Individual Factors Explaining Women's Entrepreneurship in STEM Fields

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Abstract Although the gender imbalance in starting businesses in fields of science, technology, engineering, and mathematics (STEM) poses a problem, there is only a small body of research on the individual factors driving women's entrepreneurship in STEM fields. In the current study, we investigate state-of-the-art research on the individual factors that explain women's entrepreneurship in STEM by conducting a systematic literature review. The present review addresses the question of what is known about individual factors explaining women's entrepreneurship in STEM fields in the scientific literature. A sample of 15 articles identified from 193 screened abstracts was analyzed using a theory based qualitative content analysis. The explanatory variable of entrepreneurial entry was modeled as a process consisting of entrepreneurial intention formation, intention initiation, and intention realization. Besides phase-specific driving factors, the results show that for all phases learning experiences and corresponding competencies related to STEM, and entrepreneurial as well as management experiences are crucial individual factors for women's STEM entrepreneurship. As a research program on women's entrepreneurship in STEM has not yet been established, more theory based research should contribute to developing progressive research questions and comparable research objects. Internationally comparable studies and statistics related to gender including validated scales on entrepreneurial entry and career choice should be established in the future.

Keyword Entrepreneurship · STEM · Women · Systematic review · Individual factors

1 Background

Fields of science, technology, engineering, and mathematics (STEM) are critical drivers for achieving economic growth, job creation, as well as societal and human development. However, in light of gender equality issues, the gender imbalance

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in starting businesses in STEM fields poses a problem. Although sufficient data is still not available on women's entrepreneurship in STEM fields, it seems that women establish businesses in industries that are already dominated by women, as for example industries such as personal services, health care, education, arts, entertainment, and recreation, accommodation, and food service activities. For instance, in Germany, 10.5% of TEA men established a business in the information and communications technology sector (ICT) in 2017/2018, while 0% of TEA women were found in this field (Elam et al. 2019). For 2017/2018, the global average of the ratio "Women [Women ICT (percentage of TEA women)]/Men [(Men ICT (percentage of TEA men)]" identified in the GEM Women's Entrepreneurship Report 2018/2019 is 0.3 (Elam et al. 2019). The Total early-stage Entrepreneurial Activity Rate (TEA) is a key indicator of the level of new enterprise creation. Entrepreneurs are defined here according to the OECD-EUROSTAT Entrepreneurship Indicators Programme (EIP), as "…persons (business owners) who seek to generate value, through the creation or expansion of economic activity, by identifying and exploiting new products, processes or markets" (OECD 2012). Bosma and Kelley (2019) show in the Global Entrepreneurship Monitor (GEM) for 2018/2019, that of the 49 economies surveyed by GEM in 2018, only six show equal TEA rates between men and women. Interestingly, the innovation-driven economies of the European and North American regions include many economies with a lack of gender equality. Based on American Community Survey data, Demiralp et al. (2018) found for the USA that women typically work in health occupations (e.g., physicians, dentists, physical therapists, opticians) (77.8%); only 13.1% work in computer and mathematical occupations, 6.7% in architecture and engineering, and 2.4% in life and physical sciences occupations.

The underrepresentation of women entrepreneurs in STEM fields can be explained by various factors, such as socio-cultural, political, economic, and individual factors. To support women entrepreneurship in STEM fields there is a need to increase the number of women entrepreneurs. Training and education play an important role in this regard. For designing educational and training programs it is at least necessary to have an understanding of the individual factors that facilitate women's entrepreneurship in STEM fields.

Although we can point to a growing body of literature in the field of women's entrepreneurship in STEM, it seems that there is still considerable uncertainty concerning the individual factors driving women's entrepreneurship in these fields (Kuschel et al. 2020). In the current study, we consequently plan to investigate state-of-the-art research on the individual factors that explain women's entrepreneurship in STEM by conducting a systematic literature review.

The subordinate research question we address is as follows: What information is available in the scientific literature on individual factors explaining women's entrepreneurship in branches based on sciences, technology, engineering, and mathematics?

2 Theoretical Foundation

Our systematic examination of research studies explaining individual factors of women's entrepreneurship in STEM is based on the Social Cognitive Theory of Career and Academic Interest, Choice and Performance developed by Lent et al. (1994), the Rubicon model of action phases developed by Heckhausen and Gollwitzer (1987), and the personality theory of McAdams and Pals (2006).

In line with the study results that the entrepreneurial intention results from development (Obschonka et al. 2010), the social cognitive theory of career and academic interest, choice, and performance is useful to address this developmental character (Kanny et al. 2014). Thus, in their theory Lent et al. (1994) integrate the different career states of formation and elaboration of interests, career choice selection options, and performance and persistence in educational and occupational pursuits. Following Lent et al. (1994), interest has an impact on goals, which affects action, and that again has an influence on performance. Based on the theory, the interaction of person inputs and the contextual determinants results in learning experiences, the sources of self-efficacy (Lent et al. 1994). There are a variety of personal variables, represented in an exemplary manner in theory, for example, interests, abilities, values, and gender (Lent et al. 1994). Regarding the contextual determinants, Lent et al. (1994) differentiate between proximal and distal variables. While distal variables are background factors, such as family of origin educational background, that affect learning experiences, it is proximal context variables such as, for example, personal career network contacts, that shape the structure of career relevant opportunities (Lent et al. 1994).

Learning experiences which consist of personal performance accomplishments, vicarious learning, social persuasion, and physiological states and reactions have an influence on self-efficacy and outcome expectations, respectively, while self-efficacy expectations also affect outcome expectations (Lent et al. 1994). The combination of self-efficacy expectations and outcome expectations predict interests, goals, actions, and performance (Lent et al. 1994).

In addition to this theory, we will refer to the Rubicon model of action phases with which Heckhausen and Gollwitzer (1987) modeled the course of action in four phases, the pre-decisional, pre-actional, actional, and post-actional phases. While in the pre-decisional, motivational phases, deliberation processes regarding the desirability and feasibility of wishes bring about intention formation, the pre-actional volitional second phase resulting in intention initiation is characterized by opportunity awareness and waiting for an opportunity to move towards the goal state. The second phase is followed by the actional phase, in which intention is realized in order to deactivate in the last phase, the motivational post-actional one, the intention.

Because the model can contribute to differentiating the developmental process of career choice, it can be well combined with the social cognitive theory of career and academic interest, choice, and performance.

Besides socio-demographic characteristics, we conceptualize the variables of the person inputs of the Social Cognitive Theory of Career and Academic Interest, Choice and Performance based on the personality theory of McAdams and Pals (2006).

The authors conceive personality "*as (a) an individual's unique variation on the general evolutionary design for human nature, expressed as a developing pattern of (b) dispositional traits, (c) characteristic adaptations, and (d) self-defining life narratives, complexly and differentially situated (e) in culture and social context*." (McAdams and Pals 2006, p. 204).

Due to our focus on individual variables that can be promoted through training and education, we refer to characteristic adaptations and identity. Characteristic adaptations are "motivational, social cognitive, and developmental variables that are contextualized in time, situations, and social roles." (Costa and McCrae 1985) People differ in terms of identity conceived as a person's self-concept (Heatherton et al. 2007) that they construct by narrating their life story.

