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The gender gap in PhD entrepreneurship: Why balancing employment in academia really matters

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ABSTRACT

We use original data from a questionnaire survey of 9062 individuals enrolled in PhD programmes in Italy between 2008 and 2014 to conduct an empirical investigation of gender issues in PhD entrepreneurship. The analysis focuses on the influence of the gender balance among academics at the parent university, to measure the opportunities available to female students to engage with same-sex role models and the effect of such engagement on female students' attitudes to applied research and entrepreneurship. Our evidence shows that there is a gender gap in PhD student entrepreneurship and suggests that the gender composition of the academic faculty has a significant impact on female students' attitudes to business-oriented research and its commercialisation, which, in turn, affects their entrepreneurial intention and probability of starting a business. Our results indicate that female students' entrepreneurship would benefit from the opportunities offered by a more gender-balanced work environment and reinforces arguments calling for equality in the academic workplace.

1. Introduction

Gender differences in entrepreneurship is an issue that is attracting growing research attention. While some contend that women are less interested than men in 'male-oriented' careers, such as entrepreneurship (Abbasianchavari and Moritz, 2021; BarNir et al., 2011; Forsman and Barth, 2017), greater gender equality has become a priority for modern societies and encouragement of female entrepreneurship has become the focus of numerous recent studies (Portillo Navarro and Millán Jiménez, 2016). The interest in this issue stems from the greater awareness that women bring novel perspectives and mindsets to entrepreneurial ventures (Dezsö and Ross, 2012; Dheer et al., 2019) and that female-owned enterprises can contribute significantly to national socio-economic development (Bosse and Taylor, 2012; Brush and Cooper, 2012). The Treaty of Rome agreement (Link, 2017), established gender equality as a fundamental principle of the European Union and, since that time, more women have chosen to become entrepreneurs. However, entrepreneurship continues to be male dominated in Europe (Meunier et al., 2017) and this has increased the academic research and policy focus on gender issues in the context of entrepreneurship. There is untapped potential related to the lower participation of women in start-up creation whose causes need to be addressed in order to promote gender equality and improve women's welfare and economic development (Dheer et al., 2019; Hughes et al., 2012).

The recent scientific literature is also paying more attention to academic and student entrepreneurship. While several studies examine women's involvement in science, their engagement in entrepreneurship and technology transfer activities has received less attention (Jennings and Brush, 2013). Some authors have investigated whether and to what extent gender differences affect perceptions of and attitudes to entrepreneurship among both academics (Abreu and Grinevich, 2017; Goel et al., 2015) and students (De Cruz Sánchez-Escobedo et al., 2011; Muscio and Vallanti, 2022). These studies show that gender disparities are common even in inclusive job environments, such as academia, and might affect women's decisions about entrepreneurship. In this context, female students and female academics face substantial barriers and a better awareness of the causes of this gender gap could have tangible implications for universities' goals and practices with respect to firm creation. There is currently no consensus on the reasons for this gap which makes the design of appropriate policy responses difficult (Abreu and Grinevich, 2017).

Investigations into how the gender or gender diversity of university faculty affects PhD students' employment outcomes are scarce. Previous empirical work focuses primarily on the effect of same gender

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supervisors on PhD students' performance (Neumark and Gardecki, 1998) and on labour market and academic success, following award of the PhD (Gaule and Piacentini, 2018; Neumark and Gardecki, 1998; Pezzoni et al., 2016). However, several studies suffer from identification problems, stemming from the students' ability to choose academic courses and professors, which makes it impossible to separate the causal effect of supervisor's gender from selection effects. Also, the generalisability of the findings is often limited by the fact that they tend to focus on a single institution or a specific scientific-disciplinary field.

The present paper investigates PhD students' entrepreneurial attitude and entrepreneurial activity, with a specific focus on women. PhD entrepreneurship is a relatively new, but growing research topic in the scientific literature (Bienkowska et al., 2016; Conti and Visentin, 2015), and commands attention for several reasons (Colombo and Piva, 2012; Muscio and Ramaciotti, 2019; Muscio et al., 2022), spanning from issues of social equity to the unrealized economic potential. Our analysis builds on two broad literature streams: studies on gender issues related to academic and student entrepreneurship and studies on the effect of gender role models on female students' performance and outcomes.

We extend prior work on PhD students' academic performance from several perspectives. First, we focus on gender issues in relation to the entrepreneurial attitudes and activities of PhD students, a dimension not investigated in depth by previous research, and commercialisation of research results by women. Second, we employ an instrumental variable approach to establish a causal relationship between the gender characteristics of the academic environment and the gender gap in PhD entrepreneurial attitudes. Third, we exploit unique individual-level data derived from a questionnaire survey of 9062 doctoral graduates in Italy who completed their PhD studies between 2008 and 2014. The database is representative of the entire population of PhD graduates in Italy, in all disciplinary-scientific areas, and, among other things, provides detailed information on students' entrepreneurship-related activity during and after their PhD studies. Our longitudinal dataset allows us to control for unobserved heterogeneity among universities and disciplinary-scientific areas via fixed effects. Therefore, our main results are not driven by university or disciplinary area cross-sectional differences, such as internal policies or academic attitudes to gender issues, which could influence both the PhD students' performance and the faculty characteristics (e.g., faculty gender composition). The richness of our data allows us to control for a set of student characteristics, including family background and propensity for risk, and doctoral programme and university characteristics such as disciplinary-scientific area, quality/reputation, management, location.

Using the approach outlined above and in line with the previous literature, we found a significant gender gap between PhD students' entrepreneurial intentions and startup activity. In line with the role model literature, we also found that the gender gap in student entrepreneurship can be mitigated by a larger presence of women among the academic staff.

The rest of the paper is organised as follows: Section 2 briefly reviews the two most relevant literature streams and formulates our hypotheses; Section 3 describes the data and the empirical strategy; Section 4 presents the main findings.

2. Theoretical background

2.1. The gender gap in PhD student entrepreneurship

Recent scientific literature presents strong evidence regarding the scale of academic research commercialization and entrepreneurship activities. However, empirical findings indicate a gender-based stratification in academics' participation in research commercialization, even within prestigious institutions (Abreu and Grinevich, 2017; Azoulay et al., 2009; Ding et al., 2006; Murray and Graham, 2007; Jain et al., 2009). This inequality is often attributed to the underrepresentation of women in academia. It has also been shown that "the barriers that women encounter on the way to the commercialisation of science cause an additional 'leakage' at the end of the pipeline" (Polkowska, 2013:157), which exacerbates the gender disparity in scientific fields. Overall, the existing empirical evidence leads to the conclusion that women scientists are less likely to commercialize the results of their research (Abreu and Grinevich, 2013, 2017), to patent (Whittington and Smith-Doerr, 2005; Sugimoto et al., 2015) or to disclose their inventions (Colyvas et al., 2012). Research indicates, also, that male academics tend to exhibit lower risk aversion than their female counterparts (Borghans et al., 2009; Croson and Gneezy, 2009; Ding and Choi, 2011), which generates a gender-based gap in participation in commercial science. It implies that women are more inclined to avoid potentially risky entrepreneurial activities in favour of other types of academic engagement or employment outcomes (Murray and Graham, 2007). Some authors suggest that the gender bias in research commercialisation might be due to the lower participation of female academics in STEM (Science, Technology, Engineering, Mathematics) disciplines, where innovation and technology transfer activities are more prevalent (Mercier et al., 2018). There is evidence of "systematic gender biases in patenting and entrepreneurial activities, ranging from the initial exclusion of female inventors from commercial opportunities to the predominantly male-coded environment these women face" (Sohar et al., 2018: 673–4).

Some very recent empirical research indicates that gender disparities are evident at the start of an academic career, that is, at the PhD study stage. It seems that female PhD students are less interested in private sector involvement (Muscio and Shibayama, 2023) and, in some instances, tend to be discouraged from pursuit of an entrepreneurial venture (Roach, 2017). During their PhD studies women appear also less likely than male students to become inventors (Delgado and Murray, 2023).

Based on the above arguments, we posit that:

H1. Female PhD students have a lower probability of being involved in applied (business-oriented) research and research commercialisation activities.

Analysis of gender aspects in PhD students' entrepreneurial activity is not straightforward and a comprehensive study needs to build on work in various fields (de Bruin et al., 2007), such as academic entrepreneurship (i.e., since many doctoral graduates pursue a career in academia, we need to examine the entrepreneurial activity of academic staff) and student and graduate entrepreneurship (i.e., the entrepreneurial activity of students during their university studies). It is also necessary to distinguish between actual entrepreneurial activity and entrepreneurial intention. There is a large body of empirical evidence on the magnitude and modality of academics' entrepreneurial activity and on the related persistent gender bias (Rothaermel et al., 2007; Siegel and Wright, 2015; Thursby and Thursby, 2005).

The fact that female academics feel excluded from entrepreneurial ventures (Rosa and Dawson, 2006; Murray and Graham, 2007), suggests that they will show lower levels of entrepreneurial intent. However, since it has been shown that greater gender diversity in academic spin-off boards is associated to greater economic performance, the participation of women in enterprise management can be vital (Sciarelli et al., 2021).

