How to foster women entrepreneurship in academic spin-offs

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Theme: **4. Universities as interactive partners**

Abstract

This paper aims at analyzing female participation in Italian academic spin-offs using several sources of public available data and a unique hand-collected database of all the academic spin-offs set up in the period 2002-2007 in Italy. We base our study on three complementary levels of analysis: macro-, meso-, and micro-level. We show that the gender gap in academic spin-offs is relevant and that there is a certain degree of spatial heterogeneity that may reflect cultural and environmental differences between different provinces. Furthermore, our analysis evidence a disadvantage of females in the start-up funding phase that result in low capital invested: an unfavorable circumstance that reduces their chances of success and force females to create new businesses mainly in the service sector. Social relationships and empathy among females may help compensate their disadvantages and break down the barriers to entrepreneurship.

JEL Classification: L26, J16, H11, O16, O17, P43

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1. Introduction

Female-owned businesses are one of the fastest growing entrepreneurial populations in the world. They make significant contributions to innovation, employment and wealth creation in all economies (A. Brush, De Bruin A., & Welter F., 2009). Despite the growing importance of female entrepreneurship, this phenomenon is understudied (De Bruin, Brush, & Welter, 2006).

This paper analyzes the phenomenon of female entrepreneurship in academic spin-offs. According to Djokovic & Souitaris (2008, p. 225), academic spin-offs are defined as "… companies which evolve from universities through commercialisation of intellectual property and transfer of technology developed within academic institutions".

The emergence of new ventures in knowledge-based sectors – and academic spin-offs belong to this category – is central to economic adaptation and change and, according to the endogenous growth theory (Romer, 1986), favors the achievement of a long term economic development. These new ventures are important sources of market innovations (Audretsch, 1995), as they replace less efficient existing firms with more efficient ones (Bosma, Kelley, & Amoros, 2011), and sources of new job creation (Birch, 1987), as they represent a job alternative for people with high levels of formal education.

Analyzing the new ventures scenarios of the last twenty years, one common result across countries is the underrepresentation of female entrepreneurs especially in new ventures in knowledge-based sectors (Arenius & Minniti, 2005) (Davidsson & Honig, 2003)(Delmar, Davidsson, & Gartner, 2003) (Reynolds, Carter, Gartner, & Greene, 2004) (Wagner, 2004).

Our study builds on the two previous considerations: (1) New ventures in knowledge-based sectors are important drivers for economic growth; (2) Females are underrepresented in these new ventures. Since the number of females who get a high level of education in several industrialized countries is higher than males (Hausmann, Tyson, & Zahidi, 2012) and females use different processes of opportunity identification with respect to males (DeTienne & Chandler, 2007), fostering female entrepreneurship in academic spin-offs may be one way to

contribute to economic growth through new venture creation in knowledge-based sectors.[1] For this reason, understanding the complex interplay of factors that favor (prevent) females in (from) starting new academic spin-offs is crucial.

We analyze this complex interplay of factors using a unique database of academic spin-offs set up in Italy in the period 2002-2007 as well as other public available data. We believe that Italy represents an ideal setting for our analysis. As a matter of fact, according to the GEM database, Italy reports the lowest index of entrepreneurial dynamics in the global ranking and the lowest share of new high-tech firms in comparison with the main EU countries. This evidence is in vivid contrast with the directions of Horizon 2020 (i.e., the new funding program for research and innovation of the European Union) that focuses the attention on knowledge-based innovations and promotion of new entrepreneurial culture across Europe. Furthermore, in a recent study on the factors that affect nascent entrepreneurship in high-tech sectors in Italy, Micozzi (2013) finds that the probability of starting firms in high-tech sectors is more than twice for males than for females, evidencing a non-negligible gender gap. Female entrepreneurship in academic spin-offs may, thus, contribute to close this gender-gap in entrepreneurial activities and to foster new venture creation in knowledge-based sectors.

We base our study on three complementary levels of analysis: macro-, meso-, and micro-level. At the macro-level of analysis, we use public available data, to define the gender gap situation in Italy. At this stage, particular attention is put on the female entrepreneurial phenomenon and the role of female in academic and research institutions. At the meso-level, we first focus on the distribution of spin-offs by province and geographic area and then we link this information to the data on the number of female shareholders in these same academic spin-offs. At the micro-level, we use a unique hand-collected database which comprises all academic spin-off set up from 2000 to 2007 to investigate the determinants of the number of female shareholders in academic spin-offs at the firm level.

Our work contributes to existing literature on academic spin-offs in several respects.

[1] The diversity of economic agents in terms of motivation and opportunity recognition is essential for economic growth. The participation of females in entrepreneurial activities could favor this diversity.

