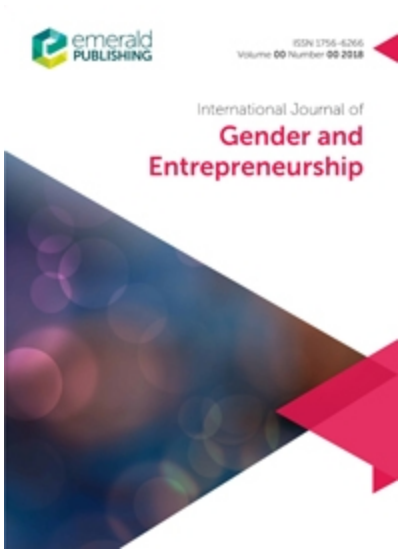

Gender, STEM Women and Entrepreneurship: A Review and Future Research Directions

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Gender, STEM Women and Entrepreneurship:

A Review and Future Research Directions

Introduction

It is an honour to be invited to contribute a personal reflective paper to the first Ambassador Special Issue of the International Journal of Gender Entrepreneurship (IJGE). This article focusses upon research relating to the entrepreneurial activity undertaken by women in Science, Technology, Engineering and Mathematics (STEM) disciplines and sectors, used here to include Medicine related entrepreneurship (sometimes considered separately, leading to the STEMM abbreviation mainly in UK literature). Research exploring the gendered barriers faced by these highly-educated, typically middle-class, women who would be considered best-placed to overcome such challenges, underscores the enduring and transversal nature of gender inequalities.

Governments invest significant financial resources in supporting STEM research and commercialisation activities due to the assumed socio-economic returns pertaining to wealth, employment creation and, economic and social development (Treanor *et al.*, 2021). Consequently, the gender gap in innovation-driven STEM entrepreneurship attracts policy attention, with policymakers indicating the notional economic loss ensuing from lower rates of STEM entrepreneurship by women (Treanor, 2019). In addition to this 'business case' for equality and diversity, the loss of innovative talent represents an issue of fairness and equality. Yet, STEM women entrepreneurs and the constraints upon and enablers for their entrepreneurial activity have been relatively under-researched despite the importance attached to such activity; for example, a recent systematic literature review (SLR) identified only 32 papers between 2005 and 2018 published in peer-reviewed, international management journals on this topic (Poggesi *et al.*, 2020).

This invited review aims to provide an overview of the main themes and trends within this research topic to inform future research recommendations. A systematic literature review (SLR), comprising of 34 peer-reviewed journal articles, informs this review of research on women entrepreneurs in STEM fields published in the management literature between January 2018 and

August 2022. This represents the intervening period since Poggesi et al.'s (2020) SLR was completed. Given that more articles have been published over the last few years than in the preceding fourteen covered by that review, this topic is attracting increased academic attention. This is, therefore, an opportune time to review what is currently known, being explored and remains to be addressed about STEM women's entrepreneurship, and based upon an analysis of the literature, indicate fruitful directions for future research.

Early research focussed upon women entrepreneurs generally was framed comparatively, with women entrepreneurs treated as a homogenous group, to explore how women's entrepreneurial performance differed from their normative male counterparts; this served to reinforce the gender binary and reproduce gendered inequalities (Ahl, 2006). Subsequently, critical feminist analyses of the influence of gender upon women's entrepreneurial behaviour emerged wherein, gender was recognised as a social construction rather than biologically predetermined behaviour (de Beauvoir, 1953), and as a performative (Butler 1993; 2004) which varies with time, place and context (Welter, 2011; Welter 2020). This feminist research challenged the underperformance discourse that positioned women as deficient, by highlighting structural, gendered barriers to women's entrepreneurship (Marlow, 2019). Women-owned businesses were found to enjoy similar outcomes to male-owned businesses when factors such as business age and sector were considered (Marlow and McAdam, 2012a).

An important strand of research emerged focussed upon women's entrepreneurial endeavours in gender atypical contexts, such as male-dominated STEM fields, which remain gendered masculine even when women outnumber men (Treanor and Marlow, 2021). This research avenue is important for several reasons. Gendered stereotypes dissuade some women from pursuing or remaining in STEM careers (Marlow and McAdam, 2015) which, is not only unfair to these individual women but also, represents an avoidable loss of talent, innovation, and potential economic and social development for economies globally. Women who do engage in STEM entrepreneurship merit research attention as highlighting their achievements provides role models for other women (Poggesi

et al., 2020). Moreover, illuminating the strategies they employ to successfully navigate these gendered contexts can inform strategies adopted by other women to navigate or challenge these gendered environments.

The remainder of this article commences with an overview of the evolution of research exploring the barriers faced by STEM women, the SLR protocol is then outlined before the trends within the research are presented. The main results are analysed, and the paper concludes with implications for future research and consideration of limitations.

Looking Back: The Emergence of a Research Area

Research into STEM women began by exploring the 'leaky pipeline' (Wickware, 1997; Blickenstaff, 2005), that is, the early exit of women from STEM careers due to masculine contexts with long hours and progression based upon unbroken employment, the implications of maternity leave representing time away from team-based laboratory work with longer term implications for sharing of outcomes, maintaining up-to-date with current developments and future team inclusion (Blackwell and Glover, 2008). Women returning from maternity leave were given more junior positions within their company or industry which inhibited vertical progression and accumulation of managerial and entrepreneurial capital (McAdam and Marlow, 2008). Most research explored the technology sector (Poggesi et al., 2020) wherein a strong association between technology and masculinity existed (Wynarczyk and Renner, 2006) with women underrepresented as senior managers, entrepreneurs and in patenting activity (Martin *et al*., 2015; Walby, 2011; Wynarczyk and Renner, 2006). Feminist analyses illustrated gendered constraints upon women's professional career progression in other STEM disciplines, such as engineering (Duberley, Cohen and Mallon, 2006; Fernando, Cohen and Duberley, 2018), and upon their entrepreneurial opportunities and behaviours, enacted as professional practice creation or partnership in veterinary (Treanor and Marlow, 2021) or human medicine (Gallagher and Olsson, 2018), as examples.