The literature focuses predominantly on university faculty and university staff start-ups and tends to ignore student entrepreneurship (Åstebro et al., 2012; Hayter et al., 2017; Shah and Pahnke, 2014). The lack of empirical evidence on PhD students is especially evident (Bienkowska et al., 2016; Muscio and Ramaciotti, 2019; Ruiu et al., 2019). While the allocation of resources to PhD programmes seems to rely on the assumption that many PhD graduates will take up positions in academia (Conti and Liu, 2015; Muscio et al., 2022; Ruiu et al., 2019), analyses of doctoral graduates' employment outcomes would tend to dispute this assumption (Conti and Visentin, 2015; Hayter and Parker, 2018), even taking account of country-level differences (Walsh et al.,

2015). This stream of work shows that entrepreneurial activity among PhD students is intensive and suggests that universities should be promoting students' startup activity and entrepreneurial intentions. The focus on PhD entrepreneurship is relatively recent, as demonstrated by several studies (Bienkowska et al., 2016; Dooley and Kenny, 2015; Muscio and Ramaciotti, 2019; Roach and Sauermann, 2015). However, despite this growing interest, evidence on gender-related issues in the context of PhD entrepreneurship is still scarce. The limited number of studies that have focused on this aspect indicates a gender gap, with male students exhibiting a greater likelihood to pursue entrepreneurial endeavours or express entrepreneurial intentions compared to their female counterparts (Muscio and Vallanti, 2022; Muscio et al., 2022; Roach, 2017). These findings raise questions about potential gender bias at the PhD study stage (De Cruz Sánchez-Escobedo et al., 2011).

The factors linked to the gender gap in the university context and the impact of sexual stereotypes on entrepreneurial intention among students, are the subject of ongoing debate and have direct implications for the design of policy responses to promote more gender-balanced entrepreneurial activities. There are implications, also, for educators (Ramadani et al., 2022; Shinnar et al., 2014; Wilson et al., 2007); greater exposure of PhD students and junior faculty to the research commercialisation process could increase their entrepreneurial activity and intention (Murray and Graham, 2007).

Based on the above arguments, we posit that:

H2. Female PhD students exhibit a lower intention to become an entrepreneur.

H3. Female PhD students have a lower probability of becoming entrepreneurs.

2.2. Gender-balanced academic environment and gender role models

In academia, achievement of a gender balance is closely linked to the need to have in place robust and equitable recruitment and career advancement procedures. Fair and transparent processes are considered crucial for both academic excellence and greater gender equality (Van den Brink et al., 2010). However, several authors highlight that, although many countries have introduced legislation and policies to address gender discrimination in employment (Nielsen, 2014, 2017; Winchester and Browning, 2015), these measures do not apply to higher education institutions and the idea that academia is a meritocratic ‘sanctuary’ is an illusion (Silander et al., 2013). In most European countries, while more women than men attend and graduate from university, women are consistently underrepresented in academic positions (Bagues et al., 2017; Monroe et al., 2008; González-Pérez et al., 2020; UNESCO, 2017; Van den Brink and Benschop, 2012). It is beyond the scope of this paper to investigate the reasons why gender disparities emerge in academia, but we need to understand whether and to what extent a better gender representation in universities might affect female students' attitudes to research commercialisation and entrepreneurship (Abbasianchavari and Moritz, 2021). The theory and the evidence suggest that female instructors and supervisors could be instrumental in more female student engagement in male-dominated fields where women's underrepresentation is due to the impression or reality that women are discriminated in favour of male peers. In this case, the presence of female faculty role models could have positive effects on female students and mitigate the negative effects of stereotyping while reducing the barriers to and social bias against women (Kang and Xiong, 2021). According to Huyghe and Knockaert (2015), role modelling is based on a cognitive process that characterises individuals who observe the attributes of people engaged in social roles similar to their own and reinforce this perceived similarity through imitation of these attributes (Gibson, 2004). The inspiration derived from observing role models is discussed in several contexts and it has been shown that peer effects have a positive influence on individual entrepreneurial activity (Nanda and Sørensen, 2010), including in schools (Falck et al., 2012) and academia (Roach and Sauermann, 2015; Stuart and Ding, 2006). Some authors provide empirical evidence on the impact of academic role models on students' academic performance. In general, they find that female students more exposed to female faculty (as instructors, supervisors, or research faculty), have a higher probability of enrolling in male-dominated areas such as STEM (Bettinger and Long, 2005; Carrell et al., 2010; Porter and Serra, 2020; Ricci et al., 2021) and completing their studies (Neumark and Gardecki, 1998). In addition, Pezzoni et al. (2016) and Gaule and Piacentini (2018) found that among female PhD students in STEM fields those with female advisors were more successful in terms of publishing and were more likely to pursue a career in academia. However, in the US context, Graddy-Reed et al. (2019) showed that although there are no relevant gender gaps in the award of National Science Foundation scholarships, both female and male advisors co-author less with female awardees, which increases the gender gap in research productivity.

Tartari and Salter (2015) investigated academics' engagement with industry and suggest that a better gender balance in academia encourages both women and men to engage with companies and that the active promotion of diversity in institutions attenuates gender-related differences in the intensity of academic engagement. These authors show that a low share of women staff increases the tendency for women to engage in work tasks or roles that inhibit access to industry and business contexts, which hampers their academic careers. Thus, since academic institutions tend to be male-dominated work environments (Parker et al., 2017), female academics and female students are required to expend more effort than their male peers to establish business ventures because of their smaller chances of engaging with same-sex peers and having women role models on academic staff.

Based on the above discussion, we hypothesise that:

H4. A larger presence of female academic faculty at the parent institution positively moderates female students' involvement in applied research and research commercialisation activities.

The organisational context can play an important role for favouring entrepreneurship and the literature proposes several gender-specific factors shaping entrepreneurship activity and intention (Westhead and Solesvik, 2016; Walter et al., 2013; Zhang et al., 2014). The stream of work on academic entrepreneurship suggests that the peer effect exerted by academics on students can have a major influence on both aspects. Entrepreneurial academic peers who promote entrepreneurship as a viable career outcome are an inspiration for students and reduce the uncertainty and concern over their ability to translate academic knowledge into an entrepreneurial venture (Van Auken et al., 2006). BarNir et al.'s (2011) investigation of the relationship between exposure to role models and entrepreneurial career intention of both male and female undergraduate students would seem to support this idea. However, the authors find that role models have a stronger effect on the entrepreneurial self-efficacy of women compared to men and have a positive effect on the entrepreneurial intentions of women. This suggests that the presence of academic role models, in terms of support, reformulating expectations and instilling confidence about engagement in traditionally male dominated fields, such as entrepreneurship, might be more relevant for female students and young female academics than for their male counterparts. Therefore, as Lockwood (2006: 36) indicates: “Because women face negative stereotypes regarding their competence in the workplace, they may derive particular benefit from the example of an outstanding woman who illustrates the possibility of overcoming gender barriers to achieve success. In contrast, men may not have the same need for same-gender role models”. Others provide support for these conclusions. According to Liu et al. (2019) and Laviolette et al. (2012), gender can affect the influence of entrepreneurial stories on students' entrepreneurial intentions.

Similarly, Stuart and Ding (2006) found that for US faculty members working in departments that had spawned other scientist entrepreneurs increased the likelihood of their becoming inventors. Role models are

particularly relevant in academic environments, which have a pervasive peer-oriented culture that results in peer influence and imitative behaviour (Haas and Park, 2010; Jain et al., 2009; Pell, 1996; Prodan and Drnovsek, 2010). While men seem to be influenced more by engagement with male peers, women seem to be influenced by female colleagues (Markussen and Røed, 2017).

Based on the previous discussion, we hypothesise that:

H5. A larger presence of female academic faculty at the parent institution positively moderates female students' entrepreneurial intentions.

H6. A larger presence of female academic faculty at the parent institution positively moderates female students' entrepreneurship.

3. Data and empirical specification

3.1. Data description

We test our research hypotheses using information from a unique database based on the responses to a questionnaire survey completed by 9062 PhD students in Italy, enrolled in a PhD programme or who graduated between 2008 and 2014.[1] The survey was administrated by CINECA, an Italian consortium that includes universities, research institutions and the Ministry of University and Research (MUR), between December 2014 and end January 2015. Thus, we observed PhD graduates up to 7 years after finishing their doctoral degree course. The questionnaire was administered to around 23,500 individuals - 50 % of the population of PhD students enrolled in a PhD course in the period of analysis. The respondents were asked to evaluate their PhD course and their institution, their entrepreneurial activity during and after the PhD, and their occupational status. All responses were verified by the Italian National Institute of Statistics (ISTAT). Data on PhD courses with very small response rates were removed to preserve anonymity. We received 9062 completed questionnaires, a 39 % response rate. The distribution of responses by scientific-disciplinary field (SSD)[2] was compared to that in a parallel survey on the PhD population, carried out by ISTAT.[3] In 2015, ISTAT identified 22,469 graduates, belonging to the 2008 and 2010 cohorts. The estimated difference between our and the ISTAT samples was always below the 5 % threshold, demonstrating good data representativeness.

We integrated the questionnaire data with data on faculty, obtained from CINECA, which allowed us to extrapolate the number of faculty members for the universe of Italian universities along with detailed information on their gender, academic position, and SSD during the period of analysis. The CINECA database allowed us to construct university-level indicators of gender composition at different levels of aggregation: from the more fine-grained SSD level to the more aggregate university level. The CINECA database does not provide information on faculty at the department or doctoral programme level. However, we associated every student response enrolled in a given PhD programme to faculty members in the same university and the SSD. In some cases, a particular SSD might cover several doctoral programmes.

Finally, we derived other university-level variables, such as research rating and university size, from MUR, and consulted institution websites for information on university policies such as start-up regulations or presence of a Technology Transfer Office (TTO).

3.2. The empirical model

We designed a regression model to test whether female PhD students behave differently from their male colleagues in relation to three different aspects related to business and entrepreneurial attitude: (a) engagement in business-related applied research and research commercialisation (AR); (b) entrepreneurship intention and (perceived) capacity (EI); (c) involvement in entrepreneurial activity during and after completing the PhD (EA). Our survey data provide information on each of these aspects for a total of seven distinct indicators presented in Table 1. This allows us to capture gender differences along different dimensions of PhD student business attitude, ranging from research to actual entrepreneurial activity, which, are typically observed at different stages of academic and professional development. The model is specified as follows:

$$y_{ijst} = \beta_0 + \beta_1 Fem_{it} + \beta_2 Fem_i \times Fem\_fac_{jst} + \beta_3 Fem\_fac_{jst} + \beta_4 X_{it} + \beta_5 Z_{jst} + \lambda_j + \lambda_s + \lambda_t + \epsilon_{ijst} \quad (1)$$

where i is the student, j is the university where student i completed his/her PhD degree, s is the individual's SSD and t is PhD graduation year. The dependent variable y varies depending on the characteristics of the type of research engaged in during the PhD (1 and 2 in Table 1), interest in entrepreneurship (3 to 5 in Table 1) and involvement in entrepreneurship activity (6 and 7 in Table 1).

