Research Policy 51 (2022) 104554

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

# For what they are, not for what they bring: The signaling value of gender for financial resource acquisition in academic spin-offs

Giancarlo Lauto [a,*], Elisa Salvador [b], Francesca Visintin [a]

[a] Department of Economics and Statistics, University of Udine, Via Tomadini 30/A, Udine I-33100, Italy
[b] Department of Strategy, Entrepreneurship & International Business, ESSCA School of Management, 56 Quai Alphonse Le Gallo, Boulogne-Billancourt 92513 CEDEX, France

ARTICLE INFO

*Keywords:*
Academic entrepreneurship
Gender
Signaling
Resource acquisition
Start-up
Entrepreneurial finance

ABSTRACT

Due to the novelty of their technology base and the multiple goals pursued by their entrepreneurial teams, academic spin-offs (ASOs) suffer information asymmetries with investors that impair their ability to raise finance. In line with the signaling theory, we expect that observable features of an ASO can mitigate such information asymmetries, especially in conditions of higher uncertainty about the venture. We put forward that a larger share of capital owned by female shareholders adds to such uncertainty due to their outsider condition in academic entrepreneurship and the negative bias of investors against female entrepreneurs.

Through a multi-level Tobit regression on a sample of Italian ASOs, we find that the amount of private investment is negatively associated with the degree of female ownership and positively associated with the investment of the parent university and full professors. The latter two factors moderate the relationship between degree of female ownership and private investment so that it becomes less negative.

The results provide evidence of the persisting gender gap in entrepreneurial finance and highlight the role of parent universities in closing such a gap.

## 1. Introduction

The constraints that women face in fully expressing their talent and potential at work cause considerable economic losses: in 2017, the International Labour Organization (ILO) estimated that reducing the gender gap in participation in the work force by 25% by 2025 could potentially increase global GDP by USD 5.3 trillion (ILO, 2017). A gender gap is evident, and concerning, also with regard to entrepreneurial activities: the World Economic Forum (2020: 5) highlights that "In many countries, women are significantly disadvantaged in accessing credit, land, or financial products, which prevents opportunities for them to start a company." Women entrepreneurs are fewer than men, particularly in the most developed countries where they reach, on average, one third of the total and tend to concentrate in the medium and low technology sectors. With regard to high technology sectors, gender differences are relevant with regard to the process of resource acquisition: the presence of women in the entrepreneurial team of a start-up reduces the amount of funding obtained by about 70% (Breschi et al., 2018), so much so that, in the USA, in 2019, all-men owned companies received 80% of venture capital funding while all-women owned ones only 2.8% (Teare, 2020). In Science, Technology, Engineering, and Mathematics, the presence of women, though growing, is still very limited, and entrepreneurship is a fundamental lever to expand women's career choices and therefore the overall pool of individual talents (IMF, 2018).

In the flourishing literature on gender in entrepreneurship, the context of academic entrepreneurship has long been overlooked (Jennings and Brush, 2013; Perkmann et al., 2021), although recent contributions have examined gender differences in terms of entrepreneurial intention (Alonso-Galicia et al., 2015; Rosa and Dawson, 2006; Goel et al., 2015; Di Paola, 2021), human capital and motivations for engaging in entrepreneurial activity (Abreu and Grinevich, 2017), knowledge base (Poggesi et al., 2020) and strategic positioning of the firm (Micozzi et al., 2016), and economic performance (Rodríguez-Gulías et al., 2018). This stream of studies, however, has not considered a stage of the entrepreneurial process that is crucial especially for science and technology-based firms, namely the initial funding of the venture.

The broader literature on entrepreneurial finance that has examined the role of gender within the entrepreneur-investor relationship (e.g., Alsos and Ljunggren 2017, Malmström et al. 2017, Kanze et al. 2018,

* Corresponding author.
*E-mail addresses:* giancarlo.lauto@uniud.it (G. Lauto), elisa.salvador@essca.fr (E. Salvador), francesca.visintin@uniud.it (F. Visintin).

https://doi.org/10.1016/j.respol.2022.104554
Received 6 September 2021; Received in revised form 2 March 2022; Accepted 9 May 2022
Available online 16 May 2022

Yang et al. 2020, Kleinert and Mochkabadi, 2021) suggests that the presence and role of women in an entrepreneurial team operates as a signal of the quality of a new venture to potential investors. According to the signaling theory (Spence, 1974), financers try to infer the information they need for their investment decision from various sets of factors representing, in their view, meaningful signals which may be voluntary or involuntary, positive or negative.

The aims of this paper are to ascertain whether the extent of female ownership of an academic spin-off (ASO) at the moment of foundation is an involuntary negative signal in the context of the initial equity investment assessment and to tease out its influence on the signaling power of other features of the entrepreneurial team. Specifically, we assess the interplay between the degree of female ownership and three signals, namely the equity investment of the parent university; the human and social capital of the founders, expressed by the status as a full professor; and their technological capabilities. We ascertain whether these three signals positively affect the ability of ASOs to raise equity investment from private investors and whether they contribute to offset the negative signal arising from the degree of female ownership. We contend that as the degree of female ownership grows, investors invest less in these ventures, unless other signals compensate for the gender-related weakness.

We focus on ASOs because of the special role of signals—and of gender in particular—in comparison to other forms of high-technology entrepreneurship. In high-technology start-ups, the relationship between investors and the entrepreneurial team is characterized by significant information asymmetries that originate from a set of interrelated factors. Indeed, these firms undertake innovation activities that are uncertain, present highly skewed returns, and depend on intangible assets (e.g., early-stage technologies) whose value is difficult to gauge. Moreover, the value of technologies depends on tacit knowledge of key individuals, who may decide to leave the firm in the future (Busenitz et al., 2005) or may be reluctant to offer full disclosure of their inventions because of imitation threats (Arundel, 2001). Also, the market demand is unproven, and the firm may deliberately pursue a frequent change in the product-technology-market combination before finalizing its strategy (Shepherd and Gruber, 2021).

Academic spin-offs are characterized by even stronger information asymmetries between the entrepreneurial team and external financers (Champenois et al., 2006) because academia is a special world *per se* and companies founded by academics are perceived as a prolongation of university culture and dynamics. Their founding teams, consistently with the noncommercial culture of academia, often pursue both economic and noneconomic goals (Ambos and Birkinshaw, 2010) Hayter, 2015), and they often develop technologies that are difficult to understand even for the most expert investors (Schoonmaker et al., 2017). Moreover, the role of gender is problematic in ASOs: on the one side, it is possible to expect that its signaling role is less prominent compared to characteristics related to the scientific and technical knowledge-base of the firm; on the other side, its strength may be reinforced by the fact that both business and academia are male-dominated fields (e.g., Gupta et al. 2009, Fotaki 2013).

This paper contributes to the literature on entrepreneurial finance and signaling theory, specifically in the context of academic entrepreneurship, along the following lines.

First, it adds to the scarce knowledge about the gendered nature of signals in academic entrepreneurship in particular and about the high-tech sectors in general. By concentrating on a team rather than a single individual, we show the consequences of female ownership on the availability of external funding. A well-established stream of literature on gender differences in high-tech entrepreneurship maintains that women receive less financing because they have lower human and social capital, invest in ventures with lower growth potential, and are less interested in opening up the capital of their companies (for a review, see, e.g., Jennings and Brush 2013). This literature typically compares all women-owned to all men-owned companies. However, the same arguments do not explain why a company with a female minority shareholder should receive systematically lower external investment than an all-men owned company and more than an all-women owned one. The presence of a female minority shareholder does not reduce the company's resource endowment, for example, in terms of social capital, expertise in a scientific field, or audacity in dealing with partners. By ascertaining whether the gender composition of an entrepreneurial team affects the amount of investment raised by private investors, we can highlight the existence of gender-based negative perceptions in the investors' investment decisions. In this sense, this work highlights the value of considering a team, rather than an individual, as the unit of analysis in the study of gender in organizations (Joshi et al., 2015), and it adds a new analytical dimension to a literature that has focused mainly with the signaling role of the gender of the entrepreneur (e.g., Busenitz et al. 2005, Eddleston et al. 2016, Alsos and Ljunggren 2017).

Furthermore, ascertaining the signaling role of gender composition of entrepreneurial teams in the context of academic entrepreneurship is even more significant as academic entrepreneurs present a series of features that, regardless of gender, could operate as negative signals to external financers: scientists—whether men or women—are characterized by the same entrepreneurial weaknesses in terms of personal resources and motivations (Shane, 2004) that are typically ascribed only to women entrepreneurs to justify their underfinancing (Greene et al., 2001; Jennings and Brush, 2013).

Also, this study disentangles the negative and positive signaling effects of different kinds of resources embedded in the entrepreneurial team. The presence of the parent university among the shareholders, the human and social capital, and the patenting portfolio of the founders are all resources that an ASO can deploy to positively signal its business potential. By ascertaining whether their impact on the ability of the new venture to attract investments varies with a greater degree of female ownership, we are able to offer proof of their signaling effect, as advocated by Connelly et al. (2011). Furthermore, our results help advance the theorizing of signals in ASOs, which have not been analyzed before: even in Colombo (2021) extensive literature review, no reference is reported about signals of academic origin. Finally, by examining the phenomenon of ASOs in Italy, this work addresses Joshi et al. (2015) call for investigations on the organizational effects of gender dynamics outside the North American context.

## 2. Theoretical background

### 2.1. Signals to equity investors in ASOs

When assessing the opportunity of investing in an ASO, equity investors suffer two kinds of information asymmetry with entrepreneurial team members (Connelly et al., 2011). The first one is related to the prioritization of economic versus noneconomic goals that is a consequence of the academic context in which the business initiative is generated (Ambos and Birkinshaw, 2010; Hayter, 2015); in the case of ASOs, the amount of money entrepreneurial team members invest indicates their orientation toward economic goals, in line with the interest of private investors (Forbes et al., 2010). The second one concerns the viability of the new venture, which depends on the ability to incorporate new technologies into a commercial offering. However, cutting-edge technologies may be difficult to assess for an investor (Schoonmaker et al., 2017), their application into products is uncertain, and the ability of the entrepreneurial team to carry out such translation is bounded by their lack of commercial and managerial competencies (Shane, 2004).

To face such uncertainty, investors targeting early-stage ventures adopt decision-making heuristics to identify targets and decide whether and how much to invest, by considering a subset of the many factors associated with business growth and profitability (Drover et al., 2017). In this process, ASOs are required to disclose information about their ownership, including the composition and the background of their entrepreneurial team, both to their parent university and potential

investors.

We propose that the features of ownership of an ASO at the start-up stage provide investors with precious information that entails both the substantive matter (i.e., the endowment of financial resources, human capital, and social capital that the owners bring and can be deployed in the firm) and their signaling value (i.e., they express a latent quality of the firm that outsiders cannot directly observe but which is highly relevant for their investment decision) (Colombo et al., 2019).

Signaling theory (Spence, 1974) posits that an observer can distinguish between high- and low-quality actors by examining their observable features that are costly to produce and difficult to fabricate and that these features should correlate with latent qualities. In our context, the sender of the signal is the entrepreneurial team of an ASO, while the observer is a potential investor. As explained in detail in the following sections, we theorize that the gender composition of an entrepreneurial team is a signal in the early financing process, which has a negative effect that grows with the share of capital owned by women. We then assess the signaling role of other features of the ownership of the ASO at the time of foundation, namely the amount of equity capital owned by the parent university, the amount invested by full professors, and the technological capabilities of the entrepreneurial team (Fig. 1). We also propose that these three elements send positive signals that can interact with the negative ones.

