Chapter 10
The Effects of the Academic Environment on PhD Entrepreneurship: New Insights from Survey Data

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Abstract This paper investigates PhD entrepreneurship. We focus on the university factors most closely associated to: (1) students' success in starting a business venture; (2) students' startup intention; (3) students' abandoning the entrepreneurial idea. The empirical analysis is based on data from a questionnaire survey, administered in 2016 in Italy. We focus on four factors related to the university entrepreneurial environment: (1) university entrepreneurship policy frameworks; (2) PhD orientation to business problems; (3) entrepreneurship training; (4) PhD lab reputation. We find that the academic environment can have a fundamental impact on students' decisions to start new ventures and on their entrepreneurial attitude.

Keywords Student entrepreneurship · Entrepreneurial university · Start-up · PhDs · Firm creation

10.1 Introduction

As knowledge has become recognized increasingly as an engine of economic growth, governments in many countries have been encouraging universities to contribute directly to economic development via knowledge transfer (Powers & McDougall, 2005). Although the transfer of knowledge from academia to society is not a new phenomenon (Geuna & Muscio, 2009; Wright et al., 2007; Rothaermel

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et al., 2007), university third-mission activities and university–industry linkages have become progressively 'institutionalized' over the last 30 years (Gibbons et al., 1994; Etzkowitz & Leydesdorff, 2000).

University-industry interactions can take various forms, including patenting, licensing and spin-off creation (Agrawal & Henderson, 2002; Bekkers & Bodas Freitas, 2008; Cohen et al., 2002; Muscio & Pozzali, 2013; Philpott et al., 2011), and recent scholarly debate has highlighted the rise of academic entrepreneurialism (Dooley & Kenny, 2015; Wright et al., 2007; Siegel et al., 2003). Increasing numbers of academics are choosing (and being encouraged) to engage in entrepreneurial activities, and the commercialization of university research via academic spin-offs is growing steadily (Thursby & Thursby, 2007). However, the literature focuses almost exclusively on entrepreneurialism by university faculty and academic staff and tends to ignore student entrepreneurship (Åstebro & Bazzazian, 2011; Åstebro et al., 2012; Shah & Pahnke, 2014). In particular, there is a lack of empirical evidence on entrepreneurship by doctoral students (hereafter *PhD entrepreneurship*) (Bienkowska et al., 2016). This is in part because students' (as opposed to university faculty) entrepreneurial activities are based, less frequently, on university Intellectual Property (IP). Typically, student startups are not recorded as "university spin-offs" unless the venture involves a university faculty member.

Nevertheless, PhD entrepreneurship is effective for fulfilling the university third mission (Etzkowitz, 2017; Etzkowitz et al., 2000; Philpott et al., 2011). PhD entrepreneurship involves the establishment of knowledge-intensive start-ups, provides high-skilled jobs, reinforces regional economic structure and helps to legitimate the role of the university in the regional economy. Moreover, PhD students can be incentivized to start a venture business due to the lack of a stable academic position and a more risk-taking attitude compared to tenured faculty members. PhD entrepreneurship responds to policy debate which questions the over-production of PhD graduates (Stephan, 2012). A large part of the investment in PhD programmes is based on the assumption that PhD graduates will continue in academia and engage in research and education, providing a fair return for public funding. However, studies of PhD graduates' employment outcomes show that taking up an academic position is not the main outcome (Conti & Visentin, 2015). We are observing a transformation to universities' goals and doctoral education programmes and a greater emphasis on new business creation by students (Muscio et al., 2013).

In this study, we investigate how both university-and student-level factors are associated to PhD students' entrepreneurial activity. We study the entrepreneurial environment surrounding PhD students situated in Italian academic institutions and analyse its influence on students' success or failure at venture business creation and the startup intention. First, our analysis of students' entrepreneurial environment provides immediate policy and managerial implications for research institutions that want to promote entrepreneurship. Second, little research has been done on the relation between environmental factors and students' personal characteristics (Pruett et al., 2009). Although there is a stream of work on how universities can support academic entrepreneurship generally (Philpott et al., 2011; Ramaciotti et al., 2017), few studies investigate how the university environment affects the decision to start a new business, particularly by PhD students who are in the unique position of being simultaneously a student and a young professional.

In what follows, we formulate some hypotheses and test them using the data collected from the responses to a questionnaire survey of doctoral students enrolled in PhD programmes between 2008 and 2014.

10.2 PhD Entrepreneurship: Theoretical Insights

Universities are under political pressure to integrate with industry and society, and the so-called ‘entrepreneurial university’ model emphasizes new business creation and knowledge spillovers (Branscomb et al., 1999; Ghio et al., 2015). Academic entrepreneurship involves multiple stakeholders such as faculty at different levels, post-doctoral fellows and students. There are many reasons why these individuals choose to focus on venture creation: greater availability of entrepreneurial and technological opportunities, lower availability of academic jobs, better information on the steps to market and access to entrepreneurship programmes. Scholarly debate on academic entrepreneurship has been overly focused on the university third mission and university–industry linkages (Siegel & Wright, 2015) and overlooks new forms of entrepreneurial activities, including PhD entrepreneurship.

For various reasons, PhD entrepreneurship deserves special attention. PhD students, potentially, may be more able to overcome the barriers to new venture creation. Unlike academic staff, they are often better positioned to gain access to the required commercial competences and assets, and they do not need to undergo ‘genetic mutation’ to become entrepreneurs (Colombo & Piva, 2012). During their early academic experience, PhD students compared to graduates and faculty members can exploit business ideas with higher technological/knowledge content. Despite the paucity of scholarly debate on PhD entrepreneurship, many universities are encouraging student entrepreneurship (Åstebro et al., 2012; Conti & Visentin, 2015).

We investigate the entrepreneurial climate in universities and what characterizes PhD curricula and research training. The succeeding sections discuss the theoretical underpinnings.

10.2.1 The University Entrepreneurship Policy Framework

Students’ entrepreneurial intentions and entrepreneurial activities are influenced by the social context (Bercovitz & Feldman, 2008; Clarysse et al., 2011; Stuart & Ding, 2006; Guerrero et al., 2018). For example, academics’ proximity to academic entrepreneurs increases the probability of also engaging in entrepreneurial activities (Muscio & Ramaciotti, 2019; Stuart & Ding, 2006). Academic spin-offs keep tighter links to universities than other young innovative firms (Azagra-Caro et al., 2012) and, in addition, the number of the institution's spin-offs has a positive influence on the entrepreneurial attitude of academics (Clarysse et al., 2011; Muscio & Ramaciotti, 2019). These results suggest that a local environment that is nurturing entrepreneurship is crucial.