The variable *Fem* is a dummy for female student. To capture the effect of faculty gender composition on female students' attitudes towards business-oriented research and entrepreneurship, we include the interaction between *Fem* and the share of female faculty staff at the university and SSD (*Fem_fac*).[4] . Most work on the gender effects of faculty on PhD students uses variables for PhD supervisor's gender and other characteristics. Since the survey data do not provide information on supervisor gender, we use the proportion of female faculty in the university and SSD of the PhD as a broader indicator of the gender characteristics of the academic environment. Although the share of female faculty does not fully capture the possible direct advantages of closer research collaboration, research networks and direct formal mentoring, which might be provided from a close supervision relationship, it suggests the broader effect of informal relationships between female students and other female members of faculty (Neumark and Gardecki, 1998). Also, the larger the share of female faculty, the higher the likelihood a female student will be matched with a female supervisor.

The vector X includes a set of individual characteristics, such as age, attitude to risk, work experience before the PhD, parents' education level, parents' entrepreneurship, a dummy for province (NUTS 3 territorial classification) of residence at the time of the survey and a dummy for graduation grade to control for individual unobservable ability and motivation. The vector Z includes indicators for entrepreneurial environment at the student's university,[5] the presence of spin-off regulations

[1] In the following sections, 'PhD student' refers to both those currently enrolled in a PhD programme and those who have graduated with a PhD degree.

[2] The 14 SSD areas are: Mathematics and Computer Science, Physics, Chemistry, Geology, Biology, Medicine, Agriculture and Veterinary, Civil Engineering and Architecture, Industrial Engineering, Humanities, Sociology, Philosophy and Psychology, Law, Economics and Statistics, Political Science.

[3] 'Indagine ISTAT sull'inserimento professionale dei dottori di ricerca' from https://www.istat.it/it/archivio/8555.

[4] *Fem_fac* is the share of female faculty (full and associate professors, lecturers, assistant professors) in the final year of PhD study. The regression results (available upon request), including average share of female faculty over a 3-year window (i.e., legal PhD duration), are qualitatively and quantitatively similar.

[5] The control variables are based on the literature on student start-up activity (Åstebro et al., 2012; Muscio and Ramaciotti, 2019; Krabel and Mueller, 2009), which identifies individual factors influencing the individual propensity to establish a firm (Abreu and Grinevich, 2013; Landry et al., 2006), and university-level control factors measuring institution research performance and size.

Table 1
Variable definition and data sources.

Variable	Description	Source
Dependent variables		
- Research-oriented and research commercialization (AR):		
1. Business collaboration	Dummy variable taking the value 1 if the student collaborated with businesses on research activity during her/his PhD programme and 0 otherwise.	Questionnaire
2. Patent application	Dummy variable taking the value 1 if the student was involved in a patent application during her/his PhD programme and 0 otherwise.	Questionnaire
- Entrepreneurship attitude and intention (EI):		
3. Entrepreneurial idea	Dummy variable taking the value 1 if the student ever discussed with her/his supervisor the idea of starting a business and 0 otherwise.	Questionnaire
4. Entrepreneurial capacity	Dummy variable taking the value 1 if the student believes she/he would be capable of starting a business and 0 otherwise.	Questionnaire
5. Abandoned entrepr. intention	Dummy variable taking the value 1 if the student had the intention to start a business start-up but abandoned the attempt and 0 otherwise.	Questionnaire
- Entrepreneurship activity (EA):		
6. Start-up founder	Dummy variable taking the value 1 if the student established or contributed to the establishment of a business start-up and 0 otherwise.	Questionnaire
7. Entrepreneur	Dummy variable taking the value 1 if the student is an entrepreneur and 0 otherwise.	Questionnaire
- Research hypotheses testing		
Female	Dummy variable taking the value 1 if the student is female and 0 otherwise.	Questionnaire
Share female faculty in SSD	Share of female faculty in the university and disciplinary-scientific sector (SSD) of the PhD programme.	MIUR
- Individual controls		
Risk preference	Dummy variables based on scalar variable ranging from 1 if the student claims that she/he is more willing to invest in technologies. Projects or products that involve low risk and certain. Low gains and 5 if she/he is more willing to invest in risky projects that involve high gains. The dummy takes value 1 if the value of the scalar is equal or above the sample median (4)	Questionnaire
Age	Age of the student at the conclusion of the PhD	Questionnaire
Graduation grade	Graduation final mark (66–110).	Questionnaire
No work experience	Dummy variable taking the value 1 if the student had no job experience before the beginning of the PhD programme and 0 otherwise.	Questionnaire
Entrepreneur parent	Dummy variable taking the value 1 if at least one of the student's parents is an entrepreneur.	Questionnaire
Graduate parent	Dummy variable taking the value 1 if at least one of the student's parents has a university degree.	Questionnaire
University entrepr. training	Dummy variables based on scalar variable ranging from 1 to 6 on the basis of the availability of training courses on entrepreneurship offered by the student's university. The dummy takes the value 1 if the value of the scalar is equal to or above the sample median (3)	Questionnaire
Conclusion PhD	Dummy variable taking the value 1 if the student has finished PhD studies.	Questionnaire
- University and contextual control factors		
Unemployment rate	Unemployment rate in the year before graduation in the province (NUTS3) where the university is located.	ISTAT
University research rating	MIUR Research rating in the SSD area of the PhD research carried out by the student. This indicator is 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
University faculty	University faculty in the same year as conclusion of the PhD.	MIUR
University female faculty	Share of university female faculty in the year of graduation of the PhD the student.	MIUR
Incubator (=1 YES)	Availability at the parent institution of a business incubator.	PniCube website
RSO (=1 YES)	Availability at the parent institution of dedicated internal rules for spinoff and startup creation.	University website
TTO (=1 YES)	Availability at the parent institution of a TTO.	University website

(or RSO), the presence of a TTO and a business incubator[6] and other time variant university characteristics, such as number of faculty members, which proxies for university size, and faculty gender composition at the university level. We also included a time-invariant indicator for research quality, measured at the SSD and university levels, and the unemployment rate in the province of the university that awarded the PhD degree.[7]

All the specifications include a set of dummies for PhD student's university, relevant SSD and graduation year and, depending on the specification considered, their interaction. Finally, we cluster standard errors based on university-SSD cells to adjust for possible serial correlation within cells.[8]

In model (1), the main variable of interest is *Fem* and its interaction with the share of female faculty *Fem_fac* (*Fem* × *Fem_fac*). The gender effect on attitude to a given aspect of research and entrepreneurship is given by the first derivative of Eq. (1) with respect to the dummy *Fem*:

$$\frac{\partial y}{\partial Fem} = \widehat{\beta}_1 + \widehat{\beta}_2 Fem\_fac \tag{2}$$

A negative value of the derivative (positive for indicator 5, that is, "*abandoning the idea of becoming an entrepreneur*") supports Hypotheses 1, 2 and 3, of a gender gap in student attitude to entrepreneurship.

The coefficient β_2 captures differences in the attitudes of female students to business-oriented research and entrepreneurship, depending on the presence of women in faculty staff. A positive coefficient β_2 (negative for indicator 5) would imply that, ceteris paribus, a larger presence of female faculty has a positive effect on female PhD students'

[6] We account for the availability of university policies supporting start-up and spin-off creation and for the availability of a business incubator at the parent university. University policies can provide monetary incentives for start-up creation and norms to reduce entrepreneurial risk (Muscio and Ramaciotti, 2019).

[7] Time series data on unemployment rates at the province level are from ISTAT.

[8] In all the specifications, standard errors are clustered at the SSD and university levels (546 clusters). Specifically, we use a variable which uniquely identifies PhD students into a combination of these two dimensions. This implies the restriction that observations are independent if they are in the same university, but in a different scientific field (Cameron and Miller, 2015).

attitudes to business-oriented research and entrepreneurship (both intention and action) which supports Hypotheses 4, 5 and 6.

3.3. Instrumental strategy

Although in the regressions we control for many observable students' individual characteristics, the distribution and characteristics of students across PhD programmes may not be random and might depend on the gender composition of the faculty. For example, a larger share of women in the faculty might be part of an internal university (time varying) strategy to increase the presence of females in academia, which is unobservable in our data. This strategy might have an influence, also, on PhD candidate selection and be aimed at attracting female PhD candidates with higher potential for or interest in innovation and entrepreneurship, based on extra funding or targeted scholarships. The same endogeneity problem arises if female students with specific characteristics correlated to their entrepreneurship attitude choose a PhD programme with a higher female faculty presence. Therefore, female students in a university and a SSD with a higher representation of female faculty may be systematically different from other female students, and this would bias our model. If this were the case, the results of an Ordinary Least Square (OLS) model would still show a possible correlation between female student entrepreneurship and presence of female faculty; however, we would be unable to disentangle the role model effect from the sorting effect.

To deal with this potential endogeneity, we employed an Instrumental Variable (IV) strategy. Thus, our instrument is share of female faculty at the national level in the same SSD as the PhD, net of the contribution of the parent university, which, we claim, is unrelated to internal personnel and gender policies at the department or university level. However, exogenous trends at the aggregate level that reflect the different evolution of the numbers of female researchers in a specific SSD, mean that it is correlated with share of female faculty at the university and SSD level.

