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University professors and research commercialization: An empirical test of the "knowledge corridor" thesis

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Abstract

There has been an increasing interest in the determinants and outcomes of successful technology transfer and commercialization of research results. In this study we test the validity of the "knowledge corridor" thesis for explaining the involvement of university professors' in the early stages of research commercialization. Statistical analysis on a sample of 86 respondents from engineering, natural science and medical faculties in a large Swedish university shows that both entrepreneurial and private industry experience significantly influence their ability to spot and generate business ideas in their research. Moreover, we find that research based business idea generation increase at a faster rate for professors with private sector work experience who have more time for research in their positions. The article ends with a discussion of our empirical findings together with its implications for support activities related to technology transfer and commercialization of research results.

Keywords: academic entrepreneurship, knowledge corridor, research commercialization.

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Summary

There has been an increasing interest in the determinants and outcomes of successful technology transfer and commercialization of research results. In this study we test the validity of the "knowledge corridor" thesis for explaining the involvement of university professors' in the early stages of research commercialization. Statistical analysis on a sample of 86 respondents from engineering, natural science and medical faculties in a large Swedish university shows that both entrepreneurial and private industry experience significantly influence their ability to spot and generate business ideas in their research. Moreover, we find that research based business idea generation increase at a faster rate for professors with private sector work experience who have more time for research in their positions. The article ends with a discussion of our empirical findings together with its implications for support activities related to technology transfer and commercialization of research results.

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Introduction and aim of study

The importance of university research in contributing to economic growth is today widely acknowledged in Western Europe (OECD, 2003a). This has among other things led to that universities nowadays not only are expected to function as providers of human capital but also as growth engines to boost regional and national economies (Rasmussen, Moen and Gulbrandsen, 2006). The high expectation on universities to support research commercialization is especially evident in engineering, natural science and medical faculties as empirical evidence demonstrate a high rate of growth oriented ventures originating from these sources (Shane, 2004; Wright, Clarysse, Mustar and Lockett, 2008). As such, our study leans on the acknowledgement of the importance of technology transfer and knowledge diffusion from universities to the private sector for long term economic growth in national economies (Link and Siegel, 2007).

Despite the increasing interest in gaining knowledge about how to support the transfer of university generated knowledge into the commercial domain there are surprisingly few studies that empirically examine the very early stages of research commercialization where the initial ideas for commercial exploitation are first identified and developed (Hindle and Yencken, 2004). Instead, the bulk of studies have examined the formation and growth of spin off companies (e.g., Mustar et al, 2006) which is post the decision to exploit a certain technology or research result. These studies are all of great merit as they have greatly contributed to our understanding of the later stage aspects of research commercialization. However, the early development and growth of a new venture centers on a business idea that must have been recognized and evaluated at some earlier point in time. As such, our knowledge of the very early stages of research commercialization is still scarce despite its relevance for both theory and practice.

In this article we aim to contribute to the emerging stream of research that have started to explore entrepreneurial activities in the pre-commercialization phase of university generated knowledge (e.g., Hindle and Yencken, 2004; Lubango & Pouris, 2007; Bercovitz and Feldman, 2008) by examining how prior entrepreneurial and private sector work experience influence university professors' ability to spot and seize potential business ideas in their research. As our theoretical point of departure we lean on research and literature that argue for a "knowledge corridor" in relation to the discovery of opportunities and business ideas. The knowledge corridor thesis suggests that each enterprising individual's idiosyncratic prior knowledge set them down a journey down a corridor where new windows of opportunity eventually will open up around them (Ronstadt, 1988; Venkataraman, 1997). The explanation is that exposure to certain kinds of life and work experience triggers an entrepreneurial conjecture and channel individuals into different knowledge corridors which influence their ability to spot and seize new business ideas and profit opportunities (Corbett, 2002).

We develop and test our hypotheses on a sample of university professors from engineering, natural science and medical faculties in a large Swedish university. University professors can in this respect be considered as key persons in the transfer of technology and research-based know-how from university settings to private enterprise. Not only do they have deep expert knowledge in their specific scientific fields combined with a developed network of valuable contacts (van Rijnsoever, Hessels and Vanderberg, 2008), but they have also reached the highest academic position which may provide them with incentives to extend their influence beyond traditional campus activities like research and teaching (Baldwin and Blackburn, 1981).

An important point of departure for our study is past policy debates concerning the need to increase industry-science relationships by supporting inter-sectorial mobility of experienced researchers (SPRU, 2000; Hauknes and Ekeland, 2002; OECD, 2002). The focus in these debates has however almost one-sidedly been on how industry may develop their R&D capacity through the flow of skilled personnel from the university sector to industry. This has left the issue of how personnel from the private sector to the university may influence technology transfer and commercialization of research results within academia largely unexplored. Our understanding of the effects of private sector work experience on public research commercialization is thus still in its infancy, something which we believe limits academic debate about the topic and hence call for further scholarly inquiry.