Research on this topic has focussed upon either STEM women academic entrepreneurs or STEM women entrepreneurs engaging in entrepreneurship outside academia (Poggesi et al., 2020). Academic entrepreneurship (AE) is understood as the commercialisation of scientific research discoveries through spin-out activity (Abreu and Grinevich, 2017). However, research exploring the gendered experiences of academic women entrepreneurs remains scarce. Outside academia, there has been a dearth of women engaging in new venture creation in STEM fields (Coleman and Robb, 2016). Given they represent a small and hard-to-reach population, it is unsurprising that research focussed upon STEM women entrepreneurs is often located within a business incubation context. Business incubators provide training, mentoring and act as network brokers, assisting novice entrepreneurs in accessing investment; consequently, they boost rates of firm survival and venture growth (BEIS, 2017). However, these environments tend to adopt a uniform approach to client support that does not recognise distinct needs or challenges of women tenants (Treanor and Henry, 2010). They are also gendered environments, with research highlighting that typically male managers and advisors influence client women's behaviours such that they mould their behaviour and gender performances to 'fit' with the prevailing masculine norms (Marlow and McAdam, 2012b), leading some to behave as 'honorary men' (Martin et al., 2015, p.175). The methodological approach employed herein is now outlined before the findings of the SLR are presented and, reflecting upon these and the wider literature, future research directions are outlined.

Methodology

SLRs provide a robust basis for identifying useful directions for future research (Thorpe et al., 2005; Poggesi et al., 2020). As per established SLR good practice (Pittaway and Cope, 2007; Poggesi et al., 2020; Thorpe et al., 2005), the information collection process, selection criteria and analysis are now detailed.

Information Collection Process

The most comprehensive databases of peer-reviewed management journals, Web of Science (WoS), Scopus and Business Source Complete Premier (EBSCO), were searched for relevant publications using search terms (shown in Table 1) in each of three separate search rows, with relevant limitations added to the subject areas in both WoS and Scopus. The search criteria and results are shown in Table 2. As this article aims to systematically review publications on STEM women entrepreneurs in the period since Poggesi et al.'s (2020) initial review, the same databases and search strings were used. The search strings were informed by previous research; STEM keywords were informed by Cheryan et al. (2016); gender keywords by Foss et al. (2019) and firm-related keywords by Poggesi et al. (2016).

[Insert Table 1 about here]

[Insert Table 2 about here]

Study Selection

Having removed duplicate articles within and across databases, the title and abstracts were reviewed of each remaining article. The inclusion and exclusion criteria informing article selection for inclusion in this review are contained in Table 3. A total of 34 articles were selected for inclusion, with 4,578 articles discarded due to a lack of relevance. This reflects the ongoing research focus in the literature into issues influencing the entry of young women into STEM study, the issues faced subsequently as employees, and the influence of women on boards. Many articles focussed upon digital entrepreneurship, defined to include firms using technology platforms for sales and marketing purposes, these were excluded from this review where the businesses were not technology (or other STEM) sector businesses. One paper (Schillo and Ebrahimi, 2022), adopting a narrower definition of digital entrepreneurship and contrasting venture-capital backed digital firms with similar firms in life-science and biotech, was included. The differential in scale between the initial search result yield and the final sample is not uncommon in management research given the strict SLR protocol (Pogessi et al., 2020; Osagie et al., 2016).

[Insert Table 3 about here]

Data Analysis

The selected papers were categorised according to focus, as determined by keywords, title and abstract, into two groups: nine papers focussed upon 'STEM women academic entrepreneurs' and 25 researching 'STEM women entrepreneurs' outside academia. This classification facilitated initial identification of relevant themes in relation to each key research subcategory during the reading process. Content analysis was informed by a reading guide capturing the main topic under investigation, the consideration of gender and the methodological approach; the main findings of which are set out in Table 4.

[Insert Table 4 here]

Trends in the Research

In recent years there has been an increasing number of publications on this topic with an average of over six papers per year (see Figure 1) published in 26 different journals, indicative of the range of theoretical perspectives employed. This journal, IJGE, leads the conversation in this field having published most papers on this topic since 2005 to present. While fifteen articles focussed on a range of STEM sectors, the technology sector remains the dominant sectoral research focus (18 papers).

Eighteen papers in the sample undertook quantitative analysis, most frequently employing regression analyses. All the qualitative papers employed semi-structured interviews; only three papers incorporated additional methods such as observation, participant observation, focus groups and content analysis (document and website). As expected, qualitative research drew upon smaller sample sizes (ranging from nine to forty) to facilitate deeper insights into the influences upon, experiences and outcomes of, STEM women entrepreneurs. This is appropriate for studies employing gender as a lens to analyse how gendered power relations, practices, stereotypes and structures shape the choices, experiences and outcomes of STEM women entrepreneurs facing a "double masculinity" penalty (Kuschel et al., 2020) due to engaging in entrepreneurship, with an associated masculine

construction (Ahl, 2006), in a normatively masculine sector (Treanor, Marlow and Swail, 2021). Such research advances knowledge and highlights potential interdependencies and relationships worthy of further exploration. The quantitative articles in this sample, with datasets ranging in size from 52 to 107,797, contribute generalisable insights. It is noteworthy that despite the potential benefits of mixed-methods research (Molina-Azorín et al., 2012), such that qualitative data could provide rich explanatory insights from a gender perspective into patterns observed from quantitative analysis, there were no mixed methods studies within this sample.

