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Abstract

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Keywords	Student Entrepreneurship; Entrepreneurial University; Start-up; PhDs; Firm Creation.

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RESPONSE TO THE EDITOR

“You were asked for a number of changes including elimination of footnotes. The response to reviewers seems to indicates that footnotes were eliminated. However, the paper contains a number of footnotes. Please take this opportunity to carefully go through your paper and make requested changes. Your next submission will result in either an acceptance or a rejection.”

RESPONSE: We apologise for the footnotes. We eliminated them and took the opportunity to check carefully the whole paper. This final version of the paper was proofread by a native English speaker.

Best wishes,
The authors

Highlights

1. We use data from a large questionnaire survey targeting PhD graduates in Italy.
2. The academic entrepreneurial environment influences PhD entrepreneurship.
3. The characteristics of PhD courses have a major impact on PhD entrepreneurship.

How does academia influence PhD entrepreneurship? New insights on the entrepreneurial university

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How does academia influence PhD entrepreneurship? New insights on the entrepreneurial university

Abstract

This work investigates the factors that affect the propensity of PhD students to create their own firms. The paper uses data from the responses to 9,062 questionnaires, administered in 2016 to PhD students in Italy, focusing on five factors: the entrepreneurial environment; the existence of university policy frameworks dedicated to entrepreneurship; the degree of applicability of the doctoral research to an industry context; student-industry collaboration during the doctoral study period; inclusion in the PhD programme of courses on entrepreneurship. The empirical evidence shows that both university- and course-level factors have a fundamental impact on students' decisions to start new ventures.

JEL classification: I23, L31, O32, O33.

Keywords: Student Entrepreneurship; Entrepreneurial University; Start-up; PhDs; Firm Creation.

1 Introduction

This paper investigates the role of universities in influencing the academic orientation of PhD students. As knowledge becomes increasingly relevant for economic growth, governments in many countries are encouraging universities to contribute actively to economic development and employment via knowledge transfer (Powers and McDougall, 2005). Although knowledge transfer from universities to society is not a recent phenomenon (Geuna and Muscio, 2009; Wright et al., 2007), third mission activities and management of university–industry linkages have been 'institutionalised' progressively over the last 30 years (Gibbons et al., 1994; Etzkowitz and Leydesdorff, 2000).

Several papers highlight the heterogeneity of university-industry interactions (Agrawal and Henderson, 2002; Cohen et al., 2002; Bekkers and Bodas Freitas, 2008; Muscio and Pozzali, 2013) and the rise academic entrepreneurialism (Dooley and Kenny, 2015; Wright et al., 2007; Siegel et al., 2003). While the academic contribution to entrepreneurial activities can take many forms (Philpott et al., 2011), the recent scientific literature focuses mostly on forms of 'tangible' knowledge transfer, ranging from patenting and licensing activities to spin-off creation. In line with the growing commercialisation of university research through academic spin-offs since the late 1980s, a scientific literature on academic entrepreneurship, investigating licensing and start-ups by faculty and staff (Thursby and Thursby, 2007), has become established. However, this body of work tends to overlook the phenomenon and extent student entrepreneurship (Åstebro and Bazzazian, 2011; Åstebro et al., 2012; Shah and Pahnke, 2014). There is a lack of empirical evidence on PhD students' entrepreneurial activities (Bienkowska et al., 2016). Existing empirical work overlooks firms started by PhD students because they are less frequently based on university Intellectual

Property (IP) than those started by faculty staff. Thus, if students or groups of students decide to start a business, this tends not to be recorded as university spin-off activity unless the new venture involves a faculty member. Nevertheless, PhDs are likely to be more motivated than tenured university academics to start an entrepreneurial venture and can contribute greatly to knowledge diffusion from academic institutions. For instance, PhD students, since they are younger and less risk averse, and do not have job tenure, are likely at the end of their doctoral studies to be more motivated than tenured university academics to start an entrepreneurial venture . Moreover, PhD entrepreneurship can be an effective university third mission activity and can contribute to regional development (Etzkowitz, 2017; Etzkowitz et al., 2000; Philpott et al., 2011). Compared to other forms of entrepreneurship, PhD entrepreneurship is more likely to result in knowledge-intensive start-ups and to provide high-skilled jobs and contribute to renewing the regional economic structure, further legitimating , the role of universities in the generation of regional economic wealth and employment.

Debate on student entrepreneurship is recent in many countries. While there is a fairly wide consensus that start-ups created by students represent a major part of the university impact on entrepreneurship, little is known about the drivers of PhD students' start-up activities. A greater awareness of these drivers could have an effect on universities' goals and practices related to increasing new firm creation by students and university faculty.

As academic funding systems are becoming an essential element of the reforms in several European countries (Muscio et al., 2013), it has been argued that, given the limited availability of permanent academic positions, universities are producing too many doctoral graduates (Stephan, 2012). The large amounts of resources that governments allocate to PhD programmes are based on the assumption that PhD

graduates will take up positions in academia and facilitate knowledge transfer, providing returns to government investment in their education. While the literature on PhD employment outcomes shows that this does not always happen (Conti and Visentin, 2015), it says little about the universities' influence the decisions of their PhDs to start business ventures. Some papers discuss 'soft' and 'hard' university initiatives to support entrepreneurship (Philpott et al., 2011; Ramaciotti et al., 2017), but do not refer explicitly to PhDs in this context. Since the incentives for students to complete their doctoral study programmes are related mainly to their career options after graduation (Mangematin, 2000), a better understanding of the academic factors that determine young professionals' choices to start a business would seem important.

