# Individual-level antecedents of spin-off involvement

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**ABSTRACT**

Much of the literature on academic entrepreneurship has focused on the level of national and regional innovation systems and the institutional role of entrepreneurial universities herein. Recently, more efforts have been done to complement the resulting higher-level insights with studies on individual-level dynamics. These studies about the "entrepreneurial scientist" often regard relations between entrepreneurial activities and scientific performance, and individual-level antecedents of entrepreneurship more generally. Individual-level research has shown that academics display different entrepreneurial profiles, depending on their selected range of activities and their strategies for combining these. This paper aims to get further insight into the variety of entrepreneurial activities and profiles. We investigate which factors drive involvement in spin off companies, and to what extent these antecedents differ from those that drive academic patenting. We especially consider the role of scientific productivity and the strategic approach towards valorization. Furthermore, mutual relations between spin offs, patenting and scientific performance are analyzed. A cross-sectional dataset is used of engineering professors from two universities (Catholic University of Leuven in Belgium and Politecnico di Milano in Italy). Survey data are combined to secondary source data on scientific and patenting outputs. The findings primarily reveal important interaction effects between spin offs, patenting and scientific performance.

**Keywords:** Entrepreneurial scientists, Knowledge and technology transfer, Spin offs.

## INTRODUCTION

The meanwhile worldwide phenomenon of academic entrepreneurship, whereby universities are becoming involved in industry-related and commercially-oriented activities, has since several decades figured high on the agenda of researchers and policy makers. Much of the literature on academic entrepreneurship focuses on the level of national and regional innovation systems and on the institutional-level roles played by entrepreneurial universities (Rothaermel et al., 2007). Recently, more efforts have been done to complement the resulting higher-level insights with research on individual-level dynamics. Studies about the “entrepreneurial scientist” often regard relations between entrepreneurial activities and scientific performance. More broadly, individual-level antecedents of entrepreneurship are investigated. Such studies are often framed within resource-based theories, whereby the considered resources are of several types (financial, human, cognitive,…).

Findings from individual-level research are advocating the importance of different entrepreneurial “profiles”. Academics select themselves into specific constellations of activities (with a baseline of scientific activities, combined to varying proportions of entrepreneurial activities: contract research, patenting and spin off development). Each activity profile requires adequate strategies for dealing with potential tensions and / or for creating leverage effects for optimal performance. This paper aims to get an insight in the specificity of profiles that include spin off involvement and into the dynamics of entrepreneurial behavior that characterize professors who are involved in spin off activity.

We start with overviewing the literature on academic entrepreneurship and more specifically individual-level antecedents that have been touched upon. We keep a special eye out for whether relations with spin off involvement have been uncovered and whether these differ from relations with other entrepreneurial activities like e.g. patenting. Hypotheses are then formulated about antecedents of spin off involvement, and they are tested on a cross-section of Belgian and Italian engineering professors. We conclude with a discussion on the specificities of spin off involvement and how it relates to other activities, mostly patenting and scientific outputs.

## BACKGROUND LITERATURE AND RESEARCH OBJECTIVE: ANTECEDENTS OF ENTREPRENEURIAL BEHAVIOR

Throughout the literature on academic entrepreneurship, several individual-level antecedents have been pointed out. At the same time, entrepreneurial activities differ in terms of the type of knowledge transferred, the degree of complexity and the risks implied (D’Este et al., 2009). the literature reveals a diversified picture of entrepreneurial profiles to be taken into account (Brennan et al., 2005; Callaert et al., 2008c; D’Este & Patel, 2007; Joly & Mangematin, 1996). As professors self-select into different constellations of entrepreneurial activities, characteristics of the average ‘academic inventor’ are likely to differ from those of the average ‘academic spin off creator’. D’Este el al. (2009) equate patenting with the ‘identification’ of entrepreneurial opportunities and spin off creation with the ‘exploitation’ of entrepreneurial opportunities. Previous empirical evidence indeed suggests that patenting, much more than spin offs, can be seen as a more ‘natural’ and spontaneous consequence or a “byproduct” of academic research (see Breschi et al., 2005; Callaert et al., 2008b,c). The activities and underlying skills that are implied by spin off involvement may hence be somewhat more detached from academic research, as they concern not only the transfer of knowledge but also the actual commercialization of products and services.

This paper aims at getting further insight into the variety of entrepreneurial activities and profiles. We investigate which factors drive involvement in spin off companies, and to what extent these antecedents differ from those that drive academic patenting. While controlling for researcher background characteristics (institution, age, field, size of research team), we consider the role of scientific productivity and the approach in collaborating with industry. Mutual relations between spin offs, patenting and scientific performance are analyzed.

In what follows, we build several hypotheses, based on a discussion of the most frequently mentioned antecedents and an overview of what has already been uncovered about their relation to entrepreneurial activities. To the extent available, we provide specific evidence on uncovered relations with spin off involvement, comparing it to findings about antecedents of patenting.