From the perspective of methodology, we can group our results according to the epistemic lens through which we look at research questions: Taking a first-person perspective ("I") allows the researcher to study the interior of the personality, experience in the mode of subjectivity, while taking a third person perspective ("it") goes along with an objective view, here on entrepreneurial behavior. The second-person perspective is of an inter-subjective nature because of the relation between an epistemic agent and the mental state of another subject.

3 Methods

To investigate state-of-the-art research on individual factors that explain women's entrepreneurship in STEM we conducted a systematic literature review. The purpose of a review is to identify relevant information from available publications on the research question. The research question here is: What is known about individual factors explaining women's entrepreneurship in STEM, as revealed by scientific literature?

For the selection of publications, inclusion and exclusion criteria will be defined in advance. We analyze the studies according to the research question, the samples, methods, and results and then we systematize the results by theoretically and methodologically derived categories.

3.1 Study Selection Criteria

The criteria for the studies to be selected from the literature review (see Table 1) are that they should be studies that are empirical or literature reviews, written in English, German or French and published in the period from 1980 to 2020. The research focus of the included studies is on individual factors that explain women's entrepreneurship in STEM fields. Accordingly, we exclude studies of a theoretical nature or ones written in languages other than English, German, or French. Likewise, excluded

Table 1 Inclusion and exclusion criteria for the review

Characteristics	Criteria of inclusion	Criteria of exclusion
Type of study	• Quantitative empirical studies • Qualitative empirical studies • Literature reviews	Theoretical studies
Languages	• English • French • German	Other languages
Year of publication	1980–2020	Prior to 1980
Research focus	Individual factors explaining women's entrepreneurship in STEM fields	• Institutional factors • Organizational factors • Cultural factors • Societal factors • Non-STEM fields

are studies related to non-STEM fields or to organizational, cultural, societal, and institutional factors.

3.2 Search Strategy

We searched the literature of relevant disciplines, such as social, educational, business, and economic sciences. As databases, we selected the following: EBSCO including Business/Economics Databases, Education Databases, Gender/Sexuality Databases, Psychology/Sociology Databases, Web of Science, Fachportal Pädagogik, including among others Education Resources Information Center (ERIC), and Google Scholar. As there are different search criteria in the available databases, we set database-dependent search criteria: For EBSCO the strategy was to search within the (1) titles of the full available texts, (2) scholarly (peer reviewed) journal articles, (3) published in the period from January 1980 to November 2020, to ensure inclusion of studies from the beginning, and (4) to find search terms.

In EBSCO, our central database, we searched for articles using the core search terms in the English language: "female" AND "entrepreneurs" AND "(science or technology or engineering or mathematics)", "women" AND "entrepreneurs" AND "(science or technology or engineering or mathematics)", "female" AND "entrepreneurship" AND "(science or technology or engineering or mathematics)", "women" AND "entrepreneurship" AND "(science or technology or engineering or mathematics)", "predictors of women" AND "entrepreneurship" AND "(science or technology or engineering or mathematics)", "predictors of female" AND "entrepreneurship" AND "(science or technology or engineering or mathematics)", "predictors of female" AND "entrepreneurs" AND "(science or technology or engineering or mathematics)", "predictors of women" AND "entrepreneurs" AND "(science or technology or engineering or mathematics)", "predictors of female"

AND "entrepreneurs", "predictors of women AND entrepreneurs". As the number of hits per category of the search terms "science", "technology", "engineering" and "mathematics" in the central database of EBSCO was low, we selected the operator "or" to widen the focus of topics by covering one single group of STEM discipline.

As the literature search in Web of Science, Fachportal Pädagogik, and Google Scholar are complementary to the EBSCO database search, we did not widen the focus here in terms of the topic: Regarding the search in Web of Science we included the criteria "titles", "custom year range: 1980–2020", and the search terms "STEM" AND "women entrepreneurs", "STEM" AND "female entrepreneurs" and in the basic search: "STEM" AND "Women and entrepreneur*". The search in Fachportal Pädagogik was conducted without any further criteria except for the key words "STEM" AND "women" AND "entrepreneurship". In Google Scholar, we searched for articles meeting the criteria (1) "any desired time period"—"beliebige Zeit", (2) "any desired language"—"beliebige Sprache", (3) "sort according to relevance"—"nach Relevanz sortieren", and (4) the key term "predictors of STEM entrepreneurship in women". We excluded pages after the first 13 because of relevance and efficiency of search. Figure 1 shows the search process which was conducted on 24 November 2020 based on the inclusion and exclusion criteria presented in Table 1. In case we could not automatically select the inclusion criteria in the databases, we needed to select the papers by ourselves.

3.3 Included Studies

Applying the predefined criteria, we reached a total number of 15 selected articles, which are analyzed to study the explanatory factors.

4 Results

4.1 Descriptive Characteristics

An overview of the general information on author, year of publication, journal, research object/question, study design, place, and results are presented in Table 2. The current studies are relatively up to date because they were published in the period from 2012 to 2020. Most studies STEM from North America and Europe, with the exception of the two studies from Hong Kong and India, and were published in management and entrepreneurship related journals. In the "International Entrepreneurship and Management Journal", three studies were published; otherwise, they were no groups of texts relevant to the study in any one journal.

Three of the included studies are qualitative (Orser et al. 2012; Ozkazanc-Pan and Muntean 2012; Martin et al. 2015), eight are quantitative (Armuña et al. 2020;