Conceptually, this IV strategy identifies the effects of the share of female faculty (and its interaction) on the output of interest using only the variation in this variable due to national but not university-specific trends. This approach is similar to the Hausman-Nevo (see Hausman and Leonard, 1996 and Nevo, 2001) approach, typically applied to identify the causal effects of local market concentration on firm outcomes.[9]

Within this framework, we run the following first-stage equation:

$$Fem\_fac_{jst} = \delta_0 + \delta_1 \overline{Fem\_fac}_{st} + other\ controls\ (jst) + \omega_{jst} \quad (3)$$

where δ_1 measures the effect of overall faculty composition at the national level in the SSD s, on internal faculty composition in the same SSD. The first stage includes year, university and SSD fixed effects, which are the exogenous controls included in the main model.

3.4. Selection

Investigating gender differences in entrepreneurship among PhD students presents methodological challenges due, among the others, to the prevalent gender-segregation observed across fields of study and academic subjects. This segregation hinders comparison of female to male students, since the two groups are distinctive in terms of educational background, past experience, mentorship opportunities and attitude to risk. Ultimately, these factors are related to individual differences in entrepreneurial attitude.

In this case, inclusion of multiple control variables may not, on its own, be enough to achieve consistent estimations. To address this issue, we employed Propensity Score Matching (PSM), to match pairs based, specifically, on the conditional probability of being female, and assessed the effect of the baseline characteristics on the outcomes of interest. Matching approaches are valuable for dealing with heterogeneity issues and for comparing like with like. Careful selection of a control group that is closely matched to the treated group, allow the matching approach to establish statistically significant differences in entrepreneurship attitudes between treated (female) and untreated (male) groups, while controlling for other relevant observable characteristics. PSM relies on the assumption that, conditional on some observable characteristics, untreated units can be compared to treated units, as though the treatment had been fully randomised.[10]

In our analysis, we employ PSM to assess whether there is a statistically significant difference in the entrepreneurship attitudes of the two groups, that is, female students (treated) and male students (untreated). The matching approach first identifies a control group (from the untreated male group) that closely resembles the treated female group in terms of other observable characteristics. Therefore, female PhD students are matched to their male counterparts along individual observable characteristics such as age, attitude to risk, work experience, parents' characteristics and PhD SSD which captures (unobserved) individual ability and motivation.[11] The selection of a control group closely aligned to the treated group in terms of observable characteristics allows more reliable analysis of gender differences in entrepreneurship attitude, while controlling for individual ability and motivation factors.

In the next step, we use the sample identified by the PMS procedure to estimate the effect of the treatment variable (female) when interacted with the share of female faculty on the outcome variable of interest. As described before, we employ IV regression analysis, aimed at investigating the moderating effect of female faculty on two comparable groups of students in terms of education background, experience and other relevant characteristics. Careful selection of a control group that closely matches the treated group allows for better control for potential biases and heterogeneity in the data and more reliable and more consistent estimation results.

4. Results

4.1. Descriptive statistics and PMS results

Table 1 presents the variables included in the regressions; Table 2 presents the descriptive statistics and the t-tests for differences in the means between male and female students. Results in Table 2 show that, in relation to gender differences in business-oriented research involvement and entrepreneurial intention and activity, there is a significant gender gap along all the dimensions considered. We observe that women are significantly less likely than men to undertake research in collaboration with firms or to commercialize their research ideas, they have a lower propensity (and lower self-confidence) for and persistence in entrepreneurship and are less likely to start a venture or become an entrepreneur. In addition, fewer female PhD students declared a high propensity for risk (almost 4 % fewer than men). It may be that the difference in attitude to risk, which is confirmed in the gender literature, explains women's lower propensity for commercialisation of research output and entrepreneurial behaviour. Finally, although the male and female students in our sample exhibit significant differences in their

[9] See, among others, Qiu and Sojourner (2019), Azar et al. (2022), Marinescu et al. (2021) and Bassanini et al. (2021).

[10] We use the nearest neighbour matching estimator to match the two groups of individuals. This algorithm matches individuals from the treatment group to individuals from the control group, based on their propensity scores, selecting the control individual whose propensity score is closest to that of the treated individual within a specified caliper range, using the Stata command psmatch2 program (Leuven and Sianesi, 2003).

[11] The full list of observable characteristics used to match the two groups is reported in Appendix Table 1A.

Table 2
Descriptive statistics.

	Overall sample				Male	Female	
	Mean	Std. dev.	Min	Max	Mean	Mean	Mean-comparison *t*-test [(1)]
Independent variables							
Business collaboration	0.186	0.389	0.000	1.000	0.214	0.157	**
Patent application	0.034	0.179	0.000	1.000	0.042	0.025	**
Entrepreneurial idea	0.247	0.431	0.000	1.000	0.287	0.207	**
Entrepreneurial (self-reported) capacity	0.587	0.492	0.000	1.000	0.644	0.527	**
Abandoned entrepreneurial intention	0.410	0.492	0.000	1.000	0.365	0.461	**
Start-up	0.065	0.246	0.000	1.000	0.085	0.045	**
Entrepreneur	0.038	0.192	0.000	1.000	0.052	0.027	**
Dependent variables							
Female	0.506	0.502	0.000	1.000	–	–	
Share female faculty at university-SSD level	0.351	0.152	0.000	1.000	0.328	0.374	**
Individual controls							
Risk preference	0.101	0.253	0.000	1.000	0.136	0.674	**
Age	31.69	2.93	27.0	39.0	31.80	31.58	
Graduation grade	108.7	3.4	80.0	110.0	108.4	108.7	
No work experience	0.488	0.500	0.000	1.000	0.514	0.464	**
Entrepreneur parent	0.100	0.300	0.000	1.000	0.093	0.106	*
Graduate parent	0.390	0.488	0.000	1.000	0.405	0.375	*
University entrepreneurship training	0.218	0.413	0.000	1.000	0.324	0.277	**
Conclusion PhD	0.860	0.347	0.000	1.000	0.862	0.857	
University and contextual control factors							
Unemployment rate	9.619	5.040	2.171	25.661	9.512	9.662	
University research rating	1.000	0.221	0.000	1.840	0.997	1.008	
University faculty (number)	1558.0	1018.1	7.0	4752.0	1545.6	1570.4	
University female faculty share	0.357	0.050	0.091	0.641	0.353	0.359	
Incubator (=1 YES)	0.808	0.394	0.000	1.000	0.789	0.814	+
RSO (=1 YES)	0.928	0.254	0.000	1.000	0.928	0.928	
TTO (=1 YES)	0.955	0.208	0.000	1.000	0.956	0.946	*

Note: [(1)] Ho: diff = 0; Ha: diff < (>) 0. +. *. ** indicate statistical significance at the 10 %. 5 % and 1 % levels, respectively.

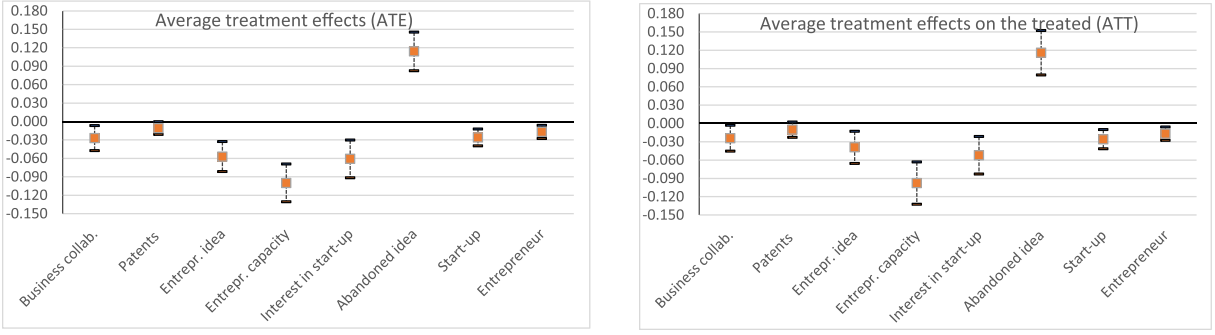

Fig. 1. The Gender Gap in the balanced sample.

attitudes and behaviours, the institutional characteristics and policies of their PhD academic environments do not differ significantly.

Fig. 1 depicts the gender differences calculated for our indicators of student business attitude, using the matched sample discussed in Section 3.4.[12] We report both the Average Treatment Effect (ATE) and the ATE on the Treated (ATT).[13]

Our results support existing findings on academic and student entrepreneurship and the results of descriptive statistics; we find that, after controlling for multiple individual characteristics, women tend to perform worse than men with respect to all seven indicators of entrepreneurship. In line with Hypothesis 1, the PSM results show that female students engage less than their male colleagues in business-related applied research (−0.03) and research commercialisation (−0.01). We find, also, that women exhibit a lower intention to become entrepreneurs. The estimated gender gaps in the indicators "ever discuss entrepreneurial ideas with supervisors" and "self-perception of ability to create a business" are respectively 8 % and 6 %, while the proportion of PhD students who declared having abandoned the idea of establishing a firm was 10 percentage points higher for women. Finally, the percentages of female PhDs who had established a start-up or become an entrepreneur are respectively 2 % and 1 % lower. This result supports Hypotheses 2 and 3 and is in line with recent evidence on the larger

[12] The results for the tests on the balanced characteristics of the sample over the matching variables are reported in Appendix Table 1A. Note that after performing the matching, the sample is correctly balanced over the observables. For reasons of space, we do not provide all the propensity score specification tests; the results are available from the authors on request.