As stated earlier, much empirical evidence concerns the relation between scientific and entrepreneurial activity. Many studies have looked specifically into the effect of academic patenting on scientific publications. They bring no evidence of alleged crowding-out or secrecy effects that would be due to seeking intellectual property rights on research results. Rather than hampering publications, it even seems that patenting activities have a positive effect on scientific output (Azoulay et al., 2007; Breschi et al., 2005; Czarnitzki et al., 2007; Fabrizio & Di Minin, 2008; Meyer, 2006; Stephan et al., 2007; Van Looy et al., 2004, 2006). Such an effect is on the one hand due to a cross-sectional ability or 'star scientist' effect whereby the most productive researchers are more likely to be successful in developing patents. This is further supported in studies that find academic entrepreneurs to be the ones having received higher grades during their education (Azoulay et al., 2007; Landry et al., 2007). At the same time, longitudinal studies reveal that additional leverage effects stem from resources that are gained through involvement in patenting and licensing activities. These resources can be financial (as indicated by research that relates the types and the levels of funding to scientific productivity, see Carayol & Matt, 2004; Stephan, 1996; Van Looy et al., 2004), but include also access to networks of people from different communities of practice, the sharing of ideas and being in touch with practice, which allow for cognitive-type spillovers between patenting and basic research activities. Especially when one considers knowledge and technology transfer from a traditional science push perspective, it makes sense that those with more prolific research outputs are also the ones who are most likely to come up with transferrable knowledge / technology (at least within fields where the link between research and practice is not too distant, cf. infra). Less straightforward than the positive relation between patenting and scientific performance, is the relation between scientific performance and spin off involvement. Buenstorf (2009), studying outputs of Max Planck scientists, found no positive relation between spin off involvement and scientific productivity, and even found a negative effect in the long run. Lowe and Gonzalez-Brambila (2007; in Buenstorf, 2009) from their part did find a positive relation between spin off involvement and scientific performance. Analyzing a cross-section of researchers, they found that faculty members who are involved in spin offs are more prolific authors than their graduate school peers or co-authors. Moreover, in longitudinal analysis, the authors found that organizing a spin-off has positive effects on researchers' subsequent publication and citation records. We therefore propose the following hypothesis: as opposed to a positive relation between patenting and scientific performance, such a relation is not present between scientific performance and spin off involvement (Hypothesis 1).

Another set of relevant factors is related to experience with commercial / entrepreneurial activities, or (previous) contacts with the industry community. This has been measured through indicators like involvement in cooperative research contracts with firms and previous employment in industry settings, but also experience in patenting activities. The resulting linkages between researchers and research users, as well as close personal ties to industry, have come forward as important factors in academic entrepreneurship (Landry et al., 2007). Dietz and Bozeman (2005) found clear evidence of a relation between previous employment in industry and patenting. The relation between industry funding and academic patenting was also confirmed in this study, but appeared less outspoken. Breschi et al. (2005) and Gulbrandsen and Smeby (2005) provided clearer evidence of a positive relation between university-industry collaborative projects and academic patenting for Italian and Norwegian researchers respectively. As for the development of spin offs, Krabel & Mueller (2009) found that experience in research cooperation with private firms has a significantly positive effect on the propensity to start a business. They also found that scientists with patenting experience are 3.35 times more likely to be a nascent entrepreneur than scientists without any patenting experience. A number of earlier studies pointed out similar links between patenting and spin off creation (Louis et al., 1989; Shane, 2004; Stuart and Ding, 2006). Given the selection effect that is due to our data gathering (sample composition of professors who are involved industry-related activities), we cannot test for the explanatory power of a ‘collaborative research’ variable[1]. As for patenting and spin off involvement, we propose that these activities are positively related (Hypothesis 2).

In studying entrepreneurial researchers, the importance of individual-level factors (observable or unobservable) is well acknowledged. D’Este and Patel (2007), who found individual-level characteristics of researchers to have a stronger impact than departmental or university characteristics on the variety and the frequency of university-industry interactions among UK researchers. Individual profiles of entrepreneurship are defined by the choice of activities performed as well as the context in which researchers link up to the industry. They are – at least partly – a reflection of individual strategic approaches. Two individual-level factors have been considered in this study: the degree of proactivity versus reactivity and exploitation versus exploration. They are explained in the following paragraphs.

The distinction between proactive and reactive approaches is based on who initiates the university-firm interactions or who is the ‘prime mover’ in the valorization trajectory. In the proactive or research push scenario (see also Landry et al., 2007), the (academic) research leads to some result that is worth further development and valorization / commercialization. A proactive stance towards the development of applications appears to be a condition for getting things out on the market. Several avenues can be taken to do so. In its most extreme form, the academic researcher creates a spinoff to fully develop and commercialize the technology, getting it out on the market. In a less extreme form – and sometimes preceding the creation of a spinoff – the academic partner takes a patent and licenses it to industry partners (sometimes to the spinoff firm). The “industry pull” or reactive scenario on the other hand represents the more traditional contract research, whereby a firm solicits an academic researcher with an applied question. Hence, whereas traditional research contracts with firms would generally allow for a more reactive approach from the academic partner, we propose that proactiveness is required especially for spin offs, but also – be it less outspoken – for patenting (Hypothesis 3a).