Despite the growing importance of female entrepreneurs, there is still a lack of researches on the phenomenon of female entrepreneurship in general, and of female academic spin-offs in particular (Fuentes-Fuentes, Cooper, & Bojica, 2012). To the best of our knowledge our paper is one of the first studies on the female entrepreneurship in Italy (few notable exceptions are Chelli & Rosti (2009), Colli A., Fernandez P.P., & Rose M.B. (2003), Brighetti & Lucarelli, 2013) and the first on female entrepreneurship in academic spin-offs.

Besides public available data, all our evidences are based on a unique database that we collected ad-hoc to analyze the problem of female entrepreneurship in academic spin-offs. These data allow us to corroborate existing evidences from other studies in the literature concerning the under representation of female in firms (and especially high-tech firms) and to offer new evidences on this issue.

Moreover, while the vast majority of the existing literature is based only on one level of analysis, we integrate the macro-, meso-, and micro- levels in a unique framework.

The remainder of the paper is organized as follow. In section 2, we present a brief literature review. In section 3, we report the results of our empirical analysis. In section 4, we summarize our main findings and discuss some policy implications.

2. Literature review

The phenomenon of female entrepreneurship is relevant due to the fact that female business owners make significant contributions to innovation, employment and wealth creation in all economies (C. Brush, Carter, Gatewood, Greene, & Hart, 2006). The empirical results of several studies that used the GEM dataset suggest that across countries there are about twice as many male as female nascent entrepreneurs (Arenius & Minniti, 2005; Davidsson & Honig, 2003; Wagner, 2004).

Despite the growing importance of female entrepreneurs, there is still a lack of researches on the phenomenon (Brush et al., 2009).

There are two main gender theories to explain the gender gap in entrepreneurship. Liberal feminism argues that males and females do not differ in their capabilities and have, thus, the

same potential. Social feminism argues that males and females develop different traits and suggests that males and females have different learning experiences. Social role theory emphasizes social forces such as cultural norms, gender stereotypes and gender role (Eagly & Wood, 1999) and considers the differences between females and males as the results of social processes (DeTienne & Chandler, 2007). In support of this theory, research has shown that female entrepreneurs are a heterogeneous group, with different backgrounds, aspirations and experiences (Marlow & Carter, 2004). These factors are linked to unique human capital, which impacts on the identification of entrepreneurial opportunities (Eddleston & Powell, 2007).

Starting from the first step of entrepreneurial process (motivation), some researchers have found that female and male entrepreneurs have similar motivations such as the need for achievement or the need for independence. Other authors suggest the opposite (Sanchez Canazares & Fuentes Garcia, 2010). Pioneer studies conducted in North America and the UK consider the search for independence and the need to control their own future as motivations that lead female to set up a new firms. Other motivating factor could be the willing to break through the ‘‘glass ceiling’’: the invisible barrier preventing female to have the same opportunity of males (Carter, 2000).

Some studies investigate the entrepreneurial propensity of students. Female university students are less willing to start their own business after graduation and perceive business as complicated and risky compared to males (Minniti et al., 2005; Wilson, Kickul, & Marlino, 2007; Marlino & Wilson, 2003) and they are more influenced by social and relational motivations such as being respected, helping others and providing jobs, while males were more motivated by the autonomous nature of entrepreneurship. Male students assigned themselves higher scores in attributes linked to initiative, creativity, optimism and self-confidence (Sanchez Canazares & Fuentes Garcia, 2010). On the contrary, other studies suggests that perceptual factors in starting a business such as risk tolerance, entrepreneurial intentions, self-efficacy and knowing other entrepreneurs are not gender dependent (Arenius and Minniti, 2005; Gupta, Turban, Arzu Wasti, & Sikar, 2009).

The entrepreneurial literature attributes an important role to the context: two females with the same set of motivational factors, but different demographic characteristics and contextual factors (i.e. presence/absence of small children in a traditional family model), might make different

decisions about entering entrepreneurship. “Motherhood” is a metaphor representing the household/family context that might have a larger impact on women than men (Jennings & McDougald, 2007) and impacts on women’s ownership of assets, their access to resources and the realization of their capabilities.

The rule of law may have positive impact on women entrepreneurship as it is closely correlated with eliminating (or at least alleviating) institutional traits that restrict the rights of women, including their economic rights. The level of societal support for entrepreneurship relates to the level of women’s entrepreneurship (Baughn, Chua, & Neupert, 2006). In some countries entrepreneurial activity may have negative connotations, and in many countries important cultural and religious barriers to activities in the economic sphere intensify the negative image of entrepreneurship for women. Having strong, positive, visible role models is therefore important for encouraging women to consider becoming entrepreneurs (Verheul, Wennekers, Audretsch, & Thurik R., 2002).

