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A tale of untold heroes: How universities affect PhDs' start-ups in Italy

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Abstract

This work investigates those factors that affect the propensity of PhD students to create their own firm. Particular attention is given to university-level factors. We use an original dataset gathered through a survey designed by the authors and administered by the Italian Ministry of University and Research to the entire population of PhD students that obtained a PhD title between 2009 and 2012, to test whether university characteristics stimulate PhDs start-ups creation. While we find that entrepreneurial training at the parent university positively influences start-up creation, we also find that universities that show a positive attitude toward entrepreneurial behaviour have more probability to spur more new ventures from their PhDs. Moreover, we do not find clear-cut evidence of the fact that collaborating with firms during the PhD is associated with a higher probability of creating a new venture. These results lead to important policy implications that regard all administrative levels, from national to university-level.

Jelcodes:O31,I23

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Abstract

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JEL classification: I23, L31, O32, O33.

Keywords: Academic Entrepreneurship, Entrepreneurial University, Knowledge Transfer, Start-up, PhDs, Firm Creation

Introduction

The role of the university as an economic and social institution is becoming increasingly important in modern societies (Florida and Cohen, 1999). As knowledge has grown in relevance for economic growth, governments in many countries have encouraged universities to contribute actively via knowledge transfer to economic development (Powers and McDougall, 2005), competitive advantage, and employment (Gomez Gras et al, 2008). Universities have long been involved in knowledge transfer activities (Geuna and Muscio, 2009) and yet, the last 30 years have witnessed a slow, but continuous process of reorganization of European universities which have 'institutionalized' their third mission and learned to better manage university–industry linkages.

Several papers have shed light on the heterogeneity of interactions between academia and industry (Agrawal and Henderson, 2002; D'Este and Patel, 2007; Muscio and Pozzali, 2013). However, the focus of the literature on 'tangible' forms of knowledge transfer such as patenting and licensing activity or spin-off creation is overwhelming. The academic spin-off phenomenon, in particular, has grown steadily as an increasing number of academics have chosen (and have been encouraged) to engage in entrepreneurial activities (Thursby and Thursby, 2007). Commercialization of university research through spin-offs has been especially evident in the US, where the promulgation of the Bayh-Dole act in 1980, according to some (Rafferty, 2008; Shane, 2004), has had a relevant impact in shaping academic engagement. It is a common opinion that spinoff activity has been less frequent in Europe than in the U.S. but this assumption can be questioned as it has been pointed out that European universities have typically collaborated more freely and frequently with industry (Geuna and Muscio, 2009). Notwithstanding the role of spin-offs in sustaining academic entrepreneurship and New-Technology-Based-Firms (NTBFs) creation, preliminary research carried out by Astebro and Bazzazian (2011) on the role of universities in stimulating local economic development shows that the economic literature almost exclusively covers licensing and start-ups by faculty and staff. Existing empirical work does not cover firms started by students, not to mention firms started by PhDs, because they are hardly based on university IP. So, if students or groups of students agree to start a business, this is not typically recorded as a university spin-off, if not in the cases when the new venture involves faculty staff. However, according to the authors, the major impact by universities on entrepreneurship is instead in the form of start-ups created by former students.

While much of the empirical research carried out in the last twenty years in the area of university entrepreneurship has been devoted to the investigation of the characteristics and the determinants of technology spin-offs, very little is known about the drivers of graduates' or PhD start-ups. It follows that the recent transformation of university goals and practices toward increasing spin-off rates and new firm creation by university faculty may be called to question.

University policies can have large effects on entrepreneurs' behaviour (Shane, 2004). However, the empirical evidence on the impact of universities on business start-up typically does not cover firms started by university graduates because these are often not based on university-generated intellectual property and so a potentially large part of the entrepreneurial activity stemming from universities never gets recorded, and is hardly ever discussed (Astebro et al., 2012).

The paucity of empirical evidence is particularly evident in the case of PhD graduates. As academic funding systems and resource allocation mechanisms for public funds become essential element of reforms of university systems in several countries (Muscio et al., 2013), the organization of doctorate programmes is increasingly subject to policy debate. In other words, an issue is whether universities

produce too many PhDs, given the limited availability of permanent academic positions (Stephan, 2012). As suggested in Conti and Visentin (2015), one key step for assessing the optimal size of a PhD programme is understanding the PhDs' preferences with regard to career outcomes. The large amount of resources that governments spend on PhD programmes is based on the assumption that PhDs will work in positions that facilitate knowledge transfer and provide returns to the government investment in their education, therefore on careers inside academia. Little is found in the economic literature on what drives PhDs to start a business venture. However, As the PhD candidate's incentives to complete the study programme depend mainly on her/his career potential after graduating (Mangematin, 2000), it seems important to have a better understanding of the academic factors which determine young professionals' decision to choose to start a business. We contribute to the literature on academic entrepreneurship by highlighting a phenomenon that is largely overlooked. In this paper we investigate the impact of the characteristics of the parent university on PhDs' choice to start a new business. We focus on this aspect because we believe it to have evident policy implications, providing insights on how to intervene on research institutions in the attempt to promote entrepreneurship. Secondly, we investigate the impact of academic orientation of the parent institution on PhD entrepreneurship. As the academic engagement has grown to become a primary objective of modern universities, we explore the effects of university effort in promoting new economic activities on PhD's choice to become entrepreneurs.

