Title: Women in Technology: Engaging the Technology Management for Gender Equality

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Abstract: Inspired by the United Nations (UN) 2030 Agenda Millennium Development Goals, this chapter is an exercise to understand how the technology management (TM) discipline could reduce gender inequality in technology industries. We conduct a literature review of the TM field in the top 10 journals and then present the studies examining women's role in technology-based industries as managers or entrepreneurs. The findings underline how gender equality is almost a non-existing topic in TM. Hence, this chapter actively calls researchers in developing data and knowledge on gender equality issues for women in technology industries. By owning the problem, TM discipline could produce research that will lay the ground for strategies and policies related to women's employment and leadership in technology industries.

Keywords: Gender inequality, Technology Management, digital economy, women managers, women entrepreneurs

1. INTRODUCTION

Gender disparity is one of the 17 accepted goals for UN Agenda 2030, namely the Goal #5. This goal refers to reducing the gender disparity and bringing equality in opportunities, employment, and decision–making as well as leadership positions across all levels. Our chapter discusses how TM discipline could contribute to gender equality, particularly in the male-dominated high-tech industry.

The UN Charter in 1945 promised equality between men and women, but the UN report declares a failure in achieving this promise even after 75 years (UN, 2019). Even worse, the UN acknowledges that the global gender gap will not close for another 100 years at the current rate of change (UN, 2019). Here are few key takeaways from the report: according to estimations, more than 2.5 billion women and girls live in countries with at least one discriminatory law in the legislator books that restrict women's ability to make decisions about marriage, divorce, child custody, getting a job, and starting a business, among others. One in five women globally has experienced sexual and/or physical violence at the hands of an intimate partner in the past year. Less than two-thirds of women (62%) are in the labor force, compared to 93% of men. Of those employed, 58% are in the informal economy earning low wages and lacking social protection. Unpaid care and domestic work remain stubbornly feminized, compromising women's ability to earn an income and build up assets for their later life. These data call us to join a fight against this inequality in all aspects of our lives. This chapter will focus on the question of what needs to be done by the TM academicians. As researchers in this discipline, we should think about how we might reduce this inequality through our research.

Academic disciplines neglect gender issues, ranging from management to entrepreneurship and engineering; TM is not different. Thus, following Ahl (2006) lead, this study proposes to use a feminist approach rather than following gender blind frameworks used for TM. Literature is

overcrowded with analysis of individual-level factors while ignoring macro factors' role in shaping TM careers (Cetindamar and Beyhan, 2019). As a study highlights, "the processes, structures, and discourses of academic entrepreneurship are constructed and gendered" (Fältholm et al. 2010: 60). The gender gap in TM is also constructed and gendered. Hence, any topic with gender has to be political and radical changes to the "sterilized" academic fields. As WEF (2018) indicates: it will take 202 years to close the economic gap while it will take 107 years to close the political empowerment. If we, the practitioners of the academic field in TM, do not make any changes, we cannot alleviate these gaps and men would continue to dominate the digital economy. A perfect example of this scenario is the top seven platform companies, namely Microsoft, followed by Apple, Amazon, Google, Facebook, Tencent, and Alibaba, account for two-thirds of the total market value of the top 70 platforms with a revenue of more than $7 trillion in 2017 (UNCTAD, 2019). These top technology companies have strong economic and political power over societies, and they are run and owned by men. These companies belong to the information and communications technology (ICT) industry, where women constitute only 33% of employees at the entry-level and 17% at the leadership level (Atal et al., 2019).

There is no easy fix for gender inequality, as it is a wicked problem involving many dimensions and stakeholders. Studies show how individual countries have different trends regarding gender inequality (Dilli and Westerhuis, 2018). However, as the TM researchers, we should start studying gender inequality in science, engineering, and technology (SET) industries as defined by Atal et al. (2019). SET industries include a range of industries such as the Research and Development industry, engineering industry, and the Information, Communication, and Technology (ICT) industry. There are limited sources to learn the total number of women working and leading in these industries. Finding data for women entrepreneurs in technology is also tricky (Cetindamar et al., 2019; Ozkazanc and Muntea, 2018). One available data says that women entrepreneurs lead only 1.7% of ventures in the ICT sector. In contrast, most women entrepreneurs are still operating in traditionally female-typed sectors (i.e., the retail and service sector industries) (GEM 2019). By gathering more data and knowledge on gender-related issues, we could develop solutions to equip women with skills and knowledge to build careers in the digital economy.