Although not all academic institutions are engaged actively in entrepreneurship (Muscio et al., 2016; Wright et al., 2007), some have adopted infrastructures that include entrepreneurship education and support, which create an environment favourable to entrepreneurial activity and encourage students to become entrepreneurs (Barbero et al., 2014; Guerrero et al., 2018; McAdam & McAdam, 2008). For example, incubation services provide students with a common working space, professional office facilities, business mentors and networking opportunities (Jansen et al., 2015; Souitaris et al., 2007). Van Rijnsoever et al. (2017) suggest, also, that incubators have a positive effect on financial aspects, for instance, by attracting start-up funding and promoting engagement with financial institutions and investors.

Another instrument that universities can put in place to support entrepreneurship comes in the form of clear rules and guidance to regulate startup activities (Caldera & Debande, 2010; Rasmussen et al., 2014). By providing a supportive context for entrepreneurial activities, rules and guidelines increase the propensity for student entrepreneurialism (Hoppe, 2016; Walter et al., 2013; Kuratko, 2005; Lockett et al., 2003). Rules and guidelines provide a framework for the startup process, regulate entrepreneurs' monetary incentives and mitigate entrepreneurial risks (Muscio et al., 2016). Also, academic rules/guidelines can contribute to clarifying the institutions' strategic orientation to entrepreneurship (Phan & Siegel, 2006; Rasmussen & Borch, 2010; Van Looy et al., 2011). They can facilitate the preparation and approval of business plans, limit potential conflicts between parent institution and entrepreneur, and provide incentives to those considering becoming an entrepreneur (Muscio et al., 2016; Rasmussen & Borch, 2010). Therefore, we argue that:

Hypothesis 1 PhD students affiliated to institutions with policies to promote and support entrepreneurial initiatives are more likely to become entrepreneurs.

10.2.2 Entrepreneurship Training

Another important factor that is particularly relevant to PhD students compared to academic staff, is access to entrepreneurship courses and training. In many countries, entrepreneurship training for doctoral students has become a significant topic in education policy (Bienkowska & Klofsten, 2012; Thune, 2009). Although personal characteristics may be important drivers of student start-up activity (Guerrero et al., 2018), the student's attitude to entrepreneurship will be influenced by access to appropriate entrepreneurship education programmes (Harris & Gibson, 2008).

Entrepreneurship is becoming a prominent field in university education and several studies show that such programmes can foster an entrepreneurial attitude in students (Blackford et al., 2009; Maresch et al., 2016; Mitra & Matlay, 2004;

Sanchez, 2011; Souitaris et al., 2007; Stamboulis & Barlas, 2014; Vanevenhoven & Liguori, 2013). Some authors suggest that, to improve the business skills of potential entrepreneurs, academic institutions should offer entrepreneurship courses (Åstebro et al., 2012; Storey & Tether, 1998). Entrepreneurship training strengthens the student's intention to establish a new business, enhancing the ability to assess individual aptitude (Oosterbeek et al., 2010) to create an academic spinoff in particular (Rasmussen & Borch, 2010; Rasmussen et al., 2014). Therefore, we posit:

Hypothesis 2 PhD students who take entrepreneurship courses are more likely to become entrepreneurs.

10.2.3 Orientation of PhD Programmes Towards Business Problems

When new ventures derive from research-driven ideas, it can be difficult to match the results of academic research to market opportunities, and experience of working in an industrial context can greatly enhance the entrepreneurial process and reduce the level of uncertainty about the application of research (Smith et al., 2009). It follows that research activities with applications in industry should spark entrepreneurialism in PhD students (Abreu & Grinevich, 2013). If the PhD research is focused on the solution to business problems, the researcher (research team) will be likely to interact with companies, whose involvement can have a positive impact on the student's choice to start his or her own firm (Dooley & Kenny, 2015). The literature shows that research oriented to resolving business problems is associated positively to the frequency of university-industry partnerships and academics' entrepreneurial intentions (Calderini et al., 2007; Muscio & Pozzali, 2013; Landry et al., 2006; Krabel & Mueller, 2009).

Since students tend to lack business sector experience, exposure to industry problems and the interaction with firms can provide opportunities to identify industrial applications for the results of their doctoral research and steer them towards an entrepreneurial career (Muscio & Ramaciotti, 2019). Students' interactions with business can offer learning opportunities that academic institutions might be unable to provide (Lester & Costley, 2010; Kessels & Kwakman, 2007; Slaughter et al., 2002), expose them to more applied research (Geisler & Rubenstein, 1989) and increase the integration of complementary forms of knowledge (Thune & Støren, 2015). Therefore, students' efforts to solve real-world business problems can result in networking relationships and provide the capabilities needed to become an entrepreneur (D'Este et al., 2012; Wright et al., 2004). Therefore, we argue:

Hypothesis 3 PhD students who engage in problem-oriented research are more likely to become entrepreneurs.

Further, we argue that this effect should depend on the scientific quality of the research environment. PhD research training is embedded in the local context of a research lab or a small group of scientists led by the PhD supervisor, and the quality of the science that the student can draw on can differ significantly among labs.

The scientific quality of the local environment depends on several factors including the PhD supervisor, who guides the student's research project, and points to interesting research areas and suitable methodologies (Delamont & Atkinson, 2001; Laudel, 2001; Shibayama et al., 2015). Scientific quality is constrained, also, by resources, which determine, for example, how certain research tasks can be performed, the access to equipment and materials and the opportunities for conference participation and publication. Scientific quality is influenced, also, by the time the PhD student can devote to research; many engage in teaching and other activities.

The prior literature identifies a positive link between scientific quality and academic entrepreneurship. That is, that universities that perform high-quality research tend to attract private funding (European Commission, 2010). Research labs led by star scientists tend to engage in a higher level of knowledge transfer activities (D'Este et al., 2012; Olmos-Peñuela et al., 2014; Lowe & Gonzalez-Brambila, 2007; Zucker & Darby, 1996). There can also be signalling effects (Spence, 1973). Commercial investors in academic ideas prefer to support start-ups that involve high-skilled human capital (Ramaciotti et al., 2017). Universities with a high research ranking tend to have more frequent interactions with industry (McCormack et al., 2014; Muscio et al., 2013).

These results imply that a high-quality research environment can reinforce the link between problem-oriented PhD research and entrepreneurial activities. Through working in such an environment, problem-oriented research can produce practically meaningful results which facilitate PhD students' entrepreneurial activities. Therefore, we argue:

Hypothesis 4 The scientific quality of the research training lab is positively associated to the likelihood of the PhD student becoming an entrepreneur.

