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Enterprising scientists: The shaping role of norms, experience and scientific productivity

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ABSTRACT

This paper studies the determinants of enterprising aspirations of university-based research scientists, using an approach which factors in individual and organizational characteristics. Specifically, we provide an understanding of the individual and departmental characteristics that affect the research scientist's aspirations to engage in patenting and licensing, industry-science interactions, and the establishment of start-up companies. Building on institutional theory and self-efficacy theory in combination with human capital theory, we find that start-up experience positively affects start-up aspirations, whereas patenting experience helps researchers to foster patenting and licensing aspirations. At the organizational level, we find that enterprising norms of the research department positively affect the aspirations to engage in both industry–science interactions and patenting activities but not start-up creation. Further, we find that scientific productivity positively moderates the relationship between industry experience and industry–science interaction aspirations, but negatively affects the relationship between patenting experience and patenting and licensing aspirations. Our findings have important implications for academics and practitioners, such as policy makers and technology transfer officers.

1. Introduction

Over the past decade, there has been an increasing emphasis on the generation of commercial outcomes from university-based research (Ambos et al., 2008). Universities have become more engaged in their so-called third mission, in which they engage in entrepreneurship and economic development, next to the traditional activities of research and teaching (Etzkowitz, 2003; Rasmussen et al., 2006; Wright et al., 2008). Subsequently, academic entrepreneurship has increasingly become a popular research area (Etzkowitz, 1998, 2003; Mowery et al., 2002; Shane, 2003; Wright et al., 2007; Rothaermel et al., 2007; Siegel et al., 2007; Larsen, 2011). Research on enterprising activities among academics has mainly focused on the university or local context by studying, among others, the productivity and effectiveness of technology commercialization (Owen-Smith and Powell, 2001, 2003), university strategies (Feldman et al., 2002), university incentives and licensing revenues (Siegel et al., 2003), university patenting activity (Coupe, 2003), firm linkages to universities (Cohen et al., 2002) and the creation and performance of university spin-offs (Link and Scott, 2005; Knockaert et al., 2011). What remains rather unexplored in the academic entrepreneurship literature is why some individual research scientists foster enterprising aspirations, while others do not.

Understanding enterprising and enterprising aspirations in an academic context is important as academic enterprises can stimulate economic activity, generate jobs, build ties between universities and industry (Prodan and Drnovsek, 2010), and

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provide additional sources of financing to universities (Siegel et al., 2007). Moreover, academia is a complex context in which research commercialization is difficult. At the heart of the problem is the inherent tension between academic and commercial demands (Hackett, 2001; West, 2008). Indeed, the third mission has to be integrated with traditional research and teaching activities (Van Looy et al., 2011) and as such, universities have to become ambidextrous organizations, at the same time striving for research excellence and promoting research commercialization (Tushman and O'Reilly, 1996; Birkinshaw and Gibson, 2004; Raisch and Birkinshaw, 2008). Whereas organizational ambidexterity has been achieved by universities through the establishment of technology transfer offices, a tension resides at the level of the individual, who has to engage in a range of activities simultaneously (Ambos et al., 2008).

A large stream of research has focused on understanding individual characteristics as determinants of entrepreneurial aspirations (Lüthje and Franke, 2003; Souitaris et al., 2007; Thompson, 2009; Lee et al., 2011). In academia, however, researchers are embedded in departments. Department norms can play crucial roles in determining the behaviors that are valued and consequently affect individual behaviors. We therefore contend that, in order to understand enterprising aspirations among research scientists, organizational norms should be considered alongside individual characteristics. Furthermore, we do not only focus on aspirations to start a business as the main commercialization route. Consistent with Wright et al. (2008), we include other important commercialization routes such as patenting and licensing, and industry-science interactions (including contract research and consulting). We assess individual and organizational factors which may drive the research scientist's aspirations to engage in these enterprising routes.

As such, our paper contributes to both entrepreneurship and technology transfer literatures.

First, it contributes to the entrepreneurship literature, which has mainly focused on start-up aspirations, by complementing these aspirations with other enterprising alternatives. It further adds to this stream of research by showing how enterprising aspirations are shaped by both individual and organizational determinants. As such, we provide more clarity to this body of work by showing that the stimulation of different types of aspirations requires different sets of individual and organizational characteristics.

Second, our research contributes to the technology transfer literature by indicating which type of enterprising aspirations *in academia* benefit from which individual or organizational factors. As such, we respond to the call by D'Este et al. (2012) for research on academics' willingness to engage in entrepreneurship to integrate organizational characteristics.

Finally, by studying the relationship between both sets of activities, our research adds to the ongoing debate on whether basic research and academic enterprising are complementary rather than competing activities (Larsen, 2011; Huang et al., 2011). Generally, our study finds that scientific productivity and past enterprising experience reinforce each other in predicting higher enterprising aspirations. Concretely, high levels of scientific productivity together with more industry working experience are related to higher levels of industry-science interaction aspirations. The picture is different for patenting for which the highest patenting and licensing aspirations are linked to researchers with higher levels of prior patenting experience but with lower scientific productivity. We reason that publishing, requiring public disclosure, can negatively affect patenting efforts, and that patenting and publishing activities may compete with one another for time and resources.

This article is structured as follows. In the next section, we introduce our conceptual framework and build hypotheses on how organizational and individual factors shape enterprising aspirations. We subsequently present our methodology, the results, and discuss the implications of our study for future research and practice.

