Conditions for Spin-Off Creation at Swiss Universities of Applied Sciences

A gender sensitive approach

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Abstract

Purpose

The promotion of research-based entrepreneurship is considered a crucial task for universities and policymakers in many Western countries. Research has shown that the university environment plays a decisive role in the spin-off activities of researchers. Although the number of science-based spin-offs has increased in recent years, women are still an exception when it comes to developing spin-off ventures. In turn, there is a lack of knowledge regarding the university environment that supports entrepreneurship from a gender perspective.

Design/methodology/approach

Based on the theoretical framework of the "entrepreneurial university", this contribution examines formal and informal conditions for academic entrepreneurship using the example of Swiss universities of applied sciences (UAS). Based on a cross-sectional data set of 1551 researchers from various disciplines`, who were surveyed in 2019, linear and logistic regression models were used to test gender-specific differences in the perception of organizational conditions concerning the entrepreneurial exploitation of research.

Findings

The results demonstrated significant differences in the perception of formal and informal conditions for entrepreneurial activities in higher education. First, they show gender differences in the perception of informal entrepreneurial support in universities; in particular, female researchers received less informal support for spin-off projects. For example, women hardly viewed commercial use of R&D knowledge as a career option and considered the existence of entrepreneurial role models at universities to be low. Second, analyses highlighted that also formal support offerings were less known among female researchers.

Originality

Our study highlights organizational barriers for female researchers regarding the development of spin-off creation at UAS, including the different formal and informal conditions for female academics in comparison to their male counterparts

Keywords: gender, spin-off, academic entrepreneurship, organizational framework

Introduction

In knowledge-based economies, such as Switzerland's, research and development (R&D) are considered decisive factors of productivity that, in turn, promote researchers to explore the entrepreneurial potential of their research by creating spin-offs (e.g., Fini *et al.*, 2017). Spin-offs are defined as companies resulting from the commercialization of intellectual property and knowledge developed in universities (Djokovic and Souitaris, 2008). As an important context for technical and social innovation, many universities inspire researchers to engage in entrepreneurial activities as part of their institutional mission (Etzkowitz, 2017; Meek and Wood, 2016). Even if institutional entrepreneurialism has not yet been de facto implemented at all universities, it remains a normative and political demand. Research on academic entrepreneurship has sought to answer the question of how to design and implement spin-off activities.

Emerging research demonstrates that female academics are less likely to become entrepreneurially active in spin-off creation than their male counterparts (Abreu and Grinevich, 2017; Rosa and Dawson, 2006; Miranda *et al.*, 2017b). The European Start-up Monitor 2018 surveyed start-ups of highly innovative technologies and found a low percentage of female-driven companies (ranging from 5.1 in Portugal to 23.9 in Poland). In Switzerland, 19.6% of highly innovative start-ups are founded by woman; the percentage ranges above the European average of 15.6 % but still is relatively low (Steigertahl *et al.*, 2018). At Swiss universities of applied sciences (UAS), "chemistry and life sciences" constitute an interdisciplinary field where qualifications in chemistry, pharmacy, biology and medical technology are in demand. Swiss UAS are characterized by a noticeable gap between the representation of women in the lower versus higher hierarchical levels of scientific personnel (Dubach et al. 2017). Among researchers about only 24% were female in 2015, this is strikingly low in comparison with the number of female professors in many EU countries.

Previous studies have found little association between entrepreneurial success and the gender of the owner (Abel-Koch, 2014; Lee and Marvel, 2014), therefore it is possible that lower participation rate of women in spin-off activities represents an opportunity for economic potential. Literature addressing the gender gap in academic entrepreneurship points to the *university environment* as a primary driver of the lower spin-off intentions of female academics (Abreu and Grinevich, 2017; Best *et al.*, 2016; Eriksson, 2014). To date, research has focused on the motivational processes and socio-organizational predictors of academic entrepreneurship within the academic environment (see for an overview, Miranda *et al.*, 2018; Hossinger *et al.*, 2020; Schmitz *et al.*, 2017). Despite this, little attention has focused on whether female and male academics perceive their university environment in a similar manner with respect to entrepreneurship, nor explored the specific organizational conditions for spin-off creation of women in STEM (science, technology, engineering, and mathematics) and HSS (humanities and social sciences). This leads to a lack of knowledge concerning the role of universities in driving the gender gap in spin-off creation.

The objectives of the present study are twofold. Drawing on the theoretical concept of the entrepreneurial university (Clark, 1998; Thorp and Goldstein, 2010) and current perspectives in

organizational and entrepreneurship research (Fini and Toschi, 2016; Kirby *et al.*, 2011; Miranda *et al.*, 2017a), this study addresses the following research questions: *What is the current state of entrepreneurial promotion for scientists at Swiss universities of applied sciences (UAS)? How does gender influence the perception of the formal and informal framework conditions in this university context?* And *how do the different affinities for spin-off creation of research disciplines influence the perceptions of female researchers?* We use linear regression and logistic regression models to examine gender differences in the perception of informal and formal support for spin-off activities at UAS.