The rest of this article is organized into three sections. In the next section, we start with a literature review that cover issues related to technology transfer and commercialization of research results. In this section we also develop our hypotheses based on the knowledge corridor thesis. Then follows the method section were we present the sample and the variables used in the study. Thereafter we present a section with the analysis and results of the test of our hypotheses. The article ends with a discussion of our empirical findings and its implications for support activities related to technology transfer and commercialization of research results.

Literature review and hypotheses development

Increased globalization and reduced basic funding are among the major changes that have influenced the emergence of a new "entrepreneurial" role of universities (Leslie and Slaughter, 1997, Burton, 1998). From a stance where most academic scientists and research universities traditionally have abstained from commercialising research this situation is

consequently now changing (Etzkowitz, 2003: 115). Universities are hence nowadays generally seen as potential contributors of innovation, job creation and technical change through university-industry collaborations and through their support of new knowledge-intensive start-ups (Chrisman, Hynes and Frasier, 1995; Etzkowitz and Leyesdorf, 2000; Rasmussen, Moen and Gulbrandsen, 2006). As a result of these changes, universities are increasingly taking technology transfer and commercialization of research results as a part of their explicit mission due to pressures on universities to contribute to economic development and opportunities to gain personal wealth.

Technology transfer and research commercialization

Technology transfer can occur either in an indirect or direct manner. Indirectly, research results can be applied and used in the commercial sector without formal contractual agreements between the university and users. Examples include the traditional tasks of universities in providing research-based education and publishing research results in scientific journals. However, university generated knowledge can also be transferred to the commercial arena in a more direct manner which encompasses activities outside of the normal university duties of basic research and teaching (Klofsten and Jones-Evans, 2000). Generally framed under the broad concept of "academic entrepreneurship", such activities include external teaching to individuals or organizations outside the university, consulting to solve specific problems, commercial sales of products developed within the university, and licensing of patents developed within the university. As such, compared to research-based education and publishing research results these latter activities are more deliberate attempts to increase individual or institutional profit, influence or prestige through the development, marketing and commercialization of research-based ideas or products (Louis et al., 1989).

Commercial exploitation of research results centers on a business idea that must have been recognized or discovered at some earlier point in time. Thus, commercialization cannot take place without prior discovery. This view is consistent with conceptual and empirical work in the entrepreneurship field where the entrepreneurial process start with the perception of opportunities for recombining resources on the market that someone believes will yield profit (e.g., Bhave, 1994; Ardichvili, Cardozo and Ray, 2003; Klofsten, 2005). However, despite the interest in increasing the transfer of university generated knowledge from academia to industry there is up to date little theory informing the processes whereby the initial ideas for research commercialization emerge. Instead, most studies have examined research commercialization *post* the decision to exploit an opportunity thus leaving the organizing processes leading up to the identification of a new potential business idea largely unexplored (Hindle and Yencken, 2004; Vohora, Wright and Lockett, 2004). To meet this observed gap in the literature it is the generation of research based business ideas that is the main focus in our study.

University professors and research commercialization

University generated knowledge is not automatically transferred into the commercial domain and the main carriers of this knowledge in the very early phases of research commercialization are academics who are directly involved in its actual production. The high level of tacit knowledge inspiring research based business idea generation often entails that such novel insights initially are subjectively constituted and created in the minds of people (Hindle and Yencken, 2004). University professors are in this respect an important group of academics for the generation of business ideas that can be developed and commercially exploited. First, they have a deep understanding of the technology underlying their research which makes them better in absorbing new knowledge and combining concepts within their

particular field of expertise (e.g., Cohen and Levinthal, 1990), something which may also stimulating the generation of novel business ideas. Second, their academic career has provided them with opportunities to build up a network of contacts and relationships which may be used as a viable platform for venturing activities (Lee and Bozeman, 2005; van Rijnsoever et al., 2008). Third, by reaching the highest academic position they have come to a career turning point where they may seek to diversify their career activities and seek influence and recognition in arenas outside the university (Baldwin and Blackburn, 1981). Hence, it seems reasonable to suggest that university professors can be seen as key persons in the early stages of the process where research results are transformed into ideas for new or improved products, services or production processes.