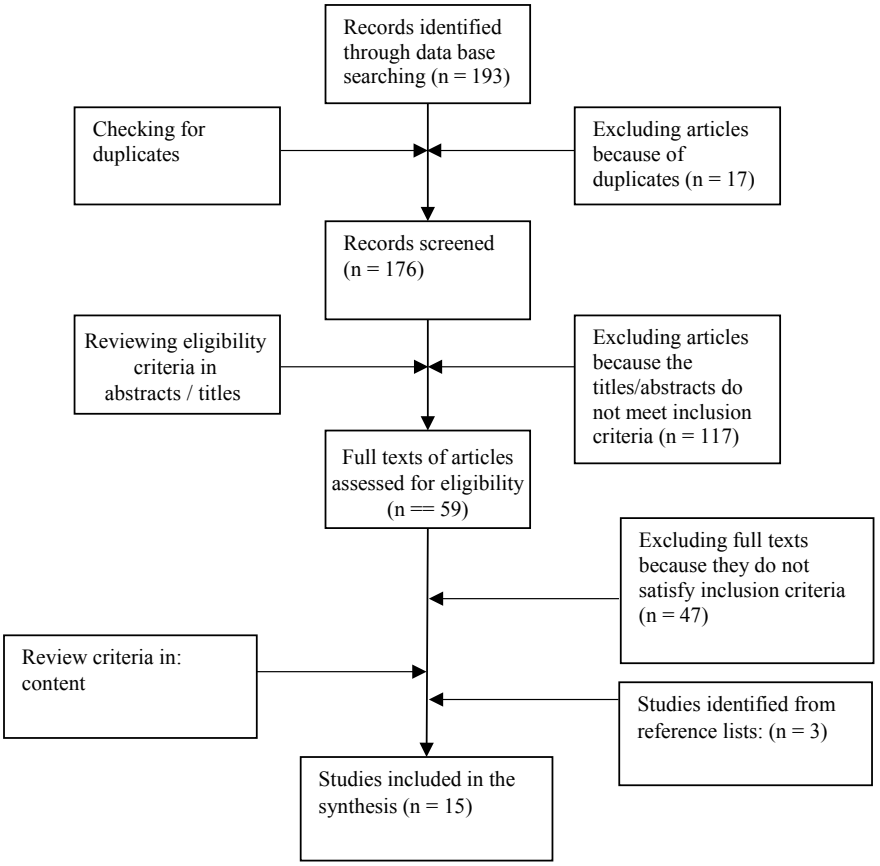

Fig. 1 Literature search procedure for articles

BarNir 2012; Colombo and Piva 2020; Demiralp et al. 2018; Dilli and Westerhuis 2018; Law and Breznik 2017; Sharma 2020; Woolley 2019), one is a mixed methods (Pascher et al. 2015), two are systematic literature reviews (Poggesi et al. 2020; Kuschel and Lepeley 2016), and one is a narrative literature review (Kuschel et al. 2020). Seven studies among the quantitative studies are of an inferential statistical nature (Armuña et al. 2020; BarNir 2012; Colombo and Piva 2020; Dilli and Westerhuis 2018; Law and Breznik 2017; Sharma 2020; Woolley 2019). They focus, from a third person perspective, respectively on explaining entrepreneurship intention, entrepreneurs' decision to incorporate innovative technologies in new ventures, entrepreneurial entry, entrepreneurial awareness, and choice of sector for entrepreneurial activity. Compared in the descriptive quantitative study (Demiralp et al. 2018) are companies and biographical backgrounds of female entrepreneurs, characteristics and outcomes of women and male entrepreneurs in STEM fields, women entrepreneurs in STEM and non-STEM fields, and self-employed women

Table 2 Information on the included studies

No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[1]	Armuña, C., Ramos, S., Juan, J., Feijóo, C. and Arenal, A	2020	From stand-up to start-up: exploring entrepreneurship competences and STEM women's intention	International Entrepreneurship and Management Journal	To explore the relationship between entrepreneurship competencies and intention (EI)	Sample: • Participants of the ActuaUPM entrepreneurship program, potential STEM entrepreneurs • Final sample of 140 participants with 82.1% men and 17.9% women • 138 valid answers Methods: • Structured questionnaire • t-test means comparison • Factor analysis to define the model of competences, • Multiple regression model to study the relationship between competences and skill factors in EI Place, Nation: Madrid, Spain	• The intention of becoming an entrepreneur predicted by competences loading in area of opportunity and ideas ($\beta = 0.339$; $t = 3.983$; p value = 0.000) followed by commitment competences ($\beta = 0.325$; $t = 3.803$; p value = 0.000) decision making ($\beta = 0.162$; $t = 1.895$; p value = 0.060), organization ($\beta = 0.180$; $t = 2.050$; p value = 0.042) • The relation between self-assessed competences and entrepreneurship intention is not moderated by gender R-square = 0.284

(continued)

Table 2 (continued)

No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[2]	BarNir, A	2012	Starting technologically innovative ventures: reasons, human capital, and gender	Management Decision	• To investigate the factors that promote the entrepreneurs' decision to incorporate innovative technologies in new ventures • "Are the reasons given for starting technologically innovative new ventures (TINVs) different from those given for starting ventures based on traditional technologies?" • "What is the role of human capital in the TINV start-up decision?" • "Do gender differences exist in the reasons and human capital associated with starting a TINV?"	Sample: • Established technology venture entrepreneurs: n = 518 • Nascent TINV entrepreneurs: n = 432 Methods: • Survey questionnaires • Panel Study of Entrepreneurial Dynamics II (PSED II), which is a national database of individuals in various stages of starting a business • Non-parametric methods and logistic regressions to test hypotheses Nation: USA	• The decision to start a TINV of female nascent entrepreneurs compared to established technology affected by general human capital (employment breath and education) ($\beta = 0.08$, $p < 0.10$ and $\beta = 0.28$, $p < 0.05$, respectively) and explain 6 percent of variance, • Industry experience was not significantly related to the decision of women • Technology background had a negative effect on the TINV start-up decision

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No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[3]	Colombo, M. G. and Piva, E	2020	Start-ups launched by recent STEM university graduates: The impact of university education on entrepreneurial entry	Research Policy	To analyze the relation between entrepreneurial entry and the human capital through university education	Sample: • The population of graduates who obtained only one MSc degree after attending one bachelor's degree program at POLIMI university • Population includes 13,840 individuals • Out of the 13,840 graduates included in the population, 2.7% established at least one limited liability company Methods: • Database 1: demographic data and information concerning the university curricula of all individuals who have enrolled in any degree program at POLIMI university • Database 2: Italian Business Register to identify all the Italian limited liability companies where POLIMI graduates had been listed as shareholders • Probit regressions to analyze the association between POLIMI recent graduates' entrepreneurial entry and the type and quality of human capital Place, Nation: Milan, Italy	• Wealth of family of origin, education, entrepreneurial experience increases the probability of entrepreneurial entry • Being female decreases the probability • The probability of establishing a new venture double (from 0.56% to 1.13%) when specialization in scientific and technical domains increases from 0.12 (i.e., the variable mean value minus one standard deviation) to 0.38 (i.e., the mean value plus one standard deviation) • The probability of entrepreneurial entry increases (from 0.60% to 1.14%) when graduates participated in economic and management courses • Pseudo R2 = 0.057

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No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[4]	Demiralp, B., Morrison, L. T. R., and Zayed, S	2018	On the commercialization path: Entrepreneurship and intellectual property outputs among women in STEM	Technology and Innovation	To compare characteristics and outcomes of women and men entrepreneurs in STEM fields; women entrepreneurs in STEM and non-STEM fields; and self-employed women and women in wage/salary employment in STEM fields	Sample: • Self-Employed women 2015 in the US: 5,200,295 • Self-employed men 2015 in the US: 9,024,328 Methods: • Literature review • Descriptive data analysis • Data from the 2015 American Community Survey (ACS) and the U.S. Census Bureau's 2007 and 2012 Survey of Business Owners (SBO) Nation: USA	• More self-employed women in STEM compared to men have received a bachelor's degree that is not related to science or engineering • The heterogeneous career paths of self-employed women in STEM (earning further graduate degrees in health care or accessing informal or on-the-job-training in STEM) • Women working in STEM wage/salary employment have more often a science and engineering related degree (e.g., nursing, architecture mathematics teacher education) compared to self-employed women in STEM who have more science- and engineering degrees • Relative to men, more self-employed women in STEM have received a master's degree