This paper investigates the impact of the entrepreneurial environment and the characteristics of PhD degree courses on PhD students' entrepreneurship for two reasons. First, their investigation has immediate policy and managerial implications and provides insights into possible interventions to encourage research institutions to promote entrepreneurship. Second, unlike aspects such as students' personal characteristics (Pruett et al., 2009), these features have not been studied in depth in the empirical literature. The research hypotheses are tested on data from a questionnaire survey addressed to 9,062 PhD students who were enrolled in PhD programmes in Italy between 2008 and 2014.

2 PhD entrepreneurship

Governments are putting pressure on universities to stimulate and support entrepreneurship. This new emphasis on linking academic institutions to industry has led to the emergence of the 'entrepreneurial university' model (Branscomb et al.,

1999), related to the potential for academic institutions to promote new business creation. However, scientific debate on academic entrepreneurship is overly-focused on the research–third mission nexus and university–industry linkages (Siegel and Wright, 2015). The emphasis in empirical work on the transfer of scientists' inventions to patents and, eventually, to spin-offs has resulted in new forms of entrepreneurial venture creation being overlooked. Academic entrepreneurship, taken as a whole, involves a plurality of stakeholders, including students, faculty staff and post-doctoral fellows, who choose to work with industry for various reasons including greater availability of entrepreneurial or technological opportunities (or lower availability of qualified posts), better information on the steps to market, access to entrepreneurship programmes, and so on. Thus, universities can be an important source of entrepreneurial activity for students and academics. First, universities generate knowledge that spills over and is leveraged by prospective entrepreneurs (Ghio et al., 2015). Second, even before the university third mission became established, universities were fostering academic entrepreneurship and encouraging members of faculty to create new firms (Rothaermel et al., 2007). Third, despite the creation of new ventures by students and recent graduates being an under-investigated phenomenon, universities support student entrepreneurship (Åstebro et al., 2012; Conti and Visentin, 2015).

Therefore, although largely neglected by the economics literature, the entrepreneurial activity of PhD students and graduates deserves special attention. For example, PhDs students may be better able than academic staff to overcome the obstacles to new venture creation. Unlike academic staff, they do not need 'genetic mutation' to become entrepreneurs and may be better placed to gain access to the required commercial competences and assets (Colombo and Piva, 2012). Also, during their early scientific-

oriented careers, PhD students may be more able than graduates and faculty members to exploit business ideas with higher levels of technological/knowledge content.

The literature on academic entrepreneurship comprises work on institutional activities and studies examining academics' individual characteristics (Castillo Holley and Watson, 2017). In the specific case of PhD students, there are many ways in which universities can influence the probability of deciding to start a new venture; the entrepreneurial skills developed during their PhD studies can influence their future entrepreneurial capabilities (Dooley and Kenny, 2015). This paper extends the studies on student entrepreneurship and reviews the main institutional factors regarded as influencing PhD students to start their own ventures. It focuses on the entrepreneurial climate in the university and the characteristics of the PhD course. The sections below discuss their theoretical underpinnings.

2.1 The entrepreneurial climate at the university and PhD entrepreneurship

Entrepreneurial activities have a social, organisational and spatial dimension (Autio et al., 2014). The internal and external academic contexts are important determinants of academic entrepreneurship (Guerrero and Urbano, 2012; Bergmann et al., 2016) and the entrepreneurial intentions of students (Miranda et al., 2017; Saridakis et al., 2016). Several studies (Bercovitz and Feldman, 2008; Clarysse et al., 2011; Stuart and Ding, 2006) point to the part played by the local social environment in stimulating graduates' entrepreneurial behaviour and determining the transition from scientific to commercial activities. While the regional context can affect start-up success (Sternberg, 2014), academic entrepreneurial activity is related endogenously to the economic impact of

the entrepreneurial university on the local community (Guerrero et al., 2015), and influences the contribution to regional economic development.

There are several reasons why the social context might influence the choice of the PhD student to start a new venture. Linan et al. (2011) find regional differences in the valuation of entrepreneurship in Spain and provide evidence of a direct relationship between a positive valuation and student entrepreneurship. Also, Stuart and Ding (2006) suggest that the proximity of academics and students to academics who have started companies (e.g., university spin-offs), significantly increases the likelihood of their engagement in entrepreneurship. In fact, “Regardless of whether there is a direct contact between the academics who are involved in the spin-offs or not, the existence of these spin-out companies in the local setting is a source of learning and norm creation” (Clarysse et al., 2011: 1089). Clarysse et al. use the number of spin-offs generated in the academics’ parent institutions to measure the social environment. They find that a favourable social environment has a positive effect on the probability that the academic will become an entrepreneur, even if this effect is not as strong as the academic’s entrepreneurial capacity. This finding can be extended to PhD entrepreneurship such that, studying at an academic institution with relevant spin-off activity will have a positive influence on the choice to become an entrepreneur and, therefore, drives PhD entrepreneurship. While academic research departments and laboratories are engaged in entrepreneurial activities to different extents (Wright et al., 2007; Gulbrandsen and Smeby, 2005), several authors highlight the relevance of department-level factors and enterprise norms for influencing entrepreneurship (Erikson et al., 2015; Bercovitz and Feldman, 2008; Huyghe and Knockaert, 2015; Kenney and Goe, 2004). Therefore, we can formulate the following hypothesis:

H1: PhDs attending institutions where entrepreneurship is thriving will be more likely to start their own firms.