Composition of the research agenda is another strategic element in academics’ entrepreneurial profiles. This has been shown in a qualitative study by Callaert et al. (2008), who found that selectivity in research topics is an important factor underlying success in entrepreneurial activities. Their findings suggest that selectivity matters even more in industry-pull (reactive) scenarios. Landry et al. (2007) also uncovered the relevance of research novelty pursued in the research agenda, especially within a pull perspective on knowledge and technology transfer. Hence, we contend that the novelty of research topics may be related for the entrepreneurial profile. In line with D’Este et al. (2009), who equated patenting with the identification of valorization opportunities and spin off creation with the exploitation of opportunities, we hypothesize that there is a positive relation between exploitation and spin off involvement. Patenting, on the other hand, is concerned with exploration rather than exploitation (Hypothesis 3b).

Finally, the following factors have been shown to influence academic productivity (scientific and/or entrepreneurial) and need to be controlled for.

First of all, some fields display a higher intensity of science-technology or research-practice interrelations. This can be due to the fact that some industrial sectors are more research intensive than others (a phenomenon which may also shift over the life span of a sector), as well as with the speed at which basic research can be translated into practical applications (Gittelman, 2008; Griliches, 1990; Verbeek et al., 2002). Entrepreneurial behavior or, more generally, knowledge and technology transfer, would be more prominent within fields like engineering and biomedical sciences (Argyres & Liebeskind, 1998; Arvantis et al., 2008; Heller and Eisenberg, 1998). As a consequence, most studies on academic entrepreneurship consider these fields rather than e.g. mathematics, astrophysics, or human and social sciences (see also Callaert et al., 2008a). Spin off activity might additionally be more pronounced in fields that are close to the industrial sectors present in the region.

Besides fields, the university / institutional setting is likely to play a role as well. The type of institute, its history and its mission define which activities and outputs are prioritized and incentivized (Azoulay et al,

[1] An alternative would be to use data on the volume of contract research (number of projects, budget). Although asked in the survey, there is a lack of data as many respondents provided no answer to these questions.

2007). Traditional universities would generally attribute higher value to publication output than to technological artifacts. Technical universities or engineering schools from their part would consider artifacts as core outputs. With patents being more directly related to artifacts than to publications, one could expect patent output to be higher in technical schools than in traditional universities. This was corroborated in a study of engineering researchers at the Catholic University of Leuven (a traditional university in Belgium) and at the Ecole Polytechnique Fédérale de Lausanne (an engineering school in Switzerland), where the latter were shown to have a patenting advantage over the former (Callaert et al, 2008b).

Finally, a significant age and seniority effect has been demonstrated on the scientific output of academic researchers (Mairesse & Turner, 2002; Stephan & Levin, 1992). Although findings about age and seniority effects on entrepreneurial behavior appear to be less uniform, there are sufficient indications for their effect. Career phase / seniority is controlled for because only full time professors have been included in the sample. Age is included as an additional control variable. Moreover, we include the size of the professor's research team as one can assume that the size of the research group is related to overall performance, not only in terms of scientific output but also entrepreneurial output.

## DATA

A cross-sectional dataset was created of autonomous engineering professors from two universities (70 professors from K.U.Leuven in Belgium, and 117 professors from Politecnico di Milano in Italy). Both universities opted for an entrepreneurial orientation and are characterized by similar regulations and attitudes towards managing knowledge and technology transfer. Survey data were used to get information regarding professors' entrepreneurial behavior and projects with industrial partners for the period from 2003 to 2007. These data were combined to secondary source data on scientific and patenting outputs, using the ISI Web of Science and the PATSTAT database respectively, for the period 1990-2008. Table 1 gives an overview of the variables used in the analyses.