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No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[5]	Dilli, S., Westerhuis, G	2017	How institutions and gender differences in education shape entrepreneurial activity: a cross-national perspective	Small Bus Econ	To investigate the role of differences in STEM education at the national level for three stages of the entrepreneurial process: entrepreneurial awareness, the choice of sector for entrepreneurial activity, and (entrepreneurial growth aspirations; not of interest here); knowledge-intensive sectors	Sample: • 19 European countries (number of respondents given in parentheses): • Austria (91), Belgium (951), the Czech Republic (39), Denmark (1079), Finland (195), France (124), Germany (901), Greece (239), Hungary (217), Ireland (279), Italy (176), the Netherlands (248), Norway (282), Poland (30), Slovenia (244), Spain (1673), Sweden (284), Switzerland (210), the United Kingdom (UK; 1933), and the USA (1051) Methods: • GEM data • Base multilevel Probit regression techniques, Nation: 19 European countries, USA	• Women see significantly fewer opportunities and are • Less likely to start a business in highly knowledge-intensive branches than men • The probability of women to see an opportunity to start a business is 3% smaller and the probability to start a business in highly knowledge-intensive sectors is 6% smaller compared to men • Gender differences can be fully explained by differences in individual characteristics for the entrepreneurial awareness and the choice of sector • Tertiary education and networks increase the chance of perceiving opportunities and of the selection into knowledge-intensive sectors

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No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[6]	Kuschel, K., Ettl, K., Díaz-Garcia, C. and Alsos, G. A	2020	Stemming the gender gap in STEM entrepreneurship - insights into women's entrepreneurship in science, technology, engineering, and mathematics	International Entrepreneurship and Management Journal	To combine "insights from research about women's entrepreneurship and research about the gender aspects of STEM fields"	• Narrative literature overview of five selected articles on women's entrepreneurship in STEM • Emphasize institutional, organizational, and individual factors influencing women's entrepreneurship in STEM fields, • Synthesis of results of five studies included in the issue Nation: Europe, USA, Canada	• The hypothesis is not confirmed that fewer STEM women than men have entrepreneurial intentions • The process of forming an entrepreneurial intention is promoted by self-efficacy, entrepreneurial competences, specifically in opportunity identification and evaluation, identity formation of integrating opposite roles of "being a woman" on the one side and the double masculinized roles of "being an entrepreneur" and "being a professional in the STEM fields" on the other side

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No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[7]	Kuschel, K. and Lepeley, M.-T	2016	Women start-ups in technology: literature review and research agenda to improve participation	Int. J. Entrepreneurship and Small Business	• To focus "on women and gender differences in new high-technology ventures (NHTVs), defined as young business ventures that develop and offer high-technology solutions" • "To make a contribution to advance the understanding and the complexity of the relationship between NHTVs and gender"	Sample: • Criteria of inclusion: • Female-owned or female founders, or women employees, or sex-role stereotypes, or gender as an independent variable • Studies of a sample of entrepreneurs or firms in the technological industry • The firm should be a start-up or be • At its early business stage • Number of included articles: 22 Methods: • Literature search and review of peer-reviewed academic articles in Google Scholar and EBSCO Collection, books, chapters, high-technology reports, ad hoc corporations, and government sources Nation: worldwide	• General human capital defined by a person's education, and employment opportunity predict the decision to start a new high-technology venture of women, • Wealth seeking and employment reasons are negatively associated with the decision • Social networks are crucial for getting funds from venture capitalists in the high-tech sector

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No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[8]	Law, K.M.Y. and Breznik, K	2017	Impacts of innovativeness and attitude on entrepreneurial intention: among engineering and non-engineering students	International Journal of Technology and Design Education	To investigate the impact of attitudinal antecedents on the entrepreneurial intention of students	Sample: • 251 (25.2%) engineering students who took an entrepreneurship course in their classes from universities in Hong Kong • 747 (74.8%) non-engineering students (Business and Science backgrounds) from universities in Hong Kong Methods: • Questionnaires • Partial least squares (PLS) approach to SEM Place, Nation: Hong Kong	• Attitudes may have a stronger impact on the intention of female students compared to men, • "Innovativeness" may impact the intention of male students stronger compared to women • For the other variables the differences were not statistically significant

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No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[9]	Martin, L., Wright, L., Beaven, Z., and Matlay, H	2015	An unusual job for a woman? Female entrepreneurs in scientific, engineering, and technology sectors	International Journal of Entrepreneurial Behavior & Research	"To understand how particular women had created and were running rapid-growth SET enterprises"	Sample: • 15 female academic entrepreneurs who had set up and were running SET businesses • The business had been set up for at least five years and employed a minimum of four people Methods: • Qualitative approach (social constructionist approach) • Four semi-structured interviews with participants over a six-month period, plus reviews of their letters, plans, diaries, and blogs, written prior to and during business development and throughout the period of research Nation: UK	• Because of the gendered concepts of "entrepreneurship" and "technology" women's entry into STEM entrepreneurship is assumed to be a process that may disadvantage the women • Self-employment in STEM results from the confidence in the technical expertise • The minority status and difficulties with gender were compensated through expertise and competence • Besides industry knowledge individual characteristics such as determination, attention to detail, strong interpersonal skills, and strong networks of family, friends, and contacts are seen as crucial in this sector • Participants cope with gendered difficulties by assimilating to the norms of the masculinized STEM field

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No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[10]	Orser, B., Riding, A., and Stanley, J	2012	Perceived career challenges and response strategies of women in the advanced technology sector	Entrepreneurship & Regional Development. An International Journal	"To examine perceived barriers to women's career advancement specific to advanced technology sectors (aerospace, defense, life sciences, engineering and information and communications technology (ICT))"	Sample: • 115 women members of Canadian Women in Technology (CanWIT) Methods: • Analysis of qualitative data from an online survey conducted in 2006 • "Line-by-line examination of statements and statement coding on a sentence and then concept basis" based "on an initial set of coding categories" • "Data in each of these categories (or 'tree nodes', as defined in NVivo) were then further coded according to the subthemes which emerged" Nation: Canada	• The challenges they face in the technology sector are regarded as a result of gender • Gender has an influence on self-efficacy and performance expectancies, lack of social capital, networking opportunities, and sense of belonging • The influence of gender on individual level barriers to STEM is evident in gender typical differences in expectations, self-efficacy, interests, role investments, and career outcomes

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No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[11]	Ozkazanc-Pan, B. and Muntean, S	2017	Networking towards (in)equality: Women entrepreneurs in technology	Gender Work Organization	• To "investigate gendering practices through which women entrepreneurs become disadvantaged in the technology sector • To "focus on women entrepreneurs' experiences networking to access valuable entrepreneurial resources and examine the role of technology incubators and accelerators in facilitating this access"	Sample: • Six incubators and accelerators • 21 individuals including 14 female entrepreneurs, one male entrepreneur who had co-founded a company with his wife and chose specifically to become a certified woman-owned business, and six administrators (three male, three female representatives of incubators or accelerators) Methods: • Qualitative fieldwork approach: open-ended interview questions, observations, and participant-observations Place, Nation: US Northeast and Midwest	• Gendered networking, organizational practices, and norms contribute to gender inequality • Women's networks do not include people giving them information on incubators or accelerators • Social networks are considered by women as relational, relationship-building compared to a transactional instrumental type of male networking practice • White male networks increase the probability of access to job and high status contacts compared to female and minority dominated networks • While women rely on strong network ties, they typically have no access to the information, and individuals with weak ties • Incubators and accelerators play a gatekeeper role in supporting technology entrepreneurship • The male dominance in the incubator or accelerator contributes to the unawareness of gendered practices and the unwillingness of gender sensitive practices,