TM degrees have been popular among women students, and there have been many women TM researchers in the field. That is why it is imperative to observe how gender issues within the TM field have emerged over time. We aim to understand better TM research's diversity and the extent to which gender inequality is addressed. That is why we conducted a systematic literature review involving the top 10 TM journals to determine the status of gender in the extant literature. Hoping this investigation will lay the ground to identify what researchers have been studying regarding gender inequality, this literature review helps to identify gaps that could become topics for future studies.

The paper has five sections. After this introduction, section 2 presents the theoretical background. Section 3 explains the methodology for a systematic literature review of the 10 TM journals. Our findings are presented in section 4, followed by a call for action to researchers in the TM field.

2. BACKGROUND: WOMEN IN TECHNOLOGY

ICT is a necessary ingredient for economic and social development in the digital economy (UNCTAD, 2019). However, disparities in access, capacity to use, and ways of engagement with ICTs result in a digital divide (Davaki, 2018). IFC (2020) reports that women are up to 50% less likely than men in accessing the Internet and 8% less likely to own a mobile phone. IFC further points out that closing the gender gap in low- and middle-income countries by 2023 could generate an additional $140 billion in revenue for mobile operators.

An OECD (2012) report reveals that the number of women students in tertiary education exceeds male students in most countries except Germany, Korea, Japan, and Turkey (Sugimoto et al., 2015). The percentage of women and the male population (aged between 30 and 34) who have completed tertiary education in the EU is 43.4% and 34%, respectively (Eurostat, 2015). Although women's access to tertiary education has increased over the years, due to gender stereotypes, women do not continue their studies in STEM (Science, Technology, Engineering, and Mathematics) fields. The underrepresentation of women in these fields might be due to many reasons, including difficulty to have work-life balance, low self-efficacy and self-confidence of women in mathematical or scientific fields, lack of role models, and low parental encouragement (Cetindamar et al., 2019; Cech et al., 2011). EU statistics show that women graduates in higher education in mathematics, science, and technology fields per thousand persons aged between 20-29 in EU-28 countries are 11.2, while for males, the same number is 22.9.

The digital literature on gender mainly focuses on gender-related education issues. For example, the study by Dilli and Westerhuis (2018) points out that, on average, the probability of finding women entrepreneurs in highly knowledge-intensive business sectors is 25 percent higher in countries that achieve gender equality in science education compared to countries that do not. However, there is a steep digital divide in terms of careers in SET industries. The following paragraphs present some facts we could find in the literature.

Kuschel et al. (2020) point out that women's underrepresentation is not limited to STEM-related educational programs. It is further prevalent in STEM employment and leadership positions. In many studies, the major problem is coined as 'leaky pipeline,' the decreasing number of women throughout the career levels (Kuschel et al. 2020; Atal et al., 2019; Polkowska et al., 2013). For example, the majority of women (59%) work as engineers after graduation, but others fall to tracks along the way; some never pursue engineering as a career (10%), others leave (31%) for reasons such as dissatisfaction with the workplace climate (21%) or to spend more time with their family (10%) (Fouad et al., 2011). The National Center for Women and IT (Ashcraft, McLain, & Eger, 2016) shows that around 50% of women in STEM fields, mostly in computing or engineering professionals, left their job in 12 years period that the study covered, while this number is 20% among non-STEM woman professionals. This research also concluded that family factors did not account for most exits from STEM jobs.

Few women make top corporate management positions (Jeong & Harrison, 2017). A study conducted by Credit Suisse in 2014 indicates that women hold 12.9% of top management team seats globally. Another report (World Bank, 2014) shows that only 18.7% of responding companies in the study had at least one woman in their senior executive team. Percentages are

considerably lower for top executive positions. In a study by incoming chief executive officers during 2013–2014, women's proportion was 2.8% worldwide and 3.2% in the US (Favaro, Karlsson, & Neilson, 2014).

