

Subtheme: 8.4. National and international student/academic technology transfer and mobility programs for continuing professional development

Triple Helix networking during PhD education: a study of mobility and attitudes towards commercialization of research

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Keywords: PhD education; commercialization of research; mobility; networking; academic entrepreneurship

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1. Introduction

The concept of entrepreneurial university was introduced in the early 1990s, and since then, interest in how higher education institutions contribute to wealth and economic growth has steadily grown (Cowen 1991; Clark 1998; Klofsten and Jones-Evans 2000; Gibb and Hannon 2006). Over time, presence of a university promotes knowledge-based development in a region. Studies have shown that this occurs as a result of numerous processes, such as commercialisation of research results (CRR) and regional access to highly educated entrepreneurially oriented individuals (Saxenian 1994; and Etzkowitz and Klofsten 2005). The positive effects on the labour market are one of the prime reasons behind the rise of numerous initiatives that foster entrepreneurial activities in academic institutions. Examples include programmes that encourage spin-off firms (Gartner 1988; Shane 2004) and projects that promote university and regional business collaboration (Bergek and Norrman 2008; Klofsten et al. 2010).

PhD education constitutes a substantial share of many universities' activities, and much university research is in the hands of PhD students. Networking during the PhD education is thus crucial to the promotion of knowledge-based regional development through Triple Helix interactions. For this reason, a university's entrepreneurial orientation and its ability to contribute to knowledge-based regional development cannot be assessed without an understanding of the PhD education process. Yet, few studies explore the network-building activities of PhD students or university support of academic entrepreneurship.

The following study investigates PhD education and the university support base for academic entrepreneurship and network-building activities defined as mobility towards external organisations. In particular, this paper analyses which factors influence PhD students' attitudes toward and willingness for commercialisation of research results (hereafter called CRR). Of particular interest are the relations between mobility during PhD education and the students' opinions.

The paper is structured as follows: Section 2 presents a theoretical background of academic entrepreneurship, networks, and mobility. Section 3 discusses previous studies of network-building activities during PhD education. Section 4 describes methods and data, and Section 5, results and analysis. Conclusions and implications are discussed in Section 6.

2. Toward the entrepreneurial university

In the last 10 years, universities have become increasingly active in regional economic and social development. Entrepreneurial universities provide research resources and highly skilled human capital, interact with industry and external organizations in general, and support knowledge and technology transfer (Clark 1998). Etzkowitz & Klofsten (2005) describe the evolution of an entrepreneurial university in three general steps.

The university first defines a strategic direction for integrating the knowledge developed within the university into the surrounding society. Such sub-strategy forms a natural part of the university's overall strategy. Various outreach activities that are not formally recognized by university administration often precede this first step.

In the second step, the university initiates organizational mechanisms for promoting technology transfer and firm formation, for example, technology transfer offices or incubators. Another aspect is the introduction of training programmes in entrepreneurship and innovation into the university curriculum.

In the final step, the university institutionalises its entrepreneurial strategy by creating formal university roles and decision-making mechanisms for the intermediating functions concerned with implementation of its strategy. Examples of such formalization are establishment of an Innovation Office, holding companies, and a Vice President of External Affairs. New organizational formats, for example, can include interdisciplinary centres for facilitating interactions between theory and practice.

In the university environment, various groups of individuals are capable of acting entrepreneurially: the academic staff, the general staff, PhD students, and master and undergraduate students. Connecting these individuals with the necessary entrepreneurial resources is one of the challenges on the path to becoming an entrepreneurial university

Access to networks is a critical resource. Social relations are important for many types of economic behaviour, such as change of career path, exchange of information, and sharing of tangible resources (Granovetter 1974; 1985). Likewise, in times of uncertainty, entrepreneurial activities depend on personal networks as sources of needed knowledge, employees, or capital (Aldrich et al. 1987; Liebeskind et al. 1996; Zellner and Fornahl 2002; Shane and Cable 2002). Networks also provide

interaction with entrepreneurs, who serve as sources of inspiration and “mental models”—examples of entrepreneurial behaviours, attributes, and experiences that other network members can observe, learn from, and strive to emulate (Fornahl 2003; Colyvas and Powell 2007). However, involving actors from the academic and industrial worlds together in networks and collaborations can be a difficult proposition due to the considerable differences between university norms and industrial modes of operation (Dasgupta and David 1994; Klofsten and Jones-Evans 2000; Fisher and Atkinson-Grosjean 2002; Mosey et al. 2006).