Concerning the opportunity recognition (second phase of entrepreneurial process) Chandler, Lyon, & DeTienne (2005) show that differences in human capital are related to choosing and applying different processes for the identification of opportunities. DeTienne and Chandler (2007) analyze gender differences in identifying entrepreneurial opportunities by using two samples of individuals (95 grade students and 189 entrepreneurs belonging to high-tech industries) and conclude that men and women have an unique stocks of human capital so they have different processes of opportunity identification. Even in this phase the social networks and the prior work/life experiences are factors related to the likelihood women will recognize opportunities and the types of opportunities they recognized. Greve & Salaff (2003) found both men and women rely on their networks when discussing ideas and engaging in activities helpful for opportunity recognition more than men.

Concerning the human capital, no clear evidence has yet been found on the relationship between education and entrepreneurship (Blanchflower, 2004), although basic literacy seems to be a necessity for starting a new business for both men and women (Reynolds et al., 2005). Some evidence also exists in some developed countries that women entrepreneurs attain a higher

education level than their male counterparts and that their overall level of education is significantly higher than in other occupations (Cowling & Taylor, 2001).

DeTienne and Chandler (2007), with regard to prior work/life experiences, found that the number of jobs held and the retail work experience of women were positively related to the number of opportunities women identified (for men, their number of start-ups was positively related to the number identified). Further, women and men use different processes to identify opportunities.

In a study carried out with a sample of 508 entrepreneurs (40 women), Fischer, Reuber, & Dyke (1993) indicate that when starting up a new firm, men have greater previous entrepreneurial experience, greater previous experience in the industry and greater levels of experience in terms of managing human resources.

From the opportunity to the beginning of firm the entrepreneurs must be able to deal with risky situations. Concerning the risk-taking propensity, it could play a significant role in the transition from potential entrepreneurship to actual business starts. Concerning the risk tolerance, there is disagreement in the literature on women's risk-taking ability (Minniti & Nardone, 2007).

Sexton (1989) found that females were more risk averse. A recent study shows as cultural bias induces women to believe themselves as risk averter, on the one hand, and men to believe themselves as risk lover, but the results of a psycho-physiological experiment with 645 individuals which simulates real-life decision in conditions of reward and punishment show as men and females, facing a risky/ambiguous task, behave the same (Brighetti & Lucarelli, 2013).

All these characteristics influence the capability to find the entrepreneurial resources for starting a new business. Social network and human capital play an important role in gaining access to information and tangible resources, such as in the phase of identification of opportunity. Concerning the financial resources, research suggests interesting differences between men and women. The difference may depend on the types of ventures women start and their lower funding requirements (Singh & Lucas, 2005). Compared to men, women obtain most funding through strong tie networks (family and friends) (Carter, Shaw, Lam, & Wilson, 2007, Singh and

Lucas, 2005), while the resources from formal financing sources (i.e. banks) are lower than men (Alsos, Isaksen, & Ljunggren, 2006).

Using the Gem data from 2001 to 2007 for ten European countries (Netherland, Belgium, France, Spain, Uk, Denmark, Sweden, Norway, Germany and Italy) the importance of knowing another entrepreneurs in Italy is significant and it is further confirmed by its interaction with the gender variable, that diminishes its coefficient and statistical significance. The gender variable looses its statistical significance when the income variable is added to the model. The latter variable shows a positive relation with entrepreneurship though significant only at 10%. Overall, these results seem to suggest that in Italy financial constraints to entrepreneurship are relevant and that the 'familiarity' with other entrepreneurs play a particularly important role. These effects of these two variables are so strong to overcome the effects of gender and age that, in other countries show a very robust and significant relation with entrepreneurship. The fact that in Italy the variable gender seems to be less important comparing with the other European countries could be linked to the main predominance of firms in traditional and low-tech sectors (Micozzi, 2013).

The financial barriers could depend on the fact that women start businesses in lower capital intensive/growth industries (Coleman, 2000, Orhan, 2001, Singh and Lucas, 2005) or bank workers perceive women less entrepreneurial than men, less creditable than men by creditors and evaluate lower their risk-taking propensity (E. Buttner & Rosen, 1988). E. H. Buttner (1999) argues that starting with a smaller capital base may disadvantage women SME owners, as a lack of working capital is one of the biggest problems for start-ups. This minor capital may be reflected in survival rates and subsequent growth opportunities. The "female underperformance hypothesis" appears in several studies (Chaganti & Parasuraman, 1996, Rosa & Hamilton, 1994). Factors analyzed in the previous sections (women's motivations for pursuing entrepreneurship, the entrepreneurial orientation, the growth intentions, the desire to achieve work-family balance, the level of education and the prior work experience, the access to financial resources) are positively related to firm revenues and sales growth, that are the traditional measures of entrepreneurial success/performance.

Chelli e Rosti (2009) investigated gender differences in the propensity for self-employment of Italian graduates by conducting Markovian analysis of a ten-year transition matrix. The results are that graduate women who choose self-employment have lower survival rates than men and than those who choose paid employment. In explanation of these differences, they argue that the disappointment provoked by the gender wage gap in paid employment may induce female graduates to become entrepreneurs whether or not they possess entrepreneurial ability.