[13] ATE measures the average difference in business attitude between female students (treated) and male students (control) and are comparable to the OLS coefficients. ATT measures the average difference in business attitudes among female students and the difference had they been males.

barriers faced by women academics in relation to starting a business.[14]

4.2. IV regressions results

In this section, we test Hypotheses 4, 5 and 6 about the differences in students' engagement with industry and entrepreneurial attitude between female and male students (with similar characteristics) and whether these differences are mitigated by a higher share of female faculty in the department. Using the matched sample of PhD students, we estimated the empirical model in specification (1), using the weights frequency of the matching with the control group (Dehejia and Wahba, 2002). In the regression model, the gender dummy (capturing the gender gap in entrepreneurship among PhD students), is interacted with the share of female faculty.[15]

As discussed in Section 3.3, to address spurious correlation between the share of female faculty and female PhD student attitude to business research and entrepreneurship (both intention and actual activity) arising from sorting on ability, we instrumented the share of female faculty with the corresponding average share of female faculty in the same SSD at the national level. This instrument provides a source of variation in the share of females, relying on national rather than local changes and, therefore, independent of gender policies at the single university/PhD programme level.

Table 4 reports the results for the first stage regression (Eq. (2)). We observe a positive and significant relation between the instrument and the instrumented variable, which confirms the relevance of our instrument. Also, the null that the equation is under-identified is always rejected, confirmed by the Kleibergen-Paap test (see Table 4), while, in all the specifications, the F statistic is well above the rule-of-thumb threshold of 10.

Table 4 presents the results of the IV linear probability model regressions specified in Eq. (1).[16] Columns (1, 2) estimate the likelihood of the PhD student participating in collaborative research with business, and patenting. Columns (3, 4, 5) report the results for student intention and (self-reported) capacity for entrepreneurship. Columns (6, 7) report the results for actual involvement in business either during the PhD or after graduation.

Confirming the previous results, we find that, after controlling for several individual, university and PhD programme characteristics, and all fixed effects, being a woman is negatively associated with all seven outcomes of interest. The gender effect as in Eq. (2) is negative and statistically significant in all of the specifications.[17] The coefficient of the interaction between the female dummy and the share of female faculty in the same university and PhD SSD, is positive and statistically significant in almost all the specifications, with the exception of the coefficients in Column 4 (entrepreneurial capacity) and Column 6 (start-up founder), which are still positive, but are less precisely estimated. These results show that the presence of a larger share of female faculty is positively related to the likelihood of female students engaging in business-oriented research and patenting (Table 3 Columns 1 and 2), female students' attitude and intention related to business activity (Columns 3 and 5) and likelihood that female students will become entrepreneurs (Columns 6 and 7).[18]

The estimated coefficients are also quantitively relevant. Table 4 shows that a one standard deviation increase in the share of female faculty, which corresponds to approximately 15 percentage points, leads to around a two-thirds reduction in the gender gap for PhD students'

Table 3
IV linear probability model: First stage estimates.

Dependent variable	Share female staff same university & SSD	Female × Share female faculty same university & SSD
Share female staff same SDD area (national level)	1.358**	0.220**
	[0.062]	[0.050]
Female × Share female staff same SDD area (national level)	−0.013	1.000**
	[0.052]	[0.012]
Individual controls	Yes	Yes
University and contextual control factors	Yes	Yes
Fixed effects		
University FE	Yes	Yes
SSD FE	Yes	Yes
Year FE	Yes	Yes
Observations	5.504	5.504
F-statistic (2, 544)	241.8	3359.6
p-Values	0.00	0

Note: Standard errors are clustered at SSD area and university level (546 clusters). +. *. ** indicate statistical significance at the 10 %, 5 % and 1 % levels, respectively. The instrument is the share of female faculty at national level in a given scientific area net of the contribution of university in which the student obtained the PhD. The first stage refers to specification in column (1) of Table 5.

[14] There is evidence that securing investment for an academic start-up is more difficult for women than for men. See https://www.timeshighereducation.com/campus/how-can-we-help-academia-produce-more-women-entrepreneurs. A recent joint policy brief issued by the OECD and the EC, highlights that the culture and society are often not supportive of female entrepreneurship (OECD and EC, 2017). This brief also highlights the lack of positive women role-models for potential female entrepreneurs.

[15] The results of the empirical analysis based on the original sample of students, are qualitatively and quantitatively similar to the results using the matched sample and are available from the authors upon request.

[16] The binary nature of several variables limits estimation of a non-linear probability model since IV probit models fail to converge due to the large number of binary controls involved if we use interacted fixed effects. However, since we are less interested in estimating the predicted probability and more interested in the marginal effects, i.e., the partial effects of the independent variables on the response probability, averaged across the distribution of the independent variables, the OLS and two stage least square estimates are appropriate (Wooldridge, 2002; Angrist and Pischke, 2009). The probit regression results are qualitatively the same as the results of the linear probability model (see Appendix Table 2A).

[17] The gender effect $\frac{\partial y}{\partial Fem} = \widehat{\beta}_1 + \widehat{\beta}_2 Fem\_fac$ is evaluated at the mean of the share of female faculty members in the sample and reported in Table 2 (i.e., $Fem\_fac = 0.356$). The gender effect is qualitatively and quantitatively similar if the interaction term is excluded from the regression. The results are available upon request.

[18] All the other controls have signs consistent with previous findings for graduate student entrepreneurship. Among individual characteristics, having a parent who is an entrepreneur is positively and significantly associated to all the outcomes of interest. This supports the idea that an entrepreneur parent is a source of entrepreneurship knowledge and socialisation by fostering intergenerational transfers of business knowledge (Markussen and Røed, 2017) and a better understanding of the challenges and opportunities related to an entrepreneur career (Eesley and Wang, 2017). Student attitude to research commercialisation and entrepreneurship is related positively to the individual's attitude to risk. Entrepreneurial training for students is positively associated to business-oriented research and attitude to entrepreneurship. Among the university control variables, in line with the findings from research on spin-offs (Landry et al., 2006; Ramaciotti and Rizzo, 2015), the existence at the parent university of a business incubator shows a significant association with intention to establish a business and reduces the likelihood of abandoning efforts to start a venture. Neither age of regulation on spin-off nor presence of a TTO has a significant effect in any of the specifications. For space reasons, we do not provide the coefficients of the full specification reported in Appendix Table 3A.

Table 4
IV linear probability model: Female faculty share and the gender gap in PhD student entrepreneurship.

	Applied R & I		Entrepreneurial Intention			Entrepreneurship	
	Business collaboration	Patent application	Entrepreneurial idea	Entrepreneurial capacity	Abandoned idea	Start-up	Entrepreneur
Female	−0.109**	−0.048**	−0.143**	−0.131**	0.170**	−0.057**	−0.033*
	[0.031]	[0.016]	[0.039]	[0.050]	[0.050]	[0.021]	[0.016]
Share female faculty same university & SSD	0.020	−0.160	−0.054	0.312	−0.175	0.359*	0.103
	[0.239]	[0.123]	[0.274]	[0.388]	[0.367]	[0.152]	[0.119]
Female × Share female faculty same university & SSD	0.211**	0.101*	0.230*	0.138	−0.219+	0.083	0.068+
	[0.079]	[0.042]	[0.098]	[0.128]	[0.128]	[0.053]	[0.041]
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University and contextual control factors	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects							
University FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SSD FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5504	5677	5340	4147	4065	5284	5712
Gender gap (at the average of female faculty share)[a]	−0.035**	−0.013**	−0.062**	−0.083**	0.093**	−0.027**	−0.009*
F-stat of excluded instruments[b]	459.4	465.4	517.1	331.7	378.8	473.6	505.6
p-Values	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: Weighted IV regressions, with weights based on the frequency at which control group individuals are matched in the PSM procedure. Standard errors are clustered at SSD and university level (546 clusters). +. *. ** indicate statistical significance at the 10 %, 5 % and 1 % levels, respectively. The instrument is the share of female faculty at national level in each scientific area net of the contribution of university in which the student obtained the PhD.

[a] The gender gap $\frac{\partial y}{\partial Fem} = \widehat{\beta}_1 + \widehat{\beta}_2 Fem\_fac$ is evaluated at the mean of the share of female faculty in the sample (i.e. *Fem_fac*=0.356).
[b] Kleibergen-Paap rk LM statistic of excluded instruments.