University policies can contribute to creating an environment favourable to the germination of and establishment of an entrepreneurial idea. Universities can define sets of rules related to start-up and spin-off creation (Muscio et al., 2016); the existence of such rules can influence entrepreneurial activity (Rasmussen et al., 2014). Despite some concern about the top-down influence of rules to promote 'entrepreneurial ideas' in academic institutions (Adekiya and Ibrahim, 2016; Philpott et al., 2011), several universities have put in place measures to support entrepreneurship (Ambos et al., 2008; Boardman and Bozeman, 2007; Siegel and Wright, 2015). This is increasing the entrepreneurial propensity of students and promoting the creation of a supportive context for business start-up activity (Hoppe, 2016; Kuratko, 2005; Walter et al., 2013). The existence of rules indicates the university's strategic entrepreneurial orientation and choice to include start-up and spin-off activity in its institutional cultural framework (Phan and Siegel, 2006; Van Looy et al., 2011). In addition, the existence of a university policy supporting entrepreneurship clarifies the potential entrepreneur's interactions with the parent university and formalises the conditions for academics and students keen to embark on entrepreneurial ventures (Rasmussen and Borch, 2010). Clear and well-defined strategies related to the formation and management of spin-offs are common in better performing universities (Lockett et al., 2003); clear rules can speed-up business plan preparation and approval and avoid potential conflicts of interest between the entrepreneur and the parent institution. Therefore, we hypothesise that:

H2: PhDs attending institutions with policies to support academic entrepreneurship will be more likely to start their own firms.

2.2 The PhD programme and PhD entrepreneurship

Evidence related to type of academic research and its effect on knowledge transfer, spans several knowledge areas (Quaglione et al., 2015). Hassan and Wafa (2012) demonstrate that there are significant differences in entrepreneurial intentions depending on the study programme. They found that students enrolled in science programmes had significantly higher entrepreneurial intentions compared to business and arts students. Thus, they hypothesise that students from technology universities will be more highly motivated to choose entrepreneurship than students from other type of universities.

Entrepreneurial ideas are affected also by the level of uncertainty involved. New knowledge or new technologies do not, in themselves, constitute entrepreneurial opportunities (Bergmann, 2017; Grégoire et al., 2010). If the new venture is based on a research-driven idea, matching market opportunities to the new technology can be difficult because it requires the identification of a new means-ends relationship. In this case, working experience in an industry context can support the entrepreneurial process and reduce the uncertainty surrounding a research-driven idea (Smith et al., 2009). It follows that research outcomes that are more easily applicable to an industry context will be more likely to spark new venture creation by both PhD students and academics more generally (Abreu and Grinevich, 2013). For instance, Prodan and Drnovsek (2010) show that patenting and applied research are two important predictors of academic entrepreneurial activities. Similarly, Calderini et al. (2007) find

that higher levels of ‘basicness’ in research have a negative effect on academic patenting and reduce the industry applicability of research results. Industry applicability has been found to be positively associated, also, to more frequent university-industry collaboration (Mansfield, 1998; Muscio and Pozzali, 2013).

Therefore, we posit that:

H3: PhDs engaged in applied research are more likely to start firms than PhDs and academics involved in basic research.

Similarly, more involvement of business in university activities can positively affect the student decision to start a firm (Dooley and Kenny, 2015). There is a large literature on the learning benefits and educational value of work experiences in education programmes (Billett, 2009; Lester and Costley, 2010; Lee et al., 2010; Jackson, 2015). Interactions with private organisations can offer students complementary learning opportunities and resources that higher education institutions are unable to provide (Lester and Costley, 2010; Kessels and Kwakman, 2007; Slaughter et al., 2002). Combining university learning with business experience strengthens the integration between complementary forms of knowledge and the ability simultaneously to acquire and practise knowledge and skills (Thune and Støren, 2015). University-industry collaboration provides students and faculty with broader experience and exposes them to more applications-oriented research (Geisler and Rubenstein, 1989). Confirming this, Powers and McDougall (2005) found that US universities that received more R&D funding from industry generated higher numbers of spin-offs. Also, contract research and academic entrepreneurship have been shown to be positively related, suggesting

that contract research works as an incubation device that is instrumental in the creation of entrepreneurial ventures (Van Looy et al., 2011).

University-industry collaboration contributes to the creation of networking relationships and the capabilities needed for scientists to create spin-off firms (D'Este et al., 2012; O'Shea et al., 2005; Wright et al., 2004). These findings hold also at the individual level. For example, Blumenthal et al. (1996) argue that academics who collaborate with industry compared to those involved in publicly funded research, are more involved in commercially oriented activities. Also, it has been suggested (Landry et al., 2006; Krabel and Mueller, 2009) that researchers involved in collaboration agreements with industry are more likely to become entrepreneurs.