2. Conceptual framework

We build upon institutional theory and self-efficacy theory, in combination with human capital theory, to study the determinants of research scientists' enterprising aspirations. We first develop hypotheses on the relationship between organizational characteristics and enterprising aspirations, followed by the hypothesis development on how individual characteristics can affect enterprising aspirations. Thereafter, we hypothesize about how scientific productivity affects the relationship between individual characteristics and enterprising aspirations.

2.1. The organizational perspective—the role of enterprising norms

North (1990) categorizes institutions as formal or informal. Scott (1995) groups institutions into regulative, normative and cognitive pillars, of which the two latter refer to informal institutions. According to Greenwood et al. (2008, p.4), informal institutions are "more-or-less taken for granted repetitive behavior that is underpinned by normative systems and cognitive understandings that give meaning to social exchange and thus enable self-producing social order". These informal institutions are typically tacit, cognitive and normative, taken-for-granted social rules that govern people's behavior. In other words they serve as "the rules of the game" and contribute to shaping human interaction (North, 1990, p. 3); and typically take the form of conventions, codes of conduct, and norms of behavior (Thornton et al., 2011). For instance, Hayek (1945: 528) notes that "we make constant use of formulas, symbols, and rules whose meaning we do not understand and through the use of which we avail ourselves of the assistance of knowledge which individually we do not possess. We have developed these practices and institutions by building upon habits and institutions which have proved successful in their own sphere and which have in turn become the foundation of the civilization we have built up." Tsoukas (1996) extends Hayek's understanding of distributed knowledge in society to the firm, understood as an organization, and equates Hayek's notion of institutions with the routines in firms. These routines typically take the form of conventions, codes of conduct, and norms of behavior. Such routines can be supportive for enterprising endeavors, or they can be hindering. Often, they come from subunit or departmental policies in organizations, as such serving as knowledge filters for knowledge transfer (Guerrero and Urbano, 2014).

We reason that if the norms of the organizational unit of the research scientist work in favor of enterprising behavior, this will positively affect the research scientist's enterprising aspirations. When studying these informal institutions in academia, an important organizational level to consider is the department level. It is well acknowledged that not all research laboratories within the same university engage in enterprising activities to the same extent (Wright et al., 2008; Gulbrandsen and Smeby, 2005). Studies at the organizational level have highlighted the importance of the subunit or department level (Bercovitz and Feldman, 2008; Kenney and Goe, 2004) in understanding enterprising activities. Specifically, these studies have pointed to the importance of workplace peers (Louis et al., 1989; Kenney and Goe, 2004; Stuart and Ding, 2006; Bercovitz and Feldman, 2008) in academic entrepreneurship. Emphasizing the importance of this organizational level in academia, Bercovitz and Feldman (2008) label the department "the localized social environment". We argue that research scientists working at departments or research laboratories with strong enterprising norms will have higher levels of enterprising aspirations. We base this assertion on the fact that individuals are usually attracted by organizations with norms similar to their own. At the same time, organizations tend to hire applicants sharing the organizations' norms (Schneider, 1987). Furthermore, when people join organizations, they are subject to socialization activities such as mentoring and job training which reinforce these norms (Van Maanen and Schein, 1979). Through these socialization processes, people change (or at least tweak) their self-concepts to be in line with organizations (Pratt, 2000) and deepen the understanding of their roles (Pratt et al., 2006). Subsequently, through attraction, selection, and retention (Schneider, 1987) and through socialization (Jen-te, 2009; Van Maanen and Schein, 1979), employees tend to adopt norms consistent with their organizations. Accordingly, we expect departments with stronger enterprising norms to have research scientists with stronger enterprising aspirations:

Hypothesis 1. *Stronger enterprising norms at department level will relate positively to start-up aspirations (H1a), industry-science interaction aspirations (H1b), and patenting aspirations (H1c).*

2.2. The individual perspective—the role of domain specific experience

In building hypotheses at the individual level, we build upon human capital theory in combination with self-efficacy theory. First, human capital theory indicates that greater human capital is associated with better performance at a *particular* task (Becker, 1975; Dimov and Shepherd, 2005). Specific human capital then refers to education and experience within a particular activity (Becker, 1975; Ucbasaran et al., 2003). Second, self-efficacy theory indicates that self-efficacy is an individual's beliefs about his or her (cap)ability to perform a given task (Gist and Mitchell, 1992). Bandura (1992) further suggests that the antecedents of self-confidence in an individual's abilities to successfully perform specific tasks come from four key sources: mastery experiences, modeling, social persuasion, and judgments of the own psychological states. In this paper, we focus on mastery experiences, which can be seen as an important element of human capital and which appear to be fundamental in building self-efficacy (Bandura, 2012). For these mastery experiences to increase self-efficacy, they should be related to the specific task that the individual aims to pursue (Knockaert et al., 2006; Lucas et al., 2009). Or, in line with human capital theory, the human capital acquired should be sufficiently *specific* to the task if it is to affect performance and self-efficacy. Following the relationship between specific human capital and self-efficacy (Wood and Bandura, 1989), the importance of self-efficacy as an antecedent for aspirations (Baum and Locke, 2004) and the importance of the similarity of the mastery experience and the subsequent task (Knockaert et al., 2006), we expect that the type of experience that matters will be different for each type of enterprising aspiration. First, in line with research in other contexts, such as independent entrepreneurship (Zhao et al., 2005) or corporate entrepreneurship (Lee et al., 2011), we argue that start-up experience will positively affect research scientists' start-up aspirations. That is because individuals with a track record of setting up a business (or: entrepreneurial human capital) are more confident of their abilities to perform well when starting up new firms, and this self-efficacy is likely to spur their start-up aspirations. Second, we argue that prior working experience (or: industry-related human capital) will positively affect industry-science interaction aspirations. While many universities have taken initiatives to promote technology transfer between science and industry (Phan and Siegel, 2006), it is recognized that commercialization of research results poses major challenges. Ambos et al. (2008) highlight the differences in time horizon between academic and industry research, the fact that academia encourages knowledge dissemination, whereas the commercial sector seeks ownership and tight control of IPR, and the incentives which differ between academia and industry. As individuals gain more working experience, they may be more inclined to engage in industry-science interactions because they are familiar with the routines and working methods in industry. Finally, we argue that research scientists with more extensive prior experience in patenting activities (or patenting-related human capital) will have higher levels of patenting and licensing aspirations. This is because patenting is complex and technical in nature (Jaffe et al., 1993) and individuals with higher levels of patenting experience will feel more confident of their abilities to succeed in future patenting and licensing activities. Subsequently, higher levels of prior patenting experience will lead to higher levels of patenting and licensing aspirations. Following the elaboration above, we offer the following hypotheses:

Hypothesis 2. *Higher levels of domain specific experience will relate positively to aspirations to engage in these domains. In particular, start-up experience will relate positively to start-up aspirations (H2a), prior industry experience will relate positively to industry-science interaction aspirations (H2b), and patenting experience will relate positively to patenting aspirations (H2c).*

2.3. Scientific productivity as a moderator in the experience-enterprising aspiration relationship

The recent pressure which has been put on research institutions and scientists to combine both missions of scientific excellence and research commercialization has led to a debate on the benefits of uniting these objectives at the individual level: to what extent is it beneficial for individuals to engage in both research excellence and commercialization activities? Two contradictory research streams seem to emerge. A first stream posits that it is beneficial for research scientists to combine both types of activities. This is because research scientists excelling in their research activities are more likely to identify breakthrough opportunities (Franzoni and Lissoni, 2007). This vision is supported by studies that have found a positive relationship between engagement in knowledge transfer activities and research performance (e.g. Powers and McDougall, 2005; Landry et al., 2006, 2007). A second research stream emphasizes that a combination of scientific and commercial goals at the individual level may have some drawbacks. For instance, Buenstorf (2009) found that academics' publications and citations decreased once they became founders, and Toole and Czarnitzki (2010) warn for the dangers of an academic brain drain through spin-off creation.

In line with the first research stream and building on self-efficacy theory, we reason that scientific productivity will positively moderate the previously hypothesized relationship between domain-specific experience and enterprising aspirations. This is because higher levels of scientific productivity can make research scientists feel more confident of their scientific abilities which are required for successful commercialization of technology. An academic researcher who has mainly gained experience in enterprising activities may only feel confident of his or her abilities to engage in enterprising activities when coupled with high levels of scientific output. For successful commercialization of research to take place, both high levels of scientific excellence and an enterprising mindset are needed (Knockaert et al., 2011). Consequently, a research scientist without any enterprising experience may not feel confident of his or her abilities to successfully commercialize research. Similarly, a research scientist who has not engaged in intensive scientific research may not feel confident of his or her abilities to commercialize research, since it is unlikely that low engagement in scientific research will lead to breakthrough findings with commercialization potential (Azoulay et al., 2007). This is very visible, for instance, in patenting, since the ability to patent-protect research or inventions is highly dependent on the novelty of the research results (Jaffe et al., 1993). Hence, we expect that scientific productivity will positively moderate the previously hypothesized relationships between prior experience and enterprising aspirations. We offer the following hypotheses:

Hypothesis 3. *Scientific productivity will positively moderate the relationship between domain specific experience and aspirations to engage in these domains. In particular, scientific productivity will reinforce the relation between start-up experience and start-up aspirations (H3a), between industry working experience and industry-science interaction aspirations (H3b), and patenting experience and patenting aspirations (H3c).*

3. Research methodology

Our sample frame is the population of doctoral and post-doctoral scientists in the natural sciences faculty of the University of Oslo, Norway. Our focus on younger scientists (doctoral and postdoctoral researchers) is inspired by the fact that these new-generation researchers are, to a greater extent than established researchers, faced with the changing institutional environment promoting engagement in both research excellence and commercialization (Zucker et al., 2002; Ambos et al., 2008).

Data were collected in February 2010 through an online questionnaire. The data-collection phase was preceded by a pilot phase from November 2009 to January 2010, during which the respondents were also requested to provide comments on the questionnaire itself, allowing for the refinement of the instrument. The survey population consisted of 924 doctoral and post-doctoral researchers. They received a request to complete the online questionnaire through email sent by the central administration and signed by the research team and the Vice Dean. The first mailing resulted in a response from 170 researchers, and was followed by a second email request one week later, which resulted in 112 additional responses. From the total of 282 responses, 79 were eliminated due to incomplete data. This resulted in 203 useable questionnaires for this paper—an effective response rate of 22 per cent. T-tests indicated no significant differences between early and late respondents in terms of age, postdocs versus doctoral researchers and the time they had been employed at the university.

3.1. Dependent variables

We used three distinct types of dependent variables in this study, measuring research scientists' a) start-up aspirations, b) industry–science interaction aspirations, and c) patenting and licensing aspirations.