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No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[12]	Pascher, U., Roski, M. and Halbfas, B	2015	Entrepreneurial aspirations and start-up motives of women chemists in Germany	International Journal of Gender and Entrepreneurship	To "explore female chemists' entrepreneurship in Germany and to analyze the motivational factors with the aim of contributing to a better understanding of highly qualified women becoming entrepreneurs"	Sample: • 7 self-employed women chemists and one self-employed chemical engineer • 65 business founders in the chemical industry and related industry fields Methods: • Combined qualitative with descriptive quantitative methods • Interpretative interview method • Qualitative study on the basis of biographical interviews tracing the professional biographies of women self-employed chemists • By focusing on motives and causes of women self-employed chemists in quantitative study, Place, Nation: Germany	• The most important reasons of the chemists starting their own business were nearly the same for women and men only differing in the ranking positions • For women, the motive lack of opportunities in organizational employment and for men the motive fulfillment of a business idea was different among the top five motives • Most of the females undertook late in their career transition from organizational employment to entrepreneurship • The rate of female entrepreneurs might result from career development opportunities in companies

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No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[13]	Poggesi, S., Mari, M., de Vita, L. and Foss, L	2020	Women entrepreneurship in STEM fields: literature review and future research avenues	International Entrepreneurship and Management Journal	"To explore the published management research on women entrepreneurs in Science, Technology, Engineering and Mathematics (also known as STEM) fields in order to offer a first, comprehensive state-of-the-art of this research"	Sample: • Data collection in Scopus, Web of Science (WoS), and Business Source Complete (EBSCO) • Inclusion criteria: Peer-reviewed academic journal, Language English, Research discipline Business, management and accounting, Research methodology Theoretical and empirical, Time period Up to 2018, Sector STEM, Relevance Article addressing women entrepreneurship in STEM fields • Included studies: 32 Methods: • Systematic literature review • "Systematically investigate the selected papers" along "the gender issue, the main topic investigated by the authors and the suggested implications, both for research and practice"	• Two clusters of entrepreneurship: academic and non-academic entrepreneurship in STEM • Reasons for the underrepresentation of women academics in STEM field entrepreneurship: higher commitment to academic careers due to lower positions in academia compared to men, missing or less prior management exposure in companies, family obligations, and ethical reservation towards research commercialization • Barriers of non-academic entrepreneurship in STEM fields: lower education levels, and industry credentials, less management expertise, and role conflicts compared to men

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No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[14]	Sharma, L	2020	Exploring entrepreneurship among STEM women with mid-career break	Journal of Small Business & Entrepreneurship	To "assess the entrepreneurial intentions and level of perceived barriers to entrepreneurship among women in STEM with mid-career break"	Sample: • Full time or part time, working (in job) or non-working women with a minimum graduate level education in science, technology, engineering or mathematics, some work experience in the corporate or academia, break from the regular service for at least one year • 227 women in STEM with mid-career break Methods: • Self-administered questionnaire • Multinomial logistic regression and ordinal logistic regression were performed Place, Nation: India	• For STEM women with mid-career break in India, the high levels of entrepreneurial intentions are not influenced by marital status, education, years of work experience, or current working status • Could not identify any predictors for the level of perceived barriers that were experienced by the majority of women as high or moderate

(continued)

Table 2 (continued)

No	Authors	Year	Title	Journal	Research object/questions	Study design	Results
[15]	Woolley, J. L	2019	Who starts high-technology firms and the relationship between founders' gender, educational and occupational backgrounds, and firm outcomes?	Academy of Management Discoveries	• "Which women become technology entrepreneurs" • "How the heterogeneity of entrepreneurs' backgrounds influences the outcomes of their firms" (not of interest here) • "What are the backgrounds of women entrepreneurs of technology firms?" • "Do female founders of technology firms have similar educational and occupational backgrounds to male founders?"	Sample: • Selection criteria of firms: a single-business venture, founded to develop, produce, and sell nanotechnology products on the merchant market • Sample size: 595 firms Methods: • Database of U.S. nanotechnology firms • Level of nanotechnology activity was identified by the firm's products, patents, and technology data • Descriptive statistics, t tests • The Firm outcomes were analyzed using event history analyzes on the data with maximum likelihood estimation and robust standard errors • Data with consistently decreasing survival prospects were modeled with Weibull, Gompertz, and exponential distributions Place, Nation: USA	• While men were more often (30% vs. 22%) often working as professors compared to women, women are more likely in their previous occupations research scientists and post-docs than men (11% vs. 6%) (0.1 significance level) • Two-thirds of the female and the male founders respectively earned doctoral degrees • More than 50% of both female and male founders have business experience • 63% of the female founders have doctorates of which nearly all (97%) were earned in STEM related fields: 36% in chemistry related areas, 20% in physics and biophysics, 20% in engineering and materials sciences, 20% in biology-related domains • High education level as well as a variety of educational backgrounds • Female founders of high-technology firms were more likely to have prior occupations as a professor or research scientist than as executive in companies

and women with wage/salary employment in STEM. While two of the three qualitative studies deconstruct from a social constructivist perspective gendering practices disadvantaging women entrepreneurs in the technology sector and investigate the gendered context and meaning making of accessing STEM entrepreneurship (Martin et al. 2015; Ozkazanc-Pan and Muntean 2018), the other qualitative study analyzes from a second-person interpretative perspective perceived barriers to women's career success specific to the advanced technology sector (Orser et al. 2012). In the mixed methods Pascher et al. (2015) analyze the motivational factors to understand the professional biographies of self-employed women chemists (Pascher et al. 2015). In the systematic reviews (Poggesi et al. 2020; Kuschel and Lepeley 2016), the focus is on women and gender differences in new high-technology ventures (NHTVs) and on published management research on women entrepreneurs in Science, Technology, Engineering, and Mathematics. The narrative review reveals insights from research on women's entrepreneurship and research on the gender aspects of STEM fields (Kuschel et al. 2020).

There is a wide range in the number of participants in the studies. In the qualitative studies, there is a range of seven to 115, while in the quantitative studies there is a range from 65 to 152 million participants. The great range, especially in the quantitative studies, is related to the fact that in the cases where the number is lower, the sample was selected for research purposes, while in the studies with larger samples reference was made to already existing national and international surveys.

The participants of the quantitative studies can be categorized as participants in educational formal or informal programs (Colombo and Piva 2020; Law and Breznik 2017), as participants in national surveys (Demiralp et al. 2018), as participants in international comparative surveys (Dilli and Westerhuis 2018), founders in a specific STEM domain (Pascher et al. 2015), nascent established technology venture and TINV entrepreneurs (BarNir 2012), and as participants, characterized by a specific position in the life course (Sharma 2020). The participants of the qualitative studies are representatives of accelerators, resp. incubators (Ozkazanc-Pan and Muntean 2018), female STEM entrepreneurs, members of a nationwide association of women in technology (Orser et al. 2012), self-employed women in a specific STEM domain (Pascher et al. 2015) and established female entrepreneurs in STEM (BarNir 2012). The number of included studies of the systematic reviews is 22 and 32, and for the narrative review, it is five.