Research based idea generation and the knowledge corridor thesis

A key starting point for understanding technology transfer and commercialization of research results is to examine the initial discovery or generation of potential research based business ideas. However, in order to spot and seize viable opportunities for potential commercial exploitation individuals need to have a predisposition towards being alert to signals of commercial potential (Gaglio and Katz, 2001; Kirzner, 1973). Research within the entrepreneurship field suggests that this ability to some extent can be explained by an individual's idiosyncratic prior knowledge (Shane, 2000), the so called knowledge corridor thesis (Ronstadt, 1988). The knowledge corridor refers to that the mere act of being involved in entrepreneurial activities enables the identification of additional ideas for new business that an individual could neither see, nor take advantage of until they engaged in this process. The explanation is that entrepreneurial experience seems to favor the development of a cognitive framework which makes individuals more alert to signals of commercial opportunities in their environment (Corbett, 2002; Baron, 2006). This cognitive frame can then generate ideas for

new means-ends relationships as well as support assessments of the potential benefit in a perceived opportunity. As such, an experientially acquired knowledge corridor enables individuals to make sense of commercial opportunities in order to generate new business ideas (Venkataraman, 1997; Parks, 2005). Consequently, if applied to academic settings, it seems fair to argue that prior entrepreneurial experience can be expected to impact the mindset and knowledge base of university professors which in turn influence their ability to generate and discover potential research based business ideas.

Arguments from the knowledge corridor thesis are well in line with an emerging stream of research that suggests that exposure to diverse life and work experiences, particularly experience from customers and markets, play a prominent role in explaining successful opportunity discovery (Shane, 2000; Politis, 2005;). In fact, this wider interpretation of the knowledge corridor thesis may be highly relevant for application in academic settings as it suggests that private sector work experience from commercial environments can influence the ability to spot and seize opportunities and ideas for research commercialization (Lubango & Pouris, 2007). Academics researchers rarely have commercially oriented networks and they also have relatively little contact with non-technical people (Clarysse and Moray, 2004). Experience from commercial environments can thus play an important role in connecting various important "dots" of information, knowledge and resources (Baron, 2006). Tacit knowledge and experiential insights about customers needs and how markets work could then help professors to receive positive recommendations and commercial evaluation at the right places, which in turn may favor their own perception of commercial potential and business ideas based on their research (Shane, 2000).

An obvious prerequisite for the ability to generate research based business ideas is that professors have enough time for research in their positions. A reasonable expectation may thus be that the more time for research the greater the likelihood of generating more research based business ideas. However, we conjecture that the time for research has a moderating effect on the relationship between prior entrepreneurial and private sector work experience and research based idea generation. The argument behind this conjecture is that we can expect that the research carried out by professors with entrepreneurial experience and greater private sector experience to a larger extent is triggered by observable problems in industry, sometimes perhaps even in response to the need to solve specific problems in interaction with industry partners (Burnside and Witkin, 2008). There may consequently in such cases be a notion – even if it is initially vague – of how to meet or fulfill a market need (see for example the case described in Klofsten, 2005:101). Moreover, the different pieces or particles of knowledge underlying research based business ideas are often a combination of both tacit (i.e., wholly or partly inexplicable) knowledge gained from practical work experience and explicit (i.e., codified) knowledge gained from analysis and abstraction. Research based idea generation can thus be seen as the result of a continuous interaction of these two main types of human knowledge (Nonaka and Takeuchi, 1995), which in turn may lead to the creation of knowledge and beliefs about new ways to serve customers and markets (Shane, 2000). In all, professors with more time for research in their positions can thus be expected to enhance the positive effect of prior entrepreneurial and private sector work experience on research based idea generation.

Formulation of hypotheses

In formal terms, the theoretical discussion above based on the knowledge corridor thesis suggests that both entrepreneurial and private industry experience significantly influence the

ability of university professors to spot and seize business ideas in their research. Moreover, we expect that the time for research in university professors' positions will moderate the relationship between prior entrepreneurial and/or private sector work experience and the number of research based business ideas. The number of research based business ideas will increase with prior entrepreneurial experience and/or private sector work experience but at a faster rate for those with more time for research in their positions. In sum, our theoretical expectations can be expressed as follows:

Hypothesis 1: University professors who have prior entrepreneurial experience will report a higher number of research based business ideas.

Hypothesis 2: University professors who have private sector work experience will report a higher number of research based business ideas.

Hypothesis 3: The effect of prior entrepreneurial experience on the number of reported research based business ideas will be enhanced with increasing time for research in their positions.

Hypothesis 4: The effect of private sector work experience on the reported number of research based business ideas will be enhanced with increasing time for research in their positions.

Method

Research approach and context of study

This study was undertaken in Sweden, which is a small country but with a highly educated workforce and a relatively large higher education sector. Sweden often ranks highly according to indicators used in the OECD. For example, according to official statistics Sweden devotes about 1.5% of GDP to higher education and research, half of which goes

towards research and doctoral programs. Sweden has in total about fifty higher education establishments where twenty-one of these have university status with the right to award doctoral degrees (Swedish National Agency for Higher Education, 2008). Only three of the universities are privately owned while the others are state owned. We focused our study to one university to control for different university policies aimed at research commercialization (Rasmussen et al., 2006). The choice fell on Lund University as it is one of the leading universities in Europe when it comes to the quality of research in areas such as medicine, science and technology. Moreover, the size and structure of the university offers the opportunity to get a satisfactory sample size with respect to the number of university professors working in these different faculties. In total, the university involves about 38 000 students and 5200 employees, including 2 700 postgraduate students and 560 full professors. The research carried out at Lund University is strong compared to other Swedish universities. Lund University receives the largest income for R&D activities, both from the state and other sources, compared to all higher educational institutions in Sweden. About half of the research conducted at Lund University is state funded while the rest of it is grant funded. Only a very small fraction is industry sponsored research.