**Table 1 - Summary of variables used**

| | Description | Source | Period |
|---|---|---|---|
| University (0/1) | K.U.Leuven (BE) = 0 or Politecnico di Milano (IT) = 1 | Sample | Time of survey |
| Age | Age in 2009 | Survey | |
| Field | **Subfields:**<br>- Aerospace<br>- Bioengineering<br>- Chem<br>- Civil & Environmental Engineering<br>- Electrical<br>- Energy<br>- Mechanical Engineering<br>- Physics, Astronomy & Computer science | Survey | Time of survey |
| Size of the research team | Number of researchers (including self, PhD students, postdocs, researcher assistants,…) | Survey | Yearly average of period 2003-2007 |
| Scientific productivity | Number of published articles | ISI Web of Science | Yearly average of period 1990-2008 |
| Number of PATSTAT patent applications in the period 1990-2008 | Number of EPO / USPTO patent applications (as inventor) | PATSTAT database | Application years 1990-2008 |
| Involvement in projects with firms (0/1) | Research collaborations directly funded by firms (no public involvement) | Survey | 2003-2007 |

| | | | |
|---|---|---|---|
| Involvement in Spin offs (0/1) | Involvement in the foundation of a firm based on the results of research activities | Survey | No restriction |
| Proactiveness in industry contacts | % of research collaborations with firms that were proposed (initial idea / contact) by the respondent professor or his research team (versus proposed by the firm partner) | Survey | 2003-2007 |
| Exploration (versus exploitation) | % of collaborative projects that involve new topics (as opposed to topics from the ongoing or previous research agenda) | Survey | 2003-2007 |

The following tables describe distributions of the variables used. When reading and interpreting data, it should be kept in mind that the sample of professors that are represented are the ones that filled in the survey about collaboration with industry. This selection effect implies that our sample does not represent the overall population of engineering professors at K.U.Leuven and Politecnico di Milano, but mainly the ones that collaborate with firms.

As shown in table 2, we distinguish between eight engineering subfields. Some represent only a minority and there are institutional differences in the constellation of subfields present in the two universities. For instance, at Politecnico di Milano, the majority are Electrical Engineers. In K.U.Leuven, most respondents are in Biology and Bioengineering.

**Table 2 - Sample breakdown**

| **ENGINEERING SUBFIELDS:** | **K.U.Leuven** | | **Politecnico di Milano** | |
|---|---|---|---|---|
| | ***N*** | ***%*** | ***N*** | ***%*** |
| Aerospace | 0 | 0 | 9 | 7,8 |
| BiOES (Biology and Bioengineering) | 18 | 25,7 | 3 | 2,6 |
| Chemistry (Chemical Engineering) | 11 | 15,7 | 14 | 12,1 |
| Civil and Environmental Engineering | 7 | 10,0 | 17 | 14,7 |
| Electrical engineering | 12 | 17,1 | 40 | 34,5 |
| Mechanical engineering | 10 | 14,3 | 15 | 12,9 |
| Energy | 0 | 0 | 18 | 15,5 |
| PAC (Physics, Astronomy and Computer Science) | 12 | 17,1 | 0 | 0 |
| *Total* | *70* | *100,0* | *116* | *100,0* |

Table 3 depicts frequencies of involvement in patenting and spin off activities. Both are binary variables (involvement or not) whereby the variable for involvement in patenting activity relates to the period 1990-2008 (see table 1). As far as patenting involvement is concerned, both institutes display similar profiles. The proportion of professors involved in patenting is comparable (31% and 37% for KUL and Milano respectively); and in both institutes, this probability increases for professors who are involved in spin offs (57% and 62% for KUL and Milano respectively). However, a clear institutional difference becomes visible for spin off involvement. At KUL, 40% of professors are involved in spin offs, compared to only 15% of Milano professors. These proportions become higher among the group of patenting professors. Such an 'advantage' is much more outspoken at K.U.Leuven: 75% of patenting professors are involved in spin offs, compared to 25% in Politecnico di Milano.

**Table 3 – Involvement in spin off and/or patenting activity**

| | | | |
|---|---|---|---|
| **OVERALL SAMPLE** | | | |
| | **No patents** | **Patents** | **Total** |
| **No spin offs** | 77 | 28 | 105 |
| **Spin offs** | 14 | 20 | 34 |
| **Total** | 91 | 48 | 139 |
| **KU LEUVEN** | | | |
| | **No patents** | **Patents** | **Total** |
| **No spin offs** | 27 | 4 | 31 |
| **Spin offs** | 9 | 12 | 21 |
| **Total** | 36 | 16 | 52 |
| **POLITECNICO DI MILANO** | | | |
| | **No patents** | **Patents** | **Total** |
| **No Spin offs** | 50 | 24 | 74 |
| **Spin offs** | 5 | 8 | 13 |
| **Total** | 55 | 32 | 87 |

Table 4 presents descriptive statistics of the other variables, broken down by institute. Several features become apparent. Professors at Politecnico di Milano are, on average, older than those at KULeuven. Research teams at KULeuven are considerably larger, and – perhaps partially related – scientific productivity is somewhat higher. Professors at Politecnico di Milano from their part have a higher patent output. On average, professors at KULeuven appear somewhat more proactive in their valorization approach, whereas professors at Politecnico di Milano appear slightly more prone to explore new research topics.