While most of the current quantitative and qualitative studies collected their data with the aid of questionnaires or interviews, except for two studies in which observations, reviews of letters, plans, diaries, and blogs are also included, the authors of the literature reviews took their data from peer-reviewed academic articles.

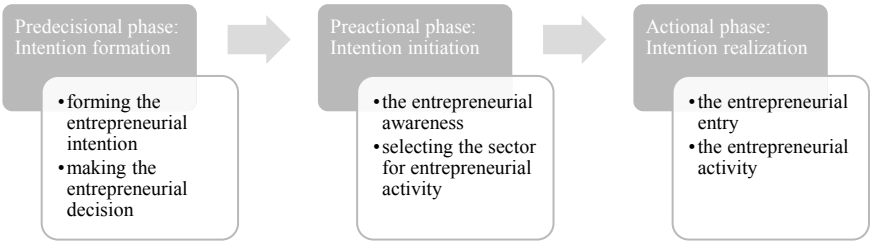

Fig. 2 Matching of dependent variables referring to an entrepreneurial action and the first three action phases of the Rubicon model

4.2 Systematization of Results

Analyzing these studies, we can differentiate between five dependent variables: (a) entrepreneurial intention, (b) entrepreneurial decision to start a venture, (c) entrepreneurial awareness, (d) choice of sector for entrepreneurial activity, and (e) entrepreneurial entry. By means of the Rubicon model of action, it becomes clear that entrepreneurial intention realization, here conceived as entrepreneurial entry or entrepreneurial activity, follows a process that needs to be explained for the whole course of action. Based on the Rubicon model of action phases developed by Heckhausen and Gollwitzer (1987) we can conclude that three of these four phases reflect the above mentioned differently explained variables in the analyzed studies. Figure 2 shows how the dependent variables of the present study are matched with the action phases of the Rubicon model.

The pre-decisional phase of entrepreneurial entry/activity results in formatting the intention of making the decision to start an entrepreneurial activity which is followed by the pre-actional phase of entrepreneurial awareness and selection of an entrepreneurial sector. As soon as the entrepreneurial intention is initiated, the entrepreneurial activity will be realized.

As the currently analyzed studies do not imply the explanatory variables "interest" and "performance" of social cognitive theory, we will adapt the social cognitive theory of career and academic interest, choice and performance in such a way that the variables to be explained, namely interests, goals, actions will be substituted by the variables in the Rubicon model of action phases: intention formation, intention initiation, and intention realization.

The individual factors are represented in the social cognitive theory of career and academic interest, choice, and performance by person inputs, learning experiences, self-efficacy, and outcome expectations. We categorize the person input variables based on the personality theory of McAdams and Pals (2006). Table 3 shows the theoretically derived coding schemes for the person input variables.

The analyzed studies, in which the predictors for entrepreneurial intention formation, initiation, and realization are studied, belong to the type of third person studies which are characterized in our case by an empirical methodology based on inferential

Table 3 Coding scheme of personal input variables based on McAdams and Pals (2006)

Code	Description	Example
Characteristic adaptations	"Motivational, social cognitive, and developmental variables that are contextualized in time, situations, and social roles" (Costa and McCrae 1985)	Abilities, competences, knowledge, attitudes, motives
Identity	Self-concept (Heatherton et al. 2007)	Narratives of being competent

statistics, while the present qualitative studies that focus on interpretative questions fall under the second-person perspective.

We group the results according to the different characteristics:

- phases of intention course,
- type of individual variables including person inputs grouped around the two dimensions of characteristics adaptations, and identity as well as sociographic characteristics, learning experiences, self-efficacy and outcome expectations, and
- methodological perspective.

Figures 3, 4, 5, 6, 7 and 8 show a systematized integration of the results by giving an overview of which types of the individual level factors analyzed in the present studies interact with the respective intention states of the entrepreneurial action of women in STEM, based on methodological perspectives.

For reasons of clarity, a separate model is developed for each intention state of the STEM entrepreneurial entry. As "contextual influences" and "background contextual affordances", the non-individual components of the social cognitive theory of career

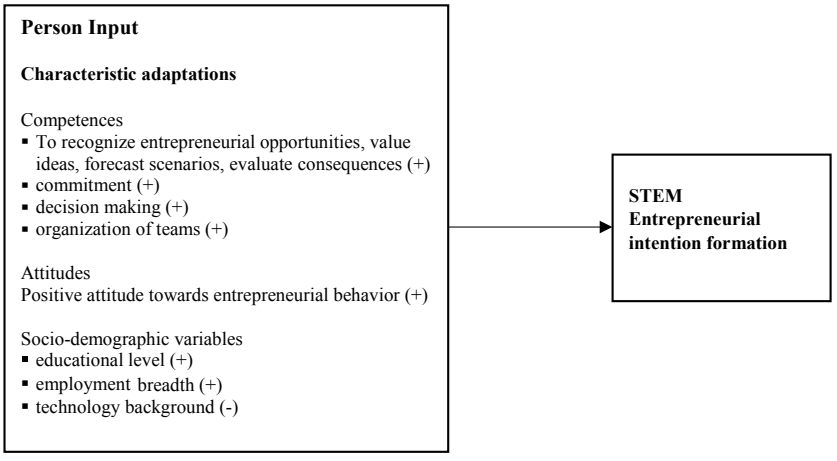

Fig. 3 Model explaining the entrepreneurial action state of intention formation in women's STEM entrepreneurship (Quantitative studies based on inferential statistics; directions of relationships are presented in parentheses)

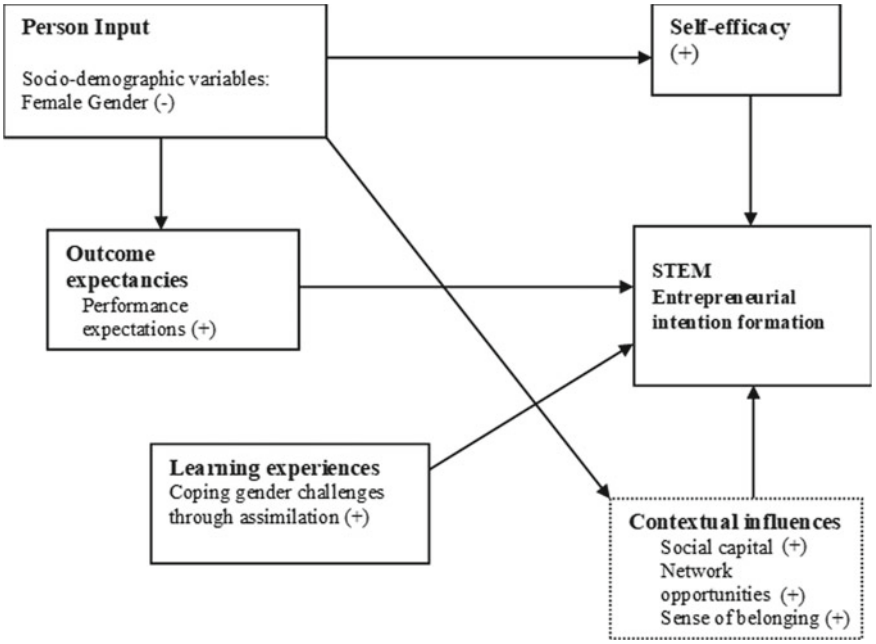

Fig. 4 Model explaining the entrepreneurial action state of intention formation of women's STEM entrepreneurship (Qualitative studies; directions of relationships are presented in parentheses)