Questionnaire design

To meet the aim of the study and test the hypotheses developed in the literature review we designed the empirical study as a questionnaire survey. The measures used in the questionnaire was derived from a careful review of previous theoretical and empirical work on academic entrepreneurship and public sector research commercialization (e.g., Louis et al., 1989; Bird, Hayward and Allen, 1993; Chrisman et al., 1995; Lee, 1996; Klofsten and Jones-Evans, 2000). The questions were pilot tested on a group of academics and based on this feedback the questions were honed and clarified for the final research instrument.

Variables and measures

Our dependent variable was gauged with a count measure based on how many number of research based business ideas the professors have had the last year. Due to a skewed distribution within the data the variable was transformed using a logarithmic transformation before put in the analysis. We are aware of the potential critique against our measure of the dependent variable. However, we have a few arguments that speak in favour of our choice. First, we believe that a self-reported measure of recognized research based business ideas is appropriate as we are not interested in the objective viability or potential of an idea but rather the respondents' subjective alertness towards the perceived commercial potential in their research. Second, we acknowledge that our count measure is biased towards the quantity rather than the quality of business idea. However, in line with arguments in McGrath and Macmillan (2000) we posit that there is a value in generating more rather than less business ideas. For example, in a larger pool of potential business ideas there is greater likelihood that one or some of them can develop into a viable business concept. Third, to control for the risk that reported business ideas are not followed by any interest or willingness to develop and pursue some of these ideas, we correlated it against potential gestation activities undertaken by the respondents. Items measuring gestation activities were taken from Reynolds (1997). In all, our tests show that our dependent variable is positively and significantly associated with a range of gestation activities, at $p < .01$. These activities include respondents seriously thinking about a business, making investments of their own money in the business idea, organizing a team with the intent to further explore the business idea, writing a business plan, seeking financial support, developing a business model, and applying for a patent (see APPENDIX for a detailed list of all gestation activities). In all, given these controls and reasons stated above we think that our measure is satisfactory given the aim and purpose of this study.

The measurement of our independent variables was following Klofsten and Jones-Evans (2000). Entrepreneurial experience was measured as a dichotomous variable, indicating if the respondent had previous experience from starting or owning a small business (0= no, 1= yes). Private sector work experience was measured as the respondent's total number of years of previous industrial/manufacturing experience. The moderator variable used to create interaction variables was the professors' time for research in their positions. This variable was measured as the professors' amount of time for research calculated in per cent of their total work time.

In addition, we include four control variables in our analysis. First, we control for faculty belonging since researchers affiliated with faculties where industrial contract research is encouraged are more favorably disposed to personal involvement in commercialization activities (Campbell and Slaughter, 1995). Engineering faculties are in this respect more likely to defend the applied research norm and see commercialization of research results as highly appropriate (Nora and Olivas, 1988; Lee, 1996). To control for this potential influence we used two dichotomous variables, indicating whether the respondent were belonging to the Science faculty or Medical faculty respectively (No = 0, Yes = 1). Engineering faculty belonging was used as the reference category and thus omitted from the analysis. Second, we control for the age of the respondent. Age may in this respect be a proxy for the accumulated "wisdom" gained during a career, which in turn might influence creativity and opportunity spotting (Shearring, 1992). Third, we control for the gender of the respondents as research indicates that entrepreneurship is a gender biased activity (Minitti, Bygrave and Autio, 2005). This variable was measured as a dichotomous variable, indicating if the respondent was a man or a woman (woman = 0, man = 1). Fourth, we included a control variable measuring whether

the respondents had taken their PhD education in the UK or the US. The rationale behind this control was that academics with experience from contexts with institutional arrangements that support research commercialization, such as UK or the US, may themselves be more prone to engage in such activities (Bercovitz and Feldmann, 2008). This variable was measured as a dichotomous variable, indicating if so was the case (No = 0, Yes = 1).

Sample characteristics

Our sampling frame consisted of full professors that belong to the faculties of medicine, engineering and science that we could find in the university's personnel register. This led to a total of 443 identified potential respondents. Of these, 164 were from the faculty of engineering, 105 were from the faculty of natural science and 174 were from the medical faculty. An invitation to participate in an electronic survey hosted on a Lund University web page was e-mailed to all potential respondents. E-mail addresses were collected from the web pages of the various institutions and checked against the university's personnel register. After two reminders we received a total of 101 responses, which is equal to an effective response rate of approximately 23.2 per cent. This response rate compares favorably to prior studies of entrepreneurship and research commercialization in academic environments (Louis et al., 1989; Bird et al, 1993). An overview of the responding professors is presented in Table 1 below.