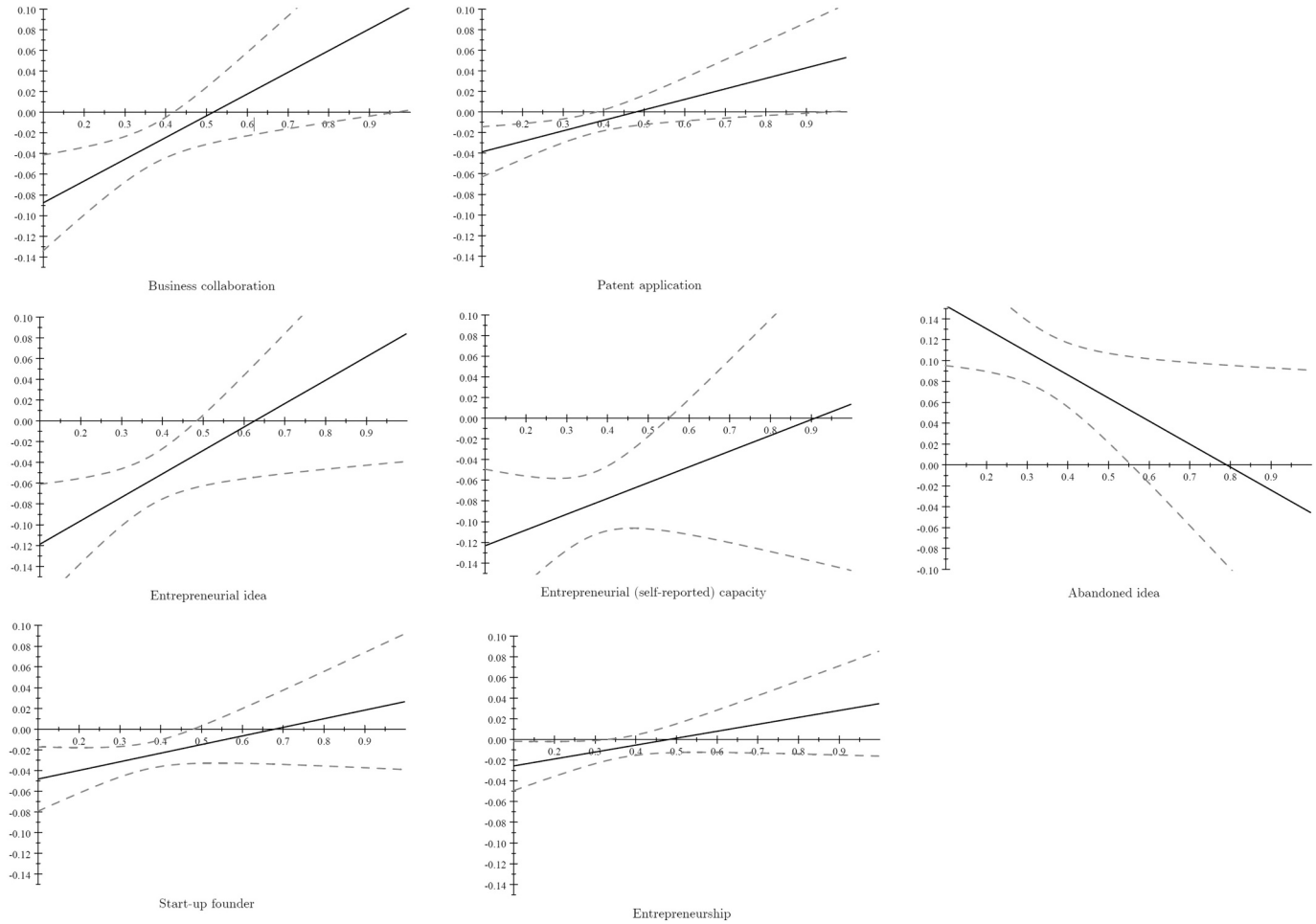

Fig. 2. Gender effect on entrepreneurial outcomes depending on female faculty share.

involvement in applied research and research commercialisation activities, a one-third reduction in the gap for intention and self-reported capacity and a more than one-third reduction in the gap for likelihood of becoming an entrepreneur.

Fig. 2 depicts estimated gender disparities for the seven entrepreneurship outcomes depending on the share of female faculty, based on the coefficients in Table 5. Fig. 2 shows that the student gender gap in entrepreneurship is statistically significant if the share of female faculty falls below the range 40 %–55 %.[19] As the proportion of women academics increases above that threshold, gender differences in business engagement among students become statistically insignificant.

Given that, towards the end of our sample period, the average proportion of female faculty members was approximately 36 %, equivalent to an estimated count of 22,000 women academics, our findings suggest a deficit of approximately 6500 female faculty staff during the period.[20] More recent data from MUR indicate that in 2020–21, the average female faculty share was around 39 %, a modest increase in female academic representation since 2014.[21] However, compared to the critical range of 40 %–55 %, there is a gap of around 5000 females. Also, there are significant persistent disparities across different scientific disciplines. In the STEM fields, including Physics and Geology, women's faculty representation is at less than one-third of male participation. These back-of-the-envelope estimations show that, despite a slight increase in the presence of female faculty, there remains a significant gap between the estimated threshold and the actual numbers. This highlights the need to address and mitigate the gender bias prevalent in academic environments, to allow all students to have equal opportunities to pursue their goals and aspirations.

4.3. Robustness checks

Table 5 reports the results of several robustness tests. Panel A shows that our results are robust to the inclusion of the interaction between university and year fixed effects and the interaction between university and SSD fixed effects. The year fixed effects interaction allows for time-specific changes in the characteristics (and behaviour) of students in a specific university, resulting from the implementation of an internal university policy or some other university-level time-variant shock. The inclusion of the interaction between university and SSD fixed effects implies that the coefficient of interest captures the effect of changes over time in the share of female faculty in a specific university-SSD grouping. Sole reliance on the variation over time in the share of female faculty across university-SSD groupings makes this a very demanding specification, but the sign and size of the interaction coefficients, although less precisely estimated, are in line with the coefficients of our more parsimonious models.

The results in Panel B refer only to STEM areas. UNESCO (2017) suggested that while, worldwide, numbers of university female graduates have grown steadily since the early 2000s, women remain the minority in STEM research fields and, especially, at PhD level. Exploring the effectiveness of role models for motivating diverse students across academic scientific disciplines (e.g., humanities versus STEM) shows that the different response to female role models can be driven by different student characteristics ex-ante or different faculty traits and academic and professional activities. For example, females studying STEM disciplines are characterised by their strong competitiveness and confidence in fields and subjects generally perceived as predominantly 'masculine' (Pregaldini et al., 2020; Buser et al., 2014, 2017).[22] The questionnaire data do not allow a deeper investigation of these aspects. However, we can check whether our results differ significantly between the STEM and the full samples.

In the STEM subsample, the coefficients of the interaction term are positive (negative in Column 5) and significant for almost all the entrepreneurship indicators and are not quantitively different from those estimated on the whole sample. The estimated average gender gap in entrepreneurship intention (Columns 4 and 5), calculated as the average share of female faculty in STEM, is somewhat larger for the STEM disciplines, which is due to the historical underrepresentation of women in STEM fields and the resulting smaller pool of potential female entrepreneurs (Kuschel et al., 2020; Gupta et al., 2019; Marlow and McAdam, 2013). The limited presence of female role models in STEM results in a dearth of inspiring examples for would-be young women entrepreneurs. Networking opportunities also play a significant role in the gender gap; entrepreneurship thrives on strong networks, mentorship and connections. However, in certain STEM disciplines, established networks and mentorship opportunities tailored to women are scarce. Furthermore, prevailing perceptions of entrepreneurship in STEM as high-risk, male-dominated and requiring aggressive competition might discourage women from considering entrepreneurship (Gupta et al., 2019). These perceptions and stereotypes create additional barriers and contribute to the larger gender gap in entrepreneurship intention within STEM fields.

Finally, Panel C presents the results for the interaction between the female dummy and share of senior female faculty, specifically associate and full professors, to examine whether role model effectiveness depends on seniority. The results are similar to the results of the main IV regressions, which suggests that seniority is not relevant for shaping female students' behaviour and attitude to entrepreneurship. These findings suggest that more equal gender representativeness in academic departments (i.e., better representation of female academics regardless of their seniority) is relevant for fostering interest and engagement of female students in entrepreneurial activities.

Overall, the empirical findings offer strong support for all our hypotheses. On the one side, we find evidence of a significant gender bias in PhD entrepreneurship, with female students engaging less than their male colleagues in business research and research commercialisation and exhibiting weaker interest in entrepreneurship and business activity. This gender gap persists even after controlling for many individual characteristics such as attitude to risk and student's research field (SSD). On the other side, we find that a larger presence of female academic faculty attenuates this bias, by inducing female students to engage more in applied research and increasing female students' interest and self-confidence in entrepreneurship. Finally, female PhD students who interact in strongly female academic environments are more likely to persist in their business intention and become an entrepreneur. In line with the existing literature, these results show that women benefit from interaction with same-sex role models and a study environment with fairer representation of females. Such an environment reduces the gender barriers and makes females more confident about their ability to start a venture. In environments where representation of female academics is low, female students suffer bias (Di Tomaso et al., 2007; Fox, 2010; Parker et al., 2017) and lack of the peer effects that encourage

[19] The cut-off threshold required to eliminate the gender gap in indicators (3), (4), and (5) is significantly higher compared to the other indicators. However, considering the wide confidence intervals, the gender gap in those indicators does not exhibit statistically significant differences from zero above a threshold of approximately 50 %–55 %. Therefore, based on our back-of-the-envelope estimations, we identify the range 40 %–55 % as the critical share of female faculty representation necessary to address gender bias in students' research commercialization and entrepreneurship involvement.

[20] The estimated variation in the number of female faculty members goes from 1800, calculated at the lower bound estimate (40 %) to 10,000 at the higher bound (55 %).

[21] The latest available data on university staff, provided by CINECA, is for the academic year 2020–2021 and show that total academic staff are 57,792 of which 22,507 are women.

[22] The related empirical evidence is scant and the results are mixed. See Gladstone and Cimpian (2021) for a review of role model effectiveness in STEM.

Table 5
IV linear probability model: robustness checks.

	Applied R & I		Entrepreneurial Intention			Entrepreneurship	
	Business collaboration	Patent application	Entrepreneurial idea	Entrepreneurial capacity	Abandoned idea	Start-up	Entrepreneur
Panel 1: All Fixed effects interactions							
Female	−0.064+	−0.059**	−0.142**	−0.186**	0.170**	−0.063**	−0.02
	[0.033]	[0.018]	[0.042]	[0.054]	[0.055]	[0.023]	[0.017]
Share female faculty same university & SSD	1.430	−0.062	−0.739	−0.383	−3.034+	1.819**	1.106**
	[0.883]	[0.477]	[1.074]	[1.634]	[1.553]	[0.586]	[0.427]
Female × Share female faculty same university & SSD	0.087	0.116**	0.212*	0.255+	−0.275*	0.107+	0.020
	[0.084]	[0.044]	[0.105]	[0.137]	[0.140]	[0.057]	[0.043]
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University and contextual control factors	No	No	No	No	No	No	No
University FE × SSD FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University FE × year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5407	5602	5241	4024	3935	5185	5616
Gender gap (at the average of female faculty share)[a]	−0.036**	−0.018**	−0.066**	−0.094**	0.067**	−0.025**	−0.004
Panel 2: STEM							
Female	−0.102**	−0.040*	−0.156**	−0.328**	0.249**	−0.053*	−0.057**
	[0.036]	[0.020]	[0.043]	[0.054]	[0.055]	[0.024]	[0.019]
Share female faculty same university & SSD	−0.665*	−0.209	−0.280	0.522	−0.369	0.469**	0.216
	[0.266]	[0.153]	[0.317]	[0.377]	[0.415]	[0.166]	[0.138]
Female × Share female faculty same university & SSD	0.157	0.114*	0.257*	0.570**	−0.293+	0.092	0.129*
	[0.101]	[0.056]	[0.120]	[0.149]	[0.153]	[0.065]	[0.054]
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University and contextual control factors	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SSD FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3949	4027	3825	3082	2326	3783	4080
Gender gap (at the average of female faculty share)[a]	−0.046**	−0.001	−0.066**	−0.127**	0.146**	−0.020**	−0.010*
Panel 3: Female senior faculty							
Female	−0.086**	−0.042**	−0.134**	−0.131**	0.163**	−0.052**	−0.029*
	[0.027]	[0.014]	[0.033]	[0.043]	[0.043]	[0.018]	[0.014]
Share female faculty same university & SSD	0.054	−0.169	−0.053	0.409	−0.201	0.418*	0.118
	[0.257]	[0.136]	[0.319]	[0.461]	[0.437]	[0.165]	[0.130]
Female × Share female faculty same university & SSD	0.192*	0.105*	0.254*	0.166	−0.232+	0.085	0.072+
	[0.084]	[0.044]	[0.103]	[0.137]	[0.136]	[0.055]	[0.042]
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University and contextual control factors	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects							
University FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SSD FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5497	5669	5335	4142	4060	5278	5704
Gender gap (at the average of female faculty share)[a]	−0.018+	−0.005	−0.045**	−0.071**	0.076**	−0.022**	−0.005