We focus on the abovementioned features for three reasons. First, they are "universal signals" that provide verifiable evidence of the sender's underlying quality and are sought after by the receiver (Colombo, 2021). Second, they are meaningful in the institutional setting of academia, in which ASOs are embedded. Third, these features can effectively discriminate between ASOs with low and high ability to generate satisfactory returns on investment (i.e., producing a "separating equilibrium" as we argue in the following sections). Therefore, potential investors can reasonably assume that only high-quality ASOs will display these attributes.

To disentangle the signaling from the substantive effect of these features, we follow the approach outlined by Colombo et al. (2019) and Stuart et al. (1999), who noted that the signaling effect is stronger when the information about firm quality is limited. As the following sections delineate, the persisting minority condition of female entrepreneurship, the diffused stereotypes about women's abilities as entrepreneurs, and the biased evaluation of female entrepreneurs (e.g., Ridgeway 2001, Edelman et al., 2018, Gupta et al. 2019, Malmström et al. 2020) fuels the skepticism of investors toward an entrepreneurial team that features increasing prominence of women, sending somewhat negative signals about the potential of an ASO.

### 2.2. The signal of gender

Status construction theory (Ridgeway, 1991; Ridgeway and Erickson, 2000) suggests that recognized social differences are associated with social worthiness and competence in matters relevant to performing a complex task. Gender has an ontological status because it influences how we see everything around us and is a status characteristic, implying differences in the social reputation, esteem, and respect of specific groups and the expectations about its members' behavior. These differences are assumed as a social reality both from the groups that benefit and those that are penalized from this association; moreover, they affect the behavior of individuals who are not consciously biased against any one group (Ridgeway and Correll, 2004; Ridgeway et al., 2009; Tinkler et al., 2015).

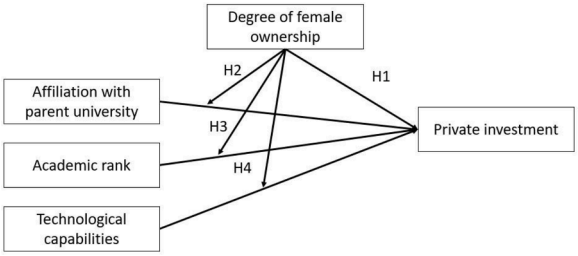


**Fig. 1.** Conceptual model.

These differences are amplified in entrepreneurship, a masculine domain (Ahl, 2006; Gupta et al., 2009), in which female entrepreneurs are perceived as intruders and outsiders and, for their nature, as not fit for the job (Bigelow et al., 2014; Eddleston et al., 2016). Consequently, to receive funding, female entrepreneurs are required to share more information (Murphy et al., 2007), to be more committed to the firm (Eddleston et al., 2016), to show more and stronger signals of legitimacy (Alsos and Ljunggren, 2017) so as to close the legitimacy gap (Edelman et al., 2018), and to offer evidence for the less attractive features of their business (Kanze et al., 2018). The negative perception of female entrepreneurs is highlighted by the fact that business angels evaluate the pitches of males more favorably even when the content is the same (Brooks et al., 2014) and scrutinize the management team of women-led firms more closely (Dean and Ford, 2017). In addition, feminine behaviors are perceived as not in line with entrepreneurship, particularly high-growth entrepreneurship. Indeed, Gupta et al. (2019) document that entrepreneurs who lead high-growth ventures are perceived as masculine, while those running low-growth firms as feminine, while investors penalize women who display an "entrepreneurial" attitude (Malmström et al., 2020) or the behaviors commonly associated with a position of power (Cuddy et al., 2011).

In the context of academic entrepreneurship, the implications of gender stereotyping for the resourcing process has not received much attention (with the notable exception of Shane et al. 2012, 2015), even though the issue appears challenging.

From one perspective, it is possible to argue that gender differences should be flattened by the fact that the scientific human capital of academic entrepreneurs—both male and female—is proven by a lengthy and systematic series of assessments and that both female and male academics typically lack business and commercialization experience (Shane, 2004). Therefore, investors should see academics as a homogeneous group of outsiders to the business world, with little or no difference between genders.

However, in practice, academia's institutional context has been—and still is—regulated by masculine norms (Fotaki, 2013; Van den Brink and Benschop, 2012) that assume the male model for an ideal scholar: male academics are more numerous, reach higher rankings (e.g., full professorship, department directorship), and have better access to research funding and visibility (Meng, 2016; Whittington, 2018). These strengths are amplified by the cumulative advantage that favors the academics in a strong position, known as the "Matthew effect"[1] (Merton, 1968, 1988). While the original concept focused on the effects of scientific prominence, Rossiter (1993) outlined the "Matilda Effect," referring to the cumulative disadvantage of women and the systematic undervaluing of women's contributions to science and other fields. While a historical and sociological explanation of the phenomenon is beyond the scope of this work, we highlight that an apparent consequence of such effects is a vicious cycle whereby the male gender signals greater scientific human capital and the ability to acquire further resources and visibility.

Male dominance also characterizes the related domain of science commercialization (Hmieleski and Powell, 2018), as female scientists are less involved in formal and informal technology transfer activities

[1] "*The Matthew effect consists in the accruing of greater increments of recognition for particular scientific contributions to scientists of considerable repute and the withholding of such recognition from scientists who have not yet made their mark*" (Merton, 1968: 58). "*It tends to give the credit to already famous people*" (Merton, 1988: 607).

(Tartari and Salter, 2015) and academic entrepreneurship (Woolley, 2019). Specifically, Clarysse et al. (2011: 1090) show that "female academics have 40–50% less chance of being engaged in an entrepreneurial venture than their male equivalents." Similar results are found by Rosa and Dawson (2006), Ebersberger and Pirhofer (2011), Haeussler and Colyvas (2011), Abreu and Grinevich (2017), and Goel et al. (2015). Consequently, female academic entrepreneurs are seen as intruders in the business world due to the masculine dominance also in academia, and, due to the Matilda effect, have fewer sources of positive signals to employ in their relationship with financers. In one of the few studies examining the phenomenon in technology-based firms, Gicheva and Link (2013) found that women-led firms are 16% less likely to attract private funding. Nevertheless, how strong is the perceived uncertainty brought by female academic entrepreneurs?

It should be noted that, typically, ASOs are founded by teams, and to assess the financing dynamics properly, this should be the unit of analysis. While the issue has not received scholarly attention concerning the financing process, studies on the performance of scientific teams in terms of citations have found a significant penalizing effect in introducing women to a team of male researchers (Beaudry and Larivière, 2016). Following this insight, we assume that introducing a female academic in an all-male team adds uncertainty and increases information asymmetry, thus sending a negative signal to investors, which will decrease the amount of financing.

Overall, as the professional norms of academia and business tend to marginalize women from academic entrepreneurship, we expect that:

**Hypothesis 1**. *The amount of private investment is negatively associated with the degree of female ownership.*

### 2.3. Negative and positive signals

The amount of investment by the parent university and by full professors and the entrepreneurial teams' technological capabilities endow the new firm with resources offering positive signals. To tease out their signaling effect, we follow the insight offered by other studies (e.g., Colombo et al. 2019) that the strength of the signaling effect merges in conditions of higher uncertainty—in our case when women own a greater share of the capital of an ASO.

Considering women are a minority group in the business and academic worlds, they face more difficulties in accessing the resources that signal the quality of an ASO. However, when they do, the impact of the signal will be more substantial and plays a significant role in reducing the extent of information asymmetries, while in the case of male-dominated ventures, signals will be weaker as the perceived information asymmetry is lower. Specifically, we explain in the following sections why we expect that private investors consider the affiliation with the parent university, the academic rank of the professors involved, and the technological capabilities of founders as progressively stronger signals when the degree of female ownership increases.

### 2.4. The signal of parent university as a shareholder

The affiliation with prominent and socially relevant actors in their organizational field that acts as third-party assurance (Connelly et al., 2011) brings legitimacy and prestige to ASOs, which helps them overcome their liability of newness, especially in the early rounds of financing when uncertainty is at its highest (Stuart et al., 1999; Pollock et al., 2010).

In the context of ASOs, the parent university is a critical factor that can play this role. The parent university may decide to invest in an ASO under public policy measures promoting technology transfer from research to industry and, specifically, to address the difficulty of ASOs reaching private investors (Bock et al., 2018). By becoming a shareholder, a parent university provides substantial resources—financial and social capital brought by connections with partners in the institution's network and human capital brought by the directors appointed by the institute (Khoury et al., 2013)—and also a certification of the scientific and technological standing of the new venture (Salvador, 2011). The equity investment by the parent university results from scrutinizing the scientific, technological, and commercial viability of the venture, evaluated by governance bodies, which are increasingly demanding as more sophisticated and expensive forms of support are provided (Rasmussen et al., 2011).

The ownership of the parent university is a credible signal of quality because the academic bodies that examine the proposal of an ASO are more competent than outsiders in evaluating the technologies on which the venture is based (Colombo et al., 2019) and the scientific standing of the academic team. Furthermore, the entrepreneurial team of a venture with poor strategy and poor financial potential would find it disproportionally more challenging convincing its parent university to own a stake in the new venture and to bear the risk of financial and reputational loss (Pollock et al., 2010; Colombo et al., 2019). In other words, investment by the parent university is a credible signal because it is costly to the sender.

Considering the size of investment by the parent university is meaningful because it expresses the entrepreneurial team's expectations about the future need for financial resources and, therefore, signals that the ASO is pursuing a growth strategy that can generate high financial returns (Busenitz et al., 2005). Indeed, even though some studies report neutral or negative effects (e.g., Bock et al. 2018), equity investment by the parent university generally improves the ability to attract funds from private investors, including venture capitalists (e.g., Bertoni et al. 2011, Gubitta et al. 2016).

We, therefore, expect that:

**Hypothesis 2**. *The amount invested by the parent university moderates the relationship between the degree of female ownership and the private investments, so that the negative relationship between the former and the latter becomes less pronounced.*

### 2.5. The signal of academic rank

The academic rank certifies scientific human capital, a precious resource that can be deployed in the venture for developing successful innovative products and companies in science-based industries (Gurdon and Samsom, 2010), as well as for raising venture capital (Fuller and Rothaermel, 2012; Higgins et al., 2011). Investors consider social capital expressed by the academic rank quite important, as scholars with higher rank tend to have developed connections within and outside the academic system that may facilitate access to other resources (Khoury et al., 2013). The greater resource endowment of full professors leads them to be "twice as likely to engage in entrepreneurial activities than their non-tenured colleagues" (Clarysse et al., 2011: 1091).

Therefore, academic rank is suitable for generating a separating equilibrium because highly regarded scholars would not commit their wealth and reputation to ventures with low expectations for success, and they would make use of privileged information in these decisions. Indeed, an entrepreneur's investment is a reliable signal of a new venture's potential (e.g., Busenitz et al. 2005). Moreover, their investment signals their dedication of time and effort to the firm despite competing obligations; it is reasonable to assume that only highly promising ventures would win the commitment of full professors. Consequently, the absence of full professors would indicate that nascent businesses cannot attract individuals with the most significant resource endowment in the academic system. Finally, as in the parent university's case, the amount invested by full professors indicates the new venture's growth orientation.

Building on these considerations, we expect that:

**Hypothesis 3**. *The amount invested by full professors positively moderates the relationship between the degree of female ownership and private investments, so that the negative relationship between the former and the latter*

*becomes less pronounced.*

### 2.6. The signal of technological capabilities

Given that the academic members of an entrepreneurial team typically develop the technologies on which an ASO builds its product and service offering, their endowment of technological capabilities is related to the firm's ability to finalize the invention process, a precondition for successful commercialization (Clarysse et al., 2011). Although the technological capabilities of the founding team may be tacit (Karnani, 2013), patenting is considered an indicator of scientists' orientation toward the production of research outcomes that can be commercialized, as academics may face a trade-off between the publication of results and the protection of intellectual property (Gans et al., 2017).