Table 1 – Characteristics of the responding professors

	Total			Engineering faculty			Medical faculty			Science faculty		
	Mn-max	Mean	S.D.	Mn-max	Mean	S.D.	Mn-max	Mean	S.D.	Min-max	Mean	S.D.
Research based business ideas	0 - 20	2.0	3.08	0 - 20	2.5	3.7	0 - 3	.89	.94	0 - 15	2.09	3.0
Age	36 - 81	56.6	8.72	39 - 81	55.9	8.6	36 - 79	57,5	8.9	42 - 76	.56	8.8
Gender	0 - 1	.89	.31	0 - 1	.89	.32	0 - 1	.84	.37	0 - 1	1	0
Education abroad (US/UK)	0 - 1	.40	.49	0 - 1	.34	.48	0 - 1	.49	.51	0 - 1	.35	.49
Time for research	5 - 100	50.1	26.9	5 - 100	40.5	25.2	10 - 100	57.3	26.3	5 - 100	.58	.26
Entrepreneurial experience	0 - 1	.40	.49	0 - 1	.43	.50	0 - 1	.44	.50	0 - 1	.25	.44
Private sector work experience	0 - 26	3.2	6.23	0 - 26	5.2	7.7	0 - 25	2.17	5.07	0 - 4	.54	1.1

From the descriptive data in Table 1 it seems to argue that the average professor is a middle aged man, and this picture seems to be consistent across the different faculties. The mean age is 56.6 years and 89 percent of the respondents are men. Although the gender bias is evident in all faculties there is a relatively great span in age between the youngest and the oldest professor in the sample, ranging from 36 years to 81 years. Moreover, about 40 percent of the respondents have taken some or all of their PhD education in the US or the UK, something which reflect the high international profile of Lund University. The average time for research in position is 50.1 percent. But also here we can see that there is a relatively great span, ranging from 5 percent to 100 percent. Moreover, on comparison the medical faculty and the science faculty have professors with higher time for research in their position than the engineering faculty.

What may be interesting to note in Table 1 is that as high as about 40 percent of the responding professors have entrepreneurial experience from starting up or owning a small business. The percentage is slightly higher in the engineering and medical faculties (43 and 44 percent respectively) while the science faculty is considerably lower (25 percent). Many of these businesses should probably be interpreted as "convenience" firms that are used to channel external income earned through activities such as consulting or commercial selling of books (Klofsten and Jones-Evans, 2000). However, this does not mean that these businesses are of little or no value for the aim and purpose of this study since they all constitute an act of organizational creation which has the potential to trigger further entrepreneurial activities.

Another thing that can be noticed in Table 1 is the relatively low average of private industry work experience among the responding professors, with an average across all faculties of 3.2 years. Professors in the engineering faculty have the highest average (5.2 years), followed by

the medical faculty (2.17 years), and finally ending with the lowest in the science faculty (0.54 years). Although the average private industry work experience is relatively low, this can probably be explained by the fact that successful promotion to professor requires significant investments which in turn may leave little time for excursions in private industry, for example writing scientific papers, running large scale research projects, supervising PhD students, and building an academic network. The relatively low average of private industry work experience among the responding professors indicate a relatively low level of inter-sectorial mobility in Sweden, at least from industry to the university sector.

We conducted a series of chi-square and t-tests to assess whether the results from the sample could be generalized to the initial population of respondents with regard to gender and faculty representation. In these analyses we found a slight under-representation of respondents from the Medical and Science faculties. The differences were however minor and at closer look not likely to distort results to any large extent. In all, the non-response analyses lead us to conclude that there were no major significant response biases in the sample between respondents and non-respondents.

Analysis and results

Given that we have metric dependent variables and several metric or dichotomous independent variables we used linear multiple regression analysis for testing our hypotheses (Hair et al., 1998). Before introducing the variables in the regression models we carefully examined the data to detect problems of multicollinearity. All correlations between independent variables were below .70, and all VIF factors were also below the threshold levels suggested by Hair, Anderson, Tatham and Black (1998). This led us to suggest that

there are no problems of multicollinearity in our data. A description of the variables used in the analysis (correlations, means and standard deviations) is displayed in Table 2.

Before making the analyses we carefully examined the data with respect to missing and uncompleted information. This examination led to that we ended up with a final sample of 86 cases with complete and accurate data for the variables of interest in our study. We are aware of the risk that smaller sample sizes can make statistical tests insensitive to real differences. Due to this we selected the .10 level as our overall threshold of significance in our analyses to avoid ignoring potentially important real differences.