The paper is organised as follows. Section 2 sets the theoretical background to academic entrepreneurship. Section 3 presents our empirical results on the effects of universities on PhDs, entrepreneurship. Section 4 discusses the results and their implications for policy.

Theoretical background

It is undeniable that increasing political pressure has being put on universities to increase their involvement with industry and stimulate entrepreneurship. This new emphasis on the increasing integration between academic institutions and industry has led to the development of the term 'entrepreneurial university' (Branscomb et al., 1999) and shed light on the potential role of academic institutions in promoting the creation of new business ventures. Many complementary factors have contributed to the strengthening of the entrepreneurial role of universities. In principle, increasing the integration of universities in the economy and aiding the transfer and commercialization of discoveries is in the interests of both inventors and society, the ultimate aim of scientific research being to improve the human condition (Litan et al. 2007).

However, as noted in Siegel and Wright (2015), the debate regarding academic entrepreneurship has focused too much on the research–third mission nexus, focussing narrowly on university–industry linkages. The emphasis on the transfer of scientists' inventions to patents and licenses, and eventually to spin-offs has led empirical works to neglect that many entrepreneurial opportunities arise from the development of informal IP and the creation of new forms of entrepreneurial ventures. Academic entrepreneurship involves a plurality of stakeholders, including students and any level, faculty staff and post-doctoral fellows who choose to work with industry because of a number of factors, including greater availability of entrepreneurial or technological opportunities (or lower availability of qualified posts), better information on the necessary steps it takes to reach market, access to entrepreneurship programmes and so on. Universities are an important source of entrepreneurial activity. First of all, universities generate knowledge that spills over and is leveraged by prospective entrepreneurs (Ghio et al., 2015). Secondly, even before the establishment of the third mission, universities have been

fostering academic entrepreneurship encouraging faculty staff to create new firms (Rothaermel et al., 2007). Thirdly, universities support student entrepreneurship (Åstebro et al., 2012; Conti and Visentin, 2015) even if the creation of new ventures by students and recent graduates is an under-investigated phenomenon. PhDs students, on the one hand, could be in a more favourable position than academic staff to overcome the obstacles to the creation of new ventures as, unlike academic staff, they do not need a 'genetic mutation' to become entrepreneurs and are better positioned than academic entrepreneurs to gain access to the commercial competences and assets they need to grow (Colombo and Piva, 2012). On the other hand conversely, for their early scientific oriented career, PhD students are able to exploit business ideas of higher technological/knowledge content compared to graduate students. For these reasons a main gap in the literature regarding how universities may spur the generation of innovative start-ups, regard the investigation of the determinants of the creation of such firms by just graduated doctorate holders. The objective of this work is therefore to identify those factors that influence the probability of PhDs to create their own firm after graduation. The main goal of the paper is to identify those university-related factors that increase the probability of these individuals to become nascent entrepreneurs. The ultimate purpose of this work is to provide important policy implications mostly for, but not limited to, university managers. Grounding on the literature on academic entrepreneurship and specifically on the creation of new ventures by academic staff, we will review in the following paragraphs the main institutional factors that may be regarded as influencing PhDs to start their own venture. As a synthesis of the abundant literature on the issue we organise the exposition of these factors grouping them in two items: individual level factors and university level factors.

2.1 Research performance and PhD entrepreneurship

A first university-level factor that could influence PhDs' choice is the quality of the university they attended. The economics literature on university third mission activities tend to find a positive relationship between the quality of the research and the conduction of commercial level activities. A high quality academic environment is associated with high volume of spillovers and elevated levels of human capital (McGuinness, 2003). There is evidence that universities with high quality research attract more easily private and public funding reinforcing the process of investing in excellent research (European Commission, 2010). Also, reputational effects could come into play. Venture capitalists, or more generally investors, prefer to support such new technologies based firms most promising both under the business profile but also for the company team assuming that a better skilled human capital might have more chances of success. Moreover, as highlighted in Muscio et al. (2013), universities with superior research ranking are also more likely to have more frequent an greater interactions with firms (see also McCormack et al., 2014). Tighter relationships with companies could arise from an entrepreneurial environment encouraging academic entrepreneurship. In other words, skilled and qualified knowledge deriving from high quality research has potential signaling effects on investors. (Spence, 1973).