To measure *start-up aspirations*, we used the scale developed by Linan and Chen (2009), asking the respondents to indicate on a 7-Likert scale the extent to which they agreed with the following statements (1 = disagree to a large extent; 7 = agree to a large extent): 1) I am ready to do anything to be an entrepreneur, 2) My professional goal is to become an entrepreneur, 3) I will make every effort to start and run my own firm, 4) I am determined to create a firm in the future, 5) I have very seriously thought about starting a firm and 6) I have the firm intention to start a firm someday. The Cronbach alpha of this measure is .94.

To measure *industry-science interaction aspirations*, we used the following questions: How likely is it that: 1) You will engage in collaboration with industry over the next 2 years?, 2) You will engage in contract research with industry over the next 2 years?, 3) You will engage in consulting activities with industry over the next 2 years? and 4) You will generate revenues for your department by working for/with industry?, with responses ranging from 1 (“unlikely”) to 7 (“likely”). The Cronbach alpha of this measure is .87.

To measure *patenting and licensing aspirations*, we used the following questions: How likely is it that: 1) You will apply for a patent over the next 5 years?, 2) You will license some of your technological developments to industry over the next 5 years?, and 3) You will become the owner of intellectual property rights (patent, copyright, trademark,…) over the next 5 years? In measuring these patenting and licensing aspirations, we again employed a 7-point scale with “Unlikely” and “Likely” as extremes. The Cronbach alpha of this measure is .89.

3.2. Independent and moderator variables

3.2.1. Organizational level

Enterprising norms were measured using the following five items: 1) The commercialization of research is one of the core objectives of my department, 2) The commercialization of research is encouraged by my department, 3) Researchers in my department engage in entrepreneurial activities, 4) Faculty in my department engage in entrepreneurial activities and 5) People in my department engage in business venturing activities. A 5-point scale ranging from "very untrue" (1) to "very true" (5) was employed. The Cronbach alpha of this measure is .86. For each department, we calculated the average score among the respondents and used these average scores as a departmental measure because these reflect the perceived shared enterprising norms in the various departments. We also calculated the intra-class correlation coefficients (ICCs) for each department. The department of theoretical astrophysics was the only one with a score below .70, indicating some divergence in the opinions of respondents. Therefore, this department (with only 7 respondents) was removed from further analysis. The remaining eight departments had scores between .720 and .912, pointing to acceptable convergence in the opinions on enterprising norms at departmental level. Subsequently, after eliminating the observations from the astrophysics department, our total number of observations equals 203.

3.2.2. Individual level

3.2.2.1. Prior start-up experience. This variable was measured using a dummy variable, indicating whether or not (value = 0) the research scientist had previously started up or attempted to start up a company.

3.2.2.2. Prior industry working experience. This variable measured the number of years of prior full-time working experience.

3.2.2.3. Prior patenting experience. This variable measured the number of patents that the research scientist applied for over the past three years.

3.2.2.4. Scientific productivity. In order to measure this variable, we asked the following question: How many academic articles have you published since you started your PhD studies? For normalization purposes, we used the log of the number of articles in the analysis.

3.2.3. Control variables

We controlled for a number of factors which could affect our dependent variables, including age and gender. Gender was coded 0 for women and 1 for men. Further, we controlled for entrepreneurial self-efficacy, which has been found to significantly affect entrepreneurial intentions (Chen et al., 1998; Zhao et al., 2005). In order to measure entrepreneurial self-efficacy, we used the scale developed by Zhao et al. (2005) and asked: How confident are you in successfully: 1) Identifying new business opportunities, 2) Creating new products, 3) Thinking creatively, 4) Commercializing an idea or new development. A 7-point scale from "no confidence" (1), to "complete confidence" (7) was used. The Cronbach alpha of this measure is .85. Further, we integrated a control dummy indicating whether the respondent was a postdoctoral (1) or a doctoral (0) researcher. We also controlled for the time the respondent had been employed at the university (measured in the number of years) and novelty of research findings. To measure novelty of research results, we used the items developed by Landry et al. (2006), and asked respondents to score these on a 5-point Likert scale (ranging from 1: "strongly disagree" to 5: "strongly agree"): "What would be required for your research results to be used in the development of new or improved product, processes or services?" 1) The use of new materials, 2) The use of radical new technology, 3) The use of new production techniques, 4) Significant financial investments. The Cronbach alpha of this measure is .79.

4. Results

Table 1 shows the descriptive statistics and correlations for all variables. The average age of the respondents is 32 years; 66 per cent are men, 28 per cent are postdoctoral researchers. The respondents on average had worked at the university for 3.24 years, and had on average published 6 academic articles. Fifteen per cent of the respondents had started up a company earlier. On average they had 2.64 years of working experience in industry. About 9 per cent of the sample had prior patenting experience. Research scientists with this kind of experience had applied on average for one patent, with the maximum number of patents applied for equaling 4.

Table 2 shows the results of the main analysis. The variance inflation factors were below 10 (maximum value of 4.9, mean VIF 1.8) indicating that multicollinearity was not an issue (Hair et al., 2010).