Table 2 - Correlations, means and standard deviations

		Variables										
		1.	2.	3.	4.	5.	6.	7.	8.	9.	Mean	Std.dev
1.	Research based business idea generation	1.00	-	-	-	-	-	-	-	-	.82	.69
2.	Science faculty	-.23*	1.00	-	-	-	-	-	-	-	.20	.40
3.	Medical faculty	.04	-.38**	1.00	-	-	-	-	-	-	.37	.48
4.	Age	-.11	-.03	.09	1.00	-	-	-	-	-	56.6	8,7
5.	Gender	-.02	.17*	-.13	.13	1.00	-	-	-	-	.89	.31
6.	Foreign education	.12	.01	.07	-.04	.00	1.00	-	-	-	50.1	26.9
7.	Percentage of research	.07	.15+	.20*	-.11	-.03	.05	1.00	-	-	.40	.49
8.	Entrepreneurial experience	.17+	-.15+	.07	.08	-.07	-.09	-.06	1.00	-	.40	.49
9.	Private sector work experience	.25*	-.22*	-.12	.30**	-.11	-.01	-.11	.19*	1.00	3.1	6.2

+ p < .10, * p < .05, ** p < .01

We have hypotheses of both independent effects (H1-H2) and interaction effects (H3-H4). An interaction effect exists if the interaction term gives a contribution over and above the independent effects model (Aiken and West, 1991; Cohen and Cohen, 1983). Therefore we introduced the variables stepwise to monitor the separate effects of our independent and interaction variables. First we entered the control, independent and moderator variables (step I). Thereafter we included the interaction variables (step II). The results from the regression analysis are presented in Table 3 below.

Table 3 - Regression analysis: research based business idea generation

STEP		Model 1	Model 2
I	Science faculty (control)	-.17	-.17
	Medical faculty (control)	-.05	-.10
	Age (control)	-.24*	-.19+
	Gender (control)	.07	.00
	Foreign education (control)	-.01	.03
	Percentage of research (moderator)	.21+	.18+
	Entrepreneurial experience (H1)	.18+	.20+
	Private sector work experience (H2)	.32**	.27*
II	Entrepreneurial experience x percentage of research (H3)	-	-.06
	Private sector work experience x percentage of research (H4)	-	.29*
	R2	.22	.29
	ΔR2	-	.07**
	F (F-sign)	2.46*	2.66**

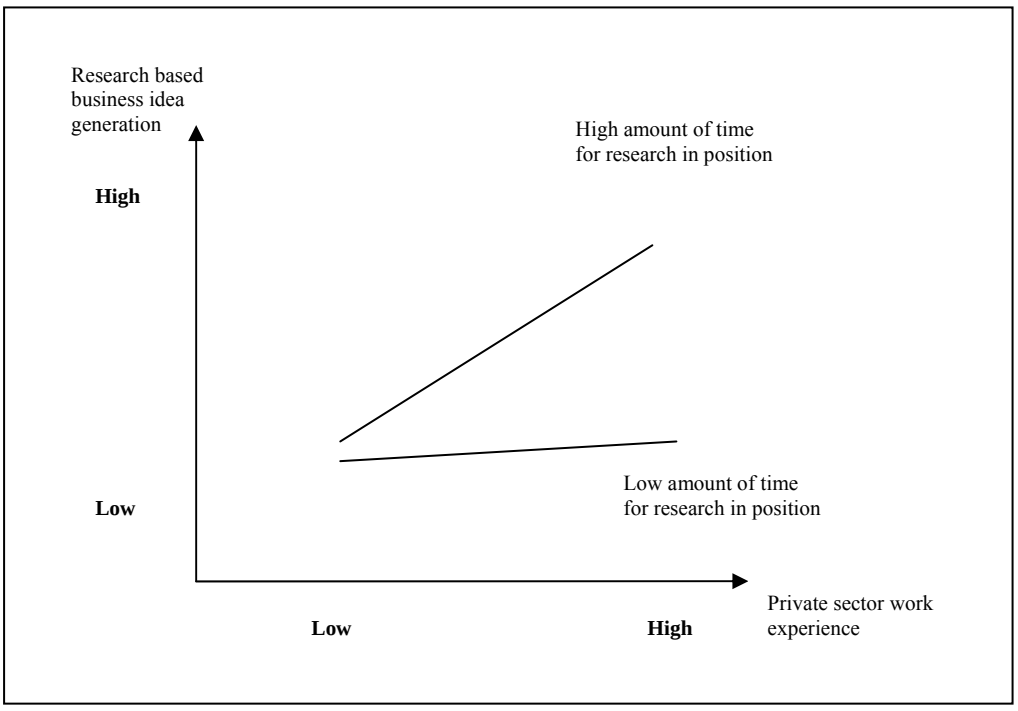
The table reports partial standardized coefficients (Beta), R-square and significance level + < .10 * < .05, ** < .01

The independent effects model is reported as step I in table 3. Here we can observe that the regression models are significant, at $p < .05$ and $p < .01$ respectively. When it comes to hypothesis 1 and hypothesis 2 we can see that both these hypotheses are supported in model 1, although at different levels of significance. The positive association between prior entrepreneurial experience and a greater amount of research based business idea generation support H1 with a significant level of $p < .10$. In a similar vein, the positive association between private sector work experience and a greater amount of research based business idea generation support H2 with a significant level of $p < .01$.