Most authors find a complementarity between research productivity and patenting (Agrawal and Henderson, 2002; Fabrizio and Di Minin, 2008) or sometimes between the former and contract research (Muscio et al., 2013). Evidence about the relationship between research productivity and entrepreneurial activity is less conclusive. In the case of spinoffs Baldini (2010) and Ramaciotti and Rizzo (2014) find no significant relationship between publication and spinoff creation but studies in the US context find evidence that universities with higher levels of publication and citations are more

active in spinoff creation (Di Gregorio and Shane, 2003; Powers and McDougall, 2005). The arguments in support of a positive relationship between research productivity and entrepreneurial activity are rooted in the idea that academic institutions that excel in terms of research activity are also more likely to employ start scientists and, as shown in Zucker et al. (1998a, 1998b) star scientists are also more active in generating start-ups. Thus, we can expect a positive relationship between scientific productivity and PhD entrepreneurial activity:

H1: The higher the university's scientific productivity, the higher will be the probability that PhDs will start a firm.

2.2 Academic engagement and PhD entrepreneurship

Another institutional-level factor potentially very important for students' entrepreneurship is the university's degree of academic engagement. Studies tend to agree, with some exception (e.g. Ramaciotti and Rizzo, 2015), that the higher is the involvement in commercial activities, the higher is the number of academic spin-offs created from that university (Powers and McDougall, 2005; Di Gregorio and Shane, 2003). For instance Van Looy et al. (2011:560) affirm that "contract research could be instrumental for creating spin off companies. Indeed, engaging in contract research might result in a better understanding of market potential and in the development of adequate business models. As such, contract research might act in a number of cases as an 'incubation' device, leading to spin off creation." Indeed, collaborating with industry contributes to building the networking relationships and capabilities needed to motivate scientists to create new ventures firms (Colyvas et al., 2002; Lockett and Wright, 2005; Lockett et al., 2005; Wright et al., 2004; O'Shea et al., 2005) and could be equally important for students.

University involvement with industry indicates higher awareness about market needs and therefore could be associated to a more favourable environment for the creation and exploitation of entrepreneurial opportunities. In other words, students attending institutions with great involvement in collaboration agreements and consultancies with industry have more opportunities to get an understanding of companies' needs and eventually identify business opportunities.

H2: The higher the academic engagement of the parent institution, the higher will be the probability that PhDs will start a firm.

2.3 Entrepreneurship courses

A third and very important university level factor, that may be even more relevant for PhDs seeking to create their own venture rather than academic staff, are entrepreneurial courses and training. Siegel and Wright (2015) entrepreneurial courses to academics are a brand new phenomenon that was not at all considered at the time of the emergence of the first TTOs during the 1980s and 1990s. Research on entrepreneurship education suggests that attitudes towards entrepreneurship may be influenced through the development of appropriate, student centred entrepreneurship education programmes (Harris and Glibson, 2008). Several studies have shown that these programmes can raise the level of entrepreneurial interest among students and their entrepreneurial attitude (Mitra and Matlay, 2004; Peterman and Kennedy, 2003; Souitaris et al., 2007; Vanevenhoven and Ligouri, 2013). This increasing empirical evidence has led to a rapid increase in the number of courses offered in higher education institutions around the world.

Storey and Tether (1998) highlight how in order to enhance the business skills of potential entrepreneurial students, universities should also be encouraged to provide courses, accessible to both staff and students, in entrepreneurship and new business development. Efforts should also be made to combine the empirical skills of scientists and engineers with the managerial skills of others who have experience in the private sector. Supporting this, Astebro et al. (2012) point out that universities may provide other advantages for prospective graduate entrepreneurs than simply providing an education that is useful when starting a new firm. For example, graduates may take courses in entrepreneurship that could impact their intentions to start up a business. Similarly, Oosterbeek et al. (2010) argue that training in entrepreneurship strengthens (or weakens) the intention among academic students to create a new business and to become an entrepreneur. This applies in particular to the case of academic spin-offs, an important class of new ventures, where the set of resources and competences important for developing and growing the business may be lacking because of the non-profit oriented nature of universities (Rasmussen and Borch 2010; Rasmussen et al. 2014). Von Graevenitz et al. (2010) provide evidence that entrepreneurship education has a positive effect on the ability of students to evaluate their capabilities and shape their entrepreneurial intentions. Similarly, Peterman and Kennedy (2003) and Souitaris et al. (2007) argue that entrepreneurial education increases the entrepreneurial intentions of respectively high school and university students.

H3: Attendance to entrepreneurship courses increases the probability that PhDs will start a firm.

2.4 Businesses involvement in PhD courses

Finally, in the same line of thinking the increasing extent of private organizations' involvement in university activities can have a positive impact on students' decision to start a company. In particular, in the specific case of PhDs, it can be argued that the involvement of businesses in PhDs programmes via private sponsorships to academic courses and involvement of students in collaboration agreements can dramatically increase their exposure to real world business problems and needs, contributing to steering their research activities towards the development of market-led technology and services. Therefore, we argue that

H4: Business involvement in PhD programmes increases the probability of PhD students deciding to start a firm.