The findings of the study highlight gender-specific perceptions of organizational conditions for spin-off creation within UAS and thus inform entrepreneurship scholars and political decision-makers how to reduce the gender disparity. This research points to significant gaps in the promotion of academic entrepreneurship in UAS, which primarily impacts women. The remainder of the paper discusses the theoretical framework and hypotheses, methodology, and results and implications.

Theory and hypotheses

In examining entrepreneurial activities within higher education, research has focused on both individual characteristics of academic entrepreneurs as well as on socio-organizational conditions (Goethner *et al.*, 2009; Krabel and Mueller, 2009). For example, work-related skills (e.g., social networks and contacts, see Goethner *et al.*, 2012) and non-work-related competences (e.g., entrepreneurial experiences) (Wright *et al.*, 2004; Hoye and Pries, 2009) are found to be crucial in predicting entrepreneurial activities among academics. In addition, personal characteristics (Shane, 2004), such as entrepreneurial passion (Obschonka *et al.*, 2019) and specific motives such as financial gains and social reputation (Lam, 2015), personal attitudes towards the commercialization of knowledge, (Henrekson and Rosenberg, 2001) and specific demographic characteristics (Bijedić *et al.*, 2017) are considered to be personal drivers of entrepreneurial activities.

Current understandings state that entrepreneurial decision-making is bounded to organizational structures, which influence the development of entrepreneurial goals and their implementation (see Ahl and Nelson, 2010; Bergmann *et al.*, 2018; Kirby *et al.*, 2011; Miranda *et al.*, 2017a). That means, when predicting entrepreneurial action, scholars frequently refer to the interaction of individual drivers with the social environment at the organizational level, including structural conditions and cultural dimensions, such as incentive and reward systems or promotion and support structures (Feola *et al.*, 2019). The structural conditions also include shared attitudes that guide the behavior of institutional members (Bercovitz and Feldman, 2008; Goethner *et al.*, 2012).

Hossinger *et al.* (2020) summarized three central factors for promoting entrepreneurial intentions of researchers at the meso-level: university characteristics; research orientation of the department; and university support mechanisms. They emphasize that entrepreneurial intention is significantly influenced by the characteristics and research orientation of universities. For example, universities that focus on applied research and possess traditions of cooperation with industry tend to encourage more entrepreneurial activity (Arvanitis *et al.*, 2008; Fischer *et al.*, 2018). While researchers in the fields of science, engineering and physics, participate in all types of entrepreneurial activities, researchers in the social sciences (e.g., education

and economics) rather veer into informal commercial activities such as consultancy and contract research (Prodan and Drnovsek, 2010; Abreu and Grinevich, 2017).

Regarding the entrepreneurial environment, a growing number of scholars recognize the value of a supportive environment in promoting academic entrepreneurship (for examples see Bergmann *et al.*, 2018; Feola *et al.*, 2019; Huyghe and Knockaert, 2015). Based on North (1990), Kirby *et al.* (2011) introduced a set of formal and informal factors to analyze entrepreneurial framework conditions in the context of universities. These factors can either facilitate or hinder a researcher's entrepreneurial thinking and action. While North (1990) defined formal institutions as laws, regulations, and guidelines, his concept of the 'informal institution' also includes ideas, beliefs, attitudes, and social values. According to entrepreneurship literature (Brush *et al.*, 2009; de la Cruz Sánchez-Escobedo, María *et al.*, 2011), North's theoretical framework facilitates the understanding of 'hidden constraints' concerning entrepreneurial activity with their contextual dependence. Starting from here it can be assumed that the university context - facilitated by both formal and informal conditions - creates a specific framework for entrepreneurial intentions and activities (Kirby *et al.*, 2011).

Gender gap in spin-off creation

Several studies have addressed the lack of entrepreneurial intention and spin-off activities amongst female academics (see Austin and Nauta, 2016; de la Cruz Sánchez-Escobedo, María *et al.*, 2011; Strobl *et al.*, 2012). There is broad agreement among entrepreneurship scholars that individual, institutional, and structural factors play an important role in driving the gender gap in academic entrepreneurship (see Foo *et al.*, 2016; Abreu and Grinevich, 2017). Individual factors that contribute to the gender gap in entrepreneurial intentions and activities include: parental entrepreneurial activities (Laspita *et al.*, 2012), job-related experiences and skills, and the intersection of gender and ethnic origin (Krabel and Mueller, 2009). Psychological studies also attributed lower self-efficacy expectations (Wilson *et al.*, 2007) and different motivations (Espiritu-Olmos and Sastre-Castillo, 2015) as reasons for the lower entrepreneurial intentions of women. For example, women frequently report choosing to engage in entrepreneurial activities in order to provide time for family and professional tasks, while men consider the implementation of a new product or innovation idea driving their entrepreneurial interest (Piacentini, 2013). Howe et al. (2014) also identified greater risk aversion, less affinity for the commercialization of knowledge, and a lack of familiarity with technology transfer issues as barriers for start-up activities among female academics. Additionally, family responsibilities can especially effect women's founding activities. Past studies reported that founders most often launch their businesses between the ages of 30 and 40, while the average age of successful founder is about 45 (Azoulay et al., 2018, Hirschfeld at al., 2020).