Previous research in entrepreneurial finance has considered patenting a signal of technological capabilities regarding investment by industrial partners and venture capitalists, especially in the first rounds of financing (Hoenig and Henkel, 2015; Mathisen and Rasmussen, 2019). Patenting is an indicator of the ability to generate inventions of great potential value: patents protect only new and not obvious inventions, require revealing details to the public, expose the invention to imitation, require a lengthy examination process, and are costly and time consuming. Moreover, patenting is a viable strategy only if the inventions have market potential (Walter et al., 2016) and can serve as a credible signal of technological capabilities (Alsos and Ljunggren, 2017).

Patenting can produce a separating equilibrium between low- and high-quality ASOs because, for a similar investment of time and resources, low-quality entrepreneurial teams would achieve a smaller number of patents than those endowed with more technological capabilities. Therefore, only the high-quality teams will invest in patenting, thus signaling their desirable quality to potential investors.

We, therefore, expect that:

**Hypothesis 4**. *The technological capabilities of the entrepreneurial team moderate the relationship between the degree of female ownership and private investments, so that the negative relationship between the former and amount invested by the latter becomes less pronounced.*

## 3. Research design

### 3.1. Sample and data collection

We tested our hypotheses on a sample of ASOs of Italian universities[2]. The Italian case appears particularly interesting to investigate our research question because female entrepreneurship—female academic entrepreneurship in particular—is less developed than in other developed countries in large part of the period in which the Italian ASOs were funded. The first edition of the Gender Equality Index based on 2010 data ranked Italy in the 21st position in the European Union (EIGE, 2022), and, according to GEM data (2022), the country is among those in which the proportion between female-to-male nascent entrepreneurs is strongly unbalanced toward the latter. Furthermore, there is evidence that the Italian academic system is characterized by strong norms favoring men (Roberto et al., 2020), and, compared to many other European countries, women are less represented in the academic community, both at the bottom and top of the professional ladder (Goastellec and Pekari, 2013; European Commission, 2021). These norms also influence technology transfer activities (Giuri et al., 2020). All these features characterize the Italian context—more clearly than others—as one in which female academic entrepreneurs occupy a marginal position; therefore, their presence in an entrepreneurial team represents a source of high uncertainty, which potential investors can overcome by observing the signals offered by an ASO.

In the absence of an official register of ASOs, we relied on a census carried out by Netval, the Italian Network of Technology Transfer Offices of Universities and Research Organizations (https://netval.it). Every year, this network surveys 72% of national universities, which employ 80% of all academic staff. Previous research on science commercialization in Italy (e.g., Muscio et al. 2016) has relied on this source. The Netval census identified 795 ASOs established between 2003 and 2016. For these firms, we collected the complete ownership records at the business registration office of the chamber of commerce; those records provided information, including the shareholders' identity and the number of shares owned. For legal entities, we ascertained their nature by examining their activity code in the firms' register and, if necessary, their website. We identified the academic shareholders by matching shareholders' names with the database maintained by the Ministry of Education and Research (cercauniversita.cineca.it), which includes all academic employees of universities as of the year 2000 (excluding postdoctoral and doctoral students and contractors). We assured the integrity of the data by manually checking for possible homonymy. This database also provides additional information such as the academic ranking of scholars. Finally, we sourced the publication records of academic shareholders and patent records of all shareholders for up to the year before the start-up, from Scopus and Espacenet, respectively.

From the original dataset, we focused on ASOs that were established by universities excluding those of the National Council of Research and Research Foundations (accounting for 22 cases) and those without any academic employees among their founders (113 cases). We also excluded 126 ASOs generated by 9 universities that owned a stake in either all or none of their ASOs because their presence or absence may result from an internal policy—formal or implicit—rather than a case-based decision. Finally, we excluded 9 ASOs that did not declare the industry in which they operated. This selection narrowed the sample to 526 ASOs—representing 68% of university-backed ASOs and 80% of those with academic founders—clustered in 240 cohorts and 37 universities.

### 3.2. Analytical strategy

We tested our hypotheses by adopting a multi-level Tobit model with random intercepts. We chose this approach because our dependent variable, the amount of investment by private shareholders, is partially continuous, as it presents the lower limit of zero, which is taken by a substantial portion of the cases: 63% to be precise (Wooldridge, 2010). We use a multi-level model because our data presented a hierarchical structure: ASOs were nested within cohorts of ASOs founded at the same institute in the same year; the cohorts were nested within a parent university. Failure to account for the clustering of ASO data in cohorts and cohorts in parent universities would have violated the assumption of independent observations, leading to unreliable coefficients and standard errors (Rabe-Hesketh and Skrondal, 2012).

A multi-level model appears justified due to the size of variation in the dependent variable across different levels of analysis. Following Aguinis et al. (2013), we calculated the intraclass correlation coefficient (ICC) of an intercept-only model (not reported here) that showed the proportion of the total variation in the dependent variable that is due to cohort and university differences. The ICC indicated that 7.6% of the private investment variance could be attributed to university-level differences and 19.5% to cohort-level differences. Although there is no threshold for the ICC, these values are consistent with previous research

[2] We consider ASOs that originate from universities; have been authorized by their parent university, although we do not require the licensing of a technology or an equity investment; stem out research on any scientific field, which is based on codified or tacit knowledge or both; and include in the entrepreneurial team at least one faculty member. By excluding the ventures started by students or research contractors, we are able to clearly identify our object of investigation, as, according to the Italian law, the creation of such ventures does not need the formal authorization of the parent university.

(e.g., Aguinis et al. 2013). We also performed likelihood ratio tests that compared the model fit of the multi-level Tobit regression to that of a traditional Tobit regression. These tests were highly significant, indicating the suitability of multi-level models.

### 3.3. Variables

Our study's dependent variable is the amount (in Euros) of *private investment* (investments from industrial partners or financial companies) in an ASO at the time of its founding. This dependent variable is often used in studies on entrepreneurial finance (e.g., Fisch 2019).

The variable expressing gender-related signal considers the percentage of an ASO's capital owned by female shareholders (*female capital*). The robustness tests consider the *percentage of female shareholders* on the total number of entrepreneurial team members.

The variables expressing the positive signals about the quality of an ASO are the nominal value of the *parent university*'s and *full professors'* investments, and the *number of patents* that entrepreneurial team members filled before the start-up. We counted the patents assigned to multiple members of the entrepreneurial team only once.

The first set of controls accounts for the effect of the amount of investment of other possible categories of shareholders: *associate professors, assistant professors, inexperienced nonacademics* (i.e., aged 35 years or less), *experienced nonacademics* (i.e., older than 35 years), and *public administrations*. We distinguish all categories of academics to capture the differences in terms of scientific experience and social capital; investment by nonacademic members who bring complementary capabilities (Visintin and Pittino, 2014) may be favorably interpreted as a signal of market orientation. The team's strength of scientific skills is expressed by the number of journal articles listed in Scopus that the team had published up to the year before the start-up (*scientific production)*. We counted the publications coauthored by multiple members of the entrepreneurial team only once. We also control for the team size because it is related to several firm performance measures (Jin et al., 2017) and the *industry*[3] in which the firm operates, as they vary in gender-related funding patterns (Kanze et al., 2020). To account for cumulative effects in ASO generation and funding (Ramaciotti and Rizzo, 2015), we considered the *cumulated number* of ASOs started at each parent university up to the year before the start-up of a given ASO. To capture the ability of a parent university to generate ventures appealing to private investors, we considered the *cumulated private investment* in ASOs up to the year before the start-up. We considered one organization-level variable, *university type*, that took the value one if the parent institution was a polytechnic school or a school of advanced study—whose research orientation tended to lean toward projects with commercial applicability and show a greater rate of generation of ASOs (Abramo et al., 2012)—and zero otherwise.

To improve the interpretability of the intercepts in the regression models, we used grand-mean centering of the continuous variables. The constant refers to the predicted mean for entrepreneurial teams of ASOs with an average value for the predictors across cohorts and parent universities.

We can exclude that the results of the regression models are severely affected by collinearity, as the correlation matrix (in Appendix) shows that all pairwise correlations have values below 0.50, except for full and associate professors' investment, and the average and maximum variance inflation factors were 1.48 and 3.05, below the threshold of 10.

[3] The industries are defined according to the NACE classification: scientific R&D and manufacturing of chemical and pharmaceutical products (NACE 20, 21 and 72); ICT, which included computer programming, consultancy and related activities, and information service activities (NACE 62 and 63); architecture and engineering services, technical testing, and specialized construction activities (NACE 43, 71, and 74); manufacturing of computers, vehicles, and electronic and optical devices (NACE 26–32); and nontechnical consulting and training services (NACE 70, 73, 82, 85, 86, 88, and 90).

## 4. Results

### 4.1. Descriptive statistics

Private investors hold a stake in 193 ASOs (i.e., 36.7% of our sample); in these ASOs, the investment ranges from €400 to €420,000, with a median of €4,900 and a mean of €13,219.

The degree of female ownership appears somewhat limited, with 39.35% of teams composed of only men and 46.20% composed of mostly men, while women hold 50% or more of the capital in 11.60% of the cases, including 8 ASOs (1.52%) in which the entrepreneurial team is composed only of women. Table 1 indicates that private investors are over-represented in ASOs whose entrepreneurial team is composed only of men and that the median private investment tends to decrease as the capital owned by women increases.

Regarding the three main expected positive signals, the parent university is a shareholder of 215 (40.87%) ASOs and full professors of 313 (59.5%) ASOs (who are only male in 290 cases), while their median investment is respectively €1,000 and €3,000. The median private investment (conditional to having received it) is higher in ASOs having as shareholders the parent university (€5,100 vs. €4,265) and full professors (€5,100 vs. €3,750).

In 288 (54.75%) ASOs, entrepreneurial team members had patenting experience before the start-up. Private investors' presence is slightly more frequent in ASOs whose founders have patenting experience (38.19% vs. 34.87%), which also presents a higher median private investment (€5,150 vs. €4,400).

### 4.2. Multi-level regression analysis

We tested our hypotheses through a series of regression models. After presenting a controls-only model, we consider the structure of the capital including: first, the share of female owned capital and then the investment for different categories of shareholders; finally, we interact the share of female capital with the three variables expressing the positive signals.

In Models 3–6, we included random effects at the cohort level for our key variable, *female capital*, to capture the potential variances in the relationships between female capital and private investment across cohorts.