The full model including interaction effects is reported as step II in table 3. As can be seen, the explained variance (R^2) increases from .22 to .29 and the increase is statistically significant at $p <.01$, which suggests an interaction effect. At a closer look we can see that the interaction term for prior entrepreneurial experience in combination with increased time for research does not show any significant association. Instead, it is the interaction term for private sector work experience that in combination with increased time for research that shows a strong and positive association with research based idea generation. As such,

although we did not find any support for hypothesis 3, the findings support the expectation underlying hypothesis 4 suggesting that more time for research in university professors' position moderates the relationship between private sector work experience and research based idea generation. To further examine the nature of the observed interaction effect we followed the procedures outlined by Aiken and West (1991) by calculating the high and low points for each of the variables (plus and minus one standard deviation from their mean) and then crossing these levels to graph the interaction. The results are shown in Figure 1 below.

Figure 1 – Interaction of time for research in position and private sector work experience on the number of research based business ideas



Research based business idea generation is in Figure 1 above graphed with two lines. The upper line represents professors with a high amount of time for research in their positions and the lower line represents professors with a low amount of time for research in their positions. As can be seen, the time for research in their positions has a large interaction effect on research based business idea generation within the context of private sector work experience.

As such, professors who have high private sector work experience have a significantly higher research based idea generation if they also have a high amount of time for research in their positions.

Discussion

The European academic sector is relatively strong in terms of research expenditures and scientific papers (OECD, 2003b). However, there is an apparent discrepancy between the top-level scientific output and the exploitation of university generated knowledge that can give rise to new product and technology cycles, something that at times has been called a European paradox (Tijssen and van Wijk, 1999). This has attracted the attention of policy makers and, as a response, European universities have now to an increasing extent started to adopt and implement formal policies and strategies with the aim to support faculty members' involvement in industrially relevant research and technology commercialization (Wright et al., 2008). Technology transfer and commercialization of academic research, however, does not emerge and form spontaneously in response to formal policies and strategies but take place in response to the initial perceptions and activities of researchers who believe that their results may be commercially viable. Simply stated, a university - like any enterprise - will only be entrepreneurial if the people in it are behaving and acting like entrepreneurs. In response to this observation, we have in this study examined the validity of the knowledge corridor thesis (Ronstadt, 1988; Venkataraman, 1997) in academic environments by analysing the influence of prior entrepreneurial and private sector experience on university professors' involvement in the very early stages of research commercialization. The result shows that both prior entrepreneurial experience and private industry experience significantly influence professors' ability to spot and generate business ideas based on their research. Moreover, we find support that the number of research based business ideas increase at a faster rate for

professors with private sector work experience who also have more time for research in their positions. We will discuss these findings below in relation to their implications for theory and practice.

Implications for theory and research on academic entrepreneurship

Activities aimed at research commercialization centers on an idea or a belief that must have been created and evaluated at some earlier point in time and thus, from a theoretical point of view, research commercialization cannot take place without prior business idea generation. We believe our focus on initial business idea generation is an important addition to contemporary theory and research on academic entrepreneurship since all new economic activity initially starts as ideas for new business (Hindle and Yencken, 2004). As such, our findings contribute to the small but growing body of knowledge informing about entrepreneurial activities in the pre-commercialization phase of university generated knowledge (e.g., Bird, et al., 1993; Hindle and Yencken, 2004; Bercovitz and Feldman, 2008). Moreover, although previous research has examined individual characteristics and personal attributes among university scholars the issue of work experience from outside the academic sector has not been explicitly studied. This despite continuing debates about the need to support inter-sectorial mobility of experienced researchers between academia and private industry. We have in this respect provided novel empirical evidence showing how experience from the private sector may influence technology transfer and commercialization of research results within academia.

Our findings suggest that prior entrepreneurial experience have a positive and significant, but weak association with research based business idea generation. The findings support the expectations that the mere fact of being involved in entrepreneurial undertakings can channel

individuals into a distinct knowledge corridor that triggers further entrepreneurial conjectures (Ronstadt, 1988). Moreover, it was the influence of private sector experience on the number of research based business ideas that came out the strongest among our observed positive and significant associations. These findings suggest that professors with private sector experience play a potentially important role in initiatives aimed at technology transfer and early stage commercialization of research results. Furthermore, in line with our expectations we also find that the number of business ideas increase at a faster rate for professors with private sector work experience who also have more time for research in their positions. Among other things, this support our expectation that it is the interplay of tacit knowledge gained from practical work experience and explicit knowledge gained from analysis and abstraction that fuels research based idea generation.