Mobility of individuals during initial network formation could be deemed essential since it is a prerequisite for face-to-face meetings and interaction (Urry 2002; Bienkowska et al. 2011). In Urry’s words (2002; p. 265), “mobility in general is central to glueing social networks together” and “connections derived from co-presence can generate relations of trust that enhance both social and economic inclusion”. Thus, mobility between academia and industry should be considered a necessary step for overcoming or preventing barriers founded on distrust.

3. An international overview of network-building activities during PhD education

Since PhD students undergo a process of socialization during their PhD education (Boden et al. 2011) and comprise the recruitment pool for future academic staff, university support of their network-building activities in areas such as collaboration and mobility can be especially important. One must keep in mind, however, that mobility and external links to industry carry inherent risks of, for example, delaying publication of research results and causing tensions within the university (Harman 1999, Bond & Paterson 2005).

Various approaches are used to stimulate PhD-student mobility among universities and industry. For instance, the Prince of Wales Scholarship Programme (POWIS) sponsors doctoral research, which firms in Wales, UK, host (University of Wales Global Academy 2011). The Chinese government initiated a Graduate Students Joint Training (GSJT) programme in 2007, which funds PhD students’ mobility to universities abroad during their dissertation work. Ten percent of the Chinese PhD population (5,000 PhD students) is enrolled in the GSJT (Li 2010). In Sweden, the AgoraLink programme promotes national and international PhD student mobility

between industry and other universities and research organisations (Bienkowska & Klofsten 2009).

The literature is sparse concerning analyses of network-building activities that focus on collaboration and mobility during the doctoral education. In her study of Australian PhD students, Harman (2002; 2004) compared candidates attached to Cooperative Research Centres (which link research with industry and promote commercialisation skills) with other candidates. Harman found that CRR-related PhD education was more common in disciplines such as engineering, science, and medicine than in social sciences, the arts & humanities, and educational sciences. But regardless of discipline, most of the PhD students surveyed—CRR-related and non-CRR-related—stated that the idea of being involved in industrial research as a candidate was appealing. CRC-related PhD students reported higher levels of satisfaction with their course experience, were more inclined to agree that their departments were very good in their fields, and had more contact with their supervisors than non-CRR-related students. CRR-related PhD students were also more optimistic about their career prospects (Harman 2002).

In France, university–industry links have been proliferating since the mid-1990s as a result of various government initiatives to improve PhD education (Paul and Perret 2001). Industrial PhD positions—usually in science and technology but sometimes in the arts & humanities or social sciences—are partially or totally funded by industry itself.

The Kyvik et al. (1999) study on international mobility of Scandinavian PhD students between research organisations concludes that new research contacts are made, international publishing is more frequent, and thesis work improves as a result of time spent abroad. Disadvantages include thesis work delays and poor contact with professors at visited organisations. Overall, benefits generally outweighed the drawbacks; but regardless, few Scandinavian PhD students appear to be taking the opportunity to study or work abroad during their PhD education (Kyvik et al. 1999).

Avveduto's study (2001) on international mobility of Italian PhD students also concludes that stays abroad are most often positive experiences. Internships in other countries build competence as well as flexibility through immersion in new scientific and cultural environments. Nevertheless, only 28 percent of the Italian PhD students had studied or worked abroad as part of their doctoral education, due usually to insufficient funding (Avveduto 2001).

These studies illustrate that initiatives to promote mobility and Triple Helix networking are growing in importance in many places all over the world. Network-building activities involve interaction with a new context - culturally and institutionally - and promotion of flexibility in assumptions and other mental processes. Possible obstacles to networking and mobility during PhD education that previous studies have identified include for example lack of time, funding, and internal support.

However, previous studies are often focused on fractions of all possible mobility and networking activities. In this paper we present a broad dataset encompassing various types of mobility linked to individual factors e.g. previous self employment and contextual factors e.g. faculty affiliation. Thus we offer an analysis of PhD education embedded in a Triple Helix environment, as well as adding to the literature on academic entrepreneurship.

4. Methods and data

The study population comprised all current PhD students at Linköping University, Linköping, Sweden. In April 2010, all PhD candidates at the university (1126 persons) received instructions for participating in a web-based questionnaire; 464 (41%) responded.

The questionnaire contained four sections. General background, section 1, comprised information on the respondent's age, gender, nationality, place of birth, geographical mobility, and experiences from entrepreneurship, working life, and voluntary organisations. Section 2 contained items on the respondent's opinions of CRR. A scale similar to a 7-point Likert scale surveyed views on combining research and commercialisation and general entrepreneurial intent. The seven possible responses were 1 – “completely disagree”, 2 – “mostly disagree”, 3 – “slightly disagree”, 4 – “undecided”, 5 – “slightly agree”, 6 – “mostly agree”, and 7 – “completely agree”.