First, the control models (models 1, 4 and 7) for each of our dependent variables are statistically significant. We find entrepreneurial self-efficacy to significantly affect the three models. Given that the coefficient for entrepreneurial self-efficacy was highly significant for all models, we carried out the same analyses without this variable as a robustness check. While these analyses indicated that the explanatory power of the models dropped, all models remained statistically significant and no changes in the conclusions at the level of the explanatory variables were found. Furthermore, it was found that men tend to have significantly higher levels of start-up aspirations than women (model 1), which confirms previous research findings (Zhao et al., 2005). However, our findings also indicate that men and women do not differ significantly in their industry-science interaction aspirations and patenting and licensing aspirations. Finally, the control models for start-up aspirations and industry-science interaction aspirations show significant results for scientific productivity, indicating that research scientists who are more productive in publishing also have higher levels of start-up aspirations and industry-science interaction aspirations. Finally, model 7 shows that the more novel the research scientist's research findings, the higher the patenting and licensing aspirations. This can be explained by the fact that novelty of the invention/technology is a prerequisite for patenting (Jaffe et al., 1993).

4.1. Results on hypothesized main effects

Using models 2, 5 and 8, we discuss our findings for the hypothesized main effects. First, we find that the department's

Table 1
Descriptive statistics and Pearson's correlations (2-tailed).

		Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Start-up aspirations	2.39	1.44	1.00												
2	Industry-science interaction aspirations	3.74	1.54	.22*	1.00											
3	Patenting and licensing aspirations	2.92	1.60	.32*	.43*	1.00										
4	Age	32.15	6.15	-.08	-.02	.00	1.00									
5	Gender	.66	.48	.32*	.23*	.28*	.02	1.00								
6	Entrepreneurial self-efficacy	3.84	1.30	.53*	.41	.49*	-.01	.29*	1.00							
7	Postdoctoral researcher	.28	.45	-.12	-.05	-.02	.37*	-.03	-.12	1.00						
8	Time at the university	3.24	3.19	-.02	.04	.00	.31*	.03	-.07	.32*	1.00					
9	Novelty of research results	2.77	1.05	.19*	.17*	.38*	.03	.12	.29*	.04	.02	1.00				
10	Scientific productivity (log)	-2.66	6.79	.08	.19*	.02	.34*	.12	-.01	.46	.41*	.08	1.00			
11	Enterprising norms	2.61	.84	.15*	.28*	.33*	-.04	.20*	.41*	-.17	-.15	.14*	-.08	1.00		
12	Prior start-up experience	.15	.36	.35*	.17*	.12	.20*	.12	.34*	-.04	.03	.00	.15*	.14*	1.00	
13	Prior industry working experience	2.64	4.08	.09	.05	.06	.60*	.08	.08	.04	.23*	-.03	.11	.05	.14	1.00
14	Prior patenting experience	.09	.40	.09	.11	.38*	-.03	.05	.10	.13*	.06	-.01	.08	.06	.09	-.02

Due to the binary nature of variables 5, 7 and 12, these correlations should be interpreted with care.
* Pearson correlations are significant at $p < .05$, $n = 203$.

enterprising norms have a significant impact on two of the three enterprising aspirations: stronger enterprising norms are related to research scientists exhibiting higher levels of industry-science interaction aspirations (Beta = .38, $p < .01$) and patenting and licensing aspirations (Beta = .29, $p < .01$). We do not find these enterprising norms to be significantly related to start-up

Table 2
Results of hierarchical regression analysis on start-up aspirations, industry–science interaction aspirations, and patenting and licensing aspirations.

	Start-Up Aspirations (a)			Industry–Science Interaction Aspirations (b)			Patenting & Licensing Aspirations (c)		
Control variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Age	-.01 (.02)	-.06+	-.06+	-.00	-.03	-.03	.00	-.00	-.00
		(.03)	(.03)	(.02)	(.04)	(.04)	(.02)	(.04)	(.04)
Gender	.41*	.43**	.43**	-.04	-.13	-.17	.35	.27	.30
	(.17)	(.16)	(.16)	(.22)	(.21)	(.21)	(.22)	(.19)	(.19)
Entrepreneurial self-efficacy	.47***	.41***	.41***	.44***	.34***	.34***	.41***	.32***	.31***
	(.08)	(.08)	(.08)	(.08)	(.09)	(.09)	(.08)	(.08)	(.08)
Postdoctoral researcher	-.35+	-.16	-.15	-.42+	-.31	-.34	-.22	-.30	-.28
	(.21)	(.22)	(.22)	(.24)	(.27)	(.26)	(.24)	(.24)	(.25)
Time at the university	-.02	.00	.00	-.02	.01	-.01	.01	.01	.01
	(.04)	(.04)	(.04)	(.04)	(.04)	(.04)	(.04)	(.04)	(.04)
Novelty of research findings	.06	.08	.07	.11	.11	.10	.40***	.40***	.39***
	(.09)	(.08)	(.08)	(.10)	(.09)	(.09)	(.09)	(.08)	(.08)
Scientific productivity	.03*	.02	.02+	.05**	.06**	.06**	-.01	-.01	-.01
	(.01)	(.01)	(.01)	(.02)	(.02)	(.02)	(.02)	(.02)	(.02)
Enterprising norms (H1s)		-.13	-.12		.38**	.37**		.29*	.30**
		(.12)	(.12)		(.14)	(.13)		(.11)	(.11)
Experience (H2s)									
Prior start-up experience (H2a)		.87**	.94*		-.10	-.05		-.10	-.14
		(.29)	(.44)		(.28)	(.28)		(.25)	(.25)
Prior industry working experience (H2b)		.06+	.06+		.04	.03		.00	.00
		(.03)	(.03)		(.05)	(.05)		(.05)	(.05)
Prior patenting experience (H2c)		.17	.16		.38*	.41*		1.49***	1.75***
		(.18)	(.17)		(.19)	(.18)		(.31)	(.23)
Moderating Effects (H3s)									
Scientific productivity × start-up experience (H3a)			-.02						
			(.09)						
Scientific productivity × industry working experience (H3b)						.01+			
						(.00)			
Scientific productivity × patenting experience (H3c)									-.08*
									(.04)
Constant term	.75*	2.24*	2.20*	2.18**	2.40+	2.28*	.12	-.31	-.19
	(.64)	(.90)	(.89)	(.74)	(1.14)	(1.12)	(.68)	(1.07)	(1.08)
Adjusted R^2	.277	.319	.316	.185	.219	.223	.256	.393	.396
F-value	10.87***	9.79***	9.64***	8.92***	7.15***	7.38***	14.37***	15.39***	24.72***
N	203	203	203	203	203	203	203	203	203

