we identified variety of routes between 'basic research' and the market, and some of the possible conditions for 'entrepreneurial intermediaries' to emerge as *bridges*, whereby scientists both within and outside the university create their own 'platforms' to mediate and commercialise their knowledge through 'boundary spanning activity'. These cases offer insights to policy makers and

university managers on the specific impact of these organizational mechanisms and potentially represent good practices.

The study presented in this paper also makes theoretical contribution in terms of the analysis of organisational transformation and strategies and issues concerning governance of new organisational forms at multiple levels. The cases presented in this paper elucidate the emerging *multi-level actors* within the University which act as interface and catalyst for industrial linkages and commercialisation of research. At **research environment level**, there are emerging bodies of intermediaries/interface organizations which connect research groups with potential users and exploitation partners in industry and society. These would constitute 'interdisciplinary platforms' for sharing experiences and practices, inter-disciplinary problem solving and joint interactions with external organizations. There is also a development at the level of **the central university support unit**. In terms of institutional management, mutual dialogue and recognition of *complementality* rather than competition between activities at different levels must be ensured.

Vinnova/VR Pilot Projects programme have supported some new organizational enabling mechanisms for linking basic research to 'research-inspired' innovation, including support for new IPR provisions. Such mechanisms may enhance both top-down and bottom-up initiatives, strategically combining research environments' own initiatives with the centralized institutional support from LU Innovation (and other local innovation support mechanisms). These institutional support infrastructure and enabling mechanisms, combined with other form of knowledge and people flows between academic and industry, would help create the 'whole circular process' from basic research to innovation, and back to research, linking basic research with needs and demands of industry and wider society. Several interviewees pointed out that a mechanism to build up a sound patent strategy is missing in the current university research system. Some interviewees commented on the current 'teacher' exemption' in Sweden as a main reason for this, and some expressed positive points, while other expressed negative consequences due to insufficient support at the institutional level. There are also constraints to organize a platform organization at the level of research environments and also at the university level, because of the conflicts with already existing individual interests and linkages concerning IPRs. We are not fully discussing these issues in this paper but it should be pointed out that the IPR ownership situation in Sweden conditions the current

individual and institutional practices and the organizational forms emerging at the university.

Governments and universities in many countries are actively experimenting with a diverse range of policy instruments or strategies to strengthen research activities and capture more effectively the benefits of research to support economic and social needs (Harman, 2005). We echo the argument of Magnusson et al. (2008) that 'holistic approaches' are needed to examine the processes of commercialization, looking at individuals, organizational features, culture and the external environment together rather than emulating a limited aspects of commercialisation of a few 'successful cases'. Furthermore, the current recognition of the limitation of centralized management of technology transfer and IPRs at universities in other national contexts as found in the US, UK and Japan may imply that lessons may be learnt from the current policy instruments and organizational strategies being developing in Sweden.

Swedish research landscape is in the middle of transition with the introduction of new Strategic Research Areas. The meaning, contexts, and strategies of 'excellent' 'strong research environments' are also in the state of influx. Knowledge exchanges and transfer from Linnaeus environments needs to be located in a wider and changing context of Swedish research landscapes, as well as wider international policy learning and knowledge transfer. A further investigation is needed to understand what is meant by excellence, creativity and relevance in academic research, and identify models of funding for science (e.g. Heinze 2008) and knowledge transfer/exchanges.

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