Empirical framework

3.1 Data

This work exploits an original dataset obtained from a questionnaire survey run between the end of 2014 and early 2015 on all Italian doctorate holders who were awarded the PhD title between 2009 and 2012. The survey was addressed to approximately 23,500 individuals and 4,339 compiled questionnaire were sent back. As it is often the case in survey data collection, the data show several missing responses to the questions used to create the variables for the econometric analysis. In order to test the robustness of the results of the econometric exercise we firstly conduct a complete-case

analysis, which records 1,400 observations corresponding to 6% of the population and referred to a total of 61 universities. Secondly, in a robustness check exercise we substitute some individual-level variables that are often missing, to the corresponding variable measured at the level of universities: although we conduct this analysis on a smaller number of universities compared to the former exercise (specifically 49), we are able to rely on 2,131 survey observations corresponding to 9% of the respondents population. In either cases a chi-square test was conducted to check if the proportion of respondents was statistically differently distributed across territorial areas and scientific sectors. The test does not reject the hypothesis that the respondents' sample is differently distributed in respect to the population.

In order to control for department and university level characteristics that may have an impact on the choice of the PhD to become an entrepreneur, the survey data has been merged with available data provided by the Ministry of University and Research (MIUR) on university characteristics. More specifically MIUR makes available for the period 2005-2011 annual university-departments-level information on amounts and source of research income, on research quality and on the staff employed. Furthermore, to better grasp the effect of university approach and management practices to the propensity of its PhDs to create a venture we merged this data with a third source of information, provided by Netval (Italian National Network for the Valorisation of University Research). Netval annual surveys datasets collect data on third mission activities of associated Italian universities, which represents 80% of all Italian universities. Netval surveys are also utilised by MIUR and ANVUR (National Agency for the Evaluation of Universities and Research Institutes) to evaluate universities' third mission activities (see e.g. ANVUR, 2013).

3.1.1 Variables

Dependent variable

We are interested in identifying (university) factors associated with the propensity of early doctorate holders to create a new venture. Our dependent variable is therefore a binary variable taking the value of 1 if the individual participated in the creation of a firm, and 0 otherwise. The number of respondents that participate in a firm creation process is 206, corresponding to almost 15% of the sample. This percentage may seems somehow high, however is very much in line with the investigation conducted by the Italian National Statistical Office (Istat) on the career path of the PhD, that find that about 13% of their respondents are working as entrepreneur or self-employed (Istat, 2015).

Independent variables

The identification of the independent variables has been based on existing literature on the determinants of academic-spin-off creation and on the determinants of start-up creation by former students graduates (e.g. Landry et al 2006, Krabel and Muller 2009, Astebro et al. 2014). This literature identifies both individual and context level determinants, where the context is mostly referred to the characteristic of the university spurring these new ventures. Drawing on these sources, we identified three main blocks of variables, which are synthetically described in Table 1.

For the first block of variables, we relied on those individual level variables that are regarded as being determinants of the individual propensity of firm creation (see e.g. Landry et al 2006, Krabel and Muller 2009). We control: for doctorate holders age and gender; for the entrepreneurial family

background introducing a dummy variable, *parent_entr*, taking the value of 1 if at least one of the parents of the individual are or were entrepreneurs; for the individual affiliation with the university introducing the dummy variable *work_univ*, taking the value of 1 if the individual at the moment of the survey was still working at the university while being or not an entrepreneur at the same time; for the individual research activity introducing the dummy variable *patent* taking the value of 1 if the individual had, at the moment of the survey, participated in patent filing, and the variable *publications*, recording the number of publications in internationally refereed journals of the individual within two years after the completion of the PhD.

The second block of variables considers those factors referred to the university. This block is heterogeneous in terms of measurement levels. Firstly we rely on three dummy variables measured at the individual level and collected through the survey sent to PhDs: *priv_phd* take the value of 1 if the PhD course of the respondents was funded totally or partially by a private entity and 0 otherwise; *entr_courses* takes the value of 1 if the individual took entrepreneurial courses or formation related to 'firm creation' and 0 otherwise; *collab_firms* takes the value of 1 if the research conducted within the PhD saw collaboration with firms and 0 otherwise. Secondly we rely on department-level data from MIUR and included some control variables at level of scientific area. Italian academic system recognise 14 scientific fields. Each department is associated with a scientific area. In order to take into account the heterogeneity of areas within universities, we created at the level of scientific areas the following variables: *res_quality* measure the quality of research as reported by the results of the evaluation of university research conducted by MIUR for the period 2004-2010; *sh_priv_income* measures the share of commercial research income to the total research income in the three years previous to the obtainment of the PhD of the individual; *n_temp_staff* represents the number of temporary staff. The two latter variables are calculated, for each respondents, as the mean value of the three previous years to the completion of the PhD course. Given the evident correlation arising between the amount of commercial income and the number of temporary staff, we chose to consider the former one as a share to the total research income. Thirdly we rely on a variable that control for the size of the university: *staff_univ* records the total number of permanent staff at the university level (each individual is associated with the average number of staff employed in the three year previous to his/her PhD completion).