Moreover, research literature shows several structural and institutional factors affecting female academic entrepreneurship, such as a lack of role models to foster spin-off activities at universities and the lack of women in research and science policy holding which hold leading positions in institutions and industry (Murray and Graham, 2007).

Both inside and outside universities, men are often dominant founders and end up serving as the gatekeepers of entrepreneurial activities and decisions related to innovation and investment (see. Muntean, Clark, Susan and Ozkazanc-Pan, 2015). Consequently, female researchers are less well placed to commercialize knowledge outside the university (Lawton-Smith *et al.*, 2017), and quite often can rely on smaller networks and fewer industry contacts, investors, and partners (Best *et al.*, 2016; Micozzi *et al.*, 2016). On a cultural level the association of entrepreneurship with male gender stereotypes (Ahl and Nelson, 2010; Gupta *et al.*, 2008; Gupta *et al.*, 2009) also affects the probability of women to become entrepreneurs (Henry *et al.*, 2013). And also outside of the university context less positive attitudes towards female entrepreneurship due to perceived difficulties associated with feasibility (Dabic *et al.*, 2012; Strobl *et al.*, 2012), can contribute to a lack of entrepreneurial women in academia.

Different market- and exploitation-oriented traditions, as well as priorities, within the different scientific fields are important in forming the framework conditions for academic entrepreneurship (Krabel and Mueller, 2009; Landry *et al.*, 2006; Stuart and Ding, 2006). While the level of entrepreneurial activity differs generally between disciplines and scientific fields, studies point out that also the barriers to spin-off activities differ in these contexts. Some evidence is given that in disciplines which show strong entrepreneurial activities, the proportion of females is lower (Abreu and Grinevich, 2017; Rosa and Dawson, 2006). Since women are particularly underrepresented in disciplines with higher entrepreneurial potential – such as it is the case for STEM-fields - they are less likely to become founders (Rosa and Dawson, 2006). Studies indicate that more individuals with leadership positions, extensive networks, and entrepreneurial experience are engage in spin-off activities at universities and that an overwhelmingly large proportion of these individuals are male (Stephan and El-Ganainy, 2007). As Abreu and Grinevich (2017) noted, female academics are both less represented in "spin-off relevant" positions within universities and predominantly active in fields such as health, social sciences, humanities, and education, which are fields that tend to lack entrepreneurial experience and hold ambivalent views regarding the commercialization of research.

Against this background of explanations and findings on gender-specific differences in entrepreneurial activities among researchers, we argue that the horizontal and vertical gender segregation in academic entrepreneurship is perpetuated by the fact that women are not as present in the disciplines with high entrepreneurial potential (Abreu and Grinevich, 2017; Rosa and Dawson, 2006) and therefore less likely to participate in academic entrepreneurship. Further, we assume that formal and informal conditions of entrepreneurship are perceived differently by men and women. We suppose that due to the interaction of specific formal and informal conditions associated with entrepreneurship, women are more likely to encounter barriers related to entrepreneurial activities (Orser *et al.*, 2012) and are less likely to be encouraged to pursue an entrepreneurial career. We assume gender significant differences in the perception of formal and informal conditions for spin-off activities.

H1. Female researchers perceive the informal conditions of spin-off activities *at their university as less supportive than their male counterparts.*

H2. Female researchers perceive the formal conditions of spin-off activities *at their university as less supportive than their male counterparts.*

H3. The formal conditions for spin-off activities *at their university are more unknown to female researchers than to their male colleagues.*

Method

Data Collection

This research was based on cross-sectional data collected in an online survey of researchers at the seven public UAS in Switzerland. Since the 1990s, Swiss UAS have created an entrepreneurial profile of knowledge transfer, for example by promoting consulting services, contract research and entrepreneurship (SBFI, 2020). The official performance mandate of UAS includes education, research and development (R&D), continuing education, and service/consulting (Lepori and Müller, 2016). Compared to other universities, the research mission of UAS focuses on "application-oriented research" which has been descripted in the literature as a driver of academic entrepreneurship. Furthermore, UAS maintains close collaborations with industry (KFH, 2014) that further promotes the exploitation of commercial knowledge.

The main objective of the survey was to assess the framework conditions for entrepreneurial activities at universities from a gender perspective. In January 2019, more than 8,000 researchers from various disciplines were randomly invited to participate in the survey by e-mail. Using Questback, an online survey tool (Unipark, 2013), participants could choose between three languages (German, English, and French). Previously, the questionnaire and the procedure were tested and optimized using an independent sample.