Among the five controls that are significant in Model 1 (Table 2), three lose their significance in Model 3 when all the explanatory variables are introduced: the *cumulated number of ASOs* generated by the parent university, *scientific production*, and *assistant professors*. The loss of statistical significance of the latter two variables suggests that they have much lesser signaling power than actors and resources that are more central for academic entrepreneurship, such as the commitment of the parent university and full professors and technological capabilities. Two variables, *inexperienced nonacademics* and *associate professors*, instead, have a significant effect on private investment in all the Models. This

**Table 1**
Presence of private investors and median investment across levels of female-owned capital.

| Category of ASO | Number (%) of ASOs | Number (%) of ASOs with private investors | Median private investment in Euro |
|---|---|---|---|
| Female capital = 0 | 207 (39.35%) | 88 (45.60%) | 5392 |
| Female capital > 0 and < 50 | 243 (46.20%) | 80 (41.45%) | 4725 |
| Female capital > 50 | 76 (14.45%) | 25 (12.95%) | 3800 |
| Total | 526 | 193 (36,69%) | 4850 |

**Table 2**
Results of Tobit regression model. Dependent variable: private investment ($N = 526$).

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| University type | 4.718 (9.271) | 3.793 (8.581) | 0.111 (6.365) |
| Cumulated private investment | -0.188 (0.148) | -0.234 (0.158) | -0.156 (0.198) |
| Cumulated number of ASOs | -0.571* (0.288) | -0.573*** (0.292) | 0.011 (0.013) |
| University size | 0.003 (0.002) | 0.031*** (0.001) | 0.002 (0.001) |
| Industry (baseline: R&D & Pharmaceutical) | | | |
| ICT | -1.332 (4.103) | -1.919 (4.079) | -2.735 (3.105) |
| Technical consultancy | -4.214 (3.176) | -4.261 (3.158) | -6.912** (2.652) |
| Manufacturing | -3.923 (5.290) | -5.351 (5.394) | -2.571 (3.802) |
| Non-technical consultancy | 8.630 (5.725) | 9.219 (5.719) | 4.061 (4.374) |
| Team size | -0.056 (0.474) | 0.055 (0.469) | -0.251 (0.359) |
| Scientific production | 0.039*** (0.013) | 0.040*** (0.013) | 0.010 (0.014) |
| Public Administrations | -6.135 (5.267) | -6.270 (5.429) | -5.850* (2.753) |
| Experienced non-academics | 0.225 (0.620) | 0.245 (0.634) | 0.300 (0.385) |
| Inexperienced non-academics | -1.110*** (0.437) | -1.147*** (0.437) | -0.757** (0.249) |
| Assistant professors | 1.453*** (0.526) | 1.510*** (0.516) | 0.414 (0.341) |
| Associate professors | 3.110*** (0.857) | 3.146*** (0.862) | 0.932** (0.351) |
| Female capital | | -0.158*** (0.059) | -0.104* (0.046) |
| Patents | | | -0.216 (0.187) |
| Full professors | | | 0.870** (0.313) |
| Parent university | | | 3.273*** (0.636) |
| Constant | -14.085*** (3.052) | -14.123*** (2.965) | -7.660*** (2.040) |
| Variance (Parent university) | 53.690 (61.108) | 48.082 (54.522) | 25.955 (16.225) |
| Variance (Parent university/Year) | 0.044 (0.083) | 0.058 (0.086) | 0.021 (0.027) |
| Variance (Private investment) | 628.639 (152.922) | 42.774 (61.833) | 363.787 (93.371) |
| Pseudo-likelihood | -1056.40 | -1053.81 | -995.89 |
| Wald chi-squared | 72.37*** | 83.52*** | 757.03*** |

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

result is consistent with the signaling theory, as associate professors' academic standing is quite close to that of full professors, while inexperienced nonacademics are likely to lack the human and social capital needed for launching a new venture.

Model 2 introduces the key explanatory variable of our study, *female capital*, which has a strongly significant negative coefficient (−0.158, $p < 0.001$): any increase of share of capital owned by women reduces the amount of equity that an ASO raises from private investors. This effect persists in Model 3, when the positive signals are introduced, although with a lesser magnitude and statistical significance (−0.104, $p < 0.05$). The model also reveals a positive and significant effect of the parent university and full professors' investment, while, contrary to expectations, patenting experience does not influence private investment.

In Model 3, the new controls turn significant. First, we find an adverse effect of the amount invested by public administrations, as private investors probably perceive the risk of red tape and complicated decision-making processes as negative signals. Second, the calculations on the coefficients reveal that ASOs offering technical consultancy receive smaller external investment than those in R&D, pharmaceutical, and nontechnical consultancy industries; no other sectoral differences were found.

The set of models presented in Table 3 examines how the three positive signals moderate the effect of female ownership. Given that the Tobit model is nonlinear, to appreciate the interaction effect, we need to consider the marginal effect of the signals at different levels of female ownership (Tables 4 and 5).

The results presented in Table 4 offer an important insight about the negative signal of the degree of female ownership, which emerged from Model 3: the strength of the signal diminishes at higher levels of female ownership. In particular, in ASOs that are not backed by the parent university or by full professors, the negative signal loses its significance when women control the majority of the capital. Furthermore, we learn that the investment of the parent university and of full professors offset the negative signal.

If the parent university does not support an ASO, an increase in women's capital is associated with a significant reduction in private

**Table 3**
Results of Tobit regression model with interactions. Dependent variable: private investment ($N = 526$).

| | Model 4 | Model 5 | Model 6 |
|---|---|---|---|
| University type | 2.504 (6.221) | 1.481 (6.243) | 0.954 (6.384) |
| Cumulated private investment | -0.212 (0.205) | -0.207 (0.199) | -0.143 (0.199) |
| Cumulated ASOs | 0.008 (0.011) | 0.010 (0.012) | 0.010 (0.013) |
| University size | 0.002 (0.001) | 0.002 (0.001) | 0.002* (0.001) |
| Industry (baseline: R&D & Pharmaceutical) | | | |
| ICT | -1.621 (3.002) | - 2.279 (2.871) | - 2.676 (3.157) |
| Technical consultancy | -5.317* (2.509) | -5.660* (2.530) | -6.584** (2.639) |
| Manufacturing | -0.838 (3.321) | -1.296 (3.656) | -2.475 (3.774) |
| Non-technical consultancy | 4.706 (4.257) | 4.471 (4.314) | 4.253 (4.416) |
| Team size | -0.300 (0.335) | -0.196 (0.313) | -0.220 (0.338) |
| Publications | 0.017 (0.013) | 0.011 (0.013) | 0.012 (0.013) |
| Public Administrations | -5.423* (2.733) | -5.514* (2.694) | -5.916* (2.773) |
| Experienced non-academics | 0.418 (0.363) | 0.220 (0.296) | 0.297 (0.374) |
| Inexperienced non-academics | -0.614** (0.235) | -0.671** (0.220) | -0.759** (0.251) |
| Assistant professors | 0.361 (0.317) | 0.422 (0.337) | 0.396 (0.355) |
| Associate professors | 0.451 (0.301) | 0.653 (0.350) | 0.945** (0.341) |
| Patents | -0.253 (0.174) | -0.210 (0.171) | -0.186 (0.184) |
| Full professors | 0.681* (0.291) | 0.900*** (0.265) | 0.901** (0.349) |
| Parent university | 3.140*** (0.509) | 2.812*** (0.660) | 3.329*** (0.652) |
| Female capital | -0.099* (0.046) | -0.090* (0.047) | -0.104* (0.046) |
| Parent university x Female capital | 0.049** (0.016) | | |
| Full professor x Female capital | | 0.023** (0.009) | |
| Patents x Female capital | | | -0.016 (0.029) |
| Constant | -3.185 (3.877) | -2.902 (3.940) | -3.380 (3.965) |
| Variance (cons_Parent university) | 30.933 (17.869) | 25.469 (15.908) | 23.666 (14.895) |
| Variance (Female capital_ Parent university/year) | 0.024 (0.030) | 0.026 (0.026) | 0.020 (0.026) |
| Variance (cons_Parent university/year) | 25.242 (26.219) | 18.498 (28.192) | 10.230 (29.331) |
| Variance (Private investment) | 317.933** (99.429) | 325.358*** (81.245) | 362.669*** (91.968) |
| Pseudo-likelihood | -991.397 | -990.75 | -994.68 |
| Wald chi-squared | 7105*** | 1998*** | 821*** |

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

**Table 4**
Average marginal effects of female capital on private investment for selected levels of parent university and full professors' investment ($N = 526$).

| | Parent university investment | | | Full professors' investment | | |
|---|---|---|---|---|---|---|
| Female capital | 0 | 1000 | 2000 | 0 | 2000 | 4000 |
| 0% | -0.057*** (0.017) | -0.045*** (0.018) | -0.030 (0.021) | -0.056*** (0.018) | -0.042** (0.018) | -0.026 (0.020) |
| 20% | -0.041*** (0.013) | -0.033** (0.015) | -0.019 (0.020) | -0.041*** (0.014) | -0.030* (0.015) | -0.016 (0.019) |
| 50% | -0.023*** (0.008) | -0.017 (0.012) | -0.006 (0.018) | -0.022** (0.010) | -0.014 (0.012) | -0.002 (0.018) |
| 80% | -0.011 (0.006) | -0.006 (0.010) | 0.005 (0.017) | -0.009 (0.008) | -0.002 (0.011) | 0.009 (0.018) |
| 100% | -0.005 (0.005) | 0.001 (0.010) | 0.011 (0.018) | -0.004 (0.007) | 0.003 (0.011) | 0.015 (0.018) |

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

**Table 5**
Average marginal effects of signals on private investment for selected levels of female capital ($N = 526$).

| Female capital | Parent university investment | Full professors' investment | Patents |
|---|---|---|---|
| 0% | 0.781*** (0.272) | 0.159*** (0.062) | -0.136 (0.085) |
| 20% | 1.027*** (0.200) | 0.295*** (0.088) | -0.052 (0.059) |
| 50% | 1.220*** (0.188) | 0.454*** (0.150) | 0.049 (0.081) |
| 80% | 1.472*** (0.304) | 0.570*** (0.212) | 0.126 (0.124) |
| 100% | 1.547*** (0.384) | 0.631*** (0.254) | 0.166 (0.151) |

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

investment, until a level of female ownership of 70%. If the parent university invests €1000, the effect loses its significance at the level of ownership of 30%. In comparison, for an investment of €2000, there is no penalty associated with adding women to the entrepreneurial team, even in the case of an all-male team. It is helpful to recall that the average investment of the parent university is €1000 and that about 10% of ASOs received funding of €2000 or more.

Regarding the interaction between female ownership and full professors' investment, the entry of a woman into an all-male entrepreneurial team is associated with a reduction in private investment if full professors have invested up to €4000 (a level comprising 82% of ASOs). A larger investment by full professors appears to mitigate the detrimental effect of female ownership.

Considering female capital generally reduces the amount of private investment, even though the strength of the negative effect is not found at any level of female ownership and can be mitigated by other signals, we conclude that *Hypothesis 1* finds partial support.