In this second block of variables, in a subsequent empirical exercise that will be conducted in the robustness check section, we also include information on university third mission activities derived from Netval. These variables are: *utt_experience* measures the age of the TTO in the year of the respondents PhD completion year and proxy its experience; *univ_spin-off* (*univ_patent*) is the average annual number of academic spin-off (patents) created by the university in the three years previous to the respondent year of PhD completion; *univ_entr_courses* measures the university approach (likert scale from 1 to 5) to the promotion of entrepreneurial courses and formation support to firm creation; *univ_entr_support* measures the average approach of the university to various items regarding entrepreneurial support (mean of all likert scale from 1 to 5 items concerned with the support to firm creation) (see Netval 2015).

Finally, the third and last block of variables controls for geographical effects. Given the territorial heterogeneity of Italian economic conditions and research and innovation performance, we included in the regressions: the variable *pat_inhab* that proxy the innovativeness of the NUTS3 region where the parent university is located, measuring the number of patents per inhabitant in the three years before the conclusion of the PhD programme; *unemp* measuring the level of unemployment in the NUTS3 region; the dummy variable *south* taking the value of 1 if the NUTS2 region is a Convergence objective region in the European Union's European Regional Development Fund, which group the Southern

Italian regions and the Islands (Sicily and Sardinia), and 0 otherwise. The former two variables have been extracted from Eurostat. Table 1 synthetically describes the variables used in the analysis. Descriptive statistics are presented in Table 2, while Table 3 reports the correlation matrix.

TABLE 1 ABOUT HERE

TABLE 2 ABOUT HERE

TABLE 3 ABOUT HERE

3.2 Method

Given the dichotomous nature of our dependent variable we investigate a conditional probability function. The chosen link function to study this equation is the logit function. Grounding on the availability of the data at our hand, we conducted two main baseline exercises. The first reports the results for the whole sample and adopt clustered standard errors in universities. Standard errors need to be clustered because universities, as explained in the first part of the paper, can affect the propensity of PhDs to undertake an entrepreneurial career. As a consequence we expect the presence of within university correlation factors that need to be taken into account for the purpose of this study. However, in a more conservative exercise, we add to the above equation university level fixed effects by including in the equation university dummies. This exercise however can only be computed on those individuals belonging to universities for which at least one respondent created a firm. The consequence is that the regression is conducted on a smaller sample of individuals and universities, which are respectively 1,320 and 48.

3.3 Results

Results are presented in Table 4. Table 5 replicate the same specification of Table 4 with university level fixed effects. We do not register any significant difference in the results of the two specifications. Firstly we can note that individual level variables seem to confirm the results previously obtained by other researchers studying the determinants of academic staff to undertake a firm creation path (Krabel and Mueller, 2009, Landry et al., 2006). Let us explore each of the variables and their results and interpretation. First of all we can see the two classic controls of age and sex show that there is no age effect on the probability of creating a firm, while being a female is correlated with a lower probability of becoming an entrepreneur. Then we can see that having already participated in patent(s) filing and having at least one parent as entrepreneur are positively associated with a higher probability of creating a firm. On the contrary working (also) in a university environment at the

moment of the survey, as it may be easily expected, is negatively associated with the probability of creating a firm. We can see that the variable publications is not significant, however this results is partly influenced by the presence of the *work_univ* dummy: by running the same specifications omitting the *work_univ* variable, we would see publications negatively associated with our dependent variable. This results is in line with expectations and is confirmed by other studies that claim that in the early stage of the career a researcher tend to focus mostly on research based activities such as publications (Bercoviz and Feldman, 2008). We reach similar conclusions, noting that when the doctorate holder is working at university, the corresponding probability of creating a firm diminishes.

Moving to the university level variables measured through the survey questions, we can see that having conducted a PhD partly or entirely funded by a company does not exert any significant effect to the probability of the individual of becoming an entrepreneur. This result may be expected as it is reasonable to assume that the student may have some chances of being employed by the company financing the PhD. Conversely we see that having collaborated with firms during the conduction of the PhD studies and having followed courses on entrepreneurship or on how to start a firm, are positively and significantly associated with the probability of creating a firm. These results are in line with investigations on the effect of entrepreneurial courses on students career (Oosterbeek et al. 2010). These results are interesting because we provide evidence that these two variables clearly identify factors on which the university could operate if the aim would be to spur more PhDs in undertaking such an entrepreneurial career. These results remain rather robust also including university fixed effects in the model (Table 5).

For what concern the specific characteristics of universities and regions in which the university is located, we find almost no influence on the probability of the doctorate holder to create a firm. Our results show that university higher in size tend to spur less nascent PhD entrepreneurs (Table 5), and that having conducted the PhD in departments (aggregated in each university by scientific areas) with high numbers of temporary researchers is associated with higher probabilities of creating a firm (Table 4).

The specification shown in Table 5 may reveal collinearity problem due to the inclusion of both university dummies and university-level variables on the one hand and NUTS3 variables on the other hand. These variables, across individuals of the same university, vary across years of award of the PhD degree, however they may results significantly correlated with university dummies. For this reason we tested for the presence of multicollinearity in this specification and found the variance inflation factor to be equal to 1.92, considerably below any critical assumed threshold (O'Brien, 2007).