Because students generally have little industry experience, any interaction with representatives from the business sector or exposure to industry problems and market opportunities could encourage them to find industrial applications for their research and to pursue an entrepreneurial career. In particular, in the specific case of PhD students, it can be argued that the involvement of businesses in PhD programmes and the involvement of students in university-industry collaborations will increase their exposure to real-world business problems and needs and steer their research activity towards the development of marketable technologies and services.

Therefore, we hypothesise that:

H4: Business involvement in PhD research programmes increases the probability that PhD students and graduates will decide to start their own firms.

A third factor that might be especially relevant for PhDs compared to academic staff in relation to starting a new venture, is access to courses on and training in

entrepreneurship. Training of doctoral students is an important topic in higher education and research policy debates in several countries (Bienkowska and Klofsten, 2012; Bienkowska et al., 2016; Thune, 2009). Courses on entrepreneurship are a relatively new phenomenon and did not exist when the first Technology Transfer Offices (TTOs) were established in the early 1980s. Research on entrepreneurship education suggests that while students' personal characteristics are powerful drivers of start-up creation (Guerrero et al., 2018), attitudes to entrepreneurship can be influenced by the development of appropriate, student-centred entrepreneurship education programmes (Harris and Gibson, 2008). As the field of entrepreneurship becomes more prominent in tertiary education (Maresch et al., 2016), there are several studies that show how these programmes can raise levels of entrepreneurialism and entrepreneurial attitudes among students (Mitra and Matlay, 2004; Blackford et al., 2009; Maresch et al., 2016; Sanchez, 2011; Souitaris et al., 2007; Stamboulis and Barlas, 2014; Vanevenhoven and Liguori, 2013). This empirical evidence has led to the inclusion of entrepreneurship courses by higher education institutions around the world.

Åstebro et al. (2012) and Storey and Tether (1998) highlight that, in order to improve the business skills of potential entrepreneurs, academic institutions should offer courses in entrepreneurship and new business development to both staff and students. Similarly, Oosterbeek et al. (2010) and Maresch et al. (2016) argue that entrepreneurship training strengthens (or reduces) the intentions of academic students to create a new business and to become an entrepreneur. This applies, in particular, to the case of academic spin-offs since, in non-profit oriented universities, the resources and competences required to develop and grow the business may be available (Rasmussen and Borch, 2010; Rasmussen et al., 2014).

Finally, some authors stress that entrepreneurship education has a positive effect on the entrepreneurial intentions of students. Von Graevenitz et al. (2010) show that attendance at entrepreneurship courses encourage students to evaluate their skills and shape their entrepreneurial decision. Similarly, Peterman and Kennedy (2003) and Souitaris et al. (2007) argue that entrepreneurship education increases the entrepreneurial intentions of students.

H5: Provision of entrepreneurship courses as part of the PhD programme increases the probability that the PhD will start a firm.

3 Empirical framework

3.1 Data and methodology

This work exploits original dataset obtained from the responses to a questionnaire survey, administered between 2014 and 2015, to Italian doctoral students enrolled in a PhD programme between 2008 and 2014. The survey was sent to around 23,500 individuals and resulted in 9,062 completed questionnaires. It was administered directly by CINECA, an Italian university, research institution and the Ministry of Education and Research (MIUR) consortium that has contact details for all Italian PhD students and graduates. The questionnaire was constructed by the authors and designed to evaluate the PhD study experience of doctoral students. It asked about their study period, level of satisfaction with the study programme, occupational status and entrepreneurial activity.

The data show that, at the time of the survey (2014-15), 69.1% of respondents enrolled in a PhD programme (2008-14) had completed their PhD studies and 72.8% were

employed; 6.5% (7.9% of those in employment) had started their own businesses and 87.1% of these businesses were active at the time of the survey.

The questionnaire data were complemented by other data sources:

- to control for department and university level characteristics that might affect the choice to become an entrepreneur, the survey data were merged with data provided by MIUR on university characteristics such as size and location;
- to capture the effect of university attitudes and management practices related to PhDs creating new ventures, we used data provided by the Italian National Network for the Valorization of University Research (NETVAL). NETVAL annual surveys collect data on the third mission activities of their associated Italian universities (80% of all Italian universities);
- data on academic rules supporting start-ups and spin-offs were drawn from an original database of information on academic rules in place in Italian public universities. Several universities have rules that frame spinoff creation as part of their third-mission strategies (Caldera and Debande, 2010). These internal rules facilitate preparation of business proposals and regulate potential conflicts of interest between the university and the spinoff (Muscio et al., 2016). The authors obtained information on academic rules from institution websites;
- data on regional economic performance were drawn from the Italian National Institute of Statistics (ISTAT) databases.