10.3 Empirical Design

10.3.1 Data and Methodology

This empirical analysis is based on data from a questionnaire survey, administered between end 2014 and beginning of 2015, to Italian doctorate students enrolled in a PhD course in the period 2008–2014. The authors designed the questionnaire and the survey was managed by CINECA, an Italian consortium of universities, research institutions and the Ministry of Education and Research (MIUR). The questionnaire asked students to evaluate their PhD course and institution, and their entrepreneurial activity and occupational status, and asked some general questions about personal characteristics. CINECA sent the questionnaire to a balanced sample of 23,500 individuals, which represented 50% of the population of doctoral students enrolled in PhD courses in the period 2008–2014. All responses were verified by the Italian

National institute of Statistics (ISTAT), which, in the case of very low response rates, did not disclose data on certain PhD courses in order to guarantee data anonymity. A total of 8755 completed questionnaires was achieved, a response rate of 37.25%. For the purposes of our analysis, we dropped cases where scientific area of the PhD programme was missing. Department and university-level variables such as research rating and size were provided by MIUR. Information on university policies, such as startup regulations, was obtained from institutions' websites.

Table 10.1 presents the responses by scientific field and university size, and the population of PhD graduates estimated by ISTAT. ISTAT publishes these data in its yearly reports on the employment conditions of PhD graduates in Italy.[1] In its 2015 report ISTAT identified 22,469 graduates belonging to two cohorts: 2008 and 2010. We compared the distribution of responses, by scientific area, obtained from our survey and by ISTAT. The estimated difference between our sample and the ISTAT sample was always below the 5% threshold, demonstrating the good representativeness of our sample (Table 10.1). The two scientific areas accounting for the majority of students are Medicine and Engineering. Students are also concentrated in larger academic institutions.

The responses show that 69.1% of students enrolled in a PhD programme completed their PhD studies during the period considered. Of these, 72.8% were employed, 6.4% had been involved in entrepreneurial ventures, 5.5% were involved in businesses that were still active at the time of the survey.

Table 10.2 presents information on the variables used in the econometric analysis. A set of logit and ordered logit regressions was run to test the research hypotheses: the main model presented in Eq. (10.1) estimates whether or not the university entrepreneurial environment is associated to the probability that students will take the decision to become an entrepreneur.

$$\Pr\left(y_{ij} = 1\right) = \alpha + \beta_1 x_j + \beta_2 \gamma_{ij} + \beta_3 \delta_j + \epsilon_{ij} \tag{10.1}$$

The dichotomous dependent variable y_{ij} is equal to 1 if student i, attending university j, started a business that was still active (or contributed to its establishment) at the time of survey, and 0 otherwise. Two other sets of models test the research hypotheses in the two scientific areas of Social Sciences and Humanities (SSH) and Life and Hard Sciences (LHS), which show different scientific behaviour (Bonaccorsi et al., 2017).

We ran two additional models as robustness checks. The first one tests the aforementioned specification on the probability that students with entrepreneurial intentions will abandon the idea to become entrepreneurs. In this model the dichotomous dependent variable y_{ij}, is equal to 1 if student i, attending university j, abandoned the entrepreneurial idea, and 0 otherwise. The second robustness check is estimated with a third model investigating whether the university entrepreneurial environment is associated to the students' entrepreneurial intentions. In this case, the

[1] https://www.istat.it/it/archivio/8555

Table 10.1 Distribution of responses

		University size								
SSD	Scientific area	Small	Medium	Large	Mega	Total	Per cent	ISTAT pop.	Per cent	Difference
1	Mathematics & Computer Science	46	26	233	245	550	6.28	517	3.17	3.11
2	Physics	29	13	200	199	441	5.04	745	4.56	0.48
3	Chemistry	20	29	182	310	541	6.18	899	5.51	0.67
4	Geology	33	19	160	140	352	4.02	399	2.44	1.58
5	Biology	66	51	315	426	858	9.80	1598	9.79	0.01
6	Medicine	32	107	550	588	1277	14.59	2420	14.83	−0.24
7	Agriculture & Veterinary	29	87	104	300	520	5.94	1071	6.56	−0.62
8	Civil Engineering & Architecture	84	53	338	306	781	8.92	1172	7.18	1.74
9	Engineering	18	106	519	411	1054	12.04	1963	12.03	0.01
10	Humanities	34	65	290	412	801	9.15	1402	8.59	0.56
11	Sociology, Philosophy and Psychology	19	68	237	299	623	7.12	1480	9.07	−1.95
12	Law	5	33	117	113	268	3.06	1171	7.17	−4.11
13	Economics and Statistics	16	31	166	161	374	4.27	925	5.67	−1.40
14	Political Sciences	11	31	114	159	315	3.60	560	3.43	0.17
	Total	442	719	3525	4069	8755	100.00	16,322	100.00	

Table 10.2 Data definition

Variable	Description	Source
Dependent variables		
Active startup	Dummy variable taking value 1 if the student established or contributed to the establishment of a still active business start-up and 0 otherwise.	Questionnaire
Abandoned idea	Dummy variable taking value 1 if the student abandoned the idea of start-up and 0 otherwise.	Questionnaire
Startup intention	Scalar variable ranging from 1 if the student has absolutely no intention to start-up and 6 if she/he very interested in starting a business.	Questionnaire
Research hypotheses testing		
Startup regulation	Dummy variable taking value 1 if the university in 2006 had a dedicated set of rules for spinoff and startup creation, and 0 otherwise.	University website
Incubator	Dummy variable taking value 1 if the university hosted a business incubator, and 0 otherwise.	PniCube website
Entrepreneurship courses	Dummy variable taking value 1 if the student attended entrepreneurship courses during her/his PhD and 0 otherwise.	Questionnaire
Business-oriented research	Scalar variable ranging from 6 if the student claims that her/his PhD research was oriented towards immediate application in a business context and 1 if she/he absolutely does not believe so.	Questionnaire
Lab environment	One factor obtained from exploratory factor analysis on a set on nine questions investigating students' opinion about the Ph.D. environment they engaged with.[a]	Questionnaire
Student-level control factors		
PhD completion	Dummy variable taking value 1 if the student completed her/his PhD studies and 0 otherwise.	Questionnaire
Year of birth	Year of birth of the student.	Questionnaire
Male gender	Dummy variable taking value 1 if the student is a male and 0 otherwise.	Questionnaire
Academic position	Dummy variable taking value 1 if the student holds an academic position.	Questionnaire
Post lauream work experience	Dummy variable taking value 1 if the student did not start the Ph.D. immediately after previous university degrees to gain some work experience and 0 otherwise.	Questionnaire
Risk preference	Scalar variable ranging from 1 if the student claims that she/he is more willing to invest in technologies, projects or products that involve low risk and certain, low gains and 5 if she/he is more willing to invest in risky projects that involve high gains.	Questionnaire

(continued)

Table 10.2 (continued)

Variable	Description	Source
University-level control factors		
Research rating	Research rating published by MIUR in 2014, based on the evaluation of research output carried out over the period 2004–2010. This composite indicator takes into account peer review evaluations of research activity carried out at academic institutions (patents, impact factor of journal articles, etc.).	MIUR
University size	Size of the academic institution. University size is expressed in terms of number of students: 1 small (<10,000); 2 medium (10,000–15,000); 3 large (15,000–40,000); 4 mega (>40,000).	MIUR