However, it should be highlighted that the penalty brought by female ownership is meaningful in substantive terms, as women hold 50% or

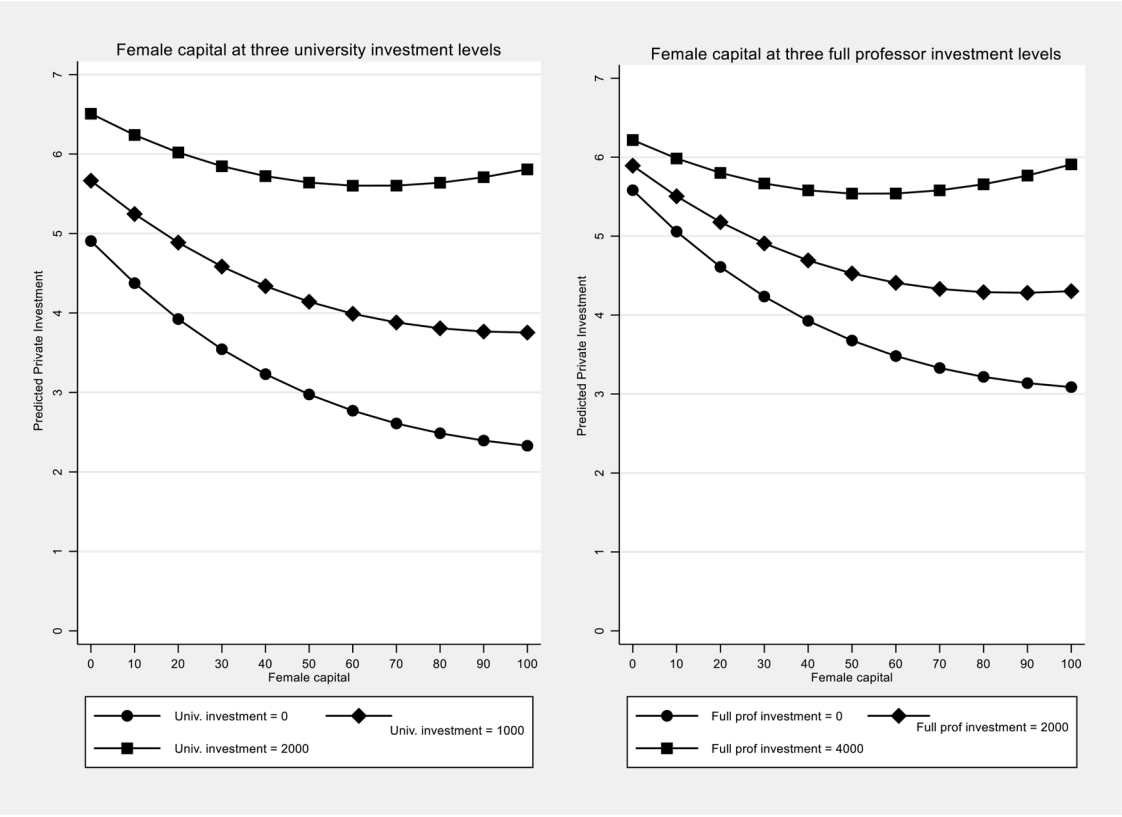


**Fig. 2.** Predicted marginal effects of parent university and full professors' investment on private investment at different levels of female capital ($N = 526$).

more of the capital only in 11.60% of the ASOs and the differences in private investment in the various configurations of the ownership structure are noticeable. Indeed, the predictive marginal effects presented in Fig. 2 indicate that the expected private investment for a male-only ASO not backed by its parent university is €4900; with an investment by the parent university of €1000, the amount increases to €6500, indicating a considerable multiplier effect. With the growth of female ownership, the expected private investment drops to €2330 for a venture owned only by women—a level that is less than half of a male-only venture. The parent university's investment improves the ability of female-owned ASOs to attract external funding and helps close the gap with male-all ventures. Calculations on the predictive marginal effects reveal that to attract a similar amount of private investment as a men-only ASO that its parent university does not back, a female-only ASO needs an investment from the parent university of about €1,600. The effect is similar for investment by full professors.

Table 5 presents the average marginal effects on investment brought by the signals relative to the parent university's and full professors' stake and the patent endowment. At any level of female ownership, holding other factors constant, parent university investment and full professors' investment have a statistically significant association with private investment. As expected via *Hypotheses 2* and *3,* the amount invested by the parent university and by full professors moderates the relationship between the degree of female ownership and the private investment, so that the negative relationship between the former and the latter becomes less pronounced. Finally, the entrepreneurial team's patenting experience does not affect the signal brought by female ownership, contrary to the expectations of Hypothesis 4.

### 4.3. Robustness tests

We tested the robustness of our results by considering an alternative measure of female engagement in the entrepreneurial team, namely the percentage of female team members. Tables 6 and 7 report the marginal effects derived from the results of three multi-level Tobit regressions in which this variable interacts with the other signals (full models are available upon request).

Table 6 confirms that increasing women's presence is associated with a reduction in the amount raised from private investors, and the penalty is greater for ASOs that do not feature their parent university or full professors among their shareholders. Comparing these results to our main model, we observe that the effect is negative and significant for any percentage of female shareholders, meaning that adding an additional woman to a female-dominated team brings a negative signal, regardless of their share of capital. This finding suggests that the negative signal is associated with the mere presence of women rather than with their decision-making power.

Table 7 reiterates the positive effect of university investment and the lack of significant effect of patenting experience for private investment, while it shows that full professors help leverage additional private investment as long as women account for 80% or less of the members.

**Table 7**
Average marginal effects of parent university and full professors' investment on private investment at different levels of female individuals ($N = 526$).

| Female individuals | Parent university investment | Full professors' investment | Patents |
|---|---|---|---|
| 0% | 0.806*** (0.272) | 0.279** (0.120) | -0.109 (0.082) |
| 20% | 1.032*** (0.195) | 0.281*** (0.094) | -0.056 (0.065) |
| 50% | 1.282*** (0.212) | 0.281*** (0.108) | 0.008 (0.137) |
| 80% | 1.476*** (0.325) | 0.284 (0.150) | 0.058 (0.212) |
| 100% | 1.539*** (0.416) | 0.288 (0.182) | 0.086 (0.259) |

*$p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

## 5. Discussion

This work shows the power of a negative involuntary signal, gender, and the interplay of such signals with two voluntary positive ones, namely the equity owned by the parent university and by full professors, on private investment in the capital of ASOs. The study shows that the amount of finance raised by an ASO from private investors is negatively associated with the share of capital in female entrepreneurial team members' hands, and in particular, that even with a tiny percentage of shares, the inclusion of a woman tends to reduce the amount of funding obtained by private investors. This finding confirms the idea of the existence of a deeply rooted propensity of business people to value men as more successful managers, more competent, self-confident, ambitious, and worthy of authority and leadership (Doering and Thébaud, 2017; Heilman et al., 1989) and shows that female ownership sends an involuntary negative signal about the business potential of a venture. As argued by Edelman et al. (2018: 135) "the image of an entrepreneur is grounded predominantly in male gender-stereotypical notions of 'masculinity.' In sum, biases against women-led entrepreneurial firms continue in the early-stage investment decision-making process."

Our results are even more noticeable given the context of investigation, namely academic entrepreneurship, where scientific knowledge should overcome any gender gap. Unfortunately, this is not so. Contrariwise, we find that the knowledge base of ASOs—measured as scientific production, which arguably should smoothen gender differences—is surprisingly a factor of lesser importance for private investors, who, when female academics are involved, assign a greater weight to endorsement by the parent university and investment by full professors. Although sad, this finding is in line with the notion that the gender of an entrepreneur affects investor decisions more than the entrepreneur's knowledge base (Gupta et al., 2009; Edelman et al., 2018; Johansson et al., 2021).

Indeed, our results indicate that including parent universities or full professors among the shareholders can operate as a positive voluntary signal that can offset the involuntary negative signal sent by the

**Table 6**
Average marginal effects of female capital on private investment for selected levels of parent university and full professors' investment ($N = 526$).

| | Parent university investment | | | Full professors' investment | | |
|---|---|---|---|---|---|---|
| | 0 | 1,000 | 2,000 | 0 | 2,000 | 4,000 |
| 0% | -0.047*** (0.015) | -0.036** (0.016) | -0.020 (0.020) | -0.035*** (0.014) | -0.035* (0.017) | -0.035 (0.021) |
| 20% | -0.040*** (0.011) | -0.032** (0.013) | -0.019 (0.018) | -0.032*** (0.012) | -0.032** (0.014) | -0.032 (0.019) |
| 50% | -0.031*** (0.007) | -0.027*** (0.010) | -0.017 (0.016) | -0.026*** (0.008) | -0.027*** (0.010) | -0.027 (0.014) |
| 80% | -0.024*** (0.004) | -0.023*** (0.006) | -0.016 (0.013) | -0.022*** (0.005) | -0.023*** (0.007) | -0.024*** (0.010) |
| 100% | -0.019*** (0.002) | -0.021*** (0.005) | -0.157 (0.012) | -0.019*** (0.004) | -0.021*** (0.005) | -0.022*** (0.008) |

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

presence of women in share ownership (e.g., (Munari et al., 2015) Gubitta et al. 2016). As a matter of fact, the intensity of the impact of the inclusion of the parent university and full professors is more vigorous for situations characterized by greater levels of perceived uncertainty. The impact is positive but small and somewhat redundant for all-male companies; it grows along with the percentage of shares in the hands of female shareholders and it reaches the highest level for all-female companies. These findings emphasize the importance of shifting the attention from the study of signals in isolation from each other to the appreciation of their complementary or substitution effects, that acknowledges the notion that signal receivers make their decisions on the basis of bundles of signals.

Surprisingly, we find nonsignificant signaling effect of the technological capabilities of the entrepreneurial team, notwithstanding the complementarity between patenting and academic entrepreneurship highlighted by Landry et al. (2010) and the evidence that in general high-technology start-ups with a patent portfolio have easier access to finance (Audretsch et al., 2012), especially from business angles (Conti et al., 2013). In analyses not reported here, we have tested whether the effect of technological capabilities is industry-dependent without finding any significant effect. We speculate that the lack of relationship with the amount of capital raised may be due to the fact that many ASOs are employed as vehicles of commercialization of research with a predominant tacit component or based on general scientific expertise (Karnani, 2013; Lee, 2020), and, when this is the case, patents do not add much information in terms of appropriability or commercial viability of the company.

The results of this study, which brings in the team dimension, are consistent with the notion that the definition of business idea and team formation are mutually dependent (Lazar et al., 2020): an external observer can gather information about the viability of the former by observing the latter. This feature of the firm has typically been overlooked by researchers studying access to external financial resources (among the few exceptions, see, for example, Beckman et al. 2007, Colombo and Grilli 2010). Our study, compared with studies focusing only on business leaders (e.g., Busenitz et al. 2005, Eddleston et al., 2016, Alsos and Ljunggren 2017), shows that the use of teams leads to a better understanding of the influence of social status and stereotypes (Ridgeway, 1991, (Ridgeway, 2007)) on access to capital. Indeed, it would be difficult to argue that the inclusion of an additional female shareholder could transform the technology or the product or that the size of the human and social capital of the other team members could alter so radically as to affect a financer decision. Importantly, our results support the notion that the negative bias against women entrepreneurs emerges as a consequence of their biological sex (consistently with the findings of, e.g., Edelman et al. 2018), rather than of the display of behaviors associated with feminine stereotypes—as other researchers have found (e.g., Cuddy et al. 2011, (Balachandra et al., 2019) , Gupta et al., 2019). Further, today, lone entrepreneurs are the exception, particularly in high-technology sectors, and focusing only on the leader limits the analysis to a small fraction of the forces having an impact on the company's potential, technical competence, and decision-making processes (e.g., Colyvas et al. 2012, Stephan and El-Ganainy 2007).

### 5.1. Managerial and policy implications

Our study offers the general insight that entrepreneurs need to thoroughly assess the negative signals that they may be sending to external financers and operate in ways to offset those signals with positive ones, deriving from a number of specific resources. In particular, it was shown that in the case of ASOs, patents and research productivity may not be as effective positive signals as could be expected.

The growing body of scientific and informative publications dealing with gender gap in general and gender financing gap in particular and the emergence of an ever growing number of women entrepreneurs will progressively transform the perception of the ideal type entrepreneur. Before this happens, however, our findings offer two important pieces of advice to female academics wanting to start a company: female scientists should be aware of the mechanisms of the gender-based negative signals in entrepreneurship; moreover, they need to concentrate on acquiring or accumulating those resources that are shown to send positive signals to external financers, therefore acting strategically regarding the definition of the entrepreneurial team and, even more importantly, actively seeking the support of their parent university and of full professors. Specifically, it seems that female full professors could play a relevant role in mentoring potential female academic entrepreneurs and—thanks to their position—act as gatekeepers to facilitate the acquisition of resources such as legitimacy and social capital.