Table 1 presents information on the variables used in the econometric analysis. A set of logit regressions was run to test the research hypotheses by estimating the correlation between the entrepreneurial climate of the university, the characteristics of

the PhD programme and the probability the student will start a new venture. Given the dichotomous nature of the dependent variable y_{ij}, which takes the value 1 if student *i*, attending university *j*, established or contributed to the establishment of a still active business start-up, the following conditional probability function is investigated:

$$\Pr(y_{ij} = 1) = \alpha + \beta_1 x_j + \beta_2 \gamma_{ij} + \beta_3 \delta_{ij} + \beta_4 \sigma_j + \beta_5 \theta_j + \epsilon_{ij} \quad (1)$$

According to the data, 588 respondents (corresponding to 6.5% of the sample) had participated in a firm creation process. These results are consistent with those provided by the AlmaLaurea survey on the career paths of Italian graduates, according to which 6.1% of graduate and postgraduate students described themselves as entrepreneurs. The independent variables include: a set of indicators x for the entrepreneurial climate at the student's home institution; a set of indicators γ for the characteristics of her/his PhD programme; a set of control variables δ for student-level characteristics; a set of control variables σ for university-level characteristics; and a control indicator θ for university-level geographical characteristics. The error term is denoted ϵ.

Identification of the control variables was based on the literature on the determinants of student start-up and academic spin-off creation (Åstebro et al., 2012; Krabel and Mueller, 2009). This body of work identifies both individual and context level determinants, where the context refers mostly to the characteristic of the university spawning these new ventures. three main sets of control variables (see Table 1) are introduced in function (1).

Individual-level variables control for those factors that are regarded as determinants of the individual propensity for firm creation (see: Abreu and Grinevich, 2013; Landry et

al., 2006). The model controls for whether students completed their PhD course, for students' age and gender, for individual affiliation to the university; and for individual research activity. The dummy variable patent, takes the value 1 if the individual participated in a patent application. University-level controls account for the university's technology transfer activity. Data on university research performance and on university size and type are drawn from government sources. Finally, since the regional context is significant for start-up creation (Feldman, 2001), a variable is included for the province level (NUTS3) unemployment rate.

Table 1 presents the variables used in the econometric model and Table 2 presents the descriptive statistics. Table 2, Column 6 indicates the value=1 for categorical variables expressed in percentages. Column 7 reports the results of independent sample t-tests, measuring the statistical difference in means between two samples: Active startup=1 and 0. According to the results of the test, in the majority of cases, the null hypothesis of equality of means between the samples is rejected. Therefore, there are there are several factors differentiating entrepreneurs from the rest of the sample. Table 3 presents the correlation matrix.

Table 1 Data source and definitions

<INSERT TABLE HERE>

Table 2 Descriptive statistics

<INSERT TABLE HERE>

Table 3 Correlation matrix

<TABLE 3>

3.2 Results

Table 4 presents the estimated parameters and marginal/impact effects. First, a basic version of model (1) with the other independent variables added step wise, in blocks of indicators (models 1 to 7). The last iteration of the econometric regression includes dummies for year of graduation and scientific area. The Variance Inflation Factor (VIF) test shows that the estimates are not affected by multicollinearity (VIF<10).

With reference to the effects of the variables of interest, the results show that university-level and PhD course factors are positively associated to student entrepreneurship. These results remain robust to the inclusion in the model of year and scientific area and suggest that there are several factors that could improve university start-up performance by influencing PhD students' decisions to become entrepreneurs.

In line with Clarysse et al. (2011), hypothesis 1 is tested using number of academic spin-offs generated by the parent institution to proxy for the entrepreneurial environment. The results presented in Table 4 show that creating a university environment favourable to the entrepreneurial process is positively associated to the probability that doctoral students will create their own firms. Two variables are used test hypothesis 2: TTOs' opinion about whether the parent university provides an entrepreneurship culture, and availability to academics and students of a set of rules for spin-off and start-up creation. While the results show that TTO opinions are not significantly associated to start-up creation, the existence of university regulations on

spin-off and start-up activity is positively associated to the decisions to become an entrepreneur. Note that the sign and level of statistical significance of the variable for start-up regulation remains relatively stable as the control variables are added to the base model.

All student-level indicators are significant and remain significant with the inclusion in the model of the other control variables, area dummies and year dummies. As expected, and supporting hypothesis 3, more time spent on applied research increases the probability of both marketable research results and firm start-up. Similarly, confirming hypothesis 4, collaborating with companies during the PhD programme is positively associated to the probability of becoming an entrepreneur. Finally, confirming hypothesis 5, provision of entrepreneurship courses is positively and significantly associated to the probability of creating a firm.

The results for the individual-level control variables show that there is a significant age effect, with younger PhD students being more likely to choose firm creation as an employment outcome. In line with other empirical studies, men are more likely than women to become entrepreneurs. Also, involvement in intellectual property and patent filing is associated to a higher probability of creating a firm. In contrast, and as expected, being a faculty member is negatively associated to the probability of creating a firm. In fact, the results show that students that are hired by a university are less likely to create firms.

For the university-level control variables, the results show that smaller universities are more dynamic in their promotion of student entrepreneurship compared to larger universities. Attending an academic institution with a medical school increases the probability of starting a firm, while attending a polytechnic university seems not to have an effect. Academic research performance has no effect on start-up creation.

Finally, the geographic location of the parent university has a clear effect on the student's choice to start a firm. Students graduating from universities located in areas with high rates of unemployment are more likely to choose to become entrepreneurs.