Section 3 queried respondents on their views of university support of commercialisation activities. Participants responded on scales with the same seven responses as in Section 2. Section 4 items concerned collaborations with external actors and professional mobility during PhD education. Analysis of data was performed in IBM SPSS, where an index of PhD students' commercialization interest

and willingness was compiled. The index was then used as a dependent variable in linear regression models.

5. Results

The survey shows that almost two thirds of the PhD students are interested in varying degrees in issues concerning CRR while one fourth of the students are uninterested. Varying levels of the university hierarchy have been graded by the respondents on the basis of their supportiveness towards CRR efforts (see table 1). The university at central administration level is perceived as supportive towards CRR by one fourth of the respondents. However, the majority of PhD students (68 %) are undecided on this issue which means that for many it is unclear where central administration stands. Concerning supportiveness towards CRR in the relation between PhD student and supervisor almost half (41 %) of the respondents indicate that they perceive their supervisor as supportive, with one sixth of the PhD students stating that their supervisor is unsupportive.

Table 1. *PhD students' perceptions of university context supportiveness towards researchers' possibilities to CRR.*

	Central admin.	Faculty	Department	Division	Research group	Supervisor
Supportive towards CRR	123 (27%)	114 (25%)	118 (26%)	132 (29%)	171 (38%)	186 (41%)
Undecided	310 (68%)	296 (65%)	288 (63%)	262 (57%)	210 (46%)	203 (44%)
Unsupportive towards CRR	25 (5%)	48 (10%)	52 (11%)	63 (14%)	75 (16%)	69 (15%)

Concerning mobility and networking it was found that one quarter of doctoral students have spent time outside the university as a part of their PhD education. Furthermore, the majority of PhD students do collaborate with organisations outside their home university. Cooperation with firms and other universities is more frequent at the faculty of Science & Engineering whereas PhD students from the other faculties are more associated with public organisations.

In table 2 we present the results of a multiple linear regression where several variables have been tested for their correlation with a CRR index. The index is comprised of three variables graded by the respondents, i.e. interest in CRR; willingness to commercialize idea within one's research area; and willingness to commercialize idea outside one's research area.

Table 2. *PhD students' interest in and willingness to CRR.*

Independent variables	Unstandardized Coefficients		Stand. Coefficients	Significance
	B	Std. Err.	Beta	
(Constant)	9,826	1,259		,000
Male gender (dummy)	-,009	,388	-,001	,982
Years of completed PhD education	-,031	,119	-,012	,795
Health Sci. Faculty (dummy)	,680	,525	,081	,196
Sci. & Eng. Faculty (dummy)	1,403	,548	,175	,011
Edu. Sci. Faculty (dummy)	-,002	1,012	,000	,998
Research Group's supportiveness of entrepr.	,287	,240	,102	,231
Supervisor's supportiveness of entrepr.	,114	,228	,042	,617
Self Employment (dummy)	2,367	,539	,204	,000
Work Experience (> 1 year)	,891	,745	,100	,233
Work Experience (< 1 year)	,461	,811	,047	,570
Mobility to other univ. during PhD edu.	,080	,523	,007	,879
Mobility to public org. during PhD edu.	,352	,858	,019	,682
Mobility to firms during PhD edu.	1,595	,741	,099	,032
European origin, non-Swedish (dummy)	-,555	,585	-,044	,343
Non-European origin (dummy)	1,727	,555	,147	,002

Dependent Variable: CRR index = interest in CRR; willingness to commercialize idea within research area; willingness to commercialize idea outside research area
 $R^2 = 14.6\%$; $\text{Adjusted } R^2 = 11.6\%$; $F\text{-test} = 4.879$; $N = 443$

The results show that PhD students that have experience from self employment have significantly higher CRR index ($p < 0,001$) when compared to students without this experience. This is to be expected as these individuals have already been involved in entrepreneurial activities, and therefore the step to CRR activities is not considered a huge one. Furthermore, PhD students from countries outside Europe (of which 81 percent are from Asia, 14 percent from Africa and 5 percent from the Americas) score significantly higher on CRR index ($p < 0,01$) than students with Swedish origin and European non-Swedish origin. A possible interpretation of this correlation could be the self-selection process of becoming a PhD student in a foreign country far away from one's home country. These individuals have most certainly a combination of both resources and abilities to spot and take advantage of opportunities in a different educational environment which could be labelled as an entrepreneurial behaviour. This in turn could help explain their higher interest and willingness for CRR.

PhD students from the Faculty of Science and Engineering have significantly higher CRR index ($p < 0,05$) than those from other faculties (i.e. Arts & Sciences,

Health Sciences and Educational Sciences). This could be explained by a similar self-selection process as described above where entrepreneurially oriented students more often choose to become a PhD student within the Faculty of Science and Engineering, both based on subject and relations with industry and other organisations outside the university. Simultaneously, the educational processes at the different faculties could be a contributing factor to the results we observe, e.g. how much the students come in contact with examples of CRR activities.