With regard to technology transfer policy, policymakers should allow universities to invest in ASOs that they deem commercially viable. Legislation forbidding universities from investing in ASOs would prevent these firms from overcoming their liability of newness by gaining the support of an authoritative stakeholder, penalizing, in particular, those founded by members of groups that are marginal in academia and business. Along similar lines, policies requiring universities to match private investment would be confusing from a signaling perspective.

Further, universities should be aware that their decision to support or not support an ASO has long-term consequences for the latter's ability to raise additional resources and should pursue the design of fair and informed evaluation processes for assessing ASOs' authorization and funding requests, which appears as a prerequisite for achieving such a goal. Relatedly, universities lacking adequate competencies in their technology transfer offices could rely on external advisors for the evaluation process.

Finally, the insight that team composition matters more than technological capabilities in influencing the funding decision highlights the importance of reducing potential biases also of university evaluators. Toward this end, universities could train assessors to recognize and address cognitive biases in financial evaluation, and technology transfer offices could adopt arrangements to limit evaluators' biases, such as assuring that evaluation committees are gender-balanced and introducing multiple-step, blinded evaluation processes. Such a process would consist of an initial assessment of the commercial and technological aspects of the business plan without divulging the constitution of the proponents; in such a system, the identities of the entrepreneurial team and information about their social capital would be disclosed only at a later stage. Considering that the mainstream entrepreneurship literature has shown that *ceteris paribus*, male- and female-led companies achieve similar performance (Farhat and Mijid, 2018), these arrangements would help mitigate the distortions in the financing process that may leave companies with potential for growth unfunded.

## 6. Conclusion

De Bruin et al. (2006: 590) argued in 2006 that "women's entrepreneurship research is at the early childhood stage." After 15 years, we can affirm that this is still true about research on women's role in the founding teams of ASOs. Our analysis is one of the first attempts to elucidate the relationship between the gender composition of entrepreneurial teams and a firm's ability to access financial resources.

A critical insight of this study is that female ownership sends a negative signal to investors about the viability of a new venture, but female-owned ASOs can reduce this effect by gaining powerful actors in their organizational fields, such as their parent university and full professors.

As the overall social structure of the academic system is reflected in novel organizational fields such as academic entrepreneurship, education institutions have the responsibility to ensure equal treatment, favor diversity, and reduce stereotypes and thus are called to lead the best practices about gender that other actors could follow. Academia should indeed be more open-minded than the rest of society at large: as reminded by Bobbitt-Zeher (2007: 1), "many consider education to be

key to reducing group inequalities." This work suggests that, by managing the consequences of gender stereotyping in the broader society, universities can facilitate the commercialization of promising research results.

The results of this study open a series of possible avenues for further research. First of all, the study focuses on the moment of founding an ASO, therefore leaving out of the scope of investigation issues such as the efficacy of the signals to anticipate the medium- and long-term performance of the new venture, for example, in terms of financial performance, employee growth, and the ability to raise additional finance. Adopting a dynamic perspective would enhance our understanding of the signaling power of ASO ownership (Connelly et al., 2011). Second, our study considers the effect of each signal in isolation from the others—except for the interaction with the degree of female ownership. A fruitful avenue for research could entail appreciating the intricacies of the complementary and substitution effects among multiple kinds of signals (Colombo, 2021). Third, our research design focuses on one side of the signaling circuit (Connelly et al., 2011)—the sender. Further research could build on our results to appreciate the variations of the signaling effect across various categories of investors, defined by characteristics such as their nature (e.g., business angel, venture capitalist, industrial investor, etc.), familiarity with the academic system, and the gender of the decision-makers in the investing firm.

Akin to other research, this too is circumscribed by limitations. First, as in much of the academic literature, we improperly referred to gender as the biological sex of entrepreneurial team members. Fruitful research avenues can be opened by a more appropriate operationalization of the concept, referring to socially constructed sex (Ahl, 2006). Second, our research design did not capture the cause-effect relationships between the variables, as the relationship between the composition of the entrepreneurial teams and private investors' presence may be endogenous. Third, our study focuses on equity investment, not considering other sources of financing that the same shareholders may provide to the firm, such as loans or research grants. Fourth, although the data for our empirical study are drawn from multiple official data sources, it was not possible to track the formal and informal collaborations of academics with industrial partners before the founding of the firm, which may be relevant in the entrepreneurial process. Fifth, our empirical study does not directly characterize the complexity of the ownership structure, as particularly complicated or concentrated ownership structures may deter private investors from financing a venture. Sixth, our data sources do not provide information about the gender of the decision maker(s) on the investor side, which can significantly influence the financing process (e.g., Ewens and Townsend 2020). We expect that most decision makers on the investors' side are male, but we do not have data to support this expectation. More fine-grained analyses of the investment decision should take into consideration the gender of the decision maker(s) on the investor side. Finally, this study considers only one country, Italy, and the results may reflect the features of its academic, regulatory, and cultural setting. However, it should be noted that Italy shares similarities in the timing and size of the phenomenon of academic entrepreneurship, the direction of policy initiatives, and the performance of ASOs with other European countries (Grimaldi et al., 2011). Nonetheless, future cross-country comparative studies may discover novel facets of the phenomenon.

Despite these limitations, we believe that this work may help scholarship move one step forward in the "grand challenge" of gender inequality (Joshi et al., 2015:1472) and the understanding of the dynamics of science commercialization (Hmieleski and Powell, 2018).

## CRediT authorship contribution statement

**Giancarlo Lauto:** Conceptualization, Data curation, Formal analysis, Methodology, Validation, Writing – original draft, Writing – review & editing. **Elisa Salvador:** Conceptualization, Data curation, Formal analysis, Methodology, Validation, Writing – original draft, Writing – review & editing. **Francesca Visintin:** Conceptualization, Writing – original draft, Writing – review & editing.

## 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.

## Acknowledgments

The authors would like to thank Laura Mongitore for her help with data collection.

Earlier versions of this paper have been presented at DRUID Summer Conference 2018, EURAM 2018, Conférence Internationale de Management Stratégique (AIMS) 2018, EGOS 2019. The authors would like to thank all participants for their feedback and suggestions. The authors are grateful to Lucia Naldi (Jönköping International Business School) for her insightful comments on an earlier version of this study. The authors would like to thank editor Ben Martin for his excellent guidance and for believing in the value of this study, and all three anonymous reviewers who offered detailed and insighful comment that were instrumental for improving our paper. Finally, we acknowledge the Erasmus+ visiting program: we developed the initial idea, and we advanced on revisions during international exchanges between ESSCA School of Management and the University of Udine.

The usual disclaimers apply.

## Appendix. Mean, standard deviation and pairwise correlations

| | Mean (S.D.) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Private investment | 4.85 (21.66) | 1 | | | | | | | | | | | | | | | | | | | | | |
| 2. Female capital | 20.30 (24.68) | 0.00 | 1 | | | | | | | | | | | | | | | | | | | | |
| 3. Female individuals | 21.94 (23.96) | -0.01 | 0.93 | 1 | | | | | | | | | | | | | | | | | | | |
| 4. Parent university | 0.97 (3.60) | 0.80 | 0.02 | 0.02 | 1 | | | | | | | | | | | | | | | | | | |
| 5. Full professors | 3.32 (7.63) | 0.65 | -0.04 | -0.02 | 0.60 | 1 | | | | | | | | | | | | | | | | | |
| 6. Patents | 3.34 (6.55) | 0.04 | -0.07 | -0.08 | 0.03 | 0.12 | 1 | | | | | | | | | | | | | | | | |
| 7. Associate professors | 2.18 (5.83) | 0.69 | 0.03 | 0.04 | 0.71 | 0.44 | 0.06 | 1 | | | | | | | | | | | | | | | |
| 8. Assistant professors | 2.04 (3.08) | 0.02 | -0.01 | -0.01 | 0.04 | 0.09 | -0.06 | -0.09 | 1 | | | | | | | | | | | | | | |
| 9. Experienced non-academics | 4.33 (7.01) | -0.02 | -0.02 | -0.01 | 0.05 | 0.11 | -0.05 | 0.05 | 0.23 | 1 | | | | | | | | | | | | | |
| 10. Inexperienced non-academics | 3.69 (5.99) | 0.10 | 0.05 | 0.04 | -0.01 | 0.18 | 0.05 | 0.10 | 0.09 | 0.10 | 1 | | | | | | | | | | | | |

(continued on next page)

(*continued*)

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11. Public administration | 0.02 (0.39) | -0.02 | -0.01 | 0.01 | -0.01 | 0.10 | 0.01 | 0.00 | 0.02 | 0.06 | -0.01 | 1 | | | | | | | | | | | | |
| 12. Publications | 66.78 (83.56) | 0.07 | 0.06 | 0.06 | 0.06 | 0.20 | 0.36 | 0.02 | -0.05 | -0.08 | 0.07 | 0.01 | 1 | | | | | | | | | | | |
| 13. Team size | 5.62 (3.53) | -0.06 | 0.10 | 0.16 | 0.01 | 0.03 | 0.06 | -0.08 | 0.11 | 0.21 | 0.16 | 0.03 | 0.08 | 1 | | | | | | | | | | |
| 14. R&D & Pharmaceutical | 0.42 (0.49) | 0.04 | 0.11 | 0.14 | -0.01 | 0.05 | 0.15 | 0.02 | -0.02 | -0.09 | 0.00 | 0.02 | 0.28 | -0.08 | 1 | | | | | | | | | |
| 15. ICT | 0.18 (0.39) | 0.00 | -0.09 | -0.13 | 0.00 | 0.02 | -0.15 | 0.00 | 0.05 | 0.11 | 0.02 | -0.01 | -0.13 | -0.02 | -0.41 | 1 | | | | | | | | |
| 16. Technical consultancy | 0.20 (0.40) | -0.06 | 0.02 | 0.04 | -0.01 | -0.02 | -0.08 | -0.02 | -0.07 | -0.01 | -0.03 | -0.03 | -0.11 | 0.07 | -0.42 | -0.24 | 1 | | | | | | | |
| 17. Manufacturing | 0.10 (0.31) | 0.00 | -0.15 | -0.17 | 0.03 | -0.04 | 0.17 | 0.05 | 0.08 | 0.06 | 0.05 | 0.05 | -0.03 | 0.01 | -0.29 | -0.16 | -0.17 | 1 | | | | | | |
| 18. Non-technical consultancy | 0.09 (0.29) | 0.02 | 0.06 | 0.07 | 0.01 | -0.06 | -0.13 | -0.06 | -0.01 | -0.05 | -0.05 | -0.02 | -0.12 | 0.06 | -0.27 | -0.15 | -0.15 | -0.11 | 1 | | | | | |
| 19. University size | 1279 (878) | 0.01 | -0.02 | 0.00 | 0.00 | 0.00 | -0.03 | 0.02 | -0.02 | -0.04 | -0.01 | 0.03 | 0.10 | -0.03 | 0.05 | -0.01 | -0.04 | 0.02 | -0.03 | 1 | | | | |
| 20. Cumulated ASOs | 9.46 (8.08) | -0.06 | 0.07 | 0.03 | -0.11 | -0.16 | 0.07 | -0.04 | -0.05 | -0.09 | 0.02 | -0.02 | -0.04 | -0.10 | 0.04 | -0.06 | 0.02 | -0.02 | 0.01 | 0.02 | 1 | | | |
| 21. Cumulated private investment | 48.49 (77.31) | -0.02 | 0.01 | -0.03 | -0.02 | -0.06 | 0.06 | -0.03 | -0.02 | -0.03 | 0.00 | -0.02 | 0.02 | -0.13 | 0.05 | -0.02 | -0.02 | 0.00 | -0.03 | 0.05 | 0.45 | 1 | | |
| 22. University type | 0.11 (0.31) | 0.01 | -0.10 | -0.12 | 0.06 | -0.02 | 0.10 | 0.04 | 0.06 | 0.02 | -0.01 | -0.02 | -0.09 | -0.10 | -0.07 | -0.05 | 0.03 | 0.17 | -0.05 | -0.17 | 0.23 | 0.14 | 1 | |

Values referring to amount of investment are expressed in thousands.