The study sample size contained 1,551 participants. Previously, we removed the respondents from our sample who did not provide any data and those with missing data on gender, as gender is a key aspect of this study. The average age of respondents was 36.7 years (SD=13.1, range: 22-69) and females accounted for 33.3% (n=517) of the participants. Roughly one-third (30.4%; n=472) were other than Swiss citizens, 41.5% (n=643) hold a Master's degree, and 42.7% (n=663) stated a PhD as their highest educational qualification. Regarding their work, 29.6% (n=459) reported “professor /lecturer with leadership responsibilities,” and 54.3% (n=842) of respondents held positions within STEM departments, including mathematics, life science, computer science, science, and technology, while the others belong to the humanities and social sciences (HSS). For employment status, 35.7% (n=554) of the participants held temporary employment. Fifty three percent (n=171) of the responding participants with entrepreneurial experience are being in STEM department. The participants in our sample are not equally distributed among all seven UAS (Bern University of Applied Sciences n=300, University of Applied Sciences Northwestern Switzerland n=253, University of Applied Sciences Eastern Switzerland n=195, University of Applied Sciences Western Switzerland n=220, Lucerne University of Applied Sciences n=241, University of Applied Sciences Southern Switzerland n=72, Universities of Zurich n=270).

Measures

Informed by previous research and best practices on entrepreneurial support measurement by Fernández-Nogueira et al. (2018), the following items on formal and informal conditions are created. *Informal framework conditions.* Using details from prior research (Kirby *et al.*, 2011; Fini *et al.*, 2017; Fernández-Nogueira *et al.*, 2018) we created a set of six criteria for assessing informal framework conditions. Participants were asked: "To what extent do you agree with each of the following statement with respect to your university?": (1) The university increases people's awareness of its spin-off projects; (2) The university is an important contact partner for existing spin-off activities; (3) Spin-offs are a possible career option at the university; (4) Superiors actively support spin-off projects; (5) Colleagues actively support spin-off projects; (6) Successful founders are well known and respected at the university. The items were presented on a five-point Likert scale ranging from 1 (Absolutely disagree) to 5 (Absolutely agree). After the reliability and validity were determined and the items were aggregated as part of passive imputation procedure. The internal consistency, as measured by Cronbach's alpha ($\alpha = 0.85$), was very strong.

Formal framework conditions. Employing the same studies as above (Kirby *et al.*, 2011; Fini *et al.*, 2017; Fernández-Nogueira *et al.*, 2018), seven items were developed to address formal framework conditions. Participants were initially asked: "How do you assess spin-off promotion at your university?": (1) For the use of research infrastructure; (2) For team-building for co-founders; (3) for the search for suitable co-founders; (4) For mentoring and consultancy services for spin-off projects; (5) During financing in the business creation phase (e.g., "financing of prototypes"); (6) During financing in the "growth phase" (e.g., when looking for investors); and, (7) For unpaid leave of absence for personal spin-off projects. The items were answered on a five-point Likert scale and later in a passive imputation procedure aggregated. Participants were also allowed to answer "Unknown" to skip single items. The reliability measured by Cronbach's alpha ($\alpha = 0.91$) was excellent.

Control variables: Based on prior academic entrepreneurship research (see Hossinger *et al.*, 2020; Goethner *et al.*, 2012; Huyghe and Knockaert, 2015), we controlled for the level of employment, nationality, temporary employment, age, occupational category, entrepreneurial experience, level of employment in the are of R&D in percent (0-100), and discipline. For the STEM disciplines the departments of technology, life science, natural sciences, and architecture (incl. facility management), health sciences, agricultural sciences, and forestry were included ($n_{STEM} = 842$, $n_{Women} = 172$, $n_{Men} = 670$). HSS disciplines included economics, design, arts and music, social work, applied psychology, and applied linguistics ($n_{HSS}=709$, $n_{Women} = 364$, $n_{Men}=345$)

Discriminant validity and common method variance

Items on formal conditions and informal conditions stated to be "Unknown" were treated as missing values for the following validity and reliability analysis. An Exploratory Factor Analysis (EFA) was performed to extract and evaluate the initial construct validity and reliability, and the metrics (Table I). The

analysis conducted by EFA included the examination of item commonalities, their factor loading and Cronbach's alpha. The item commonalities exceeded the threshold of 0.50 (Hair *et al.*, 1992), and the two factors explained 63.8% of the total item variance. The factor loads of the items and the names of the extracted factors are listed in Table I. The measurement items loaded to their respective factors as expected, indicating initial convergent and discriminant validity as factor loadings exceeded 0.50 and cross-loadings were below 0.30.

By using five imputed datasets conducted in {Lavaan.survey} (Oberski, 2014) in R (R Development Core Team, 2013), Confirmatory Factor Analysis (CFA) was performed to assess the convergent and discriminatory validity of the measurement items. The model fit can be assess using several techniques, Chi-square statistics (X^2), mean square approximation error (RMSEA), and Comparative Fit Index (CFI). Values below 0.05 for RMSEA were interpreted as very good, while values below 0.08 were interpreted as acceptable. CFI values above 0.90 and 0.95 are considered acceptable and excellent, respectively (Kline, 2005). The Chi-square value for the measurement model was significant indicating a poor fit, but Chi-square is affected by sample size, we calculated alternative fit indices. The CFI and RMSEA demonstrated a good fit of the measurement model (CFI = 0.96, RMSEA = 0.03) and confirmed a sufficient convergent and discriminatory validity, as the items were significantly loaded on their respective factors and all factor loads were above 0.60. The convergent validity can be assumed by obtaining the extracted mean variance (AVE) with a threshold value of 0.50 (Hair *et al.*, 2017). Reviewing the AVE values for all factors suggests an acceptable validity (AVE > 0.50).