[a]Questions: Competence of the supervisor; Time dedicated to research activity; Availability of equipment and res. Infrastructure; Availability of financial resources; Degree of independence/autonomy of res. subjects; Extension/quality of the international res. network; Degree of international experience; Quality of the research team; Access to labour market

dependent variable y_{ij} takes scalar values ordered progressively, ranging from 1 if the student had absolutely no intention to start-up and 6 if, on the opposite, she/he very interested in starting a business. Accordingly, we chose the following ordered logit model for the analysis:

$$\Pr\left(y_{ij} = \mathrm{z}\right) = \alpha + \beta_1 x_j + \beta_2 \gamma_{ij} + \beta_3 \delta_j + \epsilon_{ij} \tag{10.2}$$

with z ranging from 1 to 6. It must be noted that in this case we run the econometric model on a sub-sample of students that did not already start a company at the time of the survey. Therefore, we considered those students that might have been willing to become entrepreneurs but that had not yet pursued this career option.

Both models (10.1) and (10.2) include on the right-hand side: some indicators x measuring the entrepreneurial environment accessible at the university; some variables γ control for student characteristics; finally, some variables δ control for institutional characteristics. ϵ denotes the error term. The control variables were chosen on the basis of the literature student start-up activity (Åstebro et al., 2012; Muscio & Ramaciotti, 2019; Krabel & Mueller, 2009). This literature identifies individual factors influencing the individual propensity to establish a firm (e.g., Abreu & Grinevich, 2013; Landry et al., 2006), as well as university-level control factors measuring institutional research performance and size. As regional economic characteristics play a relevant role in start-up creation (Feldman, 2001), all models include province-level (NUTS3) geographical dummies. Year dummies and dummies for the PhD scientific area are also included when necessary.

The definition of the variables included in the regressions are presented in Table 10.2, while the descriptive statistics are in Table 10.3 and the correlation matrix in Table 10.4.

Table 10.3 Descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
Dependent variables					
Active startup	9049	0.055	0.228	0.000	1.000
Abandoned idea	7178	0.412	0.492	0.000	1.000
Startup intention	6308	3.863	1.719	1.000	6.000
Research hypotheses testing					
Startup regulation	9062	0.638	0.481	0.000	1.000
Incubator	9062	0.808	0.394	0.000	1.000
Entrepreneurship courses	9062	0.071	0.257	0.000	1.000
Business-oriented research	8596	1.964	1.460	1.000	6.000
Lab environment (factor = 1)	8026	0.000	0.933	−2.765	1.900
Student-level control factors					
PhD completion	9062	0.581	0.493	0.000	1.000
Year of birth	9062	1981	5.498	1950.000	1990.000
Male gender	9062	0.500	0.500	0.000	1.000
Academic position	9062	0.616	0.486	0.000	1.000
Post lauream work experience	8661	0.444	0.497	0.000	1.000
Risk preference	6689	2.805	0.759	1.000	5.000
University-level control factors					
Research rating	9062	1.000	0.234	0.000	2.080
University size	8755	3.282	0.818	1.000	4.000

10.4 Results

Table 10.5 presents the results of the regressions. The results of the variance inflation factor test confirm that our estimates do not suffer from multicollinearity.[2]

With reference to the effects of the variables of interest, we find that the entrepreneurial environment available at the parent institution university-level and PhD course factors are positively associated to student entrepreneurship. Confirming empirical work on academic entrepreneurship, we find that creating a favourable environment for the entrepreneurial process at the university, is positively associated to the probability that doctoral graduates will create their own firms. In order to test Hypothesis 1, we use a dummy variable indicating whether the parent institution introduced some guidelines and rules in support of start-up and spin-off creation and a dummy variable accounting for a business incubator at the parent university. Universities usually define these rules in an attempt to better frame academic entrepreneurial initiatives (Caldera & Debande, 2010), defining aspects such as monetary incentives for startup creation and norms reducing the entrepreneurial risk (see Muscio et al., 2016). For the purpose of this paper, these rules can be considered as a proxy of the academic entrepreneurial orientation, highlighting the

[2]The variance inflation factor test was always below 10.

Table 10.4 Correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Startup regulation	1.000												
2	Incubator	−0.042	1.000											
3	Entrepreneurship courses	−0.018	0.001	1.000										
4	Business-oriented PH.D. research	0.029	0.003	0.115	1.000									
5	Lab environment (factor = 1)	0.015	0.002	−0.021	0.152	1.000								
6	PhD completion	−0.033	−0.023	0.008	−0.044	−0.060	1.000							
7	Year of birth	0.031	−0.030	0.006	0.013	0.045	−0.308	1.000						
8	Male gender	−0.010	−0.003	0.011	0.094	0.040	0.014	−0.051	1.000					
9	Academic position	−0.004	0.001	−0.005	0.033	0.157	0.203	0.044	0.002	1.000				
10	Post lauream work experience	−0.021	0.022	0.030	0.032	−0.025	−0.005	−0.363	−0.031	−0.049	1.000			
11	Risk preference	−0.009	0.015	0.049	0.084	0.024	0.003	−0.020	0.150	0.010	−0.015	1.000		
12	Research rating	0.084	−0.058	−0.009	−0.025	0.008	−0.028	0.072	−0.019	0.063	0.012	−0.025	1.000	
13	University size	0.076	0.411	−0.020	−0.034	−0.054	−0.079	0.056	−0.009	−0.005	−0.014	−0.024	0.1678	1.000