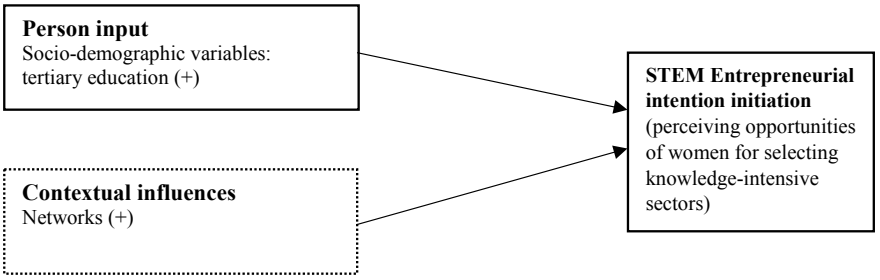

Fig. 5 Model explaining the entrepreneurial action state of intention initiation of women's STEM entrepreneurship women (Quantitative studies based on inferential statistics; directions of relationships are presented in parentheses)

and academic interest, choice, and performance are not the focus of the current study, we will present them in the figures with dashed lines. Moreover, for the last action phase, intention realization, we will distinguish between the models of academic and non-academic entrepreneurship in STEM fields (Poggesi et al. 2020) because of the available differentiated data.

Besides characteristic adaptations, such as entrepreneurial competence, and favorable attitudes towards entrepreneurship, socio-demographic variables, such as a

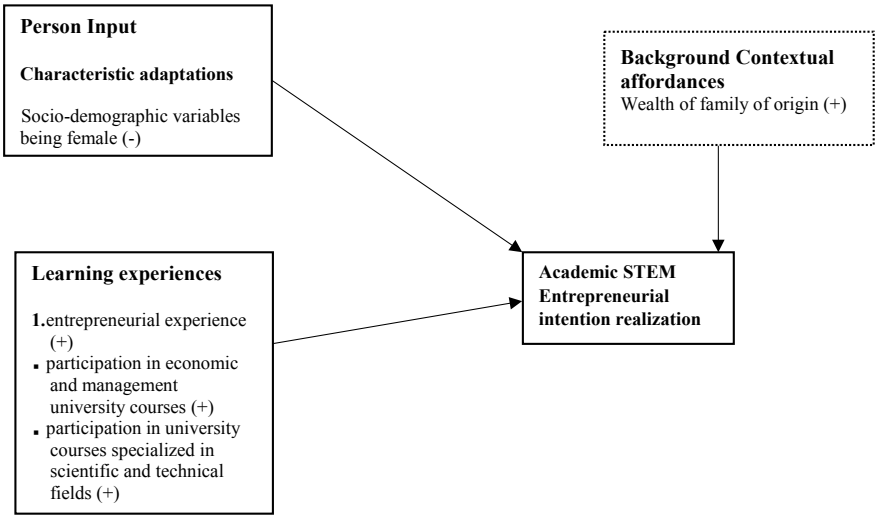

Fig. 6 Model explaining the entrepreneurial action state of intention realization in women's academic STEM entrepreneurship (Quantitative studies based on inferential statistics; directions of relationships are presented in parentheses)

high educational level, breadth of employment, contribute to women's STEM entrepreneurial intention formation (Armuña et al. 2020; BarNir 2012; Law and Breznik 2017) (see Fig. 3). The technology background is negatively related to the entrepreneurs' decision to incorporate innovative technologies in new ventures (BarNir 2012).

In the qualitative studies (Orser et al. 2012) gender is regarded as challenge women face in establishing their business in technology. Gender may influence the predictors of STEM entrepreneurial intention formation, including sense of self-efficacy, performance expectations, and the contextual influences of social capital, network opportunities, and sense of belonging. The learning experience of coping gender challenges through assimilation seems also to be positively associated with the probability of women's STEM entrepreneurial intention formation (see Fig. 4) (Kuschel et al. 2020; Kuschel and Lepeley 2016).

Figure 5 shows that for the process of intention initiation, here perceiving opportunities and selecting the field of knowledge-intensive sectors, besides the contextual influences of networks, the person input variable of tertiary education plays a crucial role (Dilli and Westerhuis 2018).

For the last process element of career choice, entrepreneurial intention realization, we developed three models, two academics (Figs. 6 and 7) and one for non-academic (Fig. 8) STEM Entrepreneurial intention realization. The first two models are differentiated by models based on qualitative and quantitative studies.

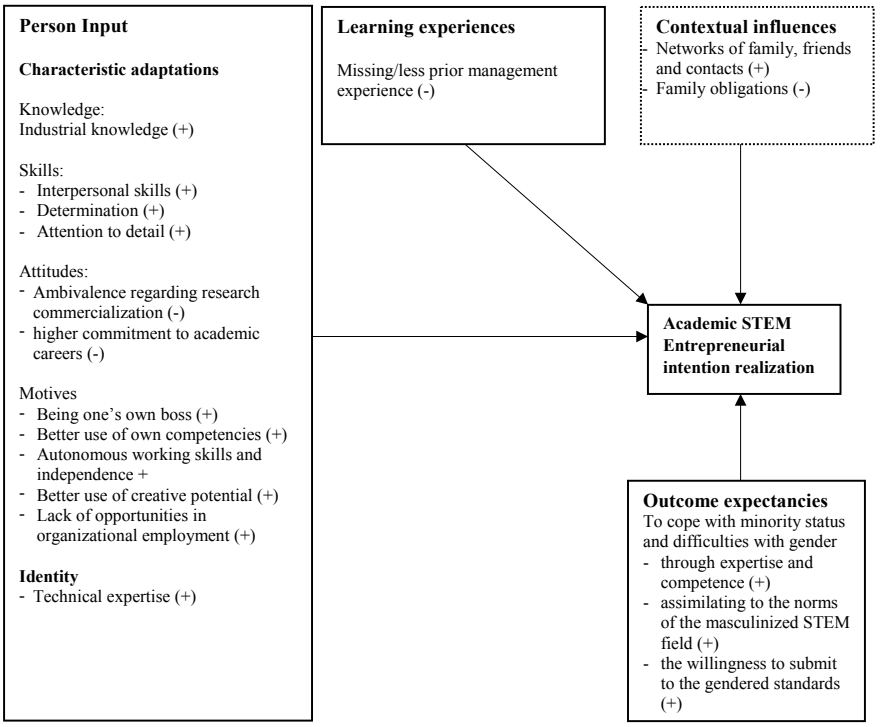

Fig. 7 Model explaining the entrepreneurial action state of intention realization in women's academic STEM entrepreneurship (Qualitative studies; directions of relationships are presented in parentheses)

For academic intention realization, we found in a quantitative study (Colombo and Piva 2020) that a specialization in scientific and technical fields, learning experiences in economic and management courses as well as entrepreneurial experiences, are positively correlated with the academic STEM entrepreneurial intention realization while being female, decreases the probability of realizing the academic STEM entrepreneurial intention of women (Fig. 6).