Discriminant validity was first assessed by comparing the values of the AVE square root of the conceptual constructs (√AVE) with the correlation of the other conceptual constructs (Fornell and Larcker, 1981). If the value of √AVE, was higher than the coefficient of correlation between the factors, this was interpreted as an indication of discriminant validity. All factors assessed met the criterion and showed discriminant validity. Second, we assessed discriminant validity by using the heterotrait-monotrait ratio of correlation (HTMT) (Henseler *et al.*, 2015). If the HTMT was below 0.90, a discriminant validity between the two constructs was assumed. The results showed that the HTMT values between the respective constructs were below 0.90 (HTMT = 0.62 for the connection between formal and informal frameworks). The results provide evidence of convergent and discriminatory validity.

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Common Method Variance (CMV) occurs when a method bias affects all measures equally (Podsakoff *et al.*, 2012) and can occur when participants systematically distort their responses to surveys (e.g., according to social desirability). To investigate the potential for CMV, all study variables were loaded on a factor to investigate the CFA model fit. If the one-factor CFA model fits the data, the CMV is considered largely responsible for the relationship between the variables (e.g. Mossholder *et al.*, 1998). Within these

data, a one-factor CFA model did not represent the data well (X^2 [54] = 689, p < 0.001, CFI = 0.73, RMSEA = 0.09), suggesting that the items were not just different aspects of an underlying construct (CMV).

Analytical strategy

Before testing our hypothesis, we conducted a descriptive analysis, including a mean value comparison. Using the individual items mentioned above, we assessed both the general level of entrepreneurial support regarding informal and formal frameworks and to uncover gender differences in the perception of entrepreneurial conditions at UASs.

A total of 18% and 30% data on formal and informal frameworks in our sample were missing information on one or more variables. To assess whether the data were missing completely at random (MCAR), Little's Chi-square test (Little, 1988) was used. This statistic tests the null hypothesis that the data were MCAR, and the result for this sample was found to be statistically significant, suggesting a violation of the MCAR assumption. Because the presence of missing values on some variables (e.g., Info 1, Info 2) clearly depends on the values on other variables in the analyses (e.g., gender, discipline), the use of a missing data handling method that makes the weaker assumption of missing at random (MAR) (e.g., model- or imputation-based procedures) is warranted. To correct for potential bias from missing data, we used a multiple imputation procedure (van Buuren and Groothuis-Oudshoorn, 2010) and predictive mean matching (pmm), which makes full use of the available information contained in the data. (e.g., Sinharay et al., 2001). All estimates presented below were pooled from 50 complete data sets with the {MICE} package version 3.4.3 (Multiple Imputation by Chained Equations; van Buuren and Groothuis-Oudshoorn, 2010). Further statistical analyses, and passive imputation of the informal and formal aggregated dependent variables i.e., calculated from the imputed components after imputation (Seaman *et al.*, 2012) were performed on these datasets and results were combined using Rubin's rule (van Buuren and Groothuis-Oudshoorn, 2010).

To test the hypotheses (H1 and H2), ordinary least squares (OLS) regressions were used while controlling for individual characteristics. To test H3, the single items of the formal conditions were recoded as new dummy variables; participants who have declared items as "Unknown" were coded as "0" and those who provided a rating of the Likert scale were coded as "1". Next, formal conditions were aggregated into the new dependent variable (known formal condition). Those "Unknown" responses have been treated as separate variables during imputation procedure. Using these newly created dependent variables to test the gender impact on the awareness of formal conditions, a logistic regression model was estimated by using the GLM function in R.

Results

Descriptive analysis of gender differences in the assessment of the organizational environment

First, to answer our hypothesis we conducted a descriptive analysis of gender differences with regard to the assessment of the formal and informal conditions. Therefore, the items of the two scales described above (for formal and informal settings) were descriptively analyzed.

Informal framework conditions for spin-off activities

Regarding the conditions of the informal environment, the next section examines gender differences in the perception of these conditions from the respondents' perspective. The mean values of the items are presented in Figure 1. A significant gender-specific difference in the mean values (M) of the aggregated scales (six items) for measuring informal conditions was observed in our data (M_{Men}=2.75, SD =1.01, M_{Women}=2.41, SD=1.07, t [161.28] =3.05, $p < 0.01$).