The female entrepreneurship in high-tech sectors

To start up a technology-based firm is often regarded to be a male domain (Nelson & Levesque, 2007, Roan & Whitehouse, 2007, Humbert, Drew, & Kelan, 2009). As a result, women entrepreneurs often faced hostile social attitudes and cultural biases when breaking into what is essentially a ‘‘male’’ world. The under-representation of women in science could represent a weakness for economic growth that largely relies on innovation and knowledge, in particular, innovation and knowledge in science and technology (Corsi & Akhunov, 2000, Saperstein & Rouach, 2002): according to the endogenous theory of growth, technology firms therefore occupy a central position in economic growth, so it is important to foster the female entrepreneurship in high-tech firms.

In science, gender bias can occur (1) in the characterization of scientific excellence, (2) in the criteria used to assess it, (3) in the choice of the explicit and implicit indicators for scientific excellence, (4) in the way the criteria are applied to men and women, (5) in the failure to integrate women in scientific networks, and (6) in the procedures through which criteria are applied to people (European Commission, 2008).

This gender bias in scientific excellence is one of the elements that prevent equal representation of women at all levels of science, and is an important reason why some countries have elected to implement targets and quotas.

The barriers identified in the previous section are emphasized in high-tech sectors for the role of women in society and for the greater difficulties in balancing family responsibilities with

working in fast-moving and competitive sectors that expect long and flexible working hours and constant training to be up-to-date with new technological development and market opportunities.

Ding, Murray F., & Stuart (2006) tracked the careers of more than 4,000 life science research faculty at U.S. universities over a thirty-year period and show that women were less likely to have the relations that can help scientists recognize the commercial potential of their research in the first place and then help them to commercialize it effectively.

Other findings are that the quality of women's research seemed equal to or slightly better than the men's, on average, but women faculty patented their research at about 40% of the rate of men. This is a very significant narrowing of the field at one of the first major steps along the road to creating a start-up company from one's research (Mitchell, 2011).

Dautzenberg (2012) reports an interesting literature review concerning the high-tech entrepreneurship showing that female start-ups are also smaller in view of the sought-after annual turnover, show an on average smaller turnover growth and the employee productivity of companies run by women is only about half as high as that of employees in companies led by men. Another gender specific characteristic is the tendency to start up technology-oriented companies in the service area and start businesses with substantially less own capital than then men. This fact depends on the tendency of female entrepreneurs to finance their start-up projects primarily through private loans and the lack of experience in obtaining external equity funds.

3. Empirical analysis

3.1 Database description and descriptive statistics

We base our empirical analysis on public available data and on a unique hand-collected database comprising all academic spin-offs that took place in Italy between 2000 and 2007 (about 300). The total number of spin-offs with available information is 265 (about 88% of the total).

In our empirical analysis, we integrate the macro-, meso-, and micro- levels in a unique framework of analysis. As Cooper et al. (2012) note in their study on female academic spin-offs in Scotland and Spain, the individual level of analysis is not sufficient to characterize the entrepreneurial process of females in universities. Consideration of the institutional perspective

(i.e., the meso- and macro- levels) provides a more comprehensive framework/lens for the specific analysis of female entrepreneurs.

Our macro-level analysis is based on data provided by MIUR (Italian Ministry of Education, University, and Research), Unioncamere (the office that register new firms in Italy), GEM consortium, and World Economic Forum. Both meso- and micro-level analyses are based on our database of academic spin-offs. For this reason, we present a list of all variables that are included in our database. All variables (excluding time invariant variables) are registered at the time of spin-off startup and in the post-incubation period (about three years after the startup). Table 1 reports some descriptive statistics for each of these variables.

Number of female shareholders	This variable is a count variable with a low average and median value (of about one), evidencing that female shareholders in academic spin-off are typically very few (or absent).
Share of majority shareholder	This variable exhibits high average and median values, denoting that, in general, a single shareholder controls academic spin-offs.
Average shareholders' share	This variable assumes high average and median values, evidencing that the number of shareholders in academic spin-offs is generally very low. Thus, the ownership structure of academic spin-offs tends to be quite concentrated.
Female majority shareholder	This variable is a dummy variable that takes the value of one when the majority shareholder of the spin-off is a female. In our sample, females are majority shareholders in less than twenty percent of cases.
Shareholder funds	This variable, which represents the amount of capital invested by shareholders into the spin-off, is included in the regression models