**Table 4 – Descriptive statistics**

| | | **N** | **Minimum** | **Maximum** | **Mean** | **Std. Deviation** |
|---|---|---|---|---|---|---|
| **Age** | ***KULeuven*** | 70 | 34 | 67 | 50,00 | 8,70 |
| | ***PoliMi*** | 115 | 39 | 75 | 57,49 | 9,11 |
| | ***Total sample*** | 185 | 34 | 75 | 54,65 | 9,65 |
| **Teamsize** | ***KULeuven*** | 70 | ,00 | 140 | 11,66 | 18,34 |
| | ***PoliMi*** | 116 | ,00 | 3 | 5,72 | 5,85 |
| | ***Total sample*** | 186 | ,00 | 140 | 7,96 | 12,45 |
| **Scientific productivity** | ***KULeuven*** | 70 | ,06 | 12 | 3,34 | 2,76 |
| | ***PoliMi*** | 116 | 0 | 7,89 | 1,77 | 1,83 |
| | ***Total sample*** | 186 | 0 | 12 | 2,36 | 2,35 |
| **Patent output** | ***KULeuven*** | 70 | 0 | 9 | ,94 | 2,24 |
| | ***PoliMi*** | 116 | 0 | 53 | 1,75 | 6,11 |
| | ***Total sample*** | 186 | 0 | 53 | 1,45 | 5,025 |
| **Proactiveness** | ***KULeuven*** | 54 | 0 | 100 | 45,35 | 31,29 |
| | ***PoliMi*** | 90 | 0 | 100 | 36,67 | 29,18 |
| | ***Total sample*** | 144 | 0 | 100 | 39,92 | 30,17 |
| **Newness** | ***KULeuven*** | 50 | 0 | 100 | 27,24 | 27,13 |
| | ***PoliMi*** | 83 | 0 | 100 | 30,41 | 23,06 |
| | ***Total sample*** | 133 | 0 | 100 | 29,22 | 24,62 |

## ANALYSES AND RESULTS

Binary logistic regressions are used for analyzing antecedents of spin off involvement and patenting involvement. Table 5a presents the basic models, including only main effects. In table 5b, potentially relevant interaction effects are included. Besides interactions with institutional variable, we include interaction effects for analyzing mutual relations between patenting, spin off involvement and scientific productivity. To create further insight into the revealed interaction effects, separate analyses for patenting and spin off subgroups are presented in table 5b as well.

**Table 5a – Antecedents of spin off involvement versus patenting (Binary Logistic Regressions) – only main effects**

| | | **SPIN OFFS (0/1)**<br>B<br>(Wald Chi²)<br>***Total sample*** | **PATENTING (0/1)**<br>B<br>Wald Chi²)<br>***Total sample*** |
|---|---|---|---|
| BACKGROUND CHARACTERISTICS | Intercept | -63,625<br>(0,00) | -51,837<br>(0,00) |
| | Univ (reference category: KUL) | 2,599**<br>(10,517) | -2,115**<br>(10,008) |
| | Field Dummies | *insignificant* | * |
| | Teamsize | ,035<br>(1,175) | -,005<br>(0,100) |
| | Age | ,052<br>(1,955) | -,026<br>(,690) |
| VALORIZATION APPROACH | Proactiveness | ,023*<br>(4,772) | ,015<br>(3,189) |
| | Research novelty | ,027<br>(2,860) | -,012<br>(1,274) |
| ACTIVITY PROFILE | Patents 0/1 | 1,597*<br>(6,278) | --- |
| | Spin off 0/1 | --- | 1,611**<br>(6,846) |
| | Scient prod (*log trans*) | -,770<br>(1,283) | ,976*<br>(3,670) |
| Number of observations | | 125 | 125 |
| Likelihood Ratio Chi Square | | 51,775** | 43,758** |

**, ** and indicate that the variable is significant at the 5% and 1% level, respectively*

**Table 5b – Antecedents of spin off involvement versus patenting (Binary Logistic Regressions) - including interaction effects**