## References


Abramo, G., D'Angelo, C.A., Ferretti, M., Parmentola, A., 2012. An individual-level assessment of the relationship between spinoff activities and research performance in universities. R&D Manag. 42 (3), 225–242.

Abreu, M., Grinevich, V., 2017. Gender patterns in academic entrepreneurship. J. Technol. Transf. 42 (4), 763–794.

Aguinis, H., Gottfredson, R.K., Culpepper, S.A., 2013. Best-practice recommendations for estimating cross-level interaction effects using multi-level modeling. J. Manag. 39 (6), 1490–1528.

Ahl, H., 2006. Why research on women entrepreneurs needs new directions. Entrep. Theory Pract. 30 (5), 595–621.

Alonso-Galicia, P.E., Fernandez-Perez, V., Rodriguez-Ariza, L., Fuentes-Fuentes, M.D.M., 2015. Entrepreneurial cognitions in academia: exploring gender differences. J. Manag. Psychol. 30 (6), 630–644.

Alsos, G.A., Ljunggren, E., 2017. The role of gender in entrepreneur–investor relationships: a signaling theory approach. Entrep. Theory Pract. 41 (4), 567–590.

Ambos, T.C., Birkinshaw, J., 2010. How do new ventures evolve? An inductive study of archetype changes in science-based ventures. Organization Science 21 (6), 1125–1140.

Arundel, A., 2001. The relative effectiveness of patents and secrecy for appropriation. Res. Policy 30 (4), 611–624.

Audretsch, D.B., Bönte, W., Mahagaonkar, P., 2012. Financial signaling by innovative nascent ventures: the relevance of patents and prototypes. Res. Policy 41 (8), 1407–1421.

Balachandra, L, Briggs, T, Eddleston, K, Brush, C, 2019. Don't pitch like a girl!: How gender stereotypes influence investor decisions. Entrepreneurship Theory and Practice 43 (1), 116–137.

Beaudry, C., Larivière, V., 2016. Which gender gap? Factors affecting researchers' scientific impact in science and medicine. Res. Policy 45 (9), 1790–1817.

Beckman, C.M., Burton, M.D., O'Reilly, C., 2007. Early teams: the impact of team demography on VC financing and going public. J. Bus. Ventur. 22 (2), 147–173.

Bertoni, F., Colombo, M.G., Grilli, L., 2011. Venture capital financing and the growth of high-tech start-ups: disentangling treatment from selection effects. Res. Policy 40 (7), 1028–1043.

Bigelow, L., Lundmark, L., McLean Parks, J., Wuebker, R., 2014. Skirting the issues: experimental evidence of gender bias in IPO prospectus evaluations. J. Manag. 40 (6), 1732–1759.

Bobbitt-Zeher, D., 2007. The gender income gap and the role of education. Sociol. Educ. 80 (1), 1–22.

Bock, C., Huber, A., Jarchow, S., 2018. Growth factors of research-based spinoffs and the role of venture capital investing. J. Technol. Transf. 43 (5), 1375–1409.

Breschi, S., Lassébie, J., Menon, C., 2018. A portrait of innovative start-ups across countries. OECD Science, Technology and Industry Working Papers 02, 1–61. https://doi.org/10.1787/f9ff02f4-en.

Brooks, A.W., Huang, L., Kearney, S.W., Murray, F.E., 2014. Investors prefer entrepreneurial ventures pitched by attractive men. Proc. Natl. Acad. Sci. 111 (12), 4427–4431.

Busenitz, L.W., Fiet, J.O., Moesel, D.D., 2005. Signaling in venture capitalist—New venture team funding decisions: does it indicate long-term venture outcomes? Entrep. Theory Pract. 29 (1), 1–12.

Champenois, C., Engel, D., Heneric, O., 2006. What kind of German biotechnology start-ups do venture capital companies and corporate investors prefer for equity investments? Appl. Econ. 38 (5), 505–518.

Clarysse, B., Tartari, V., Salter, A., 2011. The impact of entrepreneurial capacity, experience and organizational support on academic entrepreneurship. Res. Policy 40 (8), 1084–1093.

Colombo, M.G., Grilli, L., 2010. On growth drivers of high-tech start-ups: exploring the role of founders' human capital and venture capital. J. Bus. Ventur. 25 (6), 610–626.

Colombo, M.G., Meoli, M., Vismara, S., 2019. Signaling in science-based IPOs: the combined effect of affiliation with prestigious universities, underwriters, and venture capitalists. J. Bus. Ventur. 34 (1), 141–177.

Colombo, O., 2021. The use of signals in new-venture financing: a review and research agenda. J. Manag. 47 (1), 237–259.

Colyvas, J.A., Snellman, K., Bercovitz, J., Feldman, M., 2012. Disentangling effort and performance: a renewed look at gender differences in commercializing medical school research. J. Technol. Transf. 37 (4), 478–489.

Connelly, B.L., Certo, S.T., Ireland, R.D., Reutzel, C.R., 2011. Signaling theory: a review and assessment. J. Manag. 37 (1), 39–67.

Conti, A., Thursby, M., Rothaermel, F.T., 2013. Show me the right stuff: signals for high-tech start-ups. J. Econ. Manag. Strat. 22 (2), 341–364.

Cuddy, A.J., Glick, P., Beninger, A., 2011. The dynamics of warmth and competence judgments, and their outcomes in organizations. Res. Organ. Behav. 31, 73–98.

De Bruin, A., Brush, C.G., Welter, F., 2006. Introduction to the special issue: towards building cumulative knowledge on women's entrepreneurship. Entrep. Theory Pract. 30 (5), 585–593.

Dean, H., Ford, J., 2017. Discourses of entrepreneurial leadership: exposing myths and exploring new approaches. Int. Small Bus. J. 35 (2), 178–186.

Di Paola, N., 2021. Pathways to academic entrepreneurship: the determinants of female scholars' entrepreneurial intentions. J. Technol. Transf. 46 (5), 1417–1441.

Doering, L., Thébaud, S., 2017. The effects of gendered occupational roles on men's and women's workplace authority: evidence from microfinance. Am. Sociol. Rev. 82 (3), 542–567.

Drover, W., Busenitz, L., Matusik, S., Townsend, D., Anglin, A., Dushnitsky, G., 2017. A review and road map of entrepreneurial equity financing research: venture capital, corporate venture capital, angel investment, crowdfunding, and accelerators. J. Manag. 43 (6), 1820–1853.

Ebersberger, B., Pirhofer, C., 2011. Gender, management education and the willingness for academic entrepreneurship. Appl. Econ. Lett. 18 (9), 841–844.

Eddleston, K.A., Ladge, J.J., Mitteness, C., Balachandra, L., 2016. Do you see what I see? Signaling effects of gender and firm characteristics on financing entrepreneurial ventures. In: Entrep. Theory Pract., 40, pp. 489–514.

Edelman, L.F., Donnelly, R., Manolova, T., Brush, C.G., 2018. Gender stereotypes in the angel investment process. Int. J. Gend. Entrep. 10 (2), 134–157.

European Commission, 2021. She Figures 2021: Gender in Research and Innovation. Statistics and Indicators. European Commission Publications Office. https://data.europa.eu/doi/10.2777/06090.

EIGE, 2021. Gender Equality Index. EIGE. https://eige.europa.eu/gender-equality-index/2013/compare-countries/index/table.

Ewens, M., Townsend, R.R., 2020. Are early stage investors biased against women? J. Financ. Econ. 135 (3), 653–677.

Farhat, J., Mijid, N., 2018. Do women lag behind men? A matched-sample analysis of the dynamics of gender gaps. J. Econ. Financ. 42 (4), 682–709.

Fisch, C., 2019. Initial coin offerings (ICOs) to finance new ventures. J. Bus. Ventur. 34 (1), 1–22.

Forbes, D.P., Korsgaard, M.A., Sapienza, H.J., 2010. Financing decisions as a source of conflict in venture boards. J. Bus. Ventur. 25 (6), 579–592.

Fotaki, M., 2013. No woman is like a man (in academia): the masculine symbolic order and the unwanted female body. Organ. Stud. 34 (9), 1251–1275.

Fuller, A.W., Rothaermel, F.T., 2012. When stars shine: the effects of faculty founders on new technology ventures. Strateg. Entrep. J. 6 (3), 220–235.

Gans, J.S., Murray, F.E., Stern, S., 2017. Contracting over the disclosure of scientific knowledge: intellectual property and academic publication. Res. Policy 46 (4), 820–835.

Gicheva, D., Link, A.N., 2013. Leveraging entrepreneurship through private investments: does gender matter? Small Bus. Econ. 40 (2), 199–210.

Giuri, P., Grimaldi, R., Kochenkova, A., Munari, F., Toschi, L., 2020. The effects of university-level policies on women's participation in academic patenting in Italy. J. Technol. Transf. 45, 122–150.