Table 10.5 Logit and ordered logit regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variables	Active	Active	LHS active	SSH active	Abandoned	LHS abandoned	SSH abandoned	Intention	LHS intention	SSH intention
Startup regulation	0.251**	0.256**	0.312**	0.11	0.047	0.129*	−0.198+	0.025	−0.002	0.143
	[0.084]	[0.084]	[0.102]	[0.190]	[0.052]	[0.061]	[0.111]	[0.045]	[0.053]	[0.097]
Incubator	0.442**	0.443**	0.584**	0.081	−0.068	−0.108	0.009	0.03	0.045	−0.012
	[0.107]	[0.107]	[0.129]	[0.234]	[0.068]	[0.079]	[0.147]	[0.059]	[0.069]	[0.124]
Entrepreneurship courses	0.883**	0.889**	0.960**	0.873**	−0.447**	−0.478**	−0.245	0.354**	0.414**	0.014
	[0.080]	[0.081]	[0.092]	[0.217]	[0.074]	[0.083]	[0.179]	[0.063]	[0.072]	[0.145]
Business-oriented research	0.109**	0.108**	0.111**	0.162**	−0.079**	−0.081**	−0.114**	0.072**	0.058**	0.125**
	[0.019]	[0.020]	[0.022]	[0.047]	[0.014]	[0.015]	[0.035]	[0.013]	[0.013]	[0.030]
Lab environment	−0.124**	−0.233**	−0.266**	−0.265*	−0.079*	−0.085*	0.003	−0.080**	−0.093*	−0.053
	[0.033]	[0.055]	[0.065]	[0.123]	[0.035]	[0.041]	[0.074]	[0.031]	[0.036]	[0.066]
Business-oriented research * Lab environment		0.047*	0.051*	0.084+	−0.012	−0.007	−0.063+	0.024*	0.024+	0.015
		[0.019]	[0.021]	[0.051]	[0.014]	[0.016]	[0.036]	[0.012]	[0.014]	[0.031]
PhD completion	0.253+	0.249+	−0.028	1.435**	−0.005	−0.045	0.053	0.026	0.075	−0.282
	[0.150]	[0.150]	[0.173]	[0.442]	[0.087]	[0.098]	[0.203]	[0.074]	[0.083]	[0.182]
Year of birth	−0.016*	−0.015*	−0.019*	−0.009	−0.026**	−0.029**	−0.029**	0.001	−0.004	0.013+
	[0.006]	[0.006]	[0.008]	[0.013]	[0.005]	[0.005]	[0.009]	[0.004]	[0.005]	[0.008]
Male gender	0.265**	0.264**	0.342**	0.058	−0.209**	−0.274**	−0.076	0.094**	0.100*	0.038
	[0.065]	[0.066]	[0.076]	[0.149]	[0.041]	[0.045]	[0.088]	[0.035]	[0.040]	[0.075]
Academic position	−0.253**	−0.252**	−0.250**	−0.444**	−0.024	−0.019	−0.034	−0.065+	−0.042	−0.181*
	[0.065]	[0.066]	[0.076]	[0.164]	[0.043]	[0.050]	[0.094]	[0.038]	[0.044]	[0.080]
Post lauream work experience	0.135*	0.137*	0.109	0.191	−0.119**	−0.075	−0.276**	0.000	0.006	−0.023
	[0.067]	[0.067]	[0.077]	[0.171]	[0.043]	[0.048]	[0.098]	[0.037]	[0.042]	[0.083]

(continued)

Table 10.5 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Risk attitude	0.149**	0.145**	0.158**	0.118	−0.178**	−0.144**	−0.293**	0.287**	0.284**	0.307**
	[0.042]	[0.042]	[0.049]	[0.100]	[0.026]	[0.030]	[0.058]	[0.023]	[0.027]	[0.050]
University research rating	0.098	0.102	0.045	0.397	0.014	0.049	−0.015	−0.121	−0.157	−0.029
	[0.152]	[0.153]	[0.180]	[0.339]	[0.098]	[0.112]	[0.227]	[0.087]	[0.099]	[0.199]
University size	−0.252**	−0.252**	−0.244**	−0.234*	0.02	0.033	−0.034	−0.005	−0.007	−0.071
	[0.049]	[0.049]	[0.057]	[0.117]	[0.033]	[0.038]	[0.080]	[0.029]	[0.033]	[0.072]
Year dummies	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Area dummies	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Province dummies	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Constant	26.333*	26.047*	36.537*	14.097	54.225**	58.635**	58.267**			
	[12.642]	[12.683]	[15.153]	[26.593]	[9.294]	[10.798]	[17.432]			
Observations	5135	5135	3877	964	4740	3689	1005	4041	3115	926
Pseudo R-squared	0.185	0.187	0.197	0.253	0.0758	0.0765	0.0964	0.0370	0.0366	0.0685

Standard errors in brackets. $^{**}p < 0.01$, $^{*}p < 0.05$, $^{+}p < 0.1$.

inclusion of firms' startup in the cultural framework of institutions. In line with previous empirical works (Caldera & Debande, 2010; Muscio et al., 2016; Muscio & Ramaciotti, 2019), we find that the adoption of university regulations on entrepreneurship is positively associated to PhDs' decision to become entrepreneurs. These results extend previous findings on spin-off activity concerning the relevance of academic rules in supporting PhD startups (Lockett et al., 2003). We also find that these rules have no significant effect on either students evaluating or abandoning the idea to become entrepreneurs. These results are confirmed also by the second proxy of the entrepreneurial environment: we find that the availability of a business incubator at the parent university supports business creation is not significantly associated to students' intention or abandonment of the idea to establish a firm. This is probably because only those students that really needed the business incubation services engaged with it, whilst in the other two cases they did not.

Moving to student-level indicators testing the remaining hypotheses, we find that, supporting Hypothesis 2, entrepreneurship education is positively associated to students' choice to become entrepreneurs. These results are in line with investigations on the effect of entrepreneurial courses on students' future careers, confirming that, even in the case of PhDs, courses on entrepreneurship positively affect the entrepreneurial activity (Muscio & Ramaciotti, 2019) and intentions of students (Souitaris et al., 2007; Von Graevenitz et al., 2010). Conversely, we find that those students that attended the course are less likely to abandon the idea to become entrepreneurs.

Confirming Hypothesis 3, we find that those students that choose to dedicate their PhD studies to research that addresses business needs will be more likely to (or be willing to) become entrepreneurs. As suggested by Abreu and Grinevich (2013), research which is more easily applied to an industrial context is more likely to stimulate entrepreneurial ideas in academia. Therefore, carrying out research, which is applied to a business context, raises the probability of finding research results that can be relevant for the market, increases the probability of students' deciding to create a start-up.

Finally, concerning Hypothesis 4, as noted above, academic entrepreneurial activities are embedded, in institutional contexts (Autio et al., 2014; Welter, 2011), and breed from students' interaction with other researchers in given spaces (Bergmann et al., 2016). In this respect, university laboratories represent complex contexts where scientific research as well as research training and career building is carried out. Some authors (De Jong & Den Hartog, 2007; Olmos-Peñuela et al., 2014) argue that lab directors can influence lab members setting research priorities, steering research activities, mobilising organisational tasks and reallocating resources. Some papers suggest that the training that students receive in academic labs and their inter-personal relationship with peers and supervisors can determine their future prospects and employment outcomes (Miller et al., 2005; Shibayama, 2019). In this respect, we find that, while students' access to what they believe is a good quality PhD lab is negatively associated to entrepreneurial activity. Nonetheless, by testing the interaction effect of business-oriented research and lab environment, we also find that accessing good PhD labs positively moderates entrepreneurial activity and intention. Therefore, while access to good supervisors and good facilities might push students to pursue an academic career or to look for good research jobs, the availability of a high-quality PhD environment is boosting the effects of carrying out business-oriented research on the probability that they will become entrepreneurs or develop the intention to do so.