	(after taking its natural logarithm) to take any size effect into account. Average (median) shareholder funds are less than 30,000 (15,000) euros at startup and less than 40,000 (15,000) euros in the post-incubation period.
Province dummies	This is a group of dummies indicating the province where the spin-off takes place. Milan is the province where most of the spin-offs occur.
Geographic area dummies	This is a group of dummies indicating the geographic area where the spin-off is located. Most of the spin-offs take place in northern (north-east and north-west regions).
Industry dummies	This is a group of dummies indicating the industry of the spin-off using the ATECO classification of economic activity by the Italian National Institute of Statistics (ISTAT). Research and scientific development is the industry to which most of the spin-offs belong.
University dummies	This is a group of dummies indicating the university in which the spin-off is generated. The University of Padua, in the north of Italy, is the university where most of the spin-offs are generated. This result is not in contrast with the evidence that the modal province for spin-offs is Milan, since Milan, unlike Padua, has more than one university.
Year dummies	This is a group of dummies indicating the year when the spin-off occurred. Most of spin-offs took place in 2006 and 2007.

3.2 Macro-level analysis

Using a macro-level perspective, in this section we define the gender gap situation in Italy by reporting some indicators on the female entrepreneurial phenomenon and the role of female in academic and research institutions. An overall picture of the macro-level situation of females in Italy is presented in Table 2, which shows some data from a survey of the World Economic Forum of 2011 (Hausmann et al., 2012).

Since 1947, the Italian Constitution (art. 37) ensures parity between male and female workers. In 1991, the law L. 125170 actively introduced measures to ensuring equal opportunities for male and female workers. In 1997, the law L. 903 defined the framework for equal treatment for male and female workers and the Ministry for Equal Opportunity has been established. In 2006, all the existing laws on equal opportunity converged into one all-inclusive legislative decree (decree n. 171).

Despite all laws to ensure equality between males and females (especially in the working environment), the last GEM global report has consistently shown that the trend in the number of new female entrepreneurs in Italy is negative, even if this figure showed a slight increase in 2012. The last report of Unioncamere seems to confirm the same trend: only 25% of firms in Italy are set up by females, even if this figure is increased in 2012. Furthermore, some geographic disparities exist: the female activity rate in northern and central regions is more than twice than in southern regions. Both formal (e.g., childcare facilities) and informal (e.g., traditional roles, religion, family values) institutional and cultural factors contribute to this geographic disparity.

As for the role of female in academic and research institutions, the Ministry for University and Research (MIUR) works in partnership with the Equal Opportunity Ministry to reduce the gender gap in academic and research institutions. Furthermore, all major research centers have a Committee for Equal Opportunity. CNR (Italian National Center of Research), with its Commission for the Promotion of Female in Science (1999), could be considered an example in this sense. Remarkably, females represent 30% of all CNR researchers. In 2003, the Association for Female and Science was founded.

Despite all these initiatives, the gender gap between males and females who pursue an academic career in Italy is still relevant: although 58% of graduates are females, the last available data on MIUR website shows as only 45% of females are researchers, 35% associate professors, 20% full professors, and only 2 are deans (2.4%).

The gender disparities in the entrepreneurial and academic (and research) context contributes to explain the gender gap in academic spin-offs. As a matter of fact, the ownership structure of academic spin-offs shows that females are majority shareholders in less than twenty percent of cases.

In the following micro-level regression analysis, macro-level variables are accounted for through the inclusion of year fixed effects, able to capture parallel shifts in the number of females over years as a consequence of changed macro-level conditions.

3.3 Meso-level analysis

Using a meso-level perspective (provincial level), in this section we present some observations on the spatial characteristics of our database of academic spin-offs. As a matter of fact, our database of spin-offs includes several variables that can affect the number of female shareholders at a micro-level. In the following micro-level regression analysis, meso-level variables are accounted for through the inclusion of province, geographic area, industry, and university fixed effects. All of these effects have, more or less directly, a geographical connotation.[2] Understanding the spatial characteristics of our database is, thus, of particular interest.

Furthermore, the importance of the spatial dimension in high-tech entrepreneurship is relevant, especially in academic spin-offs. The Knowledge Spillover Theory of Entrepreneurship – a theory that emphasizes the role of new firm creation in exploiting knowledge created by university research (Audretsch & Lehmann, 2005) – shows as proximity and agglomeration play an important role in R&D collaborations and knowledge exploitation, so that considering the local context where the universities are located becomes really important (Boschma (2005), Hewitt-Dundas & Roper, 2011). Spin-offs are normally located very close to their parent

[2] This consideration is evident for province, geographic area and university dummies, but holds also for industry dummies, since specific industries tend to develop in specific geographic areas.

institution (Audretsch and Lehmann, 2005; Iacobucci & Micozzi, forthcoming) due to the role played by incubators or TTOs (Technology Transfer Offices), the direct involvement of academicians, and the collaboration between spin-offs and university departments.