[Insert Figure 1 about here]

Analysis of the Literature

Papers in the SLR sample were categorised as either focussing upon 'STEM Women Entrepreneurs' establishing firms outside academia or 'STEM Women Academic Entrepreneurs' based upon their research focus; each category is discussed in turn.

STEM Women Entrepreneurs

Quantitative studies either sought to identify the macro, meso or individual level factors influencing, or that could be leveraged to promote, STEM women's entrepreneurial activity (Xie and Liv, 2018; Piva and Rovelli, 2022), or they explored the performance outcomes of STEM ventures having women owners or within the entrepreneurial team, in terms of financial returns and growth (De Martini, 2018), innovation (Dai et al., 2019; Owalla et al., 2021), access to finance (Nigam et al., 2022) or likelihood of firm failure (Woolley, 2019).

DeMartini (2018) sought to investigate if the female underperformance hypothesis held for STEM women entrepreneurs in Italian high-tech start-ups, establishing that STEM women entrepreneurs did not underperform in comparison to their male counterparts. Indeed, their businesses had a similar profile to male-owned businesses in relation to employee numbers and sales revenue but were slightly more profitable and more efficient. Despite this, these STEM women raised less equity and had fewer sources of funding than their male counterparts with a higher cost of debt capital applied to the women entrepreneurs. This literature highlights that gender inequalities and

discrimination faced by women in relation to entrepreneurial capital persists across sectors (Wheadon and Duval-Couetil, 2019; Schillo and Ebrahimi, 2022), country contexts (Alakaleek and Cooper, 2018; Nigam et al., 2022) and, it seems, time. Even when monetising their inventions, STEM women entrepreneurs tend to be disadvantaged receiving less income from patent sales (McGrath et al., 2022). As Woolley (2019) notes, the educational and career backgrounds of high-tech entrepreneurs may be similar but similar types of human capital may be regarded and experienced differently.

Papers using gender as an analytical lens explored topics such as entrepreneurial belonging and gender liminality (Birkner, 2020) and, for high-tech women entrepreneurs, legitimacy (Vershinina et al., 2020), entrepreneurial learning and belonging (Kubberod et al., 2021) and networks (Ozkazanc-Pan and Muntean , 2018; Woodwark et al., 2021). Like many of the papers, Ozkazanc-Pan and Muntean's (2018) research was located within a technology incubator and highlighted the "*rarity of women in incubators and accelerators"* as Presidents and Directors, managers, advisers and "*especially as tenants"* (2018, p.388). Women were also under-represented in the firms providing partner services, on behalf of the business incubators to their client firms, such as accountants, venture capitalists and law firms, which contributed to further segregation and exclusion due to processes including tokenism and homophily. This work illustrates how gendered organisational practices within and among technology incubators, in tandem with societal norms, deleteriously influence women entrepreneurs networking to access resources, resulting in their marginalisation. Sperber and Linder's (2022) article, focussed upon blockchain start-ups and drawing upon optimal distinctiveness theory and the normative force of the factual, explains how the gender imbalance within I.T. supports the reproduction of the normative male tech entrepreneur that maintains such gendered organisational and sectoral cultures which result in the marginalisation of women outlined by Ozkazanc-Pan and Muntean (2018).

Gendered STEM sectors and masculine environments can deter women (Marlow and McAdam, 2015) and while most respondents had established STEM firms in Ármane et al.'s (2022) study, which explored the contextual embeddedness of Danish, Latvian and Turkish women's STEM

entrepreneurship, some Latvian respondents had chosen to engage in entrepreneurial activity outside STEM. STEM women in Latvia and Turkey also reported greater challenges in founding their ventures attributable to weaker start-up cultures and less institutional support; a reminder of the importance of context at multiple levels – national culture, regulatory infrastructure, attitudes towards entrepreneurship and social gender norms.

Given the historical dominance of research from the North America and Europe it is heartening to see exploration of mainstream issues now being explored in relation to STEM women entrepreneurs in different country contexts. For example, Adikaram and Razik (2022) highlight the femininity penalty faced by STEM women entrepreneurs in Sri Lanka while Gupta and Etzkowitz (2021) explore issues surrounding entrepreneurial identity for high-tech women entrepreneurs in the embedded context of a technology incubator in the patriarchal society of India. Neneh and Welsh's (2022) study examines the influence of family support in South Africa with findings echoing the importance of such support for women technology entrepreneurs (Marlow and McAdam, 2012) in Western contexts.

The multidisciplinary nature of entrepreneurship research is also evident in the literature with recent psychology-based studies of high-tech women entrepreneurs emerging. Bendell et al. (2019) quantitatively explored the behavioural and cognitive approaches to self-leadership of high-growth entrepreneurs based in a high-tech incubator in the U.S., finding that women engaged more in self-cueing behaviours which supports incremental innovation but were less aggressive in goal-setting behaviours which adversely affected intellectual property development. Nouri and AhmadiKafeshani (2020) explore the influence of heuristics and biases upon entrepreneurial entry decisions and opportunity identification in the high-tech sectors of biotech and advanced medicine in Iran. They found STEM women entrepreneurs are less likely than male counterparts to rely on the 'representativeness heuristic' (that is, assuming a small sample is generally representative) and to engage in 'escalation of commitment', that is, persist with failing courses of action.