*** $p < .001$
** $p < .01$
* $p < .05$
\+ $p < .10$

aspirations. Therefore, we do not accept H1a, but we accept H1b and H1c. Second, we find that prior experience has a large impact on the different types of aspirations. In line with previous research, we find that prior start-up experience relates positively to start-up aspirations (Beta = .87, $p < .01$). Further, we find that more prior patenting experience is positively related to patenting and licensing aspirations (Beta = 1.49, $p < .0001$). We do not find confirmation for our hypothesis that prior working experience in industry predicts industry–science interaction aspirations. Therefore, we accept H2a and H2c, but we do not accept H2b.

4.2. Results on hypothesized interaction effects

We now turn to the third set of hypotheses, and analyze the results of models 3, 6 and 9. To test these hypotheses, we used centered observations for scientific productivity and the different types of experience, calculated by subtracting their respective mean values and using these centered variables to calculate the interaction term. This is standard practice in multiple regressions to avoid potential multicollinearity problems (Kutner et al., 2005). We used $p < .10$ for assessing significance as this cut-off value provides a better balance for type I and type II errors for moderating effects (Aguinis, 2003). First, we do not find confirmation for our hypothesis that scientific productivity positively moderates the relationship between prior start-up experience and start-up aspirations. Therefore, we cannot accept H3a. We do find confirmation for H3b: scientific productivity positively moderates the relationship between prior working experience and industry-science interaction aspirations. We therefore accept H3b. Finally, we reject H3c. We find that scientific productivity negatively affects the relationship between prior patenting experience and patenting and licensing aspirations.

As Fig. 1 shows, industry-science interaction aspirations are higher for higher levels of scientific productivity and prior working experience. In the case of low scientific productivity, higher levels of industry experience are unable to mitigate the negative impact of scientific productivity on industry-science interaction aspirations. Fig. 2 shows that, irrespective of the level of scientific productivity, patenting and licensing aspirations are higher for higher levels of patenting experience. In case of higher levels of patenting experience, patenting and licensing aspirations benefit from lower scientific productivity.

5. Discussion, implications and limitations

The above findings indicate that enterprising aspirations among scientists differ according to the levels and types of previous experience and the departmental norms. In line with Wright et al. (2008), we use the notion of academic entrepreneurship in a broad sense and split up enterprising aspirations in start-up aspirations, industry-science interaction aspirations, and patenting and licensing aspirations. At the individual level, our findings suggest that scientists with prior exposure to enterprising activities are also more likely to foster enterprising aspirations. We attribute these findings to insights from human capital theory, in combination with self-efficacy theory, indicating that people who feel, through mastery experiences, more confident that they can handle specific tasks are more likely to have aspirations to engage in specific tasks. In particular, we find that those with prior start-up experience are more likely to foster start-up aspirations, whereas those with prior patenting experience are more likely to foster patenting and licensing aspirations. Interestingly, our control models indicated that scientific productivity is positively related to both start-up aspirations and industry-science interaction aspirations.

At organizational level, our findings suggest that enterprising aspirations among scientists differ due to variations in salient informal institutions. Enterprising norms positively predict patenting and licensing, and industry-science interaction aspirations, but not start-up aspirations. This may be caused by the fact that, in departments with high enterprising norms, research scientists are to a large extent encouraged to engage in industry-science or patenting activities, but to a lesser extent in new firm creation. This may in turn be caused by the fear that, in the event of new firm creation, a brain drain takes place with good scientists leaving the department to start new ventures (Toole and Czarnitzki, 2010), whereas researchers engaging in licensing, patenting and industry-science interactions typically stay in the department. Furthermore, our findings are consistent with the general notion that entrepreneurs are “norm breakers”. Our findings indicate that

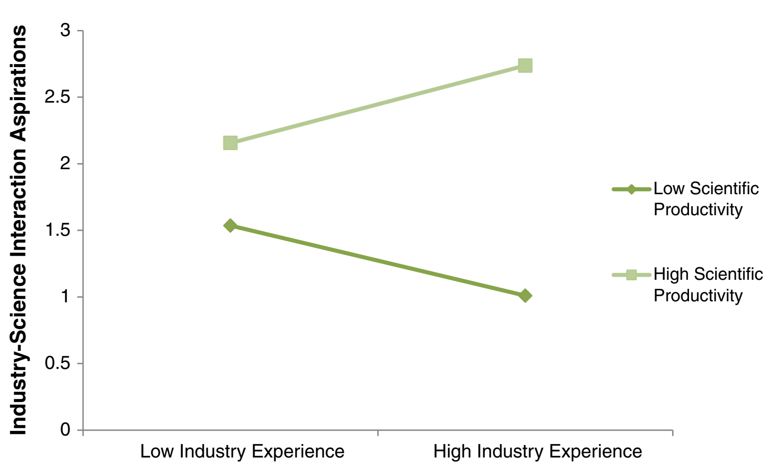

Fig. 1. Moderation graph scientific productivity × industry experience.