In Figure 1, we show the spatial distribution of the number of spin-offs by province and geographic area (the first couple of plots), the spatial distribution of the number of female shareholders at startup and in the post incubation period by province (the second couple of plots), and the spatial distribution of the average number of female shareholders per spin-off at startup and in the post incubation period by province (the third couple of plots).

The figure evidences that the provinces with the highest number of spin-offs, number of female shareholders and average number of female shareholders per spin-off are concentrated in the central and northern Italy. This broad classification simplifies the actual spatial pattern in the map, but suggests, however, the existence of non-negligible spatial heterogeneity among province both for the number of spin-offs and for the number of female shareholders.

Two Moran's I tests for spatial autocorrelation seem to support the results of the visual inspection analysis: they suggest the presence of spatial correlation in the average number of female shareholders per spin-off both at startup (p-value = 0.049) and in the post incubation period (p-value = 0.063). This spatial autocorrelation may reflect latent meso-level differences between provinces with respect to the analyzed variables. As noted by several authors (e.g., Baughn et al., 2006; Welter, 2004; Welter et al., 2006; Welter and Smallbone, 2008), these latent meso-level differences may stem from cultural and environmental factors (that in our analysis are assumed to vary spatially) that increase the difficulties of females in entering entrepreneurship and growing their businesses.

3.4 Micro-level

In this section, we analyze the determinant of the number of female shareholders in academic spin-offs using a micro-level perspective. First, we present our methodology and then we present the results of our regression analysis.

3.4.1 Methodology

Let y_i be the number of female shareholders for the spin-off i and $\mathbf{x}_i$ a vector of covariates which include the variables described in the previous section. We are interested in explaining the expected value of y_i given $\mathbf{x}_i$, i.e., $\mu_i \equiv \mathrm{E}(y_i \mid \mathbf{x}_i)$.

Our response variable has some peculiar characteristics that need to be discussed. As a matter of fact, the number of female shareholders is a count variable in which each observation can take only non-negative integer values. Furthermore, for several spin-offs the number of female shareholders is low or zero. Thus, the distribution of the number of female shareholders exhibits a low modal value and a non-negligible number of zeros. The peculiarities of our response variable force us to deviate from a simple linear model estimated by Ordinary Least Squares (OLS), given that linear OLS models can predict negative values and are, in general, not well suited for highly non-normal data.

The most popular model for count data is the Poisson regression model (Verbeek, 2012; Wooldridge, 2010). In a Poisson regression model, the response variable is assumed to follow a Poisson distribution conditional on the covariates and the logarithm of μ_i is modeled as a linear combination of the covariates. The Poisson regression model takes the form

$$y_i \mid \mathbf{x}_i \sim \mathrm{Poisson}(\mu_i), \quad \log(\mu_i) = \mathbf{x}_i'\boldsymbol{\beta}$$

where $\boldsymbol{\beta}$ is a vector of parameters to be estimated. Estimation of $\boldsymbol{\beta}$ is generally obtained by maximum likelihood.

The main limit of the Poisson regression model is that it imposes the conditional variance of y_i to be equal to its conditional mean. In empirical applications, however, the conditional variance is often greater than the conditional mean, a situation known as over-dispersion (Cameron & Trivedi, 2005). In presence of over-dispersion, inferences based on the plain Poisson regression model may be misleading. Thus, the plain Poisson regression model needs to be adjusted to handle over-dispersion. Two common adjustments to account for over-dispersion consists in (1) basing inference on the sandwich estimators for standard errors (also known as robust standard

errors), or (2) estimating an additional dispersion parameter in the model (quasi-Poisson regression model). Another way to account for over-dispersion is to use a negative binomial regression model, which is an alternative and more general model for count data (Zeileis, Kleiber, & Jackman, 2008).

Another concern with the Poisson regression model is that the number of zeros in our response variable may be larger than the number of zeros a Poisson regression model can handle (Cameron & Trivedi, 2005). To account for this problem, we use a hurdle Poisson regression model. In a hurdle Poisson regression model, a logit model governs the binary part of whether the count variable has a zero or a positive value and, if the value is positive, a truncated-at-zero Poisson regression model governs the conditional distribution of the positive counts (Mullahy, 1986; Zeileis et al., 2008).

3.4.2 Estimation results

The results of our regression analysis are presented in Table 3. In particular, we show four Poisson regression models: two models for the number of females at startup (Model 1 and 2) and two models for the number of females in the post-incubation period (Model 3 and 4). The four models differ for the included covariates. In particular, all models include the share of majority shareholders, the average shareholders' share, the female majority shareholder dummy, and the logarithm of shareholder funds among the covariates. However, while Model 1 and 3 include also province, industry and year dummies, Model 2 and 4 include geographic area and university dummies. These differences between each couple of models serve to avoid an excessive number of dummy variables in the regression equations. Furthermore, the two models for the number of females in the post-incubation period (Model 3 and 4) also include the number of females at startup as an explanatory variable. This additional variable makes it possible to take into account any memory effect in the number of female shareholders in the post-incubation period.