Reflecting calls for research investigating the influence of intersecting socio-demographic categories on entrepreneurial activity generally and for women's entrepreneurship specifically (Marlow and Martinez Dy, 2018; Martinez Dy, 2020), intersectional analyses of STEM women's entrepreneurial activity are emerging. Owalla et al. (2019) explore the intersection of gender, ethnicity, place and innovation, highlighting the scarcity and geographical clustering of women-led, technology sector SMEs in the U.K., reminding us not only of the importance of place and regional access to institutional supports, but also how such access and opportunities differ due to social positioning.

STEM Women Academic Entrepreneurs

Women academics in STEM disciplines are reportedly less likely to engage in, or be interested in, commercialisation and are under-represented in patenting and spin-out creation (Abreu and Grinevich, 2017). However, recent gendered analysis highlights that spin-out is usually undertaken by more senior academics better able to secure institutional support, whereas women are under-represented in both the professoriate and those branches of science most likely to generate commercialisation opportunities (Griffiths and Humber, 2019).

Quantitative papers within this sample explored women's different pathways into AE (Di Paola, 2021) and the direct and indirect multilevel (individual, institutional and national levels) influences upon AE engagement (Dohse et al., 2021). A particular focus upon the supports and policies University Institutions could implement to promote women's AE was apparent (Schneider et al., 2021; Dohse et al., 2021) with greater insight into the contextualised experiences of STEM women academic entrepreneurs provided by Sinell et al. (2018) in their analysis of how gender constrains AE due to the intersecting and cumulative influences of German national contextual factors pertaining to tech-transfer culture and funding, the culture and practices within individual organisations, and lastly, individual attitudes and attributes.

Within the academic context, there is also a focus upon the potential of entrepreneurship education and training programmes to support AE. Piva and Rovelli (2022) establish that including management education reduces the STEM entrepreneurship gender gap. The wider literature indicates entrepreneurial education offerings are more effective if tailored for the specific industry or sector with such offerings found to be effective in increasing knowledge and understanding of commercialisation and developing entrepreneurial competences (Treanor et al., 2021). Epstein et al. (2022) undertook a quantitative analysis of gender differences in experience and outcomes from an entrepreneurship training programme designed to support academic entrepreneurs in the U.S.A. Their paper recommends the inclusion of mentoring support for women to assess if low self-efficacy negatively affects their appraisal of the potential commercial success of their work. This could, however, be construed as a remedial, 'fix the women' approach that may inadvertently reinforce negative gendered stereotypes.

Generally, gendered analyses remain scarce, however, Cidlinská's (2019) qualitative research in the Czech Republic explores how gender and the professional identity construction of the 'proper scientist' may deter early career women academics from AE. Recent findings confirm, however, that when STEM women do engage in AE, their spin-out firms enjoy similar growth performance (Rodríguez-Gulías *et al.*, 2018) but may face challenges attracting venture capital investment, unless they have secured parent University investment and have full professors within the founding team (Lauto et al., 2022). The female underperformance hypothesis has now been disproved in relation to STEM women's entrepreneurial activity inside and outside academia.

Woolley's (2019) study of nanotechnology firm founders in the USA established they were more likely to have been from academic rather than industry backgrounds; however, the women were less likely to have been employed as professors than their male counterparts and more likely to have been a research scientist or postdoc (Woolley, 2019). These findings hold implications for universities seeking to enhance AE generally, and rates of women's AE activity specifically. Moreover, Pio et al.'s (2022) examination of the experiences of female and/or ethnic minority co-founders of University

Spin-outs within the Cambridge cluster, highlights the enduring influence of homophily (Pio et al., 2022) in this context also, which merits consideration in terms of inclusive practices at multiple levels.

Discussion

This article sought to undertake a SLR of published management research on STEM women entrepreneurs between January 2018 to August 2022 to, in conjunction with the author's reflections upon prior literature, inform recommendations for future research on this topic. To that end, search strings comprising 41 keywords were deployed across the three most comprehensive databases to identify relevant management peer-reviewed journal articles with articles subsequently selected according to the strict inclusion and exclusion criteria required of SLRs. Thirty-four papers qualified for inclusion and were categorised as focussing upon STEM women academic entrepreneurs or STEM women entrepreneurs outside academia prior to analysis.

This review found there are still a small proportion of women entrepreneurs creating new ventures within the masculine gendered STEM sector but overviews of the gender-related barriers they face in this highly masculinised context are well-rehearsed in the literature (Poggesi *et al.,* 2020; Kuschel *et al*., 2020). Second, STEM women entrepreneurs face similar challenges to other novice entrepreneurs engaged in new venture creation and so, research to date has explored mainstream entrepreneurship research topics such as: opportunity identification (Nouri and AhmadiKafeshani, 2020); firm performance (Demartini, 2018) and survival (Woolley, 2019). However, the heightened challenges faced due to this gendered context has led to gendered explorations of other mainstream topics including legitimacy (Vershinina et al., 2020), identity (Gupta and Etzkowitz, 2020), entrepreneurial learning (Kubberød *et al*., 2021), networking and network development (Ozkazanc-Pan and Clark Muntean, 2018), and issues securing funding (Demartini, 2018; Nigam et al., 2022; Lauto et al., 2022).

Looking Forward: Future research directions

The significance of context is recognised in entrepreneurship and gender and entrepreneurship research (Welter, 2011; 2020) and, in part, explains research into STEM Women's entrepreneurship. However, it can also inform future research directions, especially given Welter's (2020) call for research exploring gendered spaces and places. The de-colonialism agenda has raised awareness that we cannot assume that research findings from North America and Europe are readily applicable in different country contexts, particularly in developing or managed economies or patriarchal societies. The emergence of research exploring traditional entrepreneurship topics in different countries, characterised by different institutional contexts and levels of gender equality, facilitates establishment of an evidence-base to inform policy and practice in these jurisdictions; in addition to providing empirical evidence of the influence of context upon the operationalisation of gender. Similarly, as most published research to date has focussed upon the technology sector, research exploring the interplay of gender and STEM entrepreneurship within specific scientific fields and across different STEM professional contexts would also seem apposite, allowing greater contextualisation of findings to specific STEM industry sectors.