The individual level control variables confirm the results obtained by other researchers studying the determinants of academic spin-off creation (Krabel & Mueller, 2009). First, we find that the age effect is negatively significant, indicating that younger students will be more likely to pursue the choice to become entrepreneurs as an employment outcome. We also find that men have a higher probability than women of becoming entrepreneurs. Partially confirming the aforementioned arguments supporting Hypothesis 4, having a job in academia is negatively associated to both entrepreneurship and entrepreneurial intention. These results are confirmed by other studies showing that, in the early stages of an academic career, researchers tend to focus on research-based activities such as publications (Bercovitz & Feldman, 2008). Finally, as noted in Arenius and Minniti (2005), students' start-up activity will be driven by their risk attitude. Confirming this, we find that positive risk attitude is associated to startup activity and intention, while more risk-averse students will be more likely to abandon the idea of starting a company. Similarly, confirming Guerrero et al. (2018), earning previous work experience facilitates business creation while it is negative associated to the abandonment of the idea of business creation.

Moving to university control variables, our results show that entrepreneurial activities are more vibrant in smaller universities. Confirming the findings of other papers on spin-offs (Landry et al., 2006; Ramaciotti & Rizzo, 2015), university research performance does not affect start-up generation.

As the scientific activity and behaviour of scholars in the SSH might differ from those specialising in the LHS because of intrinsic or extrinsic factors (Bonaccorsi et al., 2017), we test the two models on two sub-samples of data including students that studied in these two areas. In general, the results for the hard sciences and the soft sciences largely confirm those obtained at the aggregate level, with the only exception of entrepreneurial intention in the SSH, where among the factors considered, only research oriented to business needs seem to be positively associated to students' intentions.

10.5 Conclusions

This paper investigated the effects of PhD students' access to the academic environment on their entrepreneurial activity. While the scientific literature and technology transfer policy alike have so far have paid little attention to PhD entrepreneurship, the findings from our study make a case for promotion of an entrepreneurial university model that is broader in scope than the models currently in place in many US and European institutions.

We shed light on the characteristics of the student's home institution associated to business creation by young, research-skilled individuals, focusing on four factors: (1) the availability of a university entrepreneurship policy framework; (2) PhD orientation towards business problems; (3) entrepreneurship training; (4) standing of the PhD lab. Our results confirm that academic institutions can play a fundamental role in influencing the entrepreneurial behaviour of their students and their commitment to offering an environment that nurtures entrepreneurship can also make a difference in terms of pursuing the third mission.

The empirical results presented here have some relevant policy and managerial implications. First of all, the definition and promotion of clear policy initiatives in support of academic entrepreneurship, such as the creation of clear academic rules for potential entrepreneurs and the establishment of a business incubator will make a difference in changing students' attitude towards new firm creation.

Secondly, our results show that the design of PhD programmes is most likely to influence PhD entrepreneurship. Students' engagement in business-oriented applied research activities and their participation in entrepreneurship courses, will have a tangible impact on the probability that they will choose to become entrepreneurs. Moreover, we find that students' access to better research laboratories will influence positively the effects of business-oriented research on their entrepreneurial activities. Therefore, supporting the creation of an entrepreneur-friendly PhD environment, could increase the institutional capability to generate a tangible impact on local communities while also offering better work opportunities for students.

Despite these relevant implications, this study faces some important limitations. First of all, the use of cross-sectional data implies some caution in identifying any cause-effect relationship (Muscio & Ramaciotti, 2018). Unfortunately, the use of single-call questionnaire data, which exposes to some risks of reverse causality, which in our case should be balanced by the high response rate and good representativeness of the sample. Secondly, as we run an individual level study, we cannot draw any conclusion in terms of institutional performance. This brings us to future developments of this type of studies, which could be extended exploring university-level factors influencing academic performance in terms of PhD startup activity.

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References

Abreu, M., & Grinevich, V. (2013). The nature of academic entrepreneurship in the UK: Widening the focus on entrepreneurial activities. *Research Policy, 42*, 408–422.

Agrawal, A., & Henderson, R. (2002). Putting patents in context: Exploring knowledge transfer from MIT. *Management Science, 48*, 44–60.

Arenius, P., & Minniti, M. (2005). Perceptual variables and nascent entrepreneurship. *Small Business Economics, 24*(3), 732–755.

Åstebro, T., & Bazzazian, N. (2011). Universities, entrepreneurship and local economic development. In M. Fritsch (Ed.), *Handbook of research on entrepreneurship and regional development*. Edward Elgar.

Åstebro, T., Bazzazian, N., & Braguinsky, S. (2012). Startups by recent university graduates and their faculty: Implications for university entrepreneurship policy. *Research Policy, 41*(4), 663–677.

Autio, E., Kenney, M., Mustar, P., Siegel, D. S., & Wright, M. (2014). Entrepreneurial innovation: The importance of context. *Research Policy, 43*(7), 1097–1108.

Azagra-Caro, J. M., Mas-Verdú, F., & Martinez-Gomez, V. (2012). Forget R&D–pay my coach: Young innovative companies and their relations with universities. In *Technology transfer in a global economy* (pp. 13–34). Springer.

Barbero, J., Casillas, J., & Wright, M. (2014). Do different types of incubators produce different types of innovations? *Journal of Technology Transfer, 39*, 151–168.

Bekkers, R., & Bodas Freitas, I. M. (2008). Analysing knowledge transfer channels between universities and industry: To what degree do sectors also matter? *Research Policy, 37*, 1837–1853.

Bercovitz, J., & Feldman, M. (2008). Academic entrepreneurs: Organizational change at the individual level. *Organization Science, 19*, 69–89.

Bergmann, H., Hundt, C., & Sternberg, R. (2016). What makes student entrepreneurs? On the relevance (and irrelevance) of the university and the regional context for student start-ups. *Small Business Economics, 47*, 53–76.

Bienkowska, D., & Klofsten, M. (2012). Creating entrepreneurial networks: Academic entrepreneurship, mobility and collaboration during PhD education. *Higher Education, 64*, 207–222.

Bienkowska, D., Klofsten, M., & Rasmussen, E. (2016). PhD students in the entrepreneurial university – perceived support for academic entrepreneurship. *European Journal of Education, 51*, 56–72.

Blackford, B. J., Sebora, T. C., & Whitehill, T. (2009). The effects of collegiate entrepreneurship education on post-graduation startup of new ventures: A first look. *International Review of Entrepreneurship, 7*(3), 1–26.

Bonaccorsi, A., Daraio, C., Fantoni, S., Folli, V., Leonetti, M., & Ruocco, G. (2017). Do social sciences and humanities behave like life and hard sciences? *Scientometrics, 112*(1), 607–653.

Branscomb, L. M., Kodama, F., & Richard, F. (1999). *Industrializing knowledge: University–industry linkages in Japan and the United States*. MIT Press.

Caldera, A., & Debande, O. (2010). Performance of Spanish universities in technology transfer: An empirical analysis. *Research Policy, 39*(9), 1160–1173.