Table 4 Logit regressions

<TABLE 4>

4 Discussion

The aim of this paper was to investigate how academic institutions affect the propensity of PhD students to create their own firms. The focus was on both the entrepreneurial environment offered to students and the characteristics of the PhD courses. The evidence presented sheds light on the characteristics of the students' home institutions associated to business creation by young, research-skilled individuals such as PhD students. These include: the entrepreneurial environment; the existence of a university policy framework dedicated to entrepreneurship; the degree of application to industry of the PhD research; collaboration with industry during the student's doctoral programme; and the provision of entrepreneurship courses in the PhD programme.

4.1 Implications for Theory

Conti and Visentin (2015) note that the conventional wisdom suggests that investment in a PhD degree is aimed at an eventual academic career. However, empirical support for this view is limited and has some limitations. The empirical evidence on students' entrepreneurial activity is equally sparse and, especially, in relation to doctoral

students' entrepreneurship (Bienkowska et al., 2016). To try to fill this gap in the literature, this paper reports the results of a country-level empirical exercise investigating how universities could support PhD students' start-up creation. The findings make the case for a broader entrepreneurial university model than currently in place in many US and European institutions. The evidence shows that both university-level and PhD course-level factors have major impacts on students' decisions to start new ventures. Thus, the academic institution is a fundamental influence on the entrepreneurial behaviour of its students.

Confirming empirical work on academic entrepreneurship (Clarysse et al., 2011), the results presented in this paper support hypothesis 1 of a positive and significant correlation between the university environment and the probability that students will create their own businesses. These results are supported, also, by recent evidence on the role of the institutional spinoff creation framework (Fini et al., 2017). With respect to hypothesis 2, the results show that university regulations on spin-off and start-up activity are positively associated to start-up creation. This is in line with Muscio et al. (2016), who show that a relevant regulatory framework at the parent university has a positive effect on spinoff creation. Moreover, these results extend previous findings on spin-off activity concerning the relevance of academic rules for supporting PhD start-ups (Lockett et al., 2003). The analysis of student-level indicators provides some interesting results. Hypothesis 3 is confirmed; the results show that students who choose applied rather than fundamental research show a higher probability of start-up creation. Similarly, confirming hypothesis 4, university-industry collaboration during the PhD study period stimulates start-up creation. These results are consistent with some empirical work on academic spin-offs (Di Gregorio and Shane, 2003; Landry et al., 2006; Muscio et al., 2016) and confirm that PhD students' engagement with industry

exposes them to business problems, orients their research towards the business context and increases recognition of market opportunities. Finally, confirming hypothesis 5, entrepreneurship courses increase start-up creation. These results add to evidence derived from investigating the effect of entrepreneurial courses on students' employment outcomes and confirm that, even in the case of PhD courses, entrepreneurship education positively affects entrepreneurship (Peterman and Kennedy, 2003; Souitaris et al., 2007; Walter and Block, 2016; Von Graevenitz et al., 2010).

The results for other individual-level effects confirm existing empirical findings about the determinants of spin-off creation by academic staff (Guerrero et al., 2018; Krabel and Mueller, 2009; Rizzo, 2015), with factors such as age, gender and patent filing influencing the likelihood of new venture creation. Academic employment was found to be negatively associated to start-up creation, confirming studies that show that in early-stage academic careers, researchers tend to focus on research-based activities such as publications (Bercovitz and Feldman, 2008). Finally, confirming previous empirical work on academic spin-offs (Landry et al., 2006; Muscio et al., 2016; Ramaciotti and Rizzo, 2015), the research performance of the academic institution has no effect on entrepreneurship.

The findings in this paper provide evidence of some convergence in entrepreneurship rates between poor and rich regions, with the unemployment rate positively associated to start-up creation. This is positive news especially for non-industrialised regions, such as those in Southern Italy, where unemployment rates are high. While universities located in Southern Italian regions underperform in terms of access to funding for teaching and research activities compared to institutions located in other regions of Italy, our results provide evidence of some convergence effects by showing that

universities in lagging regions, *ceteris paribus,* outperform universities located elsewhere for start-up activity. This is in line with Degroof and Roberts (2004), who show that universities located in weak entrepreneurial contexts tend to be more proactive in spin-off development.

4.2 Implications for Practice and Policy

The results presented in this paper have some relevant managerial and policy implications. First, PhD entrepreneurship, at least in the Italian academic context, is not marginal: 6.5% of PhD students who participated in the national survey were entrepreneurs. This provides new insights into the influence of universities on promoting economic development and reinforces the argument that universities are legitimate stakeholders in regional economic growth and wealth generation. According to the results of the present study, the phenomenon of PhD entrepreneurship is more intense in economically lagging regions and can facilitate the creation of a knowledge-based regional economy and catch-up with stronger performers of research and innovation activities. Second, the results show that the creation of an environment favouring entrepreneurship influences start-up creation. Therefore, the definition and promotion of policies to support academic entrepreneurship could orient students towards new firm creation. Third, the results show that the design of PhD programmes has a strong influence on PhD entrepreneurship. Students' engagement in real-world scenarios, application of their research results to a business context and participation in entrepreneurship courses can have a dramatic impact on their propensity to become entrepreneurs. The recent promotion in Italy of "industrial doctorates" (sponsored by the European Social Fund), which offer scholarships for PhD students intending to spend 6-18 months of their study period in industry, is in line with these findings

direction. Creating a social environment that is entrepreneur-friendly, promoting industry involvement in PhD programmes and providing courses on entrepreneurship for young scientists could improve the institutional impact on local development processes and offer better employment opportunities for students, especially in areas with the highest rates of unemployment.