The qualitative studies focusing on the academic STEM entrepreneurial intention realization reveal that the characteristic adaptations of industrial knowledge, specific skills, the self-concept of being a technical expert, and a variety of motives such as autonomous working and independence, and better use of creative potential might have a positive effect on realizing women's academic STEM entrepreneurial intentions while having missing/less prior management experience, an ambivalent attitude regarding research commercialization, and a higher commitment to academic careers seem to decrease the probability of realizing intentions (Martin et al. 2015; Pascher et al. 2015; Poggesi et al. 2020) (Fig. 7) In addition, the outcome expectations of coping with gender challenges through expertise and competence, assimilating to the

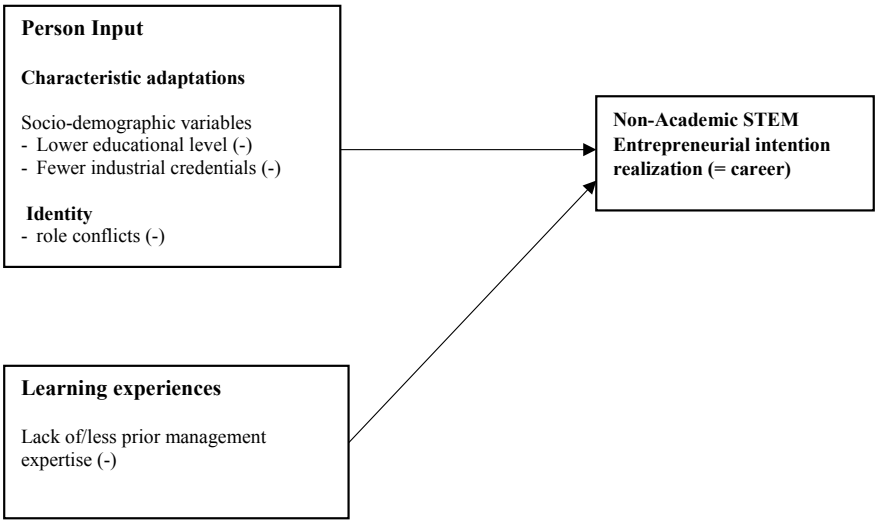

Fig. 8 Model explaining the entrepreneurial action state of intention realization in women's non-academic STEM entrepreneurship (Literature review; directions of relationships are presented in parentheses)

norms of the masculinized STEM field, and the willingness to submit to the gendered standards may promote the realization of intentions (Martin et al., 2015).

Referring to Orser, Riding, and Stanley (2012), Poggesi et al. (2020) summarized the individual level career barriers of non-academic STEM women entrepreneurs: they are seen in lower educational level, fewer industrial credentials, lack of/less prior management expertise, and role conflicts (Fig. 8).

5 Conclusions

The aim of this study was to investigate state-of-the-art research on individual factors that explain women's entrepreneurship in STEM by conducting a literature review. Based on the theoretical foundations of the Social Cognitive Theory of Career and Academic Interest, Choice and Performance developed by Lent et al. (1994), the Rubicon model of action phases developed by Heckhausen and Gollwitzer (1987), and the personality theory of McAdams and Pals (2006), we modeled the explanatory variable of entrepreneurial entry as a process consisting of entrepreneurial intention formation, intention initiation, and intention realization.

The STEM entrepreneurial intention formation of women seems to be predicted by characteristic adaptations, such as entrepreneurial competencies, favorable attitudes towards entrepreneurship, high level of education, and employment breadth.

Female gender may have a negative influence on the predicting variables of intention, for example, performance expectations and self-efficacy, while the learning experience of coping with gender challenges through assimilation seem to be positively associated with the probability of women's STEM entrepreneurial intention formation.

For the process of intention initiation, here perceiving opportunities and selecting the field of the knowledge-intensive sector, tertiary education plays a crucial role. Due to the high level of knowledge required in this sector, which includes fields of social sciences, for example, this relationship is plausible.

A differentiated perspective is addressed for intention realization: Academic intention realization might be affected positively by several learning experiences, such as specialization in scientific and technical fields, learning experiences in economic and management courses, as well as entrepreneurial experiences, by the characteristic adaptations of industrial knowledge, specific skills, self-assigned technical expertise, and a variety of motivations, such as autonomous working ability and independence, and better use of creative potential. In contrast, being female, having an ambivalent attitude regarding research commercialization and a higher commitment to academic careers seem to decrease the probability of realizing women's academic STEM entrepreneurial intentions. Being able to cope with minority status and gendered challenges through expertise and competence, assimilation to the norms of a male-dominated majority, and willingness to submit to gendered standards might positively affect women's realization of intentions.

Lower educational levels in STEM relevant fields, fewer industrial credentials, lack of/less prior management experience, and role conflicts seem to decrease the probability of realizing women's non-academic STEM entrepreneurial intentions. Regarding intention formation, we can state that while in the social cognitive theory of career and academic interest, choice and performance, personal inputs have indirect effects via learning experiences which predict both self-efficacy and outcome expectancy via interests, in our model personal inputs seem to directly affect intentions. Another surprising result is the discrepancy between the predicting factor of the educational level of established female technology venture entrepreneurs and nascent TINV entrepreneurs in the USA, on one hand, (Dilli and Westerhuis 2018), and the missing influences of education, years of work experience, or current employment status for STEM women with a mid-career break in India (Sharma 2020), on the other. While confidence in technical expertise is seen from an inter-subjective perspective as a promoter of **e**ntrepreneurial intention realization (Martin et al. 2015), the technological background of nascent TINV entrepreneurs seems to be negatively related to intentions (Dilli and Westerhuis 2018). Apparently, there is a difference between the decision to found a technological enterprise and the decision to incorporate innovative technologies into new ventures, which requires expertise that can be incorporated by externals.

For all phases, our limited conclusions about the data are that learning experiences and corresponding competencies related to STEM can be gained through formal learning or other channels, and entrepreneurial as well as management experiences are crucial individual factors for women's STEM entrepreneurship. These

competencies might also allow women, by questioning and refuting stereotypes, to master gendered challenges such as gendered organizational practices in incubators and accelerators (Ozkazanc-Pan and Muntean 2018) that contribute to gender inequality. The influence of learning experiences, education, and competencies is a reason for the key role played by a gender sensitive educational system in furthering women's STEM entrepreneurship.

Summarizing the current research studies of individual level factors explaining women's STEM entrepreneurship, we can affirm that, even though there is a growing body of scholarly literature devoted to women's entrepreneurship in STEM, research on female STEM entrepreneurship is still in an early stage. A research program has not yet been established with progressive research questions, comparable research objects, and theory based dependent variables.

Regarding research desiderata, we identify a research gap in internationally comparable studies and statistics of entrepreneurship related to gender. For instance, in Germany, a representative study on women's STEM entrepreneurship using data drawn from national statistics cannot yet be conducted because of missing relevant scales included in surveys or small sample sizes for the population studied.

The current systematic literature study contributes to a first overview of state-of-the-art research on individual factors that explain women's entrepreneurship in STEM. However, this study is exploratory, as it is limited especially by a relatively low number of included studies. We referred to peer-reviewed journals. In future studies, monographs and editions should be included in the search process.

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