Calderini, M., Franzoni, C., & Vezzulli, A. (2007). If star scientists do not patent: The effect of productivity, basicness and impact on the decision to patent in the academic world. *Research Policy, 36*, 303–319.

Clarysse, B., Tartari, V., & Salter, A. (2011). The impact of entrepreneurial capacity, experience and organizational support on academic entrepreneurship. *Research Policy, 40*, 1084–1093.

Cohen, W. M., Nelson, R. R., & Walsh, J. P. (2002). Links and impacts: The influence of public research on industrial R&D. *Management Science, 48*, 1–23.

Colombo, M. G., & Piva, E. (2012). Firms' genetic characteristics and competence-enlarging strategies: A comparison between academic and non-academic high-tech start-ups. *Research Policy, 41*, 79–92.

Conti, A., & Visentin, F. (2015). A revealed preference analysis of PhD students' choices over employment outcomes. *Research Policy, 44*, 1931–1947.

D'Este, P., Mahdi, S., Neely, A., & Rentocchini, F. (2012). Inventors and entrepreneurs in academia: What types of skills and experience matter? *Technovation, 32*(5), 293–303.

De Jong, J. P. J., & Den Hartog, D. N. (2007). How leaders influence employees' innovative behaviour. *European Journal of Innovation Management, 10*, 41–64.

Delamont S., & Atkinson P. (2001). Editorial. *Qualitative Research, 1*(3), 275–277.

Dooley, L., & Kenny, B. (2015). Research collaboration and commercialization: The PhD candidate perspective. *Industry and Higher Education, 29*, 93–110.

Etzkowitz, H. (2017). Innovation lodestar: The entrepreneurial university in a stellar knowledge firmament. *Technological Forecasting and Social Change, 123*(4), 122–129.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research Policy, 29*, 109–123.

Etzkowitz, H., Webster, A., Gebhardt, C., & Terra, B. (2000). The future of the university and the university of the future: Evolution of ivory tower to entrepreneurial paradigm. *Research Policy, 29*, 313–330.

European Commission. (2010). *Monitoring industrial research: The 2010 EU Industrial R&D Investment Scoreboard*. Seville.

Feldman, M. (2001). The entrepreneurial event revisited: Firm formation in a regional context. *Industrial and Corporate Change, 10*(4), 861–891.

Geisler, E., & Rubenstein, A. H. (1989). University-industry relations: A review of major issues. In A. N. Link & G. Tassey (Eds.), *Cooperative research and development: The industry-university-government relationship* (pp. 43–62). Kluwer Academic.

Geuna, A., & Muscio, A. (2009). The governance of university knowledge transfer: A critical review of the literature. *Minerva, 47*, 93–114.

Ghio, N., Guerini, M., Lehmann, E. E., & Rossi-Lamastra, C. (2015). The emergence of the knowledge spillover theory of entrepreneurship. *Small Business Economics, 44*, 1–18.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies*. Sage Publications.

Guerrero, M., Urbano, D., Cunningham, J. A., & Gajón, E. (2018). Determinants of graduates' start-ups creation across a multi-campus entrepreneurial university: The case of Monterrey Institute of Technology and Higher Education. *Journal of Small Business Management, 56*, 150–178.

Harris, M., & Gibson, S. G. (2008). Examining the entrepreneurial attitudes of US business students. *Education and Training, 4*(1), 35–50.

Hoppe, M. (2016). Policy and entrepreneurship education. *Small Business Economics, 46*, 13–29.

Jansen, S., van de Zande, T., Brinkkemper, S., Stam, E., & Varma, V. (2015). How education, stimulation, and incubation encourage student entrepreneurship: Observations from MIT, IIIT, and Utrecht University. *International Journal of Management Education, 13*, 170–181.

Kessels, J., & Kwakman, K. (2007). Interface: Establishing knowledge networks between higher vocational education and business. *Higher Education, 54*(5), 689–703.

Krabel, S., & Mueller, P. (2009). What drives scientists to start their own company? An empirical investigation of Max Planck Society scientists. *Research Policy, 38*, 947–956.

Kuratko, D. F. (2005). The emergence of entrepreneurship education: Development, trends, and challenges. *Entrepreneurship Theory and Practice, 29*(5), 577–597.

Landry, R., Amara, N., & Rherrad, I. (2006). Why are some university researchers more likely to create spin-offs than others? Evidence from Canadian universities. *Research Policy, 35*, 1599–1615.

Laudel, G. (2001). Collaboration, creativity and rewards: why and how scientists collaborate. *International Journal of Technology Management, 22*, 762–781.

Lester, S., & Costley, C. (2010). Work-based learning at higher education level: Value, practice and critique. *Studies in Higher Education, 35*(5), 561–575.

Lockett, A., Wright, M., & Franklin, S. J. (2003). Technology transfer and universities' spin-out strategies. *Small Business Economics, 20*(2), 185–200.

Lowe, R. A., & Gonzalez-Brambila, C. (2007). Faculty entrepreneurs and research productivity. *The Journal of Technology Transfer, 32*, 173–194.

Maresch, D., Harms, R., Kailer, N., & Wimmer-Wurm, B. (2016). The impact of entrepreneurship education on the entrepreneurial intention of students in science and engineering versus business studies university programs. *Technological Forecasting and Social Change, 104*, 172–179.

McAdam, M., & McAdam, R. (2008). High tech start-ups in University Science Park incubators: The relationship between the start-up's lifecycle progression and use of the incubator's resources. *Technovation, 28*, 277–290.

McCormack, J., Propper, C., & Smith, S. (2014). Herding cats? Management and university performance. *Economic Journal, 124*, 534–564.

Miller, C. C., Glick, W. H., & Cardinal, L. B. (2005). The allocation of prestigious positions in organizational science: Accumulative advantage, sponsored mobility, and contest mobility. *Journal of Organizational Behavior, 26*, 489–516.

Mitra, J., & Matlay, H. (2004). Entrepreneurial and vocational education and training: Lessons from eastern and central Europe. *Industry and Higher Education, 18*(1), 53–69.

Muscio, A., & Pozzali, A. (2013). The effects of cognitive distance in university-industry collaborations: Some evidence from Italian universities. *The Journal of Technology Transfer, 38*, 486–508.

Muscio, A., & Ramaciotti, L. (2018). Dataset from a qualitative survey on Ph.D. entrepreneurship in Italy. *Data in Brief, 18*, 1272–1276.

Muscio, A., & Ramaciotti, L. (2019). How does academia influence Ph.D. entrepreneurship? New insights on the entrepreneurial university. *Technovation, 82–83*, 16–24.

Muscio, A., Quaglione, D., & Vallanti, G. (2013). Does government funding complement or substitute private research funding to universities? *Research Policy, 42*, 63–75.