| | | SPIN OFFS (0/1) | | | PATENTING (0/1) | | |
|---|---|---|---|---|---|---|---|
| | | B (Wald Chi²) | B (Wald Chi²) | B (Wald Chi²) | B Wald Chi²) | B (Wald Chi²) | B (Wald Chi²) |
| | | ***Total sample (1)*** | ***'Patent' subgroup (1a)*** | ***'No patent' subgroup (1b)*** | ***Total sample (2)*** | ***'Spin off' subgroup (2a)*** | ***'No spin off' Subgroup (2b)*** |
| BACKGROUND CHARACTERISTICS | Intercept | -65,187 (0,00) | -41,375 (0,00) | -51,984 (0,00) | -52,428 (0,00) | -29,519 (0,00) | -53,041 (0,00) |
| | Univ (reference category: KUL) | 1,314 (,337) | 2,439* (4,440) | 6,343* (5,846) | 1,987 (1,056) | 2,609 (1,763) | -2,556** (7,823) |
| | Field Dummies | *insignificant* | *Insignificant* | *insignificant* | ** | *insignificant* | * |
| | Teamsize | ,048 (2,216) | ,032 (,369) | ,066 (1,774) | -,022 (1,294) | -,038 (1,354) | ,054 (1,898) |
| | Age | ,021 (,245) | ,006 (,007) | ,014 (,054) | -,029 (,669) | -,093 (,758) | -,039 (1,039) |
| VALORIZATION APPROACH | Proactiveness | ,018 (2,643) | ,035* (4,546) | -,012 (,362) | ,013 (2,028) | ,049 (1,818) | ,005 (,275) |
| | Research novelty | -,014 (,670) | -,030 (1,139) | ,024 (,610) | -,002 (,033) | -,031 (,345) | -,008 (,461) |
| ACTIVITY PROFILE | Patents 0/1 | -4,059 (2,971) | --- | --- | --- | --- | --- |
| | Spin off 0/1 | --- | --- | --- | -4,072 (3,640) | --- | --- |
| | Scient prod (*log trans*) | 1,665 (1,416) | ,453 (,164) | -5,329* (5,298) | 2,825 * (4,711) | 3,745 * (4,337) | ,171 (,084) |
| INTERACTION EFFECTS | University * patents | 1,984 (1,042) | --- | --- | --- | --- | --- |
| | University * spin off | --- | --- | --- | ,302 (,037) | --- | --- |
| | University * scientific productivity | 1,197 (0,578) | --- | --- | 3,592* (6,307) | --- | --- |
| | Scient prod * patenting | 5,041** (6,772) | --- | --- | --- | --- | --- |
| | Scient prod * spin off | --- | --- | --- | 5,209** (9,268) | | |
| Number of observations | | 125 | 46 | 79 | 125 | 30 | 95 |
| Likelihood Ratio Chi Square | | 62,150** | 24,667** | 34,52** | 59,487** | 23,559** | 26,434* |

**, ** and indicate that the variable is significant at the 5% and 1% level, respectively*

In hypothesis 1, we proposed that scientific productivity would have a positive relation with patenting and no relation with spin off involvement. This is indeed confirmed in tables 5a and 5b (Models 1 and 2 respectively). At the same time, table 5b shows important interaction effects between patenting and spin offs on the one hand and scientific productivity on the other hand. As can be seen in Model 1 and 2 respectively (table 5b), these interaction effects with scientific performance seem to overrule the positive relations between patenting and spin off involvement that are revealed in table 5a, and that support our hypothesis 2. Further analysis of the interaction effects uncovered in table 5b reveals interesting results, which we will discuss next.

First, the significant interaction between patent involvement and scientific productivity in Model 1 reveals that scientific productivity is actually relevant for spin off involvement, but only when it is considered in combination with patent involvement. We look further into this interaction effect by considering antecedents of spin off involvement for patenting versus non-patenting professors separately (Models 1a and 1b respectively). The results show a significant negative relation between spin off involvement and scientific productivity, only for the subgroup of professors who have no patents (Model 1b). For those who have patents, such a trade off effect is not present.

Also for Model 2, besides the main positive effect of scientific productivity on patenting, there is a significant interaction term revealing that the relation between scientific productivity and patenting is at the same time dependent on spin off involvement. We therefore consider antecedents of patenting for two subgroups separately: professors involved in spinoffs (Model 2a) and professors not involved in spinoffs (Model 2b). The results show that the positive relation between patenting and scientific performance is significant only for professors who are at the same time involved in spin offs. For those who are only involved in patenting, without spin offs, such a leverage effect is not present.

Finally, the data provide little support for the relevance of strategic approaches like proactiveness and research novelty. None of both variables are related to patenting. A positive relation between proactiveness and spinoff involvement was uncovered in Table 5a. Table 5b shows that this effect is only significant among the subgroup of professors who are also involved in patenting (Model 1a). Research novelty (exploration versus exploitation) does not appear to be decisive as an antecedent of either patenting or spin off involvement. As such, these results provide little support for hypotheses 3a and 3b.

## DISCUSSION AND CONCLUSION

The starting point for our study was the presence of individual-level differences in entrepreneurial profiles and approaches. For a self-selected cross-section of engineering professors who are involved in valorization activities, we analyzed antecedents of involvement in spin off and patenting activity. We studied the relevance of strategic approaches towards valorization: proactiveness versus reactiveness and exploration of novel research versus exploitation of previous and ongoing research. The results reveal that, opposed to what was hypothesized, the strategic characteristics that we measured have no predictive power towards spin off or patenting involvement. In line with what Callaert et al. (2008c) and Landry et al. (2007) suggested, such strategic considerations may be especially relevant in more traditional research contracts with industry partners. Although this would be interesting to test, our current sample of professors has insufficient variation in terms of involvement in contract research.