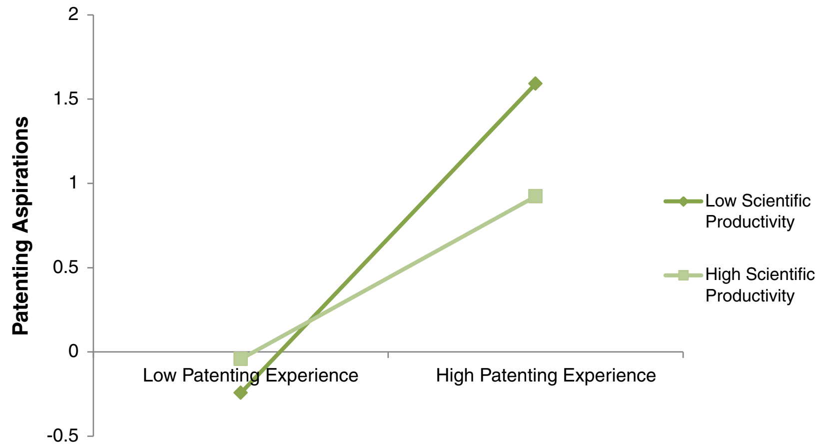

Fig. 2. Moderation graph scientific productivity × patenting experience.

those scientists who would like to spin-off a company do this regardless of the surrounding culture and commonly-held norms. Although enterprising norms do not contribute to the enhancement of start-up aspirations, they do enhance patenting and licensing, and industry-science interaction aspirations. As such, salient enterprising norms in research departments only contribute to the support of patenting and licensing, and industry-science interaction aspirations, not start-up aspirations *per se*.

Finally, our results point to some interesting findings related to the influence of scientific productivity. The literature has so far remained inconclusive on the impact of scientific productivity on enterprising aspirations (Larsen, 2011). By differentiating between different types of enterprising aspirations, our findings provide insights into the role of scientific productivity. Notably, while we find positive, direct effects of this productivity on start-up and industry-science interaction aspirations, we also find scientific productivity to be an important moderating factor. First, we find that scientific productivity significantly and positively moderates that relationship between prior industry experience and industry-science interaction aspirations. This may be explained by the fact that higher levels of scientific productivity provide researchers with higher efficacy beliefs in their abilities to successfully engage in these interactions. As researchers work on the frontier of their research domain, they feel more confident that the novelty and breakthrough nature of their research is of high relevance to industry and therefore feel more confident that their technology or developed knowledge is of value to industry. Second, we find that scientific productivity negatively moderates the relationship between patenting experience and patenting and licensing aspirations. This may be explained by the fact that researchers often have to choose between patenting or publishing. As they publish their research findings, these become part of the public domain and therefore are no longer patentable (Nelson, 2001). Alternatively, patenting and publishing activities may crowd out each other for time and resources.

This paper makes a number of contributions to academia, practitioners just as policy makers. First, for academia, it points to the need and usefulness of not merely capturing start-up aspirations but also assessing drivers of other types of enterprising aspirations, which may in turn also result in actions having important budgetary implications for universities, such as industry-science interaction or patenting and licensing activities. Second, it points to the need to integrate both individual level and organizational levels in theoretical and empirical models studying these aspirations. Hence, we respond to the call by D'Este et al. (2012) for research to combine individual and organizational determinants of academic entrepreneurship. Finally, our research contributes to the discussion on the impact of scientific productivity on enterprising aspirations by providing insights into the conditions under which this productivity is beneficial to different types of enterprising aspirations. Here, we respond to Larsen (2011) who called for insightful research on the relationships between scientific excellence and enterprising activities.

Second, for practitioners – such as technology transfer officers, research managers and university management – and for policy makers, it provides useful indications of which research scientists are more likely to foster enterprising aspirations. Given that universities have been confronted with decreased budgets and have been put under pressure to engage to a larger extent in research commercialization, this paper provides indications of individual and organizational level characteristics that may be helpful in accomplishing the university's third mission. Further, our research shows that research commercialization will most likely be a function of not only the nature of the research scientists that universities attract, but also of the existing culture of enterprising norms. As such, it will be important to build such a culture, particularly in order to generate aspirations for industry-science collaboration and patenting and licensing activities. It may also provide important indications pertinent to recruitment criteria at universities, which are often strongly focused on the scientific track record of scientists. Our research shows that prior (non-academic) experience is important for enterprising endeavors in academia. Moreover, this study indicates which factors can help universities to live up to the requirements of their third mission. Policy makers can benefit from the established important relationship between both patenting and start-up experience and enterprising aspirations. In addition to assessing university performance using the traditional yard stick of scientific output, universities can also be assessed by the extent to which they contribute to commercial successes and patenting efforts. Finally, policy makers can develop enterprising aspirations among students by favoring programs that allow students to engage in start-up firms, internships, business plan competitions, and patenting activities. While we did not study education, our highly significant results for prior experience suggest that education can help research scientists become acquainted with commercialization activities and thereby shape their enterprising aspirations.