4.3 Limitations

Although this study provides some relevant managerial and policy implications, it has some limitations. These include the cross-sectional nature of the database (see Muscio and Ramaciotti, 2018), which reduces the ability to check the robustness of results and any cause-effect implications between university-level and course-level factors on the one hand and PhD entrepreneurship on the other. Using single-call questionnaire data implies cross-sectional analysis, which, in turn, implies some reverse causality risk, although, the present case, this should be limited due to the high level of representativeness of the sample. In addition, since this is an individual-level study, we can draw no conclusions about institutional performance. Future research could explore the university-level factors influencing PhD startup activity and geographical factors such as access to policy interventions to support entrepreneurship.

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TABLES

Table 1 Data source and definitions

Variable	Description	Source
Active startup	Dummy variable taking the value 1 if the student established or contributed to the establishment of a still active business start-up and 0 otherwise.	Questionnaire survey
Research hypotheses testing		
Spinoffs	Academic spinoffs in 2005-06	NETVAL
Startup mission	Dummy variable taking the value 1 if the university TTO stated that the primary objective of its affiliated university in 2006 was “diffusion and support of a research entrepreneurship culture”, and 0 otherwise.	NETVAL
Startup regulation	Dummy variable taking the value 1 if the university in 2006 had a dedicated set of rules for spinoff and startup creation, and 0 otherwise.	University website
Basic research	Share of work-time dedicated to basic vs applied research.	Questionnaire survey
Collaboration with businesses during PhD	Dummy variable taking the value 1 if the student collaborated with businesses on research activity during her/his PhD programme and 0 otherwise.	Questionnaire survey
Entrepreneurship courses	Dummy variable taking the value 1 if the student attended entrepreneurship courses during her/his PhD programme and 0 otherwise.	Questionnaire survey
Student-level control factors		
PhD completion	Dummy variable taking the value 1 if the student completed her/his PhD studies and 0 otherwise.	Questionnaire survey
Year of birth	Year of birth of the student.	Questionnaire survey
Male gender	Dummy variable taking the value 1 if the student is male and 0 otherwise.	Questionnaire survey
Academic position	Dummy variable taking the value 1 if the student holds an academic position.	Questionnaire survey
Patent application	Dummy variable taking the value 1 if the student applied for a patent with or without co-inventors and 0 otherwise.	Questionnaire survey
University-level control factors		
Research rating	Research rating published by MIUR in 2014, based on evaluation of the research output carried out over the period 2004–10. This composite indicator accounts for peer review evaluations of research activity carried out at academic institutions (patents, impact factor of journal articles, etc.).	MIUR
Medical school	Dummy variable taking the value 1 if the student studied in a university with a medical school and 0 otherwise.	MIUR
Polytechnic university	Dummy variable taking the value 1 if the student studied in a Polytechnic university (4 in Italy) and 0 otherwise.	MIUR
University size	Size of the academic institution. University size is expressed as numbers of students: 1 small (<10,000); 2 medium (10,000–15,000); 3 large (15,000–40,000); 4 mega (>40,000).	MIUR
Geographical control factors		
Unemployment rate	Unemployment rate in 2006 in the province (NUTS3) where the university is located.	ISTAT

Table 2 Descriptive statistics (n=6,670)

Variable	Mean	Std. Dev.	Min	Max	Per cent	T-Test p-value sig.
Active startup	0.05	0.23	0.00	1.00	1=5.40	-
Research hypotheses testing						
Spinoffs	2.92	2.63	0.00	11.00		*
Startup mission	0.93	0.26	0.00	1.00	1=92.92	
Startup regulation	0.64	0.48	0.00	1.00	1=63.72	*
Basic research	75.48	27.58	10.00	100.00		**
Collaboration with businesses during PhD	0.19	0.40	0.00	1.00	1=19.37	**
Entrepreneurship courses	0.07	0.26	0.00	1.00	1=7.42	**
Student-level control factors						
PhD completion	0.58	0.49	0.00	1.00	1=58.14	**
Year of birth	1981.02	5.35	1950.00	1990.00		**
Male gender	0.52	0.50	0.00	1.00	1=51.56	**
Academic position	0.63	0.48	0.00	1.00	1=62.92	**
Patent application	0.04	0.19	0.00	1.00	1=3.81	**
University-level control factors						
Research rating	1.02	0.22	0.00	2.08		*
Medical school	0.82	0.39	0.00	1.00	1=81.69	
Polytechnic university	0.06	0.24	0.00	1.00	1=6.31	*
University size	3.34	0.76	1.00	4.00	1=3.57; 2=7.00; 3=41.06; 4=48.37	**
Geographical control factors						
Unemployment rate	6.58	3.75	2.76	18.30		**

Independent samples t-test: * significant at 5 per cent level; **significant at 1 per cent level.