The underrepresentation of women in managerial careers is somewhat amplified in the case of a career in entrepreneurship. The Global Entrepreneurship Monitor (GEM) study estimates that companies owned by women represent between 2% (in Suriname and Japan) to 41% (in Nigeria and Zambia) of the formal sector business around the world (GEM, 2012). Although the number of women in the technology industry has increased, women entrepreneurs still lead only 1.7% of ventures in the ICT sector (GEM, 2019). Women-owned startups usually operate in traditionally women-typed sectors (i.e., the retail and service sector industries), with lower participation in male-typed sectors (such as the construction and manufacturing industries) (GERA 2016).

The microeconomic foundation of endogenous economic theory is that investments in knowledge and human capital generate economic growth. However, knowledge creation can only lead to technological opportunities. It is not automatic that these opportunities are captured by both incumbent and entrepreneurial activities in an economy (Acs et al., 2009). Mostly, if women (roughly half of the population) are not involved in either creating knowledge or capturing technological opportunities, economic growth remains limited. Past studies have found that countries with the gender gap in their labor forces suffer from income losses of nearly 30% of GDP per capita (ILO, 2014). In other words, women are an essential source of economic and social growth.

Why is gender inequality a significant problem?

We consider two key reasons why TM researchers should adopt a gender perspective in their studies to shed light on the field's equality issues. The first apparent reason for considering gender issues and identifying ways to eliminate it is the outcome these researches could bring, thereby resulting in the greater good for society and the economy. If women (half of the population) are not involved in either creating knowledge or capturing technological opportunities, economic growth remains limited. As shown by a McKinsey report (Woetzel et al., 2016), realizing gender equality could increase $12 trillion in economic opportunity by 2025 in the world.

More importantly, TM researchers have social and scientific responsibilities to eliminate this long-standing problem of the gender divide in STEM education and career paths in SET industries. The UNESCO (2020) study acknowledges that women are at greater risk of being socially and economically excluded by the digital economy. As far as we could find from the literature review, there are three critical risks for women: facing double disadvantage (double glass-ceiling), exclusion from decision-making, and elimination from future visions.

(1) Facing double disadvantage: Rise of another glass-ceiling

Women are likely to face "double glass-ceiling" in the SET industries when they want to have leadership roles. Several studies have confirmed a glass ceiling that acts as a barrier to women's career advancement in company leadership (Mattis, 2004). It is highly likely that the glass ceiling will double with the digital divide, particularly in SET industries. It is important to remember the experiences in other industries where women are allowed to pursue careers. For

example, a study by Muzio and Tomlinson (2012) found out that women managed to enter a mass amount of professional companies (such as law or consultancy companies) only after the 1980s. However, this presence of women in these companies could not prevent their segregation and exploitation. It seems similar tactics are taking place at technology companies. A recent Harvard Business Review study (Wynn, 2019) has shown that large technology companies run gender equality programs. However, she points out that these companies hold women responsible for their status rather than blaming organizational level policies and having women under-represented at leadership positions. Studies (Ozkazanc & Muntae, 2018; Wynn, 2019) indicate varied ways of contributing to gender inequality at the organizational level in technology companies such as through referral hiring, leading to narrow pipelines of candidates from similar backgrounds.

This problem is not limited to developing countries. A European study (Davaki, 2018) demonstrated that equal participation of women in the ICT sector would contribute as much as €9 billion to the European economy annually and act as a quick-win for addressing the growing digital skills and job gap. In the face of one million tech jobs in Europe that will go unfilled by 2020, double-digit urban youth unemployment, and an almost non-existent wage gap in tech jobs, the advantage of increasing gender diversity in digital sectors seems unquestionable. The situation is not improving, however, and even shows signs of worsening.

(2) Exclusion from decision making: Continuation of hierarchies of value and power dominated by men

As masculine culture materializes itself in power relations, industry structures, and governance mechanisms (Karatas-Ozkan et al., 2015), women should belong in the leading mechanisms to create an inclusive workplace. Only then women could contribute to building company-level processes that could ensure equal representation and participation. This kind of intervention for inclusivity is helpful in many ways: balancing the design of products & services and generating work governance structures hosting diversity (Cetindamar and Beyhan, 2019).