Note: Weighted IV regressions, with weights based on the frequency at which control group individuals are matched in the PSM procedure. Standard errors are clustered at SSD area and university level (546 clusters). +. *. ** indicate statistical significance at the 10 %, 5 % and 1 % levels, respectively. The instrument is the share of female faculty at national level in a given scientific area net of the contribution of university in which the student obtained the PhD. The IV probit panel (Panel 4) reports the coefficients from the IV probit regressions.

[a] The gender gap $\frac{\partial y}{\partial Fem} = \widehat{\beta}_1 + \widehat{\beta}_2 Fem\_fac$ is evaluated at the mean of the share of female faculty in the sample (i.e. Fem_fac = 0.356 in the overall sample and = 0.312 in the STEM sample).

entrepreneurship. We also found that, unlike males, female students working in unbalanced work environments are more likely to suppress entrepreneurial intention.

4.4. *Female faculty business engagement and female students' entrepreneurship*

Our main regressions show that the presence of women among faculty positively affects female students' entrepreneurship intention and activity and reduces the gap with their male counterparts. However, further research is needed to delve more deeply into the mechanisms underlying this relationship. Understanding the specific characteristics and experience (especially experience of entrepreneurship) of female faculty members would provide valuable insights into how these individuals influence and support female students in their entrepreneurial pursuits. For example, in line with a recent study by Diegoli and Gutierrez (2018), we would expect that larger entrepreneurial engagement of female faculty will produce a bigger impact on female students' entrepreneurial intention.

The available data does not allow further investigation of the channels through which the presence of female faculty encourages female students' business approaches and business engagement. CINECA data do not provide information on faculty characteristics (other than gender, SSD and seniority) or academic and professional activities. Here, to

Table 6
IV linear probability model: Female faculty share and the gender gap in PhD student entrepreneurship for high and low of female academic engagement in business related activity.

	Applied R & I		Entrepreneurial Intention			Entrepreneurship	
	Business collaboration	Patent application	Entrepreneurial idea	Entrepreneurial capacity	Abandoned idea	Start-up	Entrepreneur
Panel 1: High female faculty business engagement							
Female	−0.059	−0.063**	−0.199**	−0.264**	0.225**	−0.046	−0.072**
	[0.044]	[0.024]	[0.055]	[0.067]	[0.072]	[0.031]	[0.025]
Share female faculty same university & SSD	0.036	−0.020	0.356	0.335	−0.534	0.250	0.041
	[0.324]	[0.162]	[0.367]	[0.426]	[0.466]	[0.201]	[0.162]
Female × Share female faculty same university & SSD	0.173	0.124*	0.309*	0.376*	−0.412*	0.090	0.161**
	[0.111]	[0.060]	[0.135]	[0.169]	[0.180]	[0.077]	[0.061]
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University and contextual control factors	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects							
University FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SSD FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3013	3076	2914	2238	2227	2885	3117
Panel 2: Low female faculty business engagement							
Female	−0.076+	−0.014	−0.046	−0.196**	0.125+	−0.025	−0.030
	[0.045]	[0.023]	[0.058]	[0.074]	[0.073]	[0.028]	[0.021]
Share female faculty same university & SSD	0.561+	−0.164	−1.594**	0.262	0.976	0.486*	0.148
	[0.306]	[0.209]	[0.476]	[0.598]	[0.656]	[0.220]	[0.170]
Female × Share female faculty same university & SSD	0.132	0.013	0.017	0.204	−0.065	0.038	0.077
	[0.119]	[0.062]	[0.153]	[0.198]	[0.195]	[0.072]	[0.056]
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University and contextual control factors	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects							
University FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SSD FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2489	2539	2394	1866	1802	2357	2556

Note: Weighted IV regressions, with weights based on the frequency at which control group individuals are matched in the PSM procedure. Standard errors are clustered at SSD area and university level (546 clusters). +. *. ** indicate statistical significance at the 10 %, 5 % and 1 % levels, respectively. The instrument is the share of female faculty at national level in each scientific area net of the contribution of university in which the student obtained the PhD. The sample is split into high and low female faculty business engagement according to the median values of the share of female faculty involved in spinoff activity at university level.

proxy for the pervasiveness of female academics' entrepreneurial orientation and examine further how exposure to female faculty influences entrepreneurial interest among female students, we use information on spinoff involvement of female faculty, available at the university level from the MUR database (see: Bolzani et al., 2014; Bolzani et al., 2021; Fini et al., 2020). Academic spinoff activity is related to academic researcher involvement in technology transfer (Perkmann et al., 2013) and commercialisation of research and can be considered an indicator of academic entrepreneurship. By investigating female academic involvement in spinoff activity, we can gauge the level of entrepreneurial orientation among female academics and its potential impact on female students and propose a direct connection between faculty experience and activities and students' aspirations.

We then extend our analysis by conducting a separate examination of PhD students in universities with more business oriented female faculty versus the rest. To do this, we use the matched sample of students and split it according to the median value of share of female faculty involved in spinoff activity at the university level and then run separate IV regressions for the two groups. Table 6 reports the coefficients of the interaction terms between the dummy for female student and the share of female faculty, for these two sets of regressions.

Table 6. IV linear probability model: Female faculty share and the gender gap in PhD student entrepreneurship for high and low female academic engagement in business.

Although the smaller sample sizes for these two groups provide noisier results, the moderating effect of female faculty on the entrepreneurship gender gap is stronger and more significant for students in universities above the median, that is, in universities where female faculty engagement in industry activities is stronger. The coefficients of the group below the median are smaller and generally not statistically significant.

These results offer further insights into the influence of faculty involvement in entrepreneurial activities on students' entrepreneurial intention. The results support the argument that exposure to female faculty members can be powerful and inspiring and encourage female students' interest in business and entrepreneurship. This is in line with the notion of role model influence and suggests that female faculty members are influential and can positively shape the entrepreneurial motivations of female students.

5. Conclusions

Building on previous research on women in academia (Roach and Sauermann, 2015; Stuart and Ding, 2006; Tartari and Salter, 2015), this study investigated gender differences in PhD entrepreneurship and the effects of gender-related role-models on PhD students. Using original data from a large survey of PhD graduates in Italy between 2008 and 2014, we analysed how the university's institutional environment, in terms of faculty gender balance, affects the entrepreneurial behaviour of students. Our focus was on gender issues and female entrepreneurship. We observed that female students' interest in business creation and their attitude to entrepreneurship are significantly affected by the opportunity to study and conduct research in a gender-balanced environment, where they can engage with, be inspired by and be guided by same-sex

peers. These conditions mitigate gender differences and help women to catch up with men in business venture and start-up activity.

Our findings are especially relevant for research and gender policy. Academic institutions are under political pressure to integrate with industry and society and are being pushed to adopt the so-called 'entrepreneurial university' model, which emphasises new business creation and knowledge spillovers (Ghio et al., 2015). Our results are in line with previous studies and show that measures to support entrepreneurship activities would promote more entrepreneurship activity among faculty and students. However, on their own, these measures would not reduce gender disparities and would not exploit the full potential of academia for invention and spin-off creation. Women's under-representation among business founders is a case of lost opportunities in the context of the university third mission and economic development and equality. Our findings suggest that it will be crucial to change the gender balance in the academic community.

Although in Italy gender equality among academic faculty has been increasing since 2010, the findings from this study can be generalised to other academic contexts in other countries (Filandri and Pasqua, 2021). Increased university entrepreneurship in many settings is caused by other factors (e.g., lack of employment opportunities), than the policies or strategies implemented (Meoli et al., 2018), or is due to contextual factors (Bienkowska et al., 2016; Roach and Sauermann, 2015). Our results are in line with the European Commission strategy and recommendations related to gender equality in research and innovation (EIGE, 2016), aimed at equality in scientific careers, a gender balance in decision-making processes and inclusion of a gender dimension in the content of research and innovation. Academic establishments and employment policies must provide equal opportunities for recruitment and career advancement of female academic staff to increase their critical mass (Etzkowitz et al., 1994). This would promote women's entrepreneurship, without affecting men's entrepreneurial opportunities.