TABLE 4 ABOUT HERE

TABLE 5 ABOUT HERE

3.4 Robustness checks

The empirical framework here proposed is not without limits, and some robustness checks are needed in order to validate our results. With reference to the effects of variables of our main interest (*entr_courses* and *collab_fir*ms – provided *priv_phd* is not affecting PhDs probability) a main limit in the empirical framework rests in the potential endogeneity of these variables. The usual approach in these cases is to instrument the potentially endogenous variable(s) and test its effect in two steps estimations. The most important element to take into account when adopting an instrumental variable approach is to consistently estimate the first step, which is not feasible when the variable to be instrumented is dichotomous (Dong and Lewbel, 2012). For these reasons we rely on a different method in order to test if and how university may influence the probability that a PhD undertake an entrepreneurial career. Specifically, by relying on a further source of university-level data (Netval data on university third mission activities), we test whether university private income on the one hand and the provision of support for entrepreneurial activities on the other hand (and especially in providing entrepreneurial courses), are associated with a higher probability of doctorate holders to create their own firm.

From the Netval data we were able to derive some variables proxying the approach that the university has in respect to the valorization of research results, and in particular to support entrepreneurial types of activities. However Netval does not collect data on the whole population of Italian universities and the information we need for our exercise are sometimes missing in Netval responses. For this reason we remain with a smaller sample of universities, however accounting for a larger number of individuals answers due to the exclusion of some missing individual level variables (2131 individuals belonging to 49 universities).

We estimate a logit model and focus specifically on university-level variables. The idea is to find two variables at the level of university measuring the amount of collaboration with private firms during the PhD and the number of entrepreneurial or similar courses offered by the university. We proxy the first variable with the amount of commercial income received by the scientific sector department in which the PhD was graduated (*sh_priv_income*), and the entrepreneurial courses with a question included in the 2013 Netval survey (*univ_entr_courses*), asking to universities to indicate in a likert scale from 1 to 5, with which intensity they are "providing courses and training support for entrepreneurial activities". Although the approach is not measured in years before 2013, we may assume that the university approach to such activities derive from previous years university strategies.

Furthermore we rely on various questions of the 2013 Netval Survey that are intended to measure the strategic approach to the university in support of firm creation (see Netval 2015) and test the relationship with our dependent variable. The variable we constructed is named *univ_entr_support* and need to be tested in a separate specification because among the items for the construction of this variable we also include *univ_entr_courses*.

In both specifications (1) and (2) of Table 6, we further control for the experience of the university in formally dealing with technology transfer activities, by including the variable *utt_exp* which measure the age of the technology transfer office constitution in the year of the individual PhD conclusion. We then include a variable that count the number of spin-off and patents created in the previous three years of the PhD conclusion (*univ_spin-off* and *univ_patent* respectively). These specifications are conducted clustering standard errors across universities, while controlling for university dummies is not feasible as it would produce too high level of multicollinearity.

TABLE 6 ABOUT HERE

The results show that entrepreneurial course and university support in general for entrepreneurial processes are positively associated with the propensity of the doctorate holders to become entrepreneur (H3 and H4 not rejected). On the contrary the share of private income and the quality of the research, remain non-significant in respect to the probability of creating a firm by PhDs (H1 and H2 rejected). It must be specified that we are not able to exactly specify in our regressions if private firms were or not collaborating with the PhD student during the PhD course. So, summing up, while a favouring environment to entrepreneurial processes at the university level are positively associated to the probability of doctorate holders to create their own firm, we cannot reach clear cut conclusions about the collaboration with firms of the doctorate holders during the PhD course.

Moreover we can also see from Table 6 that TTOs level variables, such as the TTO experience, the number of academic spin-offs, the number of patents, are not explaining our dependent variable probability. In other words, as it may be expected, third mission activities of the university, directed mostly in supporting the exploitation of research results by academic permanent staff, seems to do not affect the decision/probability of the PhDs to their entrepreneurial career.

4. Conclusions

The aim of this paper is to attempt to improve our understanding on PhDs choice to start a business venture. In particular, we focus on the impact of the characteristics of the academic institution they attended on the probability of doctorate holders' choice to start a business, independently of the fact that they also have or not other employment status. In our view this research objective is particularly relevant for its implications in terms of economic policy both at the national, regional and at the university level as it would allow to identify the academic characteristics that may foster business creation and economic development for young highly scientifically skilled individuals.

In our analysis of the determinants of graduates' start-up we focus on four factors: the research quality of the scientific institution attended, its academic engagement, measured in terms of industry funding, the provision of courses on entrepreneurship, and students' collaboration with industry during the study period. We find that the design of PhD programmes involving collaboration with the private sector and students' access to courses on entrepreneurship has a positive impact on students' decision to start a new venture.