The literature on gender and entrepreneurship more generally, has led to a maturing body of research that has usefully highlighted the sex discrimination and gendered inequalities faced by entrepreneurial women (Marlow and Martinez Dy, 2018). Similarly, there is a maturing literature highlighting the disadvantage faced by entrepreneurial STEM women, particularly within incubation contexts, due to their biological sex (Brush *et al*., 2019). It is hoped future research will highlight an improvement in women's representation, experiences and outcomes as the numbers of women as managers, advisors and tenants increases over time. While research into STEM entrepreneurship has highlighted the effects of gender, it has not always advanced our understanding of the operationalisation of gender, how gender regimes operate to (re)produce these outcomes (although notable exceptions exist including the work of Marlow and McAdam). Exploration of the interactions between and activities undertaken by women as different role-holders within business incubation

environments, which represent gendered places, may afford novel explorations of the articulations of gender and the ensuing power relations. These business incubation facility managers, Technology Transfer Officers (TTOs) and business advisors represent gatekeepers, influencing engagement in STEM entrepreneurship, and so, warrant research attention. Therefore, exploring *how* business incubation managers identify and support clients during their tenancy or *how* TTOs regard and relate to women entrepreneurs, as examples, would be important lines of inquiry in future research. This is particularly so, since the biases held by such gatekeepers may result in their offering different support or inform an emphasis upon 'fitting in' rather than revealing or challenging gender or other diversity and inclusion issues.

Moreover, gendered explorations of the experiences of STEM academic women entrepreneurs are largely missing and represent an important avenue of research. While studies exploring the effectiveness, and potential gendering effects, of entrepreneurial education interventions for STEM women are welcome (Armuña *et al*., 2020; Achtzehn *et al*., 2021), such programmes alone cannot overcome or remove the gendered structural barriers faced by STEM women academics. Further research exploring good-practice exemplars and recommending practical solutions to facilitate gender-aware institutional support for, and investment in, women-founded spin-outs regardless of seniority, which recognise work-life balance and progression challenges for academic women, is necessary. Researchers must pay adequate attention to the practical implications and potential real-world impact of their findings, regardless of context, to assist in improving the situations and experiences of the women who generously share their stories.

However, an enduring focus upon women, within research employing a gender lens, risks reinforcing a tendency for gender to be considered a synonym for women (Kelan, 2010; Marlow, 2019) and limits our understanding of the influence of gender upon entrepreneurial behaviour, particularly given the multiplicity of genders in contemporary society (Marlow, Hicks and Treanor, 2019). Fruitful avenues of future research should take a broader perspective of gender and not simply research women. STEM male entrepreneurs have been largely overlooked; their entrepreneurial identity

construction, experiences and gendered performances have largely been assumed to date, rather than being researched and contrasted with the assumed hegemonic masculine entrepreneurial prototype. The experiences and outcomes of LGBTQ+ STEM entrepreneurs and those not conforming to the traditional sex-binary within environments perpetuating a hegemonic male entrepreneurial norm should also be explored.

Research that can inform how to construct more inclusive entrepreneurial ecosystems to support STEM venturing, both within organisations and across communities is required. This will necessitate a fine-grained understanding of how gender power and homophily operate and are deployed, given that contexts become gendered through individual, organizational and institutional practices, such that women, ethnic minorities, non-heterosexual and non-able-bodied entrepreneurs are distanced from the extant resources of the relevant ecosystem (Treanor, 2021).

From a methodological perspective gendered analyses will continue to rely upon the semi-structured interview given its appropriateness, but the addition of more novel qualitative research methods may be fruitful. Longitudinal analyses may provide more informed understandings of the operationalisation of gender, and how gendered performances, expectations, challenge and resistance, may evolve over time for and by gendered subjects within gendered places, industries and societies. Gender informed quantitative analyses and mixed method studies may also contribute to advancing debate. Moreover, gender and entrepreneurship research has tended to focus upon the individual woman as the unit of analysis, which is less appropriate in the context of STEM entrepreneurship where team venturing is more common (Ensley and Hmieleski, 2005). While there has been some quantitative exploration of the influence of team composition upon performance outcomes, gendered analyses of the dynamics and performance outcomes of mixed and single sex teams would be highly informative.

Limitations

This research is subject to the same limitations as all SLRs (Newbert, 2007; Poggesi et al., 2020). First, the keywords used may not capture all relevant publications; however, they have been considered comprehensive and effective in other studies (Poggesi et al., 2020). Second, while the search was replicated in each of the three most comprehensive databases (WoS, Scopus and EBSCO), the possibility remains that they may not contain all the relevant papers published on this topic. However, the comprehensiveness of these databases suggests that the abstracts returned are representative of the population of management publications on this topic (Poggesi et al., 2020). Finally, the strict criteria for inclusion and exclusion deployed in this research when evaluating returned abstracts will have generated results that other criteria, and potentially another researcher, may not have generated. The clarity and transparency of the criteria would limit this likelihood but should, at least, suffice in producing a comparable study to that of Poggesi et al. (2020) to aid evaluation of the recent progress and direction of research on this topic.