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The single items, which reflect various aspects of informal conditions in detail, are examined below in order to examine gender differences within the disciplines STEM (n_{STEM}=842) and HSS (n_{HSS}=709) more precisely. Overall, more than 30% of the respondents in the STEM disciplines and more than 40% of the respondents within the HSS assessed the level of informal conditions for spin-off activities as unknown or weak (see Figure 2). For example, only 23% (n=132) of men and 17% (n=23) of women in STEM disciplines and only 17% (n=56) of men and 14% (n=35) of women in HSS disciplines found their university to actively *raise awareness for entrepreneurial projects (No.1).* Furthermore, 29% (n=160) of male respondents and 25% (n=34) of the female respondents in STEM, but only 18% (n=61) of the male respondents and 13% (n=33) of female respondents in HSS considered their UAS to be an *important contact partner for entrepreneurial projects (No.2).* These results are shown in Figure 2 below.

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A similar result was found for item *No.3*, *spin-off creation as a career option.* Thirty-four percent (n=193) of male researchers and 25% (n=34) of female researchers in the STEM disciplines and 20% (n=62) of male researchers, but only 11% (n=28) of female researchers in the HSS disciplines stated that spin-off activities are considered to be a career opportunity in the context of UAS.

Also, the support for *spin-off projects by colleagues and superiors (No.4* and *No.5)* was perceived as rather weak. Twenty-nine percent (n=172) of male researchers and 22% (n=34) of female researchers in STEM disciplines, and only 14% (n=47) of male researcher and 6% (n=18) of female researcher in HSS disciplines reported that supervisors actively support spin-off projects *(No. 4).* However, only 25% (n=44) of male and 16% (n=19) of female researchers in the STEM disciplines and 14% (n=44) of male and 6% (n=18) of male researchers in the HSS disciplines stated that they received support from colleagues in spin-off projects *(No.5).*

However, descriptive analyses suggested that informal conditions for spin-offs at UAS was rated weak by all participants. Gender differences were only given, such that men rated informal conditions slightly better than women.

Formal framework conditions for spin-off-activities

Regarding the formal conditions, respondents replied whether concrete measures were available or that they were unaware of these conditions. Overall, all respondents were more uncertain about the formal conditions at UASs. For example, between 35% and 71% of the researchers in the STEM disciplines (n=842) and between 54% and 79% of the researchers in the HSS disciplines (n=709) considered the formal conditions to be "Unknown" and thus did not determine the degree of conditions at their UAS.

Thirty-two percent (n=151) of male and 26% (n=29) of female researchers in the STEM disciplines and 15% (n=42) of male and 12% (n= 26) of female researchers in the HSS disciplines stated that they were free to *use the university's research infrastructure for spin-off projects (No. 1).* However, 35% (n= 162) of men and 58% (n= 65) of women in the STEM disciplines and 54% (n=145) of men and 71% (n= 158) of women in the HSS disciplines responded with "Unknown".

The support offered by the university through team-building measures *(No.2)* or the search for co-founders *(No.3)*, was perceived as generally "unknown" by half of the respondents in the STEM disciplines areas and by more than half of the respondents in the HSS disciplines (see Figure 3 STEM and Figure 4 for HSS). Only 14% (n= 64) of men and 12% (n= 12) of women in STEM disciplines and 10% (n=26) of men and 4% (n=9) of women in HSS disciplines considered the opportunities for *team building at the UAS (No.2)* to be well developed. Forty-six percent (n=217) of men and 69% (n=77) women in the STEM field and 57%

(n=154) of men and 78% of (n= 174) women answered this question with “Unknown”. Only 14% (n=64) of the male researchers and 12 % (n=14) of the female researchers of the STEM disciplines and 11% (n=29) of male and 6% (n=14) of female researchers in the HSS disciplines indicated that they could *receive support at their university to find suitable co-founders (No.3).*

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For component measure No.4*, mentoring offers are considered to be available, 21*% (n=102) of men and 15% (n=17) of women researchers in STEM disciplines and 18% (n= 47) of men and 9% (n=21) of women in HSS disciplines indicated that *mentoring offers are available.* In contrast, 51% (n=136) of men and 69% (n=153) of women in HSS disciplines rated this item as "Unknown". Also, internal offers to *locate suitable financing opportunities in the "start-up phase" (No. 5)* and to *attract suitable investors (No. 6)* were “Unknown” to more than half of the respondents in the STEM and HSS disciplines at seven UAS (see Figure 3 and 4).

For measure *No.5, targeted support in finding suitable financing offers* (e.g., enabling a prototype in the start-up phase), was perceived as "available" by 14% (n=64) of the male researchers and 11% (n=8) of the female researchers in STEM disciplines and only 8% (n=22) of the men and 4% (n=8) among women in the HSS disciplines. Only 11 % (n=51) of the male researchers and 11 % (n=12) of the female researchers in the STEM disciplines and 7 % (n=20) of the male researchers and 4 % (n=8) of the female researchers in the HSS disciplines have *sufficient internal support for* spin-off activities *in the "growth phase" such as searching for investors (No.6).* To take *unpaid leave for entrepreneurial projects (No.7)* was seen as likely on the scale by 19% (n= 91) of men and 8% (n=9) of women in STEM disciplines and only 10% (n=27) of men and 4% (n=9) of women in HSS disciplines. We then considered whether these gender differences were statistically significant in the next section.