Global Entrepreneurship Monitor, 2022. Female/Male TEA. Global Entrepreneurship Monitor. https://www.gemconsortium.org/data.
Goastellec, G., Pekari, N., 2013. Gender differences and inequalities in academia: findings in Europe. In: Teichler, U., Höhle, E. (Eds.), The Work Situation of the Academic Profession in Europe: Findings of a Survey in Twelve Countries. Springer, Dordrecht, pp. 55–78.
Goel, R.K., Göktepe-Hultén, D., Ram, R., 2015. Academics' entrepreneurship propensities and gender differences. J. Technol. Transf. 40 (1), 161–177.
Greene, P.G., Brush, C.G., Hart, M.M., Saparito, P., 2001. Patterns of venture capital funding: is gender a factor? Ventur. Cap. 3 (1), 63–83.
Grimaldi, R., Kenney, M., Siegel, D.S., Wright, M., 2011. 30 years after Bayh–Dole: reassessing academic entrepreneurship. Res. Policy 40 (8), 1045–1057.
Gubitta, P., Tognazzo, A., Destro, F., 2016. Signaling in academic ventures: the role of technology transfer offices and university funds. J. Technol. Transf. 41 (2), 368–393.
Gupta, V.K., Turban, D., Wasti, S.A., Sikdar, A., 2009. The role of gender stereotypes in perceptions of entrepreneurs and intentions to become an entrepreneur. Entrep. Theory Pract. 33 (2), 397–417.
Gupta, V.K., Wieland, A.M., Turban, D.B., 2019. Gender characterizations in entrepreneurship: a multi-level investigation of sex-role stereotypes about high-growth, commercial, and social entrepreneurs. J. Small Bus. Manag. 57 (1), 131–153.
Gurdon, M.A., Samsom, K.J., 2010. A longitudinal study of success and failure among scientist-started ventures. Technovation 30 (3), 207–214.
Haeussler, C., Colyvas, J.A., 2011. Breaking the ivory tower: academic entrepreneurship in the life sciences in UK and Germany. Res. Policy 40 (1), 41–54.
Hayter, C.S., 2015. Public or private entrepreneurship? Revisiting motivations and definitions of success among academic entrepreneurs. J. Technol. Transf. 40 (6), 1003–1015.
Heilman, M.E., Block, C.J., Martell, R.F., Simon, M.C., 1989. Has anything changed? Current characterizations of men, women, and managers. J. Appl. Psychol. 74 (6), 935.
Higgins, M.J., Stephan, P.E., Thursby, J.G., 2011. Conveying quality and value in emerging industries: star scientists and the role of signals in biotechnology. Res. Policy 40 (4), 605–617.
Hmieleski, K.M., Powell, E.E., 2018. The psychological foundations of university science commercialization: a review of the literature and directions for future research. In: Acad. Manag. Perspect., 32, pp. 43–77.
Hoenig, D., Henkel, J., 2015. Quality signals? The role of patents, alliances, and team experience in venture capital financing. Res. Policy 44 (5), 1049–1064.
ILO, 2017. Economic Impacts of Reducing the Gender Gap. International Labour Organization.
IMF, 2018. Economic Gains From Gender Inclusion: New Mechanism, New Evidence. International Monetary Fund.
Jennings, J.E., Brush, C.G., 2013. Research on women entrepreneurs: challenges to (and from) the broader entrepreneurship literature? Acad. Manag. Ann. 7 (1), 663–715.
Jin, L., Madison, K., Kraiczy, N.D., Kellermanns, F.W., Crook, T.R., Xi, J., 2017. Entrepreneurial team composition characteristics and new venture performance: a meta–analysis. Entrep. Theory Pract. 41 (5), 743–771.
Johansson, J., Malmström, M., Lahti, T., Wincent, J., 2021. Oh, it's complex to see women here, isn't it and this seems to take all my attention! J. Bus. Ventur. Insights 15, e00218.
Joshi, A., Neely, B., Emrich, C., Griffiths, D., George, G., 2015. Gender research in AMJ: an overview of five decades of empirical research and calls to action: thematic issue on gender in management research. Acad. Manag. J. 58 (5), 1459–1475.
Kanze, D., Conley, M.A., Okimoto, T.G., Phillips, D.J., Merluzzi, J., 2020. Evidence that investors penalize female founders for lack of industry fit. Sci. Adv. 6 (48), eabd7664.
Kanze, D., Huang, L., Conley, M.A., Tory Higgins, E., 2018. We ask men to win and women not to lose: closing the gender gap in start-up funding. Acad. Manag. J. 61 (2), 586–614.
Karnani, F., 2013. The university's unknown knowledge: Tacit knowledge, technology transfer and university spinoffs findings from an empirical study based on the theory of knowledge. J. Technol. Transf. 38, 235–250.
Khoury, T.A., Junkunc, M., Deeds, D.L., 2013. The social construction of legitimacy through signaling social capital: exploring the conditional value of alliances and underwriters at IPO. Entrep. Theory Pract. 37 (3), 569–601.
Kleinert, S., Mochkabadi, K., 2021. Gender stereotypes in equity crowdfunding: the effect of gender bias on the interpretation of quality signals. Journal of Technology Transfer. https://doi.org/10.1007/s10961-021-09892-z.
Landry, R., Saïhi, M., Amara, N., Ouimet, M., 2010. Evidence on how academics manage their portfolio of knowledge transfer activities. Res. Policy 39 (10), 1387–1403.
Lazar, M., Miron-Spektor, E., Agarwal, R., Erez, M., Goldfarb, B., Chen, G., 2020. Entrepreneurial team formation. Acad. Manag. Ann. 14 (1), 29–59.
Lee, P., 2020. Tacit knowledge and university-industry technology transfer. In: Rooksby, J.H. (Ed.), Research Handbook on Intellectual Property and Technology Transfer. Edward Elgar Publishing.
Malmström, M., Johansson, J., Wincent, J., 2017. Gender stereotypes and venture support decisions: how governmental venture capitalists socially construct entrepreneurs' potential. Entrep. Theory Pract. 41 (5), 833–860.
Malmström, M., Voitkane, A., Johansson, J., Wincent, J., 2020. What do they think and what do they say? Gender bias, entrepreneurial attitude in writing and venture capitalists' funding decisions. J. Bus. Ventur. Insights 13, e00154.
Mathisen, M.T., Rasmussen, E., 2019. The development, growth, and performance of university spinoffs: a critical review. J. Technol. Transf. 44 (6), 1891–1938.
Meng, Y., 2016. Collaboration patterns and patenting: exploring gender distinctions. Res. Policy 45 (1), 56–67.
Merton, R.K., 1968. The Matthew effect in science. the reward and communication systems of science are considered. Science 159 (3810), 56–63.
Merton, R.K., 1988. The Matthew effect in science, II. Cumulative advantage and the symbolism of intellectual property. ISIS 79, 606–623.
Micozzi, A., Micozzi, F., Pattitoni, P., 2016. Fostering female entrepreneurship in academic spinoffs. In: Audretsch, D., Lehmann, E., Meoli, M., Vismara, S. (Eds.), University Evolution, Entrepreneurial Activity and Regional, Competitiveness. Springer, London, pp. 49–70.
Munari, F., Pasquini, M., Toschi, L., 2015. From the lab to the stock market? The characteristics and impact of university-oriented seed funds in Europe. Journal of Technology Transfer 40 (6), 948–975.
Murphy, P.J., Kickul, J., Barbosa, S.D., Titus, L., 2007. Expert capital and perceived legitimacy: female-run entrepreneurial venture signalling and performance. Int. J. Entrep. Innov. 8 (2), 127–138.
Muscio, A., Quaglione, D., Ramaciotti, L., 2016. The effects of university rules on spinoff creation: the case of academia in Italy. Res. Policy 45 (7), 1386–1396.
Perkmann, M., Salandra, R., Tartari, V., McKelvey, M., Hughes, A., 2021. Academic engagement: A review of the literature 2011-2019. Research Policy 50 (1), 104114. https://doi.org/10.1016/j.respol.2020.104114.
Poggesi, S., Mari, M., De Vita, L., Foss, L., 2020. Women entrepreneurship in STEM fields: literature review and future research avenues. Int. Entrep. Manag. J. 16 (1), 17–41.
Pollock, T.G., Chen, G., Jackson, E.M., Hambrick, D.C., 2010. How much prestige is enough? Assessing the value of multiple types of high-status affiliates for young firms. J. Bus. Ventur. 25 (1), 6–23.
Rabe-Hesketh, S., Skrondal, A., 2012. Multi-Level and Longitudinal Modeling Using Stata. STATA Press, College Station, TX.
Ramaciotti, L., Rizzo, U., 2015. The determinants of academic spin-off creation by Italian universities. R&D Manag. 45 (5), 501–514.
Rasmussen, E., Mosey, S., Wright, M., 2011. The evolution of entrepreneurial competencies: a longitudinal study of university spinoff venture emergence. J. Manag. Stud. 48 (6), 1314–1345.
Ridgeway, C.L., 1991. The social construction of status value: Gender and other nominal characteristics. Soc. Forces 70 (2), 367–386.
Ridgeway, C.L., Correll, S.J., 2004. Unpacking the gender system: a theoretical perspective on gender beliefs and social relations. Gend. Soc. 18 (4), 510–531.
Ridgeway, C.L., Erickson, K.G., 2000. Creating and spreading status beliefs. Am. J. Sociol. 106 (3), 579–615.
Ridgeway, C.L., 2001. Gender, status, and leadership. J. Soc. Issues 57 (4), 637–655.
Ridgeway L., C., 2007. Gender as a Group Process: Implications for the Persistence of Inequality. In: Correl J, S (Ed.), Social Psychology of Gender (Advances in Group Processes), 24. Emerald Group Publishing Limited, Bingley, pp. 311–333.
Ridgeway, C.L., Backor, K., Li, Y.E., Tinkler, J.E., Erickson, K.G., 2009. How easily does a social difference become a status distinction? Gender matters. Am. Sociol. Rev. 74 (1), 44–62.
Roberto, F., Rey, A., Maglio, R., Agliata, F., 2020. The academic "glass-ceiling": investigating the increase of female academicians in Italy. Int. J. Organ. Anal. 28 (5), 1031–1054.
Rodríguez-Gulías, M.J., Fernández-López, S., Rodeiro-Pazos, D., 2018. Gender differences in growth of Spanish university spin-offs. Gend. Manag. Int. J. 33 (2), 86–103.
Rosa, P., Dawson, A., 2006. Gender and the commercialization of university science: academic founders of spinout companies. Entrep. Reg. Dev. 18 (4), 341–366.
Rossiter, M.W., 1993. The Matthew Matilda effect in science. Soc. Stud. Sci. 23 (2), 325–341.
Salvador, E., 2011. Are science parks and incubators good "brand names" for spinoffs? The case study of Turin. J. Technol. Transf. 36 (2), 203–232.
Schoonmaker, M.G., Solomon, G.T., Rau, P.A., 2017. Early-stage of innovations: selection system criteria for funding US biotech SMEs. J. Small Bus. Manag. 55, 60–75.
Shane, S., 2004. Academic Entrepreneurship: University Spinoffs and Wealth Creation. Edward Elgar, Cheltenham, UK.
Shane, S., Dolmans, S.A.M., Jankowski, J., Reymen, I.M.M.J., Georges, A., Romme, L., 2015. Academic entrepreneurship: which inventors do technology licensing officers prefer for spinoffs? J. Technol. Transf. 40, 273–292.
Shane, S., Dolmans, S., Jankowski, J., Reymen, I., Romme, G., 2012. Which inventors do technology licensing officers favor for start-ups? Front. Entrep. Res. 32, 1–15.
Shepherd, D.A., Gruber, M., 2021. The lean start-up framework: closing the academic–practitioner divide. Entrep. Theory Pract. 45 (5), 967–998.
Spence, M., 1974. Competitive and optimal responses to signals: An analysis of efficiency and distribution. J. Econ. Theory 7 (3), 296–332.
Stephan, P.E., El-Ganainy, A., 2007. The entrepreneurial puzzle: explaining the gender gap. J. Technol. Transf. 32 (5), 475–487.
Stuart, T.E., Hoang, H., Hybels, R.C., 1999. Interorganizational endorsements and the performance of entrepreneurial ventures. Adm. Sci. Q. 44 (2), 315–349.
Tartari, V., Salter, A., 2015. The engagement gap: exploring gender differences in university–industry collaboration activities. Res. Policy 44 (6), 1176–1191.
Teare, G. 2020. *Global VC funding to female founders dropped dramatically this year*. Crunchbase News, December 21, 2020. https://news.crunchbase.com/news/global-vc-funding-to-female-founders/.
Tinkler, J.E., Whittington, K.B., Ku, M.C., Davies, A.R., 2015. Gender and venture capital decision-making: the effects of technical background and social capital on entrepreneurial evaluations. Soc. Sci. Res. 51, 1–16.
Van den Brink, M., Benschop, Y., 2012. Slaying the seven-headed dragon: the quest for gender change in academia. Gend. Work Organ. 19 (1), 71–92.
Visintin, F., Pittino, D., 2014. Founding team composition and early performance of university—based spinoff companies. Technovation 34 (1), 31–43.

Whittington, K.B., 2018. A tie is a tie? Gender and network positioning in life science inventor collaboration. Res. Policy 47 (2), 511–526.
Wooldridge, J.M., 2010. Econometric Analysis of Cross Section and Panel Data. MIT press.
Woolley, J.L., 2019. Gender, education, and occupation: How founder experiences influence firm outcomes. Acad. Manag. Discov. 5 (3), 266–290.
World Economic Forum, 2020. Global Gender Gap Report 2020.
Yang, S., Kher, R., Newbert, S.L., 2020. What signals matter for social startups? It depends: the influence of gender role congruity on social impact accelerator selection decisions. J. Bus. Ventur. 35 (2), 105932.