Concluding Comment

Findings from this systematic literature review on STEM women entrepreneurs indicates growing research interest in this area given the increasing quantity of publications in recent years. However, given the social and economic contribution of STEM commercialisation and enterprises, and the increasing awareness of equality, diversity and inclusion issues, this topic remains underexplored. One contribution of this article is to raise awareness of this under-researched topic and, second, to provide an overview of what is known and remains under-explored. Finally, in conjunction with wider reflection upon the field, it informs recommendations for future research that can advance current knowledge and understanding in this field. I am honoured to have been invited to contribute to this Ambassador issue of IJGE on this topic and hope this article contributes to IJGE remaining at the forefront of this conversation.

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Table 1 Search Terms

Row	Search String
1	"STEM" or "STEMM" or ("science" and "technolog*" and "engineering" and "math*") or "science" or "technolog*" or "engineering" or "math*" or "high-tech*" or "high tech*" or "comput*" or "ICT" or "IT" or "SET" or "physics" or "chemistry" or "biology" or "biotech*" or "bio-tech*" or "medicine" or "medic*"
	AND
2	"gender*" or "woman" or "female"
	AND
3	"firm*" or "enter*" or "own*" or "business*" or "corporation*" or "compan*" or "entrep*"or "venture*" or "start-up*" or "start up*" or "startup" or "spin off*" or "spin-off*" or "incubator*" or "incubation"

Table 2 Search Criteria and Results

Database	Criteria	Results
WoS	Search in: Topic Document type: Article Subject area: Business, management and accounting Publication Data: January 2018 to August 2022 Language: English	3036
Scopus	Search in: Abstract, Title, Keywords Document type: Article Subject area: Business, management and accounting Publication Data: January 2018 to August 2022 Language: English	1074
EBSCO	Search in: Abstract Publication type: Academic Journal Document type: Article Peer reviewed: YES Subject area: Business, management and accounting Publication Data: January 2018 to August 2022 Language: English	502

Table 3 Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Publication type: Peer-reviewed Academic Journal Article Discipline: Business, management & Accounting Language: English Timeframe: Jan 2018 up to August 2022 Relevance: Focussed upon STEM(M) women entrepreneurs/entrepreneurship	Sector – papers not focussed upon or including STEM(M) sector(s) discarded Not entrepreneurs/entrepreneurship – papers focussed upon employees, CEOs, Board members, executive directors, managers, TMTs, leadership, board/organisational diversity, students, entrepreneurial intentions of non-entrepreneurs discarded Women - if gender/woman/female not mentioned as a key variable or gender not mentioned as an analytical lens the paper was discarded ICT adoption/Usage focus (as opposed to technology/high-tech sector businesses) discarded

Table 4: Final SLR Dataset

	Author(s)	Title	Year	Specific STEM discipline	Country/Countries	Sample	Theoretical perspective	Methodological Approach	Journal
1	Schillo, RS; Ebrahimi, H	Gender dimensions of digitalisation: a comparison of Venture Capital backed start-ups across fields	2022	Technology, life science and biotech	N. America and advanced economies of Europe	8164 VC-funded firms - digital start-ups contrasted with IT hardware, life science and biotech start-ups	Gender, digital and STEM entrepreneurship inequalities	QUANTS Descriptive statistics and OLS regression analysis	TECHNOLOGY ANALYSIS & STRATEGIC MANAGEMENT
2	Gupta, N; Etzkowitz, H	Women founders in a high-tech incubator: negotiating entrepreneurial identity in the Indian socio-cultural context	2021	High-tech	India	High-tech women entrepreneurs within an academic incubator at an elite Institute of Technology	Entrepreneurial identity	QUAL Semi-structured interviews	INTERNATIONAL JOURNAL OF GENDER AND ENTREPRENEURSHIP
3	Xie, XM; Lv, JC	Female technology entrepreneurs: resource shortages and reputation challenges - a view of institutional support	2018	High-tech	China	316 female-owned high-tech ventures less than eight years old in China	Gender and RBV barriers	QUANTS (Hierarchical regression)	INTERNATIONAL ENTREPRENEURSHIP AND MANAGEMENT JOURNAL
4	Sperber, S; Linder, C	Gender bias in IT entrepreneurship: the self-referential role of male overrepresentation in digital businesses	2022	IT	N. America	107 Blockchain start-ups	Draws upon Optimal distinctiveness theory and the Normative Force of the Factual to explain how the IT gender imbalance becomes normative	QUANTS (Conditional Process Analysis (CPA) using OLS and Logistic regression)	EUROPEAN JOURNAL OF INFORMATION SYSTEMS
5	Kubberod, E; Jones, S; Pettersen, IB	Learning to not belong: entrepreneurial learning experiences of women high-tech entrepreneurs	2021	High-tech	Norway	Nine high-tech entrepreneurs	Entrepreneurial learning and belongingpi	QUAL (In-depth interviews)	INTERNATIONAL JOURNAL OF ENTREPRENEURIAL BEHAVIOR & RESEARCH
6	Vershinina, N; Rodgers, P; Tarba, S; Khan, Z; Stokes, P	Gaining legitimacy through proactive stakeholder management: The experiences of high-tech women entrepreneurs in Russia	2020	High-tech	Russia	23 Russian high-tech women entrepreneurs	Entrepreneurial legitimacy	QUAL (Semi-structured interviews)	JOURNAL OF BUSINESS RESEARCH
7	Woolley, JL	GENDER, EDUCATION, AND OCCUPATION: HOW FOUNDER EXPERIENCES	2019	High-tech, nanotechnology firms	U.S.A.	1178 (co)founders of the 595 nanotech firms	Human Capital and gender	QUANTS (Weibull failure (event) time model)	ACADEMY OF MANAGEMENT DISCOVERIES