Limitations and suggestions for further research

There may be some limitations in our research design that provide some interesting avenues for further research. First, we acknowledge that business ideas based on university generated scientific knowledge are far from the same as a viable and profitable commercial opportunity. For example, most inventions do not reach the market, and of those few who do only less than half of them become at least a moderate success (e.g., Åsterbo, 2003). A range of factors, from misjudgment to decreasing interest as the project evolves, can significantly hamper the commercialization process. Further studies of activities and organizing processes aimed at research commercialization in academic environments from initial perception of business ideas, through venture idea development and resource acquisition to new venture team formation will in this respect be a highly relevant avenue for further studies.

Moreover, some words of caution may be needed since we have not controlled for whether the professors in our sample are primarily conducting basic research or if they are moving along applied research trajectories. This may perhaps influence their ability to come up with and produce commercial applications (e.g., Calderini, Franzoni and Vezzulli, 2006) and thus it calls for further investigations of this issue. Adding to this, we do not know how increasing focus on business idea generation impact other more traditional measures of research productivity, for example whether there is a trade-off between publishing and engaging in research based idea generation and commercialization. It may thus be that professors with private sector experience use some or all of their time for research to search for potential business idea while neglecting their duty to publish. Although related studies find no trace of trade-offs between patenting and publishing (Breschi, Lissonio and Montobbio, 2008) we believe this question deserves much further attention before a conclusion can be reached.

Furthermore, the relatively weak association between prior entrepreneurial experience and research based business idea generation ($p < .10$) may warrant caution. We therefore call for carefulness before making broad generalizations across contexts based on this finding. The weak significance level may in this respect perhaps be explained by that we have used a relatively coarse measure of prior entrepreneurial experience, i.e., a dichotomous variable indicating if the respondent has had previous experience from starting or owning a small business or not. This may also be an explanation for why we could not find any evidence in support of hypothesis 3 arguing that the time for research has a moderating effect on the relationship between prior entrepreneurial work experience and research based idea generation. Future studies can address this potential shortcoming by using a metric variable measuring either the total number of start-ups that the respondent has been involved in (i.e., Dyke, Fischer and Reuber, 1992, Politis, 2008) or the number of years of self-employment

experience. Qualitative in-depth studies may also be needed to more closely examine the process of how prior entrepreneurial experience influence research based business idea generation in academic environments.

Implications for practice

Despite the above mentioned potential limitations we believe our findings provide some implications for practice. At the national level, our results seem to support current efforts aimed at promoting researchers' mobility. Especially, our results suggest that such programs should not only focus on the flow of skilled research personnel from the university sector to industry but should also encourage research personnel from the private sector to move to the university. The mobility rates of professors in and out of academia can in this respect be used as an indicator for the innovation potential in the economy as it can be assumed to reflect knowledge circulation and exchange that promote the generation and exploitation of research based business ideas. At the university level, our results suggest that commercialization of research results can be encouraged by avoiding only internal promotion without any experience from mobility in and out of the university sector. In line with our results, increasing mobility may then lead to increased awareness of business needs within academia and put an emphasis not only on academic puzzle solving but also on potential commercial application. At the individual level, our findings suggest that academics interested in technology transfer commercialization of research results can increase their generation of research based business ideas by being open to opportunities for spending time in the private sector to build an experiential knowledge base about the behavior of customers and markets. This experiential knowledge base can then be used to create and define problems or inefficiencies related to production, distribution etc., and to actively develop research-based ideas or products to solve them.

Conclusions

The main motivation for this study has been the limited scholarly knowledge of increased mobility of researchers between academic institutions and industry, and its effects on the generation of research based business ideas. In all, we find significant associations between both prior entrepreneurial and private sector work experience and research based business idea generation, the latter relationship being particularly strong. In addition we find that professors who have high private sector work experience have a significantly higher research based idea generation if they also have a high amount of time for research in their positions. These results are largely in favor of our theoretical expectations and consequently support the validity of the knowledge corridor thesis in academic environments, suggesting that when university professors' gain entrepreneurial and private sector experience this set them off a journey down a corridor where windows of opportunity will open up around them.

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APPENDIX:

Gestation activities (items taken from Reynolds, 1997)

Seriously thought about business **
Looked for facilities/equipment
Rented or leased facilities/equipment
Bought facilities/equipment
Initiated savings to invest
Invested own money in the firm **
Organized start-up team **
Written business plan **
Sought financial support **
License, patents, permits applied for **
Developed first model or prototype *
Received money from sales
Devoting full time to new business
Received financial support **
Created a new legal entity
Hired employees to work for wages *

*The asterisks (*) mark correlations between gestation activities and the dependent variable, significance level * < .05, ** < .01*

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