Muscio, A., Quaglione, D., & Ramaciotti, L. (2016). The effects of university rules on spinoff creation: The case of academia in Italy. *Research Policy, 45*, 1386–1396.

Olmos-Peñuela, J., Castro-Martínez, E., D'Este, P., & D'Este, P. (2014). Knowledge transfer activities in social sciences and humanities: Explaining the interactions of research groups with non-academic agents. *Research Policy, 43*, 696–706.

Oosterbeek, H., van Praag, M., & Ijsselstein, A. (2010). The impact of entrepreneurship education on entrepreneurial skills and motivation. *European Economic Review, 54*(3), 442–454.

Phan, P. H., & Siegel, D. S. (2006). The effectiveness of university technology transfer. *Foundations and Trends in Entrepreneurship, 2*, 77–144.

Philpott, K., Dooley, L., O'Reilly, C., & Lupton, G. (2011). The entrepreneurial university: Examining the underlying academic tensions. *Technovation, 31*, 161–170.

Powers, J. B., & McDougall, P. (2005). Policy orientation effects on performance with licensing to start-ups and small companies. *Research Policy, 34*, 1028–1042.

Pruett, M., Shinnar, R., Toney, B., Francisco, L., & Fox, J. (2009). Explaining entrepreneurial intentions of university students: a cross cultural study. *International Journal of Entrepreneurial Behavior & Research, 15*(6), 1355–2554.

Ramaciotti, L., & Rizzo, U. (2015). The determinants of academic spin-offs creation by Italian universities. *R&D Management, 45*(5), 501–514.

Ramaciotti, L., Muscio, A., & Rizzo, U. (2017). The impact of hard and soft policy measures on new technology-based firms. *Regional Studies, 51*(4), 629–642.

Rasmussen, E., & Borch, O. J. (2010). University capabilities in facilitating entrepreneurship: A longitudinal study of spin-off ventures at mid-range universities. *Research Policy, 39*, 602–612.

Rasmussen, E., Mosey, S., & Wright, M. (2014). The influence of university departments on the evolution of entrepreneurial competencies in spin-off ventures. *Research Policy, 43*, 92–106.

Rothaermel, F. T., Agung, S. D., & Jiang, L. (2007). University entrepreneurship: A taxonomy of the literature. *Industrial and Corporate Change, 16*, 691–791.

Sanchez, J. (2011). University training for entrepreneurial competencies: Its impact on intention of venture creation. *International Entrepreneurship Management Journal, 7*, 239–254.

Shah, S. K., & Pahnke, E. C. (2014). Parting the ivory curtain: Understanding how universities support a diverse set of startups. *Journal of Technology Transfer, 39*, 780–792.

Shibayama, S. (2019). Sustainable development of science and scientists: Academic training in life science labs. *Research Policy, 48*, 676–692.

Shibayama, S., Baba, Y., & Walsh, J. P. (2015). Organizational design of university laboratories: Task allocation and lab performance in Japanese bioscience laboratories. *Research Policy, 44*, 610–622.

Siegel, D. S., & Wright, M. (2015). Academic entrepreneurship: Time for a rethink? *British Journal of Management, 26*, 582–595.

Siegel, D. S., Waldman, D. A., & Link, A. N. (2003). Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: An exploratory study. *Research Policy, 32*, 27–48.

Slaughter, S., Campbell, T., Holleman, M., & Morgan, E. (2002). The "traffic" in graduate students: Graduate students as tokens of exchange between academe and industry. *Science, Technology and Human Values, 27*(2), 282–312.

Smith, B. R., Matthews, C. H., & Schenkel, M. T. (2009). Differences in entrepreneurial opportunities: The role of tacitness and codification in opportunity identification. *Journal of Small Business Management, 47*(1), 38–57.

Souitaris, V., Zerbinati, S., & Al-Laham, A. (2007). Do entrepreneurship programmes raise entrepreneurial intention of science and engineering students? The effect of learning, inspiration and resources. *Journal of Business Venturing, 22*, 566–591.

Spence, M. (1973). Job market signalling. *The Quarterly Journal of Economics, 87*(3), 355–374.

Stamboulis, Y., & Barlas, A. (2014). Entrepreneurship education impact on student attitudes. *The International Journal of Management Education, 12*, 365–373.

Stephan, P. E. (2012). *How economics shapes science*. Harvard University Press.

Storey, D., & Tether, B. (1998). New technology-based firms in the European Union: An introduction. *Research Policy, 26*, 933–946.

Stuart, T. E., & Ding, W. W. (2006). When do scientists become entrepreneurs? The social structural antecedents of commercial activity in the academic life sciences. *American Journal of Sociology, 112*(1), 97–144.

Thune, T. (2009). Doctoral students on the university-industry doctoral interface: A review of the literature. *Higher Education, 58*, 637–651.

Thune, T., & Støren, L. A. (2015). Study and labour market effects of graduate students' interaction with work organisations during education. *Education + Training, 57*, 702–722.

Thursby, J. G., & Thursby, M. C. (2007). University licensing. *Oxford Review of Economic Policy, 23*(4), 620–639.

Van Looy, B., Landoni, P., Callaert, J., van Pottelsberghe, B., Sapsalis, E., & Debackere, K. (2011). Entrepreneurial effectiveness of European universities: An empirical assessment of antecedents and trade-offs. *Research Policy, 40*, 553–564.

Vanevenhoven, J., & Liguori, E. (2013). The impact of entrepreneurship education: Introducing the entrepreneurship education project. *Journal of Small Business Management, 51*(3), 315–328.

Van Rijnsoever, F. J., van Weele, M. A., & Eveleens, C. P. (2017). Network brokers or hit makers? Analyzing the influence of incubation on start-up investments. *International Entrepreneurship and Management Journal, 13*, 605–629.

Von Graevenitz, G., Harhoff, D., & Weber, R. (2010). The effects of entrepreneurship education. *Journal of Economic Behavior and Organization, 76*, 90–112.

Walter, S. G., Parboteeah, K. P., & Walter, A. (2013). University departments and self-employment intentions of business students: A cross-level analysis. *Entrepreneurship Theory and Practice, 37*, 175–200.

Welter, F. (2011). Contextualizing entrepreneurship-conceptual challenges and ways forward. *Entrepreneurship Theory and Practice, 35*(1), 165–184.

Wright, M., Vohora, A., & Lockett, A. (2004). The formation of high-tech university spinouts: The role of joint ventures and venture capital investors. *The Journal of Technology Transfer, 29*, 287–310.

Wright, M., Clarysse, B., Mustar, P., & Lockett, A. (2007). *Academic entrepreneurship in Europe*. Edward Elgar.

Zucker, L. G., & Darby, M. (1996). Star Scientists and institutional transformation: Patterns of invention and innovation in the formation of the biotechnology industry. *Proceedings of the National Academy of Sciences of the United States of America, 93,* 12709–12716.