		INFLUENCE FIRM OUTCOMES							
8	Kuschel, K; Ettl, K; Diaz-Garcia, C; Alsos, GA	Stemming the gender gap in STEM entrepreneurship - insights into women's entrepreneurship in science, technology, engineering and mathematics	2020	Range of STEM disciplines	N. America and Europe	Overview of five articles in SI set in context of wider literature, research themes and future agenda	Gender, STEM women entrepreneurs	Guest editor review for Special Issue	INTERNATIONAL ENTREPRENEURSHIP AND MANAGEMENT JOURNAL
9	Armane, S; Gartig, SI; Tegtmeier, S; Brem, A	STEM educated women entrepreneurs in Denmark, Latvia and Turkey: a context-based explorative study	2021	Engineering	Denmark, Latvia and Turkey	21 interviews with seven women entrepreneurs from Denmark, Latvia and Turkey	Context, embeddedness	QUAL (Semi-structured interviews)	INTERNATIONAL JOURNAL OF ENTREPRENEURIAL VENTURING
10	Adikaram, AS; Razik, R	Femininity penalty: challenges and barriers faced by STEM woman entrepreneurs in an emerging economy	Online First	Range of STEM disciplines	Sri Lanka	15 STEM women entrepreneurs	Intersectionality, gender and social role theory	QUAL (Semi structured interviews)	JOURNAL OF ENTREPRENEURSHIP IN EMERGING ECONOMIES
11	Piva, E; Rovelli, P	Mind the gender gap: the impact of university education on the entrepreneurial entry of female and male STEM graduates	2022	Range of STEM disciplines	Italy	13,840 STEM MSc holders graduating between 2005-2009	Human capital – including management-related education reduces STEM entrepreneurship gender gap	QUANTS Probit and Logit models	SMALL BUSINESS ECONOMICS
12	Poggesi, S; Mari, M; De Vita, L; Foss, L	Women entrepreneurship in STEM fields: literature review and future research avenues	2020	Range of STEM disciplines	N/a	SLR of 32 papers	Gender and STEM entrepreneurship	SLR	INTERNATIONAL ENTREPRENEURSHIP AND MANAGEMENT JOURNAL
13	Neneh, BN; Welsh, DHB	Family support and business performance of South African female technology entrepreneurs	2022	Technology	S. Africa	184 Technology entrepreneurs	Family embeddedness, gender	QUANTS Survey; fuzzy-set qualitative comparative analysis (fsQCA), factor and correlation analysis	INTERNATIONAL JOURNAL OF ENTREPRENEURIAL BEHAVIOR & RESEARCH
14	Demartini, P	Innovative Female-Led Startups. Do Women in Business Underperform?	2018	Technology	Italy	226 tech-based start-ups aged at least two years	Gender – female underperformance hypothesis	QUANTS Descriptive statistics and financial analysis	ADMINISTRATIVE SCIENCES

15	Bendell, BL; Sullivan, DM; Marvel, MR	A Gender-Aware Study of Self-Leadership Strategies among High-Growth Entrepreneurs	2019	High-tech	U.S.A.	118 (59 matched pairs) High-growth entrepreneurs based in a high-tech incubator	Behavioural and cognitive entrepreneurial approaches (i.e., self-leadership including self-goal-setting, self-cueing and self-dialogue)	QUANTS Regression analyses	JOURNAL OF SMALL BUSINESS MANAGEMENT
16	Nouri, P; AhmadiKafeshani, A	Do female and male entrepreneurs differ in their proneness to heuristics and biases?	2020	High-tech sectors of advanced medicine and biotech	Iran	10 male and nine female medicine/biotech entrepreneurs	Influence of heuristics (affect and representativeness) and biases (overconfidence; illusion of control and escalation of commitment) upon entrepreneurial entry and opportunity-identification decisions	QUAL Semi-structured interviews	JOURNAL OF ENTREPRENEURSHIP IN EMERGING ECONOMIES
17	McGrath, PJ; Chen, T; Nerkar, A	Pipes, prisms, and patent sales: How personal wealth expands and contracts the gender gap in entrepreneurship	2022	Range of STEMM sectors	USA	107,797 US patent holders	Economic sociology lens	QUANTS Cox Proportional hazards regression analysis	STRATEGIC ENTREPRENEURSHIP JOURNAL
18	Dai, Y; Byun, G; Ding, FS	The Direct and Indirect Impact of Gender Diversity in New Venture Teams on Innovation Performance	2019	Range of high-tech sectors	China	132 high-tech firms within technology parks	Entrepreneurial founding team (diversity) and firm performance (innovation)	QUANTS Hierarchical linear regression	ENTREPRENEURSHIP THEORY AND PRACTICE
19	Woodwark, M; Wood, A; Schnarr, K	Standing on the shoulders of giantesses: how women technology founders use single and mixed gender networks for success and change	2021	Technology	Canada	25 tech women entrepreneurs	Networks	QUAL Semi-structured interviews	INTERNATIONAL JOURNAL OF GENDER AND ENTREPRENEURSHIP
20	Owalla, Beldina; Nyanzu, Elvis; Vorley, Tim	Intersections of gender, ethnicity, place and innovation: Mapping the diversity of women-led SMEs in the United Kingdom	2021	Technology Vs traditional feminine sectors	U.K.	Longitudinal Small Business Survey (LSBS) data of 29,257 SMEs over the period 2015-2018	Intersectionality; women's entrepreneurship; economic geography	QUANTS Logistic regression	INTERNATIONAL SMALL BUSINESS JOURNAL-RESEARCHING ENTREPRENEURSHIP
21	Ozkazanc-Pan, B; Muntean, SC	Networking towards (in)equality: Women entrepreneurs in technology	2018	Technology	USA	Six University or other Public/publicly-funded business incubators or accelerators from North-Eastern or Mid-Western States; 14 female entrepreneurs; one male	inequality regimes; networking; incubator and accelerator structures and practices	QUAL Interviews; observations; participant observation and website analysis	GENDER WORK AND ORGANIZATION