In the table, we report coefficient estimates and standard errors for each covariate with the exception of the groups of dummy variables (province, geographic area, industry, university and

year dummies) for which we report Wald tests of joint significance instead. All our inference is based on robust standard errors.[3,4]

Looking at the coefficient estimates of Table 3, we note that the number of female shareholders at startup is larger when the majority shareholder is a female and lower for firms with a higher average shareholder's share (i.e., in case of concentrated ownership) (Model 1 and 2). These results extend also to the number of female shareholder in the post-incubation period (Model 3 and 4). The firm size seems to have a (negative) relationship with the number of females only at startup (Model 1 and 2) and not in the post-incubation period (Model 3 and 4). There is also a weak evidence (Model 2) of a positive relationship between the share of the majority shareholder and the number of female shareholders at startup when we do not control for province, industry and year effects. Furthermore, at startup we observe province (Model 1), industry (Model 1) and university (Model 2) effects that are likely to reflect latent meso-level factors.[5] Finally, we evidence that the number of female shareholders at startup exerts a large influence on the number of female shareholders in the post-incubation period (Model 3 and 5), evidencing a certain degree of persistence in the number of female shareholders over time.

In Table 4, we report the results of two hurdle Poisson regression models: Model 5 for the number of females at startup and Model 6 for the number of females in the post-incubation period. The table is divided in two panels: in the lower panel (zero-hurdle part), we present zero-hurdle logit models for modeling zero vs. count observations; in the upper panel (count part), we report truncated-at-zero Poisson regression models for the count values.

[3] Since over-dispersion tests provided mixed results, we decided to present robust standard errors in the table in order to mitigate the risk of basing our inference on underestimated standard errors due to over-dispersion. Basing inference on non-robust standard errors produced, however, similar results. We also estimated quasi-Poisson and negative binomial regression models. Results of these alternative models are qualitatively similar to those in the table and, thus, are not reported.

[4] At the bottom of each model we report joint Wald tests for the overall significance of the estimated models to test for the hypothesis that all coefficients in the model apart from the intercept are equal to zero (Regression c^2). All the test statistics strongly reject the hypothesis that the conditional mean is constant and independent of the explanatory variables.

[5] Time-varying latent macro-level factors are accounted for by including year fixed effects, which, however, do not seem to significantly influence the number of female shareholders either at start-up or in the post-incubation period.

The reported models include the same covariates in the zero-hurdle part as in the count part of the models.[6] The covariates in the zero-hurdle part help in distinguishing between zero and larger counts, as evinced by their significance. As for the count part, the results in Table 4 are not qualitatively different from those in Table 3.[7] Given the coherence among the signs of the estimated coefficients in the models of Table 4 and Table 3, we believe that we can rule out that excess zeros exerts a large influence in our models. Therefore, it seems reasonable to deem such influence not strong enough to invalidate our inferences based on the simpler Poisson regression models of Table 3.

All results are largely supported by economic theory and previous findings in the literature. The negative relationship between the number of female shareholders and the capital invested by shareholders into the spin-off at startup may indicate a disadvantage of females in the start-up (funding) phase.[8] Several studies show that the capital invested by female entrepreneurs is indeed lower than the capital invested by males entrepreneurs and motivate this finding with the tendency of female entrepreneurs to finance their start-up projects primarily through private loans and/or females' lack of expertise in obtaining external funds (Dautzenberg, 2012). A lower capital invested at start-up may lead females to create new businesses mainly in the service sector (where less initial funds are needed), a well-documented evidence in the literature (see for example Sullivan & Meek, 2012).[9] This is in fact the case with our database, where the spin-offs in which the number of female shareholders is particularly high all belong to the service sectors. The lack of initial capital may also explain why academic spin-offs prevalently owned by females produce fewer patents and licenses and/or are more failure-prone then academic spin-offs prevalently owned by males: in our database the relationship between the number of female shareholders and the number of patents and licenses is indeed negative and the average number of female shareholder in failed spin-offs is about 3.5 times the number of female shareholder in non-failed spin-offs.

[6] To simplify the model to be estimated, we have excluded the groups of dummy variables from the regression equations and decided to focus only on governance and size variables.
[7] The only exception is the insignificant coefficient of the female majority shareholder dummy in the count part of Model 5. However, this variable is still significant, as expected, in the zero-hurdle part of the model.
[8] The negative relationship between the number of female shareholders and the capital invested by shareholders into the spin-off at startup should merely suggest an association rather than a causal nexus.
[9] The preference for service sectors may also be a consequence of risk perception. Slovic (2000) points out that socio-political factors could contribute to determine gender differences in risk perception.