Studies show that initial hope for online spaces that are free from discrimination has mostly evaporated. Experience shows that the masculine biases inherent in the creation of technology and the harsh realities of trolling, cyberstalking, and revenge porn (Clark-Parsons, 2018). A recent UNESCO report (2020) puts an alarm that women are excluded from the development of artificial intelligence (AI) and draws attention to why women's inclusion is critical for the governance of a highly influential digital technology. The report indicates that only 22% of the world's AI professionals are women, compared with 78% who are male, but more importantly, women are not in the decision-making positions. Thus, products and services are designed in a non-inclusive manner, resulting in numerous harms on women. The example of Amazon's recruiting program generated biases in employing women (Cossins, 2018). Since men wrote the program and used past employment data, machine learning repeated the system's biases in employment decisions.

(3) Elimination from the development of future visions: No women voice about future visions

Maclaran and Chatzidakis (2020) focus on a philosophical stance to discuss the "Feminising (digital) utopias." Accordingly, women must contribute to imaginative speculation around better future worlds. Suppose women do not get engaged with discussions about the future. In that case,

men will continue criticizing economic structures and develop their alternative futures about physical and digital spaces (e.g., their homes, workplaces, or third places). As the study of Mackarab and Chatzidakis (2020) reminds us, one man or women's utopia can so easily be someone else's dystopia. Thus, women cannot leave men to make critical discussions on future society and how it can be reached by engaging in discussions on envisioning alternative future (or futures). Otherwise, women will live in a future society where the hidden infrastructures perpetuate specific value and power hierarchies appreciated by men.

Why do we focus on TM discipline?

TM discipline has a history of almost 70 years, but it has mainly been a self-sustained discipline in the last 30 years with the proliferation of education programs (Cetindamar et al., 2016a and 2016b). Graduated students from these programs, later on develop careers in management or entrepreneurship. A study (Van der Hoven et al., 2012) identifies a range of different titles used for corporate executives responsible and accountable for their firm's TM practices: Technical Director, Technology Director, Chief Scientist, Vice President of R&D, and Innovation Director. Overall, although a top managerial position for TM has various titles, these professionals fulfill some typical specific roles, and they are in high demand by large corporations, technology-based companies and government (Cetindamar et al., 2016b). Thus, if TM discipline could get involved in women's career paths and produce more research on this topic, it could benefit both the economy and society.

In sum, this chapter focuses on TM literature to find out what has been discussed regarding gender issues in management and entrepreneurship. The following section on methodology introduces the systematic literature review, followed by the findings.

3. METHODOLOGY

The literature review is a central component of academic research that helps bring together all the past studies in any research field. It facilitates explicitly the building of frameworks as well as new or improvised theories. Specifically, the literature review helps identify research gaps that help find and study new problems (Roztocki and Weistroffer 2009). When done systematically, the literature review showcases a well-researched understanding of a research area by avoiding biases and presenting all the existing findings relevant to the research area (Petticrew 2006; Aliaga-Isla and Rialp 2013).

For the present chapter, a systematic review of literature is conducted to gather studies about women managers or entrepreneurs in the technology sector. Due to the vast amount of literature in this area, we confined our research to the top 10 TM journals. Following paragraphs provides detail of how systematic literature review was conducted.

Research approach and data collection

Given the importance of women in technology, this review sheds light on the existing studies. We try to showcase past studies conducted on women managers or entrepreneurs to locate the missing pieces of the research, thereby identifying future research problems that can help women's growth in the TM sector. We followed the steps outlined by Standard Preferred

Reporting Items for Systematic Reviews and Meta-Analyses (Moher et al. 2009) and used the Scopus database to select the journal articles. Table 1 showcases the keywords used to search for journal articles.

TABLE 1: Details about the process of systematic literature reviews

Feature	**Women as Entrepreneur**	**Women as Manager**
Keywords	(entrepreneurship* OR startup* OR startup* OR new venture) AND (women OR woman OR female* OR gender* OR diversit*)	(management* OR board*) AND (women OR woman OR female* OR gender* OR diversit*)
# of studies retrieved Limited to: - Top 10 journals - English language - All years to 2020*	42	201

Keywords

Scopus database was used to identify all the articles for this literature review. Keywords provided in Table 1 were used to search the articles. Using Boolean expressions, we combined the keywords to find the relevant articles. By using these keywords, we restricted our search for articles. Due to many articles in this area, we chose articles only from the top 10 TM journals. Furthermore, only peer-reviewed journal articles published in English were chosen for the literature review.