More specifically our findings reveal that while collaborating with firms during the PhD is positively correlated with the propensity of the individual to create a firm, the overall propensity of the university toward collaborating with industry is not associated to the same probability. Other than this somehow controversial outcome, this work find other more clear-cut results. First of all undertaking an entrepreneurial courses, in line with other studies on undergraduate students, is positively associated to the propensity of the PhD to create firm. Moreover a university that provides these types

of courses is also associated with a higher number of doctorate holders becoming entrepreneurs. Finally we also find that a university that favour an entrepreneurial environment is associated with a higher probability of seeing its PhDs to create their own firm.

This work points therefore to relevant policy implications. PhD entrepreneurship is a relevant phenomenon largely ignored by the scientific literature and by technology transfer policies. However the results presented in this paper make a strong case for the promotion of an entrepreneurial university model with a wide scope. The achievement of universities' third mission must be achieved not just fostering research commercialisation via patent sale and licensing or via spinoff creation and university-industry collaboration. PhD entrepreneurship offers large opportunities to foster the creation of new generations of highly dynamic, advanced knowledge-based companies that can dramatically improve regions' and countries' innovation performance especially in 'moderate innovator' countries such as Italy (Innovation Union Scoreboard, 2015). Increasing the involvement of students in university-industry collaborations and the organisation of ad-hoc courses for scientists on entrepreneurship can reshape institutions' capability to have a tangible impact on local development processes granting at the same time better employment opportunities for students.

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TABLES

Table 1. Variables description

	Variable	Description
	Individual level variables	
	age	Age of the individual at the moment of the survey
	female	Sex of the individual at the moment of the survey
	parent_entr	Dummy variable taking the value of 1 if the individual has at least one parent entrepreneur
	work_univ	Dummy variable taking the value of 1 if the individual is still working (also) at the university at the moment of the survey
	patent	Dummy variable taking the value of 1 if the individual filed at least one patent
	publications	Number of publications on international refereed journal within two years after the completion of the PhD
	University level variables measured at the individual level	
H3	entr_courses	Dummy variable taking the value of 1 if the individual participated in an entrepreneurial course
H4	priv_phd	Dummy variable taking the value of 1 if the PhD course was funded (at least partly) by a company
H4	collab_firms	Dummy variable taking the value of 1 if the individual collaborated with firms during the conduction of the PhD
	University level variables	
H1	res_quality	Research quality index at the department (aggregated by scientific areas) level as provided by MIUR
	n_temp_staff	Number of temporary staff at the department (aggregated by scientific areas) level
H2	sh_priv_income	Share of private income on total income at the department (aggregated by scientific areas) level
	staff_univ	Number of permanent staff at the university level
	University third mission activities variables	
	utt_experience	Number of years since TTO formation, at the moment of PhD conclusion
	univ_spin-off	Number of spin-off created at the university
	univ_patent	Number of university patents (size of patent portfolio)
H3	univ_entr_courses	University approach (likert scale from 1 to 5) to the promotion of entrepreneurial courses and formation support
H3	univ_entr_support	University approach to various items regarding entrepreneurial support (mean of various items likert scale from 1 to 5)
	Territorial controls	
	pat_inhab	Number of patents per inhabitants at the NUTS3 region level
	unemp	Unemployment rate at the NUTS3 region level
	south	Dummy variable taking the value of 1 if the university is located in a Convergence Region (southern Italian regions)

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
y	1400	0.105	0.307	0	1
age	1400	36.056	4.562	29	62
female	1400	0.466	0.499	0	1
patent	1400	0.051	0.220	0	1
publications	1400	4.021	4.651	0	25
parent_entr	1400	0.095	0.294	0	1
work_univ	1400	0.717	0.450	0	1
priv_phd	1400	0.101	0.302	0	1
entr_courses	1400	0.107	0.310	0	1
collab_firms	1400	0.190	0.392	0	1
res_quality	1400	1.020	0.204	0	1.84
n_temp_staff	1400	95.569	63.019	8.5	440
sh_priv_income	1400	0.455	0.631	0.002	8.469
staff_univ	1400	1578.584	975.610	43	4336.5
pat_inhab	1400	94.533	75.391	2.279	308.527
unemp	1400	7.375	3.973	2.601	17.406
south	1400	0.251	0.433	0	1