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Gender-specific effects of formal and informal framework conditions

Ordinary Least Squares (OLS) regression and logistic regression models, were performed to evaluate gender differences in the perception of formal and informal conditions (hypotheses 1-3). First, we verified that the data meet the linearity and homoscedasticity assumptions for OLS regressions and verified multicollinearity problems by calculating variance inflation factors (VIFs). The highest VIF was 1.3, which is significantly below the critical value of 10 (Hair *et al.*, 2006) and indicates that multicollinearity is not an issue in our study.

The OLS regression models are reported in *Table II*. It should be noted that M1 and M3 were baseline models, consisting only of control variables. While the results indicated that researchers from the STEM disciplines consider the informal conditions (b_{STEM}=0.268, $p < 0.001$) but not the formal conditions

(b_{STEM}=0.112, $p = 0.5$) to be better developed. Only temporary employment contract ($b_{Contract}$= 0.271, $p < 0.01$) showed a significant positive effect on formal conditions (M3), while the other control variables in the models (M1 and M3) demonstrated no significant influence on informal and formal conditions.

Models 2 and 4 capture the direct effects of gender on formal and informal conditions. While OLS-regression model (M2) revealed a significant negative gender effect on informal conditions (b_{Female}=-0.195, $p < 0.01$), no significant gender effect on formal conditions (b_{Female}= -0.013, p=0.52) was evident. The results, therefore, support our hypothesis (H1) that female researchers rated the informal conditions significantly weaker than their male colleagues, while hypothesis (H2) was not supported.

---- INSERT TABLE II ----

Next we conducted additional logistic regression models (M5 and M6) to investigate the extent that the belonging to a gender category influenced whether formal conditions were evaluated by the participants or considered "Unknown". The dependent variables, known formal condition, were formed from the mean of the aggregated items, by using passive imputation as described above (with dichotomous expression; 0=unknown, 1=known).

The model (M5), showed a significant positive effect of discipline (b_{STEM}=0.521, $p < 0.001$) and entrepreneurial experience ($b_{Entrepreneur}$=0.502, $p < 0.001$) on the dependent variable known formal conditions. While controlling for discipline, age, occupational status, nationality, and performance in R&D, M6 revealed a significant negative effect of female researcher (b_{Female}=-0.440, $p < 0.001$) on formal conditions. Therefore, the formal conditions are more often considered to be “Unknown” to female researchers than to their male colleagues, which supports the hypotheses H3.

Discussion

This study is an initial evaluation into the impact of framework conditions on academic entrepreneurship at UAS in Switzerland starting from a gender-perspective. In particular, the analysis intended to identify gender-differences in formal and informal framework conditions to the disadvantage of spin-off activities of female researchers. Building on the institutional theory of North (1990) in the context of academic entrepreneurship, our study examined framework conditions of UASs using a unique sample of Swiss scientists. Therefore, the perceptions of organizational conditions for entrepreneurial activities were analyzed by surveying the seven public Swiss UASs (n=1,551). This study is an initial evaluation into the impact of framework conditions on academic entrepreneurship at UAS in Switzerland starting from a gender-perspective. In particular, the analysis intended to identify gender-differences in formal and informal framework conditions to the disadvantage of spin-off activities of female researchers. Building on the institutional theory of North (1990) in the context of academic entrepreneurship, our study examined framework conditions of UASs using a unique sample of Swiss scientists. Therefore, the perceptions of

organizational conditions for entrepreneurial activities were analyzed by surveying the seven public Swiss UASs (n=1,551). Briefly, the results of our empirical analyses highlight informal and formal conditions for spin-off activities in the context of UAS still exist but only to a limited extent. Regression analysis reveals gender to negatively predict informal conditions beyond various control variables. In contrast, when testing our second hypothesis, we did not find gender to predict awareness of formal framework conditions.

However, our results also demonstrate that female researchers were less informed about formal framework conditions and concrete entrepreneurial support measures. Our descriptive analysis also highlights that among the UAS only limited concrete support for spin-off activities for researchers exist, and that these support measures are largely unknown to our participants. The result was similar for informal conditions, which referred to the existence of role models, entrepreneurial career options, and spin-off promotion by superiors. In our sample, the informal conditions that promote entrepreneurial activity in UAS were rated by the respondents as low.

Female researchers remain less active in entrepreneurship than their male counterparts at Swiss UAS today. This is also reflected in our sample, where only 59 female founders out of a total of 320 founders at UAS can be found. Our data highlight that formal and informal conditions for entrepreneurial activities were assessed as unfavorable. Despite the wide range of measures to support technical and social innovation in Switzerland (Dasilva and Gabrielsson, 2019) and growing initiatives to raise awareness of social and cultural entrepreneurship (see Bornstein et al., 2014), formal support services for employees at UAS seem barely visible for academics. While recent studies indicate a strong interest in entrepreneurship among researchers at UAS (Morandi et al., 2019a), our results shed light on the unfavorable "informal" situation and concrete support for entrepreneurial activities.