						copreneur in a certified woman-owned business; six administrators (three male and three female).			
22	Wheadon, M.; Duval-Couetil, N	Token entrepreneurs: a review of gender, capital, and context in technology entrepreneurship	2019	Technology	N/a	Literature review	Context and gender	QUAL Conceptual	ENTREPRENEURSHIP & REGIONAL DEVELOPMENT
23	Nigam, N.; Benetti, C; Mavoori, H	Access to venture capital: Does gender (still) really matter?	2022	Range of STEM disciplines	India	87 technology start-ups	The influence of gender, human and social capital upon STEM entrepreneurs' access to venture capital, and/or amount secured.	QUANTS Regression models	STRATEGIC CHANGE
24	Alakaleek, W.; Cooper, S. Y.	The female entrepreneur's financial networks: accessing finance for the emergence of technology-based firms in Jordan	2018	Technology	Jordan	16 STEM women entrepreneurs	Networking	QUAL Interviews	VENTURE CAPITAL
25	Birkner, S.	To belong or not to belong, that is the question?! Explorative insights on liminal gender states within women's STEMpreneurship	2020	Range of sectors	Germany, Austria and Switzerland	Semi-structured narrative interviews with 30 women STEMpreneurs.	Entrepreneurial belonging, liminality, liminal gender states.	QUAL Analysis of secondary interview data followed by semi-structured narrative interviews with 30 women STEMpreneurs	INTERNATIONAL ENTREPRENEURSHIP AND MANAGEMENT JOURNAL
26	Lauto, G; Salvador, E; Visintin, F	For what they are, not for what they bring: The signalling value of gender for financial resource acquisition in academic spin-offs	2022	Range of STEM disciplines	Italy	526 Academic Spin-Offs (ASOs)	Signalling theory, investment under uncertainty and gender bias	QUANTS Multilevel Tobit regression analysis	RESEARCH POLICY
27	Pio, E; Vyakarnam, S; Barakat, S; McCammon, M	Exotic meets suave: the micro dynamics of homophily in the Cambridge cluster	2022	High-tech	U.K.	Experiences of female and/or ethnic minority (co)founders of high-tech University spin-outs	Homophily	QUAL Entrepreneurial narrative via interview	JOURNAL OF ENTERPRISING COMMUNITIES-PEOPLE AND PLACES IN THE GLOBAL ECONOMY

28	Cidlinská, K	How not to scare off women: different needs of female early-stage researchers in STEM and SSH fields and the implications for support measures	2019	Range of STEM sectors	Czech Republic	Early career researchers within Czech academic setting	Professional identity and gender resulting in masculine construction of the 'proper scientist'; influence on women's academic entrepreneurship (AE) activity	QUAL Interviews, focus groups, workshop notes and evaluation forms	HIGHER EDUCATION
29	Rodríguez-Gulías, M.J.; Fernández-López, S.; Rodeiro-Pazos, D.	Gender differences in growth of Spanish university spin-offs	2018	Range of STEM sectors	Spain	120 male and female owners	RBV - Influence of Financial, Human (gender) and technological resources on firm growth	QUANTS t-tests and dynamic panel data models	GENDER IN MANAGEMENT
30	Di Paola N	Pathways to academic entrepreneurship: the determinants of female scholars' entrepreneurial intentions	2021	Range of STEM disciplines	Italy	52 academic entrepreneurs	Antecedents of academic entrepreneurial intentions	QUANTS fsQCA	JOURNAL OF TECHNOLOGY TRANSFER
31	Schneider, N; Blaese, R; Liebig, B	Conditions for spin-off creation at Swiss universities of applied sciences – a gender sensitive approach	2021	Range of STEM disciplines	Switzerland	1,551 researchers in a Swiss University of Applied science	'Entrepreneurial University' construct and institutional context re: formal and informal support for spin-out	QUANTS Linear and logistic regression models	INTERNATIONAL JOURNAL OF GENDER AND ENTREPRENEURSHIP
32	Dohse, D; Goel, RK; Gktepe-Hultn, D	Paths academic scientists take to entrepreneurship: Disaggregating direct and indirect influences	2021	Range of STEM disciplines	Germany	2,604 STEM academic researchers	Factors directly and indirectly influencing AE activity both personal, career and context related	QUANTS Mediation analysis	MANAGERIAL AND DECISION ECONOMICS
33	Epstein, A; Duval-Couetil, N; Huang-Saad, A	Gender differences in academic entrepreneurship: experience, attitudes and outcomes among NSF I-CORPS participants	2022	Range of STEM disciplines	U.S.A.	2,195 STEM faculty and early career researchers	Entrepreneurship training programme design to support female technology commercialisation and AE activity	QUANTS Chi-Square bd ANOVA	INTERNATIONAL JOURNAL OF GENDER AND ENTREPRENEURSHIP
34	Sinell, A; Muller-Wieland, R; Muschner, A	Gender-Specific Constraints on Academic Entrepreneurship and Engagement in Knowledge and Technology Transfer	2018	Range of STEM disciplines	Germany	40 academic entrepreneurs	Multi-level analysis: meta-level i.e. national contextual factors (tech-transfer culture, funding etc.); operational level (organisational strategies, practices and culture) and individual level (attributes and attitudes) exploring gender differences	QUAL Exploratory case study based upon semi-structured interviews	TECHNOLOGY INNOVATION MANAGEMENT REVIEW