According to our results, what matters mostly is the role of scientific productivity. As predicted in hypothesis 1, we find no main effect of scientific productivity on spin off involvement, whereas a positive effect on patenting is confirmed. At the same time, the observed interaction effects reveal interesting mutual relations between scientific productivity, patenting and spin off performance. First of all, the results suggest that the leveraging of scientific productivity through patenting activities is facilitated by spin off involvement. A possible explanation lies in the cognitive feedback loops that occur when a researcher is involved in patenting, whereby application (patenting) enhances understanding and further scientific insight (Callaert et al., 2008c). These feedback loops from application into understanding may be more pronounced for professors who are more closely involved in the application and further development of their patent, through active participation in a spin off company that exploits the development. On the other hand, our results show that spin off involvement can imply a trade off with scientific productivity, namely for professors who have no patents. A possible explanation for such an observation is that professors who are actively involved in a spin off company without having protected the intellectual property that lies at the base of the company activities, may be more careful in publishing too much information that could be picked up by industrial competitors. This ‘secrecy problem’ (as it has been referred to in the literature on academic entrepreneurship by e.g. Florida & Cohen, 1999) would affect only professors who are involved in spin offs without having protected their intellectual property. No such trade off was observed for professors who are involved in spin off companies but who have patents.

In summary, our findings reflect the following quadrant of relations with scientific performance (*including annual average number of publications for professors in each of the quadrants*):

| | | **Spin offs** | |
|---|---|---|---|
| | | **0** | **1** |
| **Patents** | **0** | ***Neutral effect on science*** *(2.50 pubs)* | ***Trade off effect on science*** *(1.48 pubs)* |
| | **1** | ***Neutral effect on science*** *(2.71 pubs)* | ***Leveraging effect on science*** *(3.39 pubs)* |

Although caution is warranted when drawing conclusions, these findings would plea for a ‘more-is-better’ tactic: the ones involved in both patenting ánd spin offs, are also scientifically the most productive ones, a finding which again provides support for ‘star scientist’ conceptualizations. At the same time, these findings urge for awareness of potential trade offs between spinoff involvement and scientific productivity, a risk that appears to be more pronounced for professors who are not patenting.

Finally, we acknowledge some limits of our study. Caution is warranted when drawing conclusions based solely on only these analyses. This is mostly due to three reasons; each of which represent interesting avenues for further research. First , as already mentioned, there is a selection effect implied by surveying professors who are actively involved in valorization and industry-related activities. Moving beyond this selection, the inclusion of more variation in terms of collaborative research contracts and networking with industry could further nuance the uncovered relations between scientific productivity and entrepreneurial profiles. Second, we acknowledge that our measurement of ‘strategic approaches towards valorization’ is rather basic. Broadening the operationalisation of this concept (e.g. by including patenting strategies: firm versus university assignee; the specific role of the professor in the spinoff; different types / volumes of contract research,…) may reveal more relevance of individual strategic profiles. Thirdly, the design is cross-sectional. It reveals inter-individual differences in entrepreneurial profiles, but it does not allow to capture any shifts in profiles over time. Furthermore, we considered only appointed professors. A longitudinal and career perspective, taking into account also younger researchers, could reveal interesting shifts in entrepreneurial profiles or behavior and antecedents over time. Overall, the more encompassing models that would be interesting for further research will in any case require a broader dataset with a larger number of professors, whereby a longitudinal dimension would open many further analytical opportunities. We hope that the current analysis inspires other scholars to engage in such efforts.

## REFERENCES


Argyres, N., Liebeskind, J. (1998). “Privatizing the intellectual commons: Universities and the commercialization of biotechnology research,” Journal of Economic Behavior and Organization, 35(4), 427–454.

Arvantis, S., Kubli, U., & Woerter, M. (2008), “University-industry knowledge and technology transfer in Switzerland: What university scientists think about co-operation with private enterprises.” Research Policy, 37, 1865-1883.

Azoulay, P., Ding, W., Stuart, T. E. (2007), “The determinants of faculty patenting behavior: Demographics or opportunities,” Journal of Economic Behavior and Organization, 63 (4), 599–623.

Brennan, M.C., Wall, A.P., & McGowan, P. (2005), “Academic entrepreneurship: Assessing preferences in nascent entrepreneurs,” Journal of Small Business and Enterprise Development, 12(3), 307-322.

Breschi, S., Lissoni, F., & Montobbio, F. (2005). “From publishing to patenting: Do productive scientists turn into academic inventors?” Revue d'économie industrielle,110, 75-102.

Callaert, J., Llerena, P., Van Looy, B., & Debackere, K. (2008a). “Harvesting the benefits from involvement in scientific and inventive activities: towards conditions.” Paper presented at the DRUID 25th Celebration Conference on ENTREPRENEURSHIP AND INNOVATION - ORGANIZATIONS, INSTITUTIONS, SYSTEMS AND REGIONS (Copenhagen, CBS, Denmark, June 17 - 20, 2008)

Callaert, J., Van Looy, B., Debackere, K., & Foray, D. (2008b). Revisiting the scientific advantage of academic inventors: Unraveling underlying knowledge dynamics. In George T. Solomon (Ed.), Proceedings of the Sixty-Sixth Annual Meeting of the Academy of Management (CD), ISSN 1543-8643.