Table 3Correlation matrix

	Spinoffs	Startup mission	Startup regulation	Basic research	Collaboration with businesses during PhD	Entrepreneurship courses	PhD completion	Year of birth	Male gender	Academic position	Patent application	Research rating	Medical school	Polytechnic university	University size
Spinoffs	1.00														
Startup mission	0.05	1.00													
Startup regulation	0.07	-0.13	1.00												
Basic research	-0.03	0.00	0.00	1.00											
Collaboration with businesses during PhD	0.11	0.01	0.02	-0.37	1.00										
Entrepreneurship courses	0.05	-0.01	-0.01	-0.11	0.12	1.00									
PhD completion	0.04	-0.01	-0.04	0.06	-0.01	0.01	1.00								
Year of birth	0.07	0.01	0.02	0.05	0.03	0.00	-0.31	1.00							
Male gender	0.03	0.03	-0.03	-0.06	0.06	0.01	0.02	-0.05	1.00						
Academic position	0.08	-0.01	0.01	0.06	0.02	-0.01	0.23	0.03	-0.01	1.00					
Patent application	0.05	0.01	0.01	-0.09	0.15	0.07	0.05	-0.02	0.04	0.05	1.00				
Research rating	0.33	0.03	0.06	0.06	-0.02	-0.02	-0.02	0.09	-0.01	0.07	-0.01	1.00			
Medical school	-0.13	-0.04	-0.01	0.04	-0.07	-0.01	-0.05	-0.01	-0.06	-0.02	-0.04	0.00	1.00		
Polytechnic university	0.45	0.07	0.04	-0.08	0.14	0.05	-0.01	0.07	0.06	0.02	0.07	0.08	-0.37	1.00	
University size	0.07	-0.09	-0.03	0.03	-0.05	-0.01	-0.10	0.05	-0.01	-0.02	-0.05	0.13	0.47	-0.15	1.00
Unemployment rate	-0.46	0.04	0.00	-0.03	-0.04	0.01	0.01	-0.09	0.01	-0.09	-0.02	-0.43	-0.11	-0.11	-0.18

Table 4Logit regressions

VARIABLES	-1-	-2-	-3-	-4-	-5-	-6-	-7-	m.e. at means
Spinoffs	0.018		-0.006	0.007	0.043+	0.053*	0.067*	0.002*
	[0.019]		[0.021]	[0.022]	[0.026]	[0.027]	[0.028]	[0.001]

Startup mission	0.105		0.131	0.147	-0.013	0.102	-0.056	-0.002
	[0.219]		[0.233]	[0.243]	[0.247]	[0.242]	[0.248]	[0.008]
Startup regulation	0.260*		0.330**	0.330**	0.268*	0.281*	0.252*	0.008*
	[0.113]		[0.121]	[0.125]	[0.126]	[0.124]	[0.126]	[0.004]
Basic research		-0.008**	-0.008**	-0.007**	-0.007**	-0.007**	-0.007**	-0.000**
		[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.000]
Collaboration with businesses during PhD		0.500**	0.539**	0.513**	0.512**	0.574**	0.521**	0.017**
		[0.118]	[0.132]	[0.138]	[0.138]	[0.133]	[0.138]	[0.005]
Entrepreneurship courses		1.650**	1.746**	1.748**	1.736**	1.721**	1.730**	0.057**
		[0.118]	[0.130]	[0.136]	[0.137]	[0.133]	[0.137]	[0.005]
PhD completion				0.688*	0.610*	0.292*	0.631*	0.021*
				[0.308]	[0.309]	[0.126]	[0.308]	[0.010]
Year of birth				-0.039**	-0.037**	-0.037**	-0.036**	-0.001**
				[0.010]	[0.010]	[0.010]	[0.010]	[0.000]
Male gender				0.567**	0.584**	0.641**	0.582**	0.019**
				[0.124]	[0.125]	[0.121]	[0.125]	[0.004]
Academic position				-0.486**	-0.470**	-0.496**	-0.461**	-0.015**
				[0.120]	[0.121]	[0.118]	[0.121]	[0.004]
Patent application				0.619**	0.598**	0.575**	0.619**	0.020**
				[0.216]	[0.216]	[0.209]	[0.216]	[0.007]
Research rating					-0.402	-0.254	-0.206	-0.007
					[0.274]	[0.274]	[0.291]	[0.010]
Medical school					0.369*	0.286+	0.425*	0.014*
					[0.174]	[0.168]	[0.175]	[0.006]
Polytechnic university					-0.147	0.073	-0.188	-0.006
					[0.251]	[0.240]	[0.251]	[0.008]
University size					-0.382**	-0.320**	-0.372**	-0.012**
					[0.085]	[0.082]	[0.086]	[0.003]
Unemployment rate						0.038*	0.042*	0.001*
						[0.017]	[0.017]	[0.001]
Constant	1.741	-5.634	-4.743	74.125**	70.783**	70.457**	69.300**	
	[5.035]	[4.725]	[5.276]	[20.473]	[20.543]	[18.985]	[20.633]	

Area dummies	No	No	No	No	No	No	Yes	Yes
Year dummies	No	No	No	No	No	No	Yes	Yes
Observations	7,506	8,300	6,928	6,685	6,662	6,701	6,662	6,662
Pseudo R-squared	0.0377	0.102	0.114	0.138	0.147	0.131	0.149	

Standard errors in brackets

** p<0.01, * p<0.05, + p<0.1