Our data indicate gender-specific differences in the assessment of organizational conditions at UAS and partly confirm our hypotheses. Although no gender difference in the perception of formal conditions was identified, our analyses revealed that female researchers rate informal conditions for entrepreneurial activity as less accessible compared to their male counterparts. The descriptive results on the perception of informal relationships demonstrates that women receive less support from superiors and colleagues regarding spin-off projects and that they generally consider spin-off projects less regularly as a possible career option. Against the background of recent research indicating the important role of informal conditions for academic entrepreneurship (Huyghe and Knockaert, 2015; Bercovitz and Feldman, 2008), our results reveal strong institutional barriers to female spin-off activities. Therefore, our findings indicate that the concept of entrepreneurship remains strongly gendered (Gupta et al., 2018), making it not only problematic for women accessing support from colleagues and supervisors but also preventing the development of entrepreneurial career intentions of female scientists due to the lack of early sensitization and entrepreneurial role models in the work environment. This is supported by past research highlighting the motivating role of same-gender role models for women in entrepreneurship (Bechthold and Rosendahl Huber, 2018)

The results provide growing evidence of gender differences in the perception of organizational conditions in specific disciplines (STEM vs. HSS). Despite numerous support offers for start-up activities of

students at Swiss UAS (Morandi et al., 2019b) and the first targeted support offers for (prospective) female founders (Liebig and Schneider, 2019), female scientists seem unaware of those opportunities in all areas central to entrepreneurial activities - training, financing, mentoring, and coaching. Reasons for the invisibility of start-up promotion among women may be the hitherto unrecognized potential of female entrepreneurship in start-up and gender equality promotion at Swiss universities of applied sciences (Liebig & Schneider, 2019). Since joint efforts to link start-up promotion with the universities gender equality agenda still lack, (potential) female entrepreneurs keep falling through the cracks.

Contrary to past research (Huysentruyt, 2014), the findings illustrate that even in disciplines that lack an affinity for spin-off activities and support a high proportion of women, it appears that entrepreneurship is more likely to be expressed by men. Consequently, the under-representation of female academic founders cannot be exclusively attributed to their under-representation within fields, and cannot be explained by varying levels of entrepreneurship in universities (Rosa and Dawson, 2006). Our study supports the findings of Abreu and Grinevich (2017) that shows the gender gap in academic entrepreneurship exists across the entire spectrum of academic disciplines. This is explained by the lower number of women in higher education and the lack of entrepreneurial experience among women. However, there appears a lack of organizational support for scientists to leverage R&D results, which previous research has shown to be fundamental to spin-off projects (e.g., Kirby et al., 2011; Miranda et al., 2017a; Feola et al., 2019).

The results of this study should be considered in light of the following limitations. First, the results of this study are only applicable to the UAS context. Second, self-selection bias is a common limitation of this type of study. Academics who already have an interest in the topic of the study are more likely to be persuaded to participate in such a survey. Third, we have accounted for nonresponse and used multiple imputation to account for missing variable information. These methods rely on the assumption that the data are missing at random (i.e., recoverable by observed variables), which is an untestable assumption. Fourth, the study was exploratory and cross-sectional, which makes it difficult to establish causal relationships between the variables and gender. It would be valuable to analyze the influence that control variables such as age, entrepreneurial experience, and job category may have on the proposed model.

Conclusions

Universities play a central role regarding the observed differences in high entrepreneurial intentions and low spin-off activities among scientists at UAS (Morandi et al., 2019a). This, in turn, can perpetuate and transform gender inequalities in entrepreneurship. Our results promote a more comprehensive understanding of the departmental and gender-specific perception of entrepreneurial frameworks and provide new insight into their contextual dependency. It highlights the low status of informal entrepreneurial support for female scientists, as strong institutional barrier to female spin-off activities at UAS. However, the empirical data also illustrate the contextual nature of gender-specific perceptions of institutional conditions, which differ considerably between universities. From a gender perspective, practitioners and university managers still have to ensure that entrepreneurial activities are accessible to women. Especially, female academic

entrepreneurship can be promoted by a strong collaboration between TTOs and gender equality officers to realize specific measures addressing female scientists. Moreover, research institutions should aim to achieve a more inclusive entrepreneurial setting in the local work environments and cultures of research institutes.

Moving forward, research is needed that analyses the complexity of factors causing barriers and drivers of female academic entrepreneurship. Such knowledge will help to develop recommendations and measures for policymakers to overcome the gender gap. Future research that explores the gender gap in academic entrepreneurship should also consider disciplines, which are relevant for less vocationally oriented university types, such as basic sciences in STEM, such as physics or mathematics. More than that, the investigation of gender-specific differences in spin-off formation could focus on disciplines characterized by non-entrepreneurial traditions (e.g., humanities), as well as hybrid disciplines in the field. The analysis could incorporate additional explanatory variables of entrepreneurship, such as risk propensity or inter- and transdisciplinarity. Finally, we urge future research to uncover the barriers and drivers of female academic entrepreneurship with respect to interfering conditions located outside of university contexts.

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