Our study has some limitations, including its use of cross-sectional data, which raises some caveats related to determination of cause and effect; however, our IV procedure was aimed specifically at limiting reverse causality and selection bias risks. Also, we focus on just one gender aspect of the academic environment, that is, the gender composition of academic faculty; data limitations do not allow us to study the relationship between student and their supervisor in depth. Future work could focus on the dynamics of student networking in academia, from a gender perspective, to determine which individuals help to trigger the entrepreneurship decision. Another limitation is the individual level nature of our study. The questionnaire survey provided detailed student-level information and allowed us to control for a number of factors influencing students' entrepreneurial choice. However, we cannot derive any conclusions about institutional performance, which matters for the evaluation of university policies.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A

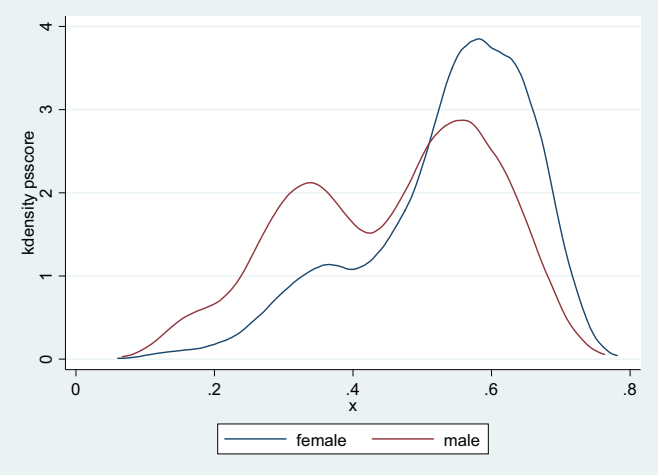

Fig. 1A. Common support region (PSM).

Table 1A
Covariate Balance for female and male students after Propensity Score Matching.

Variable		Mean		
		Treated	Control	
Risk preference	U	0.075	0.148	**
	M	0.075	0.080	
Age	U	31.55	31.76	**
	M	31.53	31.61	
Graduation grade	U	108.7	108.4	**
	M	108.7	108.6	
No work experience	U	0.464	0.517	**
	M	0.464	0.450	
Entrepreneur parent	U	0.109	0.093	*
	M	0.108	0.116	
Graduate parent	U	0.381	0.406	+
	M	0.381	0.397	
University entrepreneurship training	U	0.298	0.349	**
	M	0.298	0.295	
Conclusion PhD	U	0.849	0.855	
	M	0.850	0.854	
Entrepreneurial training course	U	0.298	0.349	**
	M	0.298	0.295	
Unemployment rate	U	9.663	9.522	
	M	9.660	9.786	
area_1	U	0.038	0.082	
	M	0.038	0.036	
area_2	U	0.044	0.076	**
	M	0.044	0.043	
area_3	U	0.070	0.064	
	M	0.070	0.059	+
area_4	U	0.043	0.038	
	M	0.043	0.041	
area_5	U	0.140	0.079	**
	M	0.140	0.151	
area_6	U	0.186	0.107	**
	M	0.186	0.176	
area_7	U	0.055	0.055	
	M	0.055	0.060	
area_8	U	0.079	0.080	
	M	0.079	0.079	
area_9	U	0.063	0.177	**
	M	0.063	0.064	
area_10	U	0.100	0.080	**
	M	0.100	0.103	
area_11	U	0.074	0.056	**
	M	0.074	0.080	
area_12	U	0.030	0.024	
	M	0.030	0.024	
area_13	U	0.040	0.049	+
	M	0.040	0.043	
area_14	U	0.038	0.032	
	M	0.038	0.040	

Note: Covariate means for treated (female) and untreated (male) students after propensity score matching (PSM) using local linear matching. Includes results of t-tailed *t*-test of group means. U and M are for unmatched and matched sample, respectively. +. *. ** indicate statistical significance at the 10%, 5% and 1% levels.

Table 2A
Probit estimates (robustness check).

	Applied R & I		Entrepreneurial intention			Entrepreneurship	
	Business collaboration	Patent application	Entrepreneurial idea	Entrepreneurial capacity	Abandoned idea	Start-up	Entrepreneur
Female	−0.417**	−0.664**	−0.380**	−0.380**	0.477**	−0.407*	−0.543**
	[0.126]	[0.226]	[0.110]	[0.119]	[0.119]	[0.187]	[0.209]
Share female faculty same university & SSD	−0.148	0.045	−0.278	−0.719*	0.155	1.257*	−0.562
	[0.382]	[0.711]	[0.325]	[0.362]	[0.349]	[0.526]	[0.626]
Female × Share female faculty same university & SSD	0.874**	1.388*	0.540+	0.418	−0.573+	0.332	1.390*
	[0.330]	[0.563]	[0.278]	[0.302]	[0.300]	[0.476]	[0.549]
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University and contextual control factors	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects							
University FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SSD FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

(*continued on next page*)

Table 2A (*continued*)

	Applied R & I		Entrepreneurial intention			Entrepreneurship	
	Business collaboration	Patent application	Entrepreneurial idea	Entrepreneurial capacity	Abandoned idea	Start-up	Entrepreneur
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5341	4428	5193	4159	4230	4601	4775

Note: +. *. ** indicate statistical significance at the 10%, 5% and 1% levels, respectively. The instrument is the share of female faculty at national level in a given scientific area net of the contribution of university in which the student obtained the PhD. Coefficients from the probit regressions are reported.

Table 3A
IV linear probability model: Female faculty share and the gender gap in PhD student entrepreneurship – full specification.

	Applied R & I		Entrepreneurial Intention			Entrepreneurship	
	Business collaboration	Patent application	Entrepreneurial idea	Entrepreneurial capacity	Abandoned enterpr. idea	Start-up	Entrepreneur
Female	−0.109**	−0.048**	−0.143**	−0.131**	0.170**	−0.057**	−0.033*
	[0.031]	[0.016]	[0.039]	[0.050]	[0.050]	[0.021]	[0.016]
Share female faculty same university & SSD	0.020	−0.160	−0.054	0.312	−0.175	0.359*	0.103
	[0.239]	[0.123]	[0.274]	[0.388]	[0.367]	[0.152]	[0.119]
Female × Share female faculty same university & SSD	0.211**	0.101*	0.230*	0.138	−0.219+	0.083	0.068+
	[0.079]	[0.042]	[0.098]	[0.128]	[0.128]	[0.053]	[0.041]
Individual controls							
Risk preference	0.059**	0.026**	0.118**	0.198**	−0.129**	0.026*	0.035**
	[0.018]	[0.010]	[0.023]	[0.025]	[0.028]	[0.012]	[0.009]
Age	−0.004*	0.001	−0.002	0.011**	0.008*	0.005**	0.001
	[0.002]	[0.001]	[0.002]	[0.003]	[0.003]	[0.001]	[0.001]
Graduation grade	−0.002	−0.000	0.003+	−0.002	0.009**	−0.000	0.002*
	[0.002]	[0.001]	[0.002]	[0.003]	[0.002]	[0.001]	[0.001]
No work experience	−0.045**	0.001	−0.035**	−0.046**	0.033+	−0.015*	−0.014**
	[0.011]	[0.006]	[0.013]	[0.017]	[0.018]	[0.007]	[0.005]
Entrepreneur parent	0.062**	−0.008	0.047*	0.129**	−0.070**	0.056**	0.035**
	[0.016]	[0.008]	[0.019]	[0.024]	[0.025]	[0.010]	[0.008]
Graduate parent	−0.012	−0.000	−0.026*	−0.038*	0.012	−0.007	−0.012*
	[0.010]	[0.005]	[0.013]	[0.016]	[0.017]	[0.007]	[0.005]
University entrepreneurship training	0.053**	−0.008	0.091**	0.073**	−0.068**	0.003	0.013*
	[0.011]	[0.006]	[0.013]	[0.016]	[0.017]	[0.007]	[0.005]
Conclusion PhD	−0.038*	0.003	0.015	0.005	0.005	0.009	0.009
	[0.019]	[0.010]	[0.023]	[0.031]	[0.031]	[0.013]	[0.010]
University and contextual control factors							
Unemployment rate	0.000	0.001	0.003	−0.011+	0.007	−0.007**	−0.006**
	[0.004]	[0.002]	[0.005]	[0.006]	[0.006]	[0.003]	[0.002]
University research rating	−0.106**	0.012	0.008	−0.034	−0.066	−0.009	0.014
	[0.032]	[0.016]	[0.038]	[0.050]	[0.049]	[0.020]	[0.016]
University staff	−0.091	−0.050	0.736**	0.577*	−0.271	0.097	−0.053
	[0.185]	[0.096]	[0.227]	[0.294]	[0.308]	[0.124]	[0.093]
Share university female staff	−0.323	−1.262**	−1.257	−2.140	4.379**	0.578	1.016*
	[0.933]	[0.487]	[1.141]	[1.549]	[1.561]	[0.642]	[0.476]
Incubator (=1 YES)	−0.091	−0.051	0.297*	0.316*	−0.329*	0.778**	0.885**
	[0.094]	[0.051]	[0.125]	[0.152]	[0.140]	[0.057]	[0.042]
RSO (=1 YES)	0.066	−0.001	−0.104+	−0.001	−0.017	0.004	0.007
	[0.042]	[0.022]	[0.054]	[0.065]	[0.076]	[0.028]	[0.021]
TTO (=1 YES)	0.029	−0.059*	−0.016	−0.018	−0.157*	−0.037	−0.042+
	[0.048]	[0.025]	[0.059]	[0.075]	[0.075]	[0.031]	[0.025]
Fixed effects							
University FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SSD FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5504	5677	5340	4147	4065	5284	5712
R-squared	0.022	0.003	0.029	0.044	0.031	0.051	0.089

Note: Weighted IV regressions, with weights based on the frequency at which control group individuals are matched in the PSM procedure. Standard errors are clustered at SSD and university level (546 clusters). +. *. ** indicate statistical significance at the 10%, 5% and 1% levels, respectively. The instrument is the share of female faculty at national level in each scientific area net of the contribution of university in which the student obtained the PhD.

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