Experience of mobility to firms during PhD education is correlated to higher CRR index ($p < 0,05$) than both non-mobility and mobility to other universities and public organisations. It is notable that mobility per se is not correlated to CRR index; rather it is the specific mobility towards firms that is linked to higher interest and willingness to CRR. Here it is also probable that the PhD students with higher initial interest in entrepreneurship pursue the path of mobility to firms, while this also possibly boosts their CRR interest and willingness.

Moreover, the results show that other variables in the model such as gender, previous work experience and supervisors' supportiveness of CRR were not significantly correlated with CRR index ($p > 0,05$).

6. Conclusions and policy recommendations

This study has focused on an analysis of which factors influence PhD students' attitudes towards CRR. To measure this we have constructed a CRR index which is a combination of three survey questions addressing interest in CRR in general, as well as willingness to commercialize ideas both within and outside one's research area. The literature review showed that comprehensive studies dealing with PhD education, CRR and mobility are rare, although there are several previous studies on specific PhD programs. Furthermore, mobility has previously been treated separately from commercialisation aspects. The relevance of this paper is also underlined by the fact that PhD students present a large group of research staff at universities today and perform a large portion of all research. Focusing on this category of research staff is motivated by their specific working conditions, e.g. a substantial part of their working time is devoted for research; their work is performed within a temporary educational program with a clear start and end. Most PhD students are also young (average age of

respondents in this study is 28 years) and in the beginning of their professional career, hence being susceptible to new ideas and change.

On the basis of our empirical findings three major conclusions can be drawn. Firstly, the majority of PhD students are undecided concerning the supportiveness of CRR from various levels of the university context. This finding gives rise to new questions dealing with e.g. the efficiency of university policies and activities. In other words, how can the university reach the PhD students concerning CRR issues? In terms of policy recommendations we propose that there is a need for greater correspondence between activities, information and policies regarding commercialisation, some of which should be targeted towards the entire PhD student population.

Secondly, we observed that individual variables (i.e. experience from self employment and country of origin) were most significantly correlated to the CRR index. These results are in line with the mainstream entrepreneurship research, which puts large emphasis on the skills and entrepreneurial behaviour of the individual when explaining entrepreneurial processes including opportunity recognition and exploitation (Kirzner 1973, Venkataraman 1997). From a policy point of view universities should consider active recruitment of students internationally, both on Master and PhD level. Potential barriers to international mobility of students should be identified and lowered as much as possible. Entrepreneurial orientation, e.g. previous self employment, might also be incorporated as an important part of the criteria when recruiting PhD students.

Thirdly, this study shows that Faculty of Science and Engineering as well as mobility to firms are related to higher scores on the CRR index. It can be concluded that PhD students from the other faculties, i.e. Arts and Sciences, Health Sciences and Educational Sciences, have lower interest and willingness to CRR. This poses a challenge when it comes to involving all parts of the university when stimulating entrepreneurial behaviour. It is important to take into consideration the varying traditions and cultures within different disciplines and therefore use differentiated approaches when reaching out with CRR-related activities. For example, publishing of books which is a type of commercial selling of products could be used when discussing CRR within the Humanities, while provision of testing and calibration facilities resonates well with disciplines such as Biology and Chemistry (Klofsten and Jones-Evans, 2000). Mobility and collaboration are important mechanisms for

creating and consolidating networks, as well as stimulating entrepreneurial behaviour. Specifically, our results suggest that mobility to firms should be encouraged and developed into a suitable part of PhD education as it broadens perspectives and opens up for new opportunities. Nevertheless, it is crucial not to enforce it against existing disciplinary traditions. Mobility and collaboration can be implemented in smaller scale PhD programmes, for example through courses, graduate schools or interactive research design. PhD students involved in such programmes could serve as inspiration and role models for new and prospective PhD students, while at the same time strengthening the ties between academia and other parts of the society. Over time, such ties could stimulate recognition of opportunity in a broad sense as well as encouraging various types of entrepreneurial behaviour.

Concerning future studies of the entrepreneurial university it is crucial to investigate further the careers and motivations of individuals within the university context. We see a need for international comparisons between universities concerning CRR interest and willingness among PhD students as well as senior researchers. Valuable comparisons could be made between universities with respect to historical trajectories and strategic orientation. It would also be interesting to study both similarities and differences between PhD students and their senior colleagues when it comes to attitudes towards CRR as well as perceived supportiveness from the various levels of the university.

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