Two other important findings are that the number of female shareholders is higher for spin-offs where the majority shareholder is a female and that the number of female shareholders at start-up positively influences the number of female shareholder in the post-incubation period. These findings could be explained considering the importance of social relationships among females: the empathy among females may allow them to break the barriers to entrepreneurship down.

4. Conclusions

Fostering female entrepreneurship in academic spin-offs could represent an important way to add variety to the economic process, enhance country competitiveness, and fully realize country innovation potential.

Using several sources of public available data and a unique hand-collected database of all the academic spin-offs set up in the period 2002-2007 in Italy, we analyzed female participation in Italian academic spin-offs. Our study is based on three complementary levels of analysis: macro-, meso-, and micro-level.

Our results show that despite several policy measures thought to reduce the gender gap in Italy, this problem still remains important and this is especially true in high-tech industries. Furthermore, we find a relevant spatial heterogeneity in the number of spin-offs and female shareholders by province, with Northern provinces characterized by both a higher number of spin-offs and female participation than Southern provinces. This spatial heterogeneity may reflect meso-level differences in cultural and environmental factors at a provincial level. Finally, our econometric models show a negative relationship between the number of female shareholders and the capital invested by shareholders into the spin-off at startup, an unfavorable circumstance that evidences a disadvantage of females in the start-up funding phase, which may sensibly reduce their chances of success (in terms of number of patents and licenses and probability of failure) and force them to create new businesses mainly in the service sectors (where less initial capital is needed). Since the number of female shareholders is higher for spin-offs where the majority shareholder is a female and that the number of female shareholders at start-up positively influences the number of female shareholder in the post-incubation, our

analysis suggests also that social relationships and empathy among females may help compensate their disadvantages breaking down the barriers to entrepreneurship.

Summarizing our results and the results of previous researches we can identify several barriers that may obstacle a full development of female entrepreneurship in general and of female entrepreneurship in academic spin-offs in particular. Examples of these barriers include social, cultural and institutional barriers that influence the roles and responsibilities of females in the society, structural barriers in the academic context, and individual barriers linked to the personal factors that affect the propensity to become an entrepreneur such as the disadvantage in the funding stage.

In order to foster female entrepreneurship in academic spin-offs, the government should break down these barriers promoting a cultural shift towards a more balanced recognition of the roles of females in the academic and entrepreneurial contexts (and more in general in the society), favoring venture capital supply for female-owned startups, introducing fiscal incentives for female entrepreneurs, and supporting the development of networks of female entrepreneurs.

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Table 1. Descriptive statistics.

Variables	at start up mean	median	std. dev.	in the post-incubation period mean	median	std. dev.
number of females	1.05	1.00	1.38	0.99	1.00	1.32
share of majority shareholder	38.29	33.05	19.74	41.03	38.00	21.71
average shareholders' share	21.13	16.67	12.81	24.69	19.64	17.96
shareholder funds	28376	15000	36387	39461	15000	71138
		%			%	
majority shareholder type	female	17.36		female	19.62	
	non female	82.64		non female	80.38	
geographic area	north-east	33.96				
	north-weast	23.77				
	center	24.91				
	south/islands	17.36				
Year	2000	3.77				
	2001	3.02				
	2002	4.53				
	2003	11.32				
	2004	19.62				
	2005	14.34				
	2006	20.38				
	2007	23.02				
modal industry	Research and scientific development					
modal province	Milan					
modal university	Padua					

Table 2. Gender gap indicators for Italy.

Economic Empowerment	Italy
Female adult unemployment rate (% of female labor force)	10
Male adult unemployment rate (% of male labor force)	8
Share of female in wage employment in the non-agricultural sector (% of total non-agricultural employment)	44
Female's access to finance programs (%)	5
Ability of female to rise to positions of enterprise leadership (%)	3.2
Education	
Female teachers, primary education (%)	95
Female teachers, secondary education (%)	67
Female teachers, tertiary education (%)	36
Female school life expectancy, primary to secondary (years)	13
Male school life expectancy, primary to secondary (years)	13
Marriage and Childbearing	
Mean age at marriage for female (years)	30
Fertility rate (births per female)	1.4
Adolescent fertility rate (births per 1,000 girls aged 15-19)	7
Antenatal care coverage, at least one visit (%)	98
Births attended by skilled health personnel (%)	100
Maternal mortality ratio (per 100,000 live births)	4 (3-5)
Contraceptive prevalence, married female (%, any method)	63
Female HIV prevalence, aged 15–49 (%)	0.2
Male HIV prevalence, aged 15–49 (%)	0.3
Infant mortality rate (probability of dying between birth and age 1 per 1,000 live births)	3
Overall population sex ratio (male/female)	0.96
Social Institutions and Political Rights	
Year female received right to vote	1945
Quota type	No legislated
Length of maternity leave	5 months
Maternity leave benefits (% of wages paid in covered period)	80
Provider of maternity coverage	Social insurance

Source: World Economic Forum