Table 3. Correlation matrix

1	y	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2	age	0.016															
3	female	-0.097	-0.055														
4	patent	0.130	-0.037	-0.037													
5	publications	-0.019	-0.098	-0.119	0.122												
6	parent_entr	0.107	-0.034	0.024	-0.021	0.001											
7	work_univ	-0.080	-0.150	0.017	0.013	0.207	-0.002										
8	priv_phd	0.037	-0.043	-0.019	0.059	0.003	0.028	-0.030									
9	entr_courses	0.252	0.000	0.015	0.105	0.026	0.065	-0.003	0.013								
10	collab_firms	0.169	-0.069	-0.086	0.175	0.033	0.027	-0.005	0.174	0.131							
11	res_quality	-0.051	-0.107	0.016	0.041	0.022	0.026	0.080	0.079	-0.021	-0.018						
12	n_temp_staff	0.027	0.028	-0.005	0.115	0.120	-0.004	0.015	0.037	-0.006	0.065	0.071					
13	sh_priv_income	0.073	-0.002	-0.065	0.058	0.014	0.010	-0.018	0.064	0.032	0.151	0.006	0.038				
14	staff_univ	-0.040	-0.001	0.036	-0.031	0.007	-0.027	0.001	-0.031	-0.039	-0.052	-0.037	0.124	-0.071			
15	pat_inhab	-0.019	-0.093	0.011	0.050	0.020	0.062	0.059	0.066	0.041	0.070	0.434	0.134	-0.026	0.134		
16	unemp	0.024	0.066	-0.007	-0.020	0.001	-0.043	-0.066	-0.081	-0.021	-0.051	-0.491	-0.116	0.006	-0.016	-0.760	
17	south	0.044	0.060	-0.002	-0.012	0.010	-0.049	-0.092	-0.071	0.010	-0.027	-0.445	-0.097	0.042	-0.044	-0.600	0.840

Table 4. Logistic regressions

	Coef.	Rob. Std. Err.
Individual level vars		
age	0.014	0.016
female	**-0.530**	0.143
patent	**0.843**	0.372
publications	-0.019	0.019
parent_entr	**0.938**	0.190
work_univ	**-0.554**	0.238
University level vars		
priv_phd	0.086	0.276
entr_courses	**1.582**	0.217
collab_firms	**0.626**	0.201
University level controls		
res_quality	-0.327	0.403
n_temp_staff	**0.002**	0.001
sh_priv_income	-0.093	0.178
staff_univ	0.000	0.000
Other controls		
pat_inhab	-0.002	0.002
unemp	-0.028	0.058
south	0.302	0.394
year_phd_2010	0.035	0.196
year_phd_2011	-0.106	0.225
year_phd_2012	-0.043	0.237
Scientific Sector dummies	Included	
Wald chi2	1024.06	
Observations	1400	
Universities	61	

Std. Err. adjusted for 61 clusters in University_ID
Coefficient in bold are significant at the .05 level

Table 5. Logistic regressions with university fixed effects

	Coef.	Rob. Std. Err.
Individual level vars		
age	0.018	0.016
female	**-0.621**	0.184
patent	**0.848**	0.318
publications	-0.030	0.023
parent_entr	**0.964**	0.239
work_univ	**-0.564**	0.193
University level vars		
priv_phd	0.131	0.259
entr_courses	**1.626**	0.217
collab_firms	**0.643**	0.215
University level controls		
res_quality	0.070	0.642
n_temp_staff	0.002	0.002
sh_priv_income	-0.061	0.187
staff_univ	**-0.002**	0.000
Other controls		
pat_inhab	0.004	0.011
unemp	0.162	0.271
south	0.436	2.683
year_phd_2010	0.020	0.255
year_phd_2011	-0.239	0.269
year_phd_2012	-0.376	0.383
Scientific Sector dummies	Included	
Universities dummies	Included	
Wald chi2	256.64	
Observations	1320	
Universities	48	

Coefficient in bold are significant at the .05 level

Table 6. Robustness checks

	(1)	(2)
Individual level variables		
age	0.0311	0.0297
	(0.0192)	(0.0196)
female	-0.464***	-0.490***
	(0.124)	(0.120)
patent	0.885**	0.800*
	(0.433)	(0.439)
publications	-0.0365*	-0.0341*
	(0.0215)	(0.0207)
parent_entr	1.045***	1.049***
	(0.187)	(0.183)
work_univ	-0.593***	-0.584***
	(0.227)	(0.224)
University level vars		
res_quality	-0.476	-0.351
	(0.464)	(0.473)
n_temp_staff	0.00139	0.000975
	(0.00172)	(0.00172)
sh_priv_income	-0.132	-0.0730
	(0.203)	(0.157)
staff_univ	-0.000127	-0.000231
	(0.000156)	(0.000143)
University third mission variables		
utt_experience	0.0385	0.00929
	(0.0415)	(0.0423)
univ_spin-off	-0.0361	-0.0284
	(0.0988)	(0.0859)
univ_patent	-0.000404	1.10e-05
	(0.00142)	(0.00132)
univ_entr_courses	0.141*	
	(0.0850)	
univ_entr_support		0.454***
		(0.162)
Other controls		
pat_inhab	0.00262	0.00376*
	(0.00243)	(0.00228)
unemp	0.0212	0.0124
	(0.0704)	(0.0678)
south	0.213	0.376
	(0.434)	(0.417)
year_phd_2010	-0.120	-0.0363
	(0.201)	(0.200)
year_phd_2011	-0.230	-0.126
	(0.239)	(0.231)
year_phd_2012	-0.0883	0.0446
	(0.344)	(0.317)
Scientific Sector dummies	Included	Included
Wald chi2	1508.4***	1238***
Observations	2231	2231

Std. Err. adjusted for 49 clusters in University_ID in parentheses;
*** p<0.01, ** p<0.05, * p<0.1