Third, a theoretical implication is that the notion of ‘enterprising aspirations’ is important because it reflects relatively abstract human aspirations. As such, self-efficacy theory (Bandura, 1997) is important. Such generalized enterprising aspirations can, under certain conditions, emerge into more specific types of aspirations, as dealt with in this paper. For instance, Sarasvathy (2001: 249) writes that “characteristics of decision makers, such as who they are, what they know, and whom they know, form the primary set of means that combine with contingencies to create an effect that is not preselected but that gets constructed as an integral of the effectuation process. The effectuator merely pursues an aspiration and visualizes a set of actions for transforming the original idea into a firm-not into the particular predetermined or optimal firm, but a very generalized aspiration of a firm.” We posit that aspirations conceptualized in this way can also be applied to a broader context than which has been the case in the entrepreneurship literature so far. That is, ‘enterprising aspirations’ are not only applicable to new venture creation (which has been typically studied by entrepreneurial intentions researchers), but also to science-industry interactions, and even patenting and/or licensing routes. This is an important insight, yet an underexplored research domain. As we contend, future research could take such a broader view as the starting point, because enterprising endeavors often start with an underlying (abstract or generalized) aspiration that may or may not transform into an enterprising aspiration, and not only into the more specific enterprising aspirations dealt with in this paper. For instance, in line with the framework presented by Sarasvathy (2001), generalized entrepreneurial aspirations may also be the starting point for the development of not only new firms, but also new industrial markets, and even completely new industries as so vividly described by Sarasvathy and Dew (2005; 2013). In order to understand emergence and social change, we need to know more about how these types of human aspirations are formed and nurtured. Hence, future research could seek to follow how enterprising aspirations over time not only are transformed into new technology and new products, but also how these are transformed into new markets and industries.

While our study was the first to consider different types of enterprising aspirations and to unite individual and organizational determinants of these aspirations, our research also has a number of limitations. First, our study was cross-sectional in nature. Future longitudinal studies can assess how enterprising aspirations are shaped over time. For instance, future studies could also show how changes in the departmental norms affect these aspirations. Second, the study is based on data from one university. Although it is a relatively large university with multiple science departments, replications of these findings at other universities may be fruitful. Alternatively, future research could purposefully integrate the individual, department and university levels through building multi-level models.[1] Third, even though the number of scientific publications is a widely accepted measure of scientific productivity (Defazio et al., 2009), future research can incorporate more fine grained measures of the quality of the scientific work, by incorporating the scientific level and the number of citations linked to this work. Fourth, we specifically focused on young researchers as these are more likely to develop their career capital and to consider diverse options due to uncertainty about which career track will be the most beneficial to them (Krabel and Muller, 2009). In contrast, professors are typically more focused on establishing their reputation in the scientific community, and therefore less suited for our research objectives. Furthermore, our focus on young researchers is warranted as employees tend to learn the norms of the organization in a relatively short period of time. Typically, the length of time it takes new employees to understand the values and goals of the organization varies from eight weeks for clerical jobs, 20 weeks for professionals, to greater than 26 weeks for executives (Williams, 2003). Despite this variation, in most instances, employees acquire the necessary knowledge, skills, and behaviors to become effective organizational members within a year (Christiansen, 2010). While we purposefully focused on young researchers, future research could study enterprising aspirations with tenured faculty, as such extending our findings on the development of such aspirations in academia.

Finally, our study finds that scientific productivity moderates the effect of human capital on aspirations. However, the organizational environment can also act as a barrier or facilitator in this relationship. In other words, a positive individual's perception about the organizational enterprising norms could moderate the relationship between an individual's specific prior experience and the different types of aspirations. Additional analyses that we conducted, however, did not provide indications of such moderating effects. Nonetheless, future studies should continue to investigate organizational and individual moderating effects on enterprising aspirations. Specifically, future research could look into how other organizational characteristics, such as climate and culture at the level of the university departments and the overall university, in combination with individual characteristics, impact enterprising aspirations.

6. Conclusions

Our findings suggest that prior domain-specific experience and enterprising norms in combination with scientific productivity are highly related to scientists' enterprising aspirations. In this paper, we have shown when, why and how enterprising norms contribute to shaping scientists' enterprising aspirations. Contrary to our expectations, enterprising norms do not facilitate start-up aspirations, but facilitate both industry-science interaction aspirations and patenting and licensing aspirations. Second, building on self-efficacy and human capital theories, we have also shown when, why, and how domain-specific experience contributes to shaping scientists'

[1] Note that, when considering multi-level methodologies, discussion exists on the number of observations needed per level. One rule of thumb which seems generally accepted for designs in which individuals are nested in groups is a minimum of 30 units at each level of the analysis (Maas and Hox, 2005).

enterprising aspirations. Specifically prior domain-specific experience influences the likelihood of favoring an enterprising future, and the level of industry-science interaction aspiration is highest among those who are scientifically productive. Beyond these insights, we also found that the novelty of research is associated with patenting and licensing aspirations only, and that prior domain-specific experience contributes toward forming domain-specific enterprising aspirations. Finally, we have addressed the conditions under which scientists differ in their enterprising aspirations. Building on insights from self-efficacy and human capital theories, we have also shown when and why such aspirations are shaped.

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