Callaert, J., Van Looy, B., Foray, D., & Debackere, K. (2008c). “Combining the production and the valorization of academic research: A qualitative investigation of enacted mechanisms.” In: Mazza, C., Quattrone, P., & Riccaboni, A. (Eds.) European Universities in Transition: Issues, Models and Cases (Chapter 7). Edward Elgar Publishing.

Carayol, N., & Matt, M. (2004). Does research organization influence academic production? Laboratory Level Evidence from Large European University. Research Policy, 33(8), 1081–1102.

Czarnitzki, D., Glänzel, W., Hussinger, K. (2007), “Patent and publication activities of German professors: An empirical assessment of their co-activity,” Research Evaluation, 16(4), 311-319.

D’Este, P., & Patel, P. (2007), “University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry?” Research Policy, 36(9), 1295-1313.

Fabrizio, K. R., & DiMinin, A. (2008), “Commercializing the laboratory: Faculty patenting and the open science environment,” Research Policy, 37(5), 914-931.

Florida, R., & Cohen, W.M. (1999), “Engine or infrastructure? The university role in economic development,” in: L.M. Branscomb, F. Kodama, R. Florida (Eds.), Industrializing Knowledge: University-Industry Linkages in Japan and the United States. London: MIT Press, pp. 589-610.

Furman, J.L. & MacGarvie, M. (2009), “Academic collaboration and organizational innovation: The development of research capabilities in the US pharmaceutical industry, 1927-1946,” Industrial and Corporate Change, 18(5), 929-961.

Gittelman, M. (2008), “A note on the value of patents as indicators of innovation: Implications for management research,” Academy of Management Perspectives, 22(3), 21–27.

Griliches, Z. (1990), ""Patent statistics as economic indicators: A survey," Journal of Economic Literature, 28, 1661–1707.

Heller, M., & Eisenberg, R. (1998), "Can patents deter innovation? The anticommons in biomedical research," Science, 280 (5364), 698–701.

Joly, P.B., & Mangematin, V. (1996). "Profile of public laboratories, industrial partnerships, and organization of R&D: The dynamics of industrial relationships in a large research organization." Research Policy, 25, 901-922.

Landry, R., Amara, N., & Ouimet, M. (2007), "Determinants of knowledge transfer: Evidence from Canadian university researchers in natural sciences and engineering." Journal of Technology Transfer, 32, 561-592.

Louis, K. S., Blumenthal, D., Gluck, M.E., & Stoto, M.A. (1989), "Entrepreneurs in academe: An exploration of behaviors among life scientists," Administrative Science Quarterly, 34(1), 110–131.

Mairesse, J., & Turner, L., (2002). "A look at individual differences in scientific research productivity: An econometric analysis of the publications of the French CNRS physicists in condensed matter (1980–1997)." Proceedings of the conference rethinking science policy: Analytical frameworks for evidence-based policy (21-23 March), SPRU, Brighton (UK).

Meyer, M. (2006), 'Knowledge integrators or weak links? An exploratory comparison of patenting researchers with their non-inventing peers in nano-science and technology', Scientometrics, 68 (3), 545-560.

Shane, S. (2004). Academic Entrepreneurship: University Spinoffs and Wealth Creation, Cheltenham UK and Northampton, US: Edward Elgar.

Stephan, P. E. (1996). The economics of science. Journal of Economic Literature, 34(3), 1199–1235.

Stephan, P. E., Gurmu, S., Sumell, A. J., & Black, G. (2007), "Who's patenting in the university? Evidence from the survey of doctorate recipients," Economics of Innovation and New Technology, 16(2), 71–99.

Stephan, P. E., & Levin, S.G. (1992). Striking the Mother Lode in Science: The Importance of Age, Place, and Time. New York: Oxford University Press.

Stuart, T.E., Ding, W.W., 2006. The social structural determinants of academic entrepreneurship: an analysis of university scientists' participation in commercial ventures. American Journal of Sociology 112 (1), 97–144.

Van Looy, B., Ranga, M., Callaert, J., Debackere, K., Zimmermann, E. (2004). "Combining entrepreneurial and scientific performance in academia: Towards a compounded and reciprocal Matthew Effect?" Research Policy, 33, 425-441.

Van Looy, B., J. Callaert and K. Debackere (2006), 'Publication and patent behavior of academic researchers: Conflicting, reinforcing or merely co-existing?', Research Policy, 35 (4), 596-608.

Verbeek, A., Debackere, K., Luwel, M., & Andries, P. (2002). "Linking science to technology: Using bibliographic references in patents to build linkage schemes," Scientometrics, 54 (3), 399–420.