Selection of articles

As the chapter's focus is on women managers or entrepreneurs, the review started with an initial search of articles using the keywords mentioned above. For the present review, we looked for articles only in the most influential top 10 journals in TM (Thongpapanl, 2012): *Journal of Product Innovation Management*, *Research Policy*, *Research-Technology Management*, *R&D Management*, *IEEE Transactions on Engineering Management*, *Technological Forecasting and Social Change*, *International Journal of Technology Management*, *Technovation*, *Technology Analysis & Strategic Management*, and *Journal of Engineering and Technology*. The first search resulted in 243 articles. The articles' elimination started with authors reading the titles and abstracts and removing articles that did not focus on women. Also, all the duplicate articles were also removed, resulting in a full-text analysis of 73 articles.

To understand the women managers and entrepreneurs more deeply, we dropped articles that did not address gender issues. Nvivo was used for the full-text analysis of the paper. The same elimination criterion helped reduce another 39 articles, and this chapter is the full-text analysis of 34 articles across ten journals. The next section presents an extensive analysis of these 34 papers. Out of these 34 articles, 12 articles examined women entrepreneurs, whereas 22 articles examined women managers. Figure 1 shows the selection process of the article.

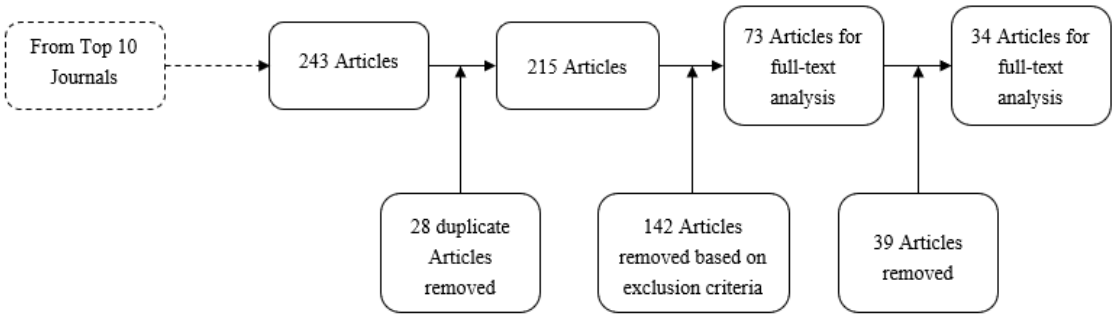

Figure 1: Selection Process

Data analyses

For analyzing 34 articles, Nvivo software, as well as MS Excel, were used. All necessary credentials of the articles such as author name, article title, journal name, year of publication, research questions, hypothesis, research methodology, and key findings were extracted from the paper. Content Analysis was performed using Nvivo to analyze the articles (Neesen et al. 2018; Kraus et al., 2020).

Stage one of content analysis includes deductive coding, which identifies essential information of the research articles. Deductive coding involves surface-level analysis by gathering essential information about the research article (Krippendor 2004). Stage one resulted in creating five key codes comprising of research objective/ question, hypothesis, research method, data analysis, and key findings.

Stage two is inductive coding, which involves a more in-depth analysis of the information acquired. Here, all the identified information is subdivided based on the content's similarity or difference (Krippendor 2004). By conducting inductive coding, each of the identified codes was sub-divided. The research methodology was divided into the research method, data source, number of participants, and sampling process. Data analysis was divided into a method of analysis and critical variables for analysis. By sub-division of articles, it was easier to find similar information under one category.

Key demographics

Figure 2 shows the publication years of articles spreading from 1993 to 2020, with the majority being in the bracket of 2016-2020. From all the 34 articles, 66% of articles came from three journals, including *Research Policy, Technological Forecasting and Social Change*, and *IEEE Transactions on Engineering Management*. 53% of the articles studied women from the US, while the remaining studies were from China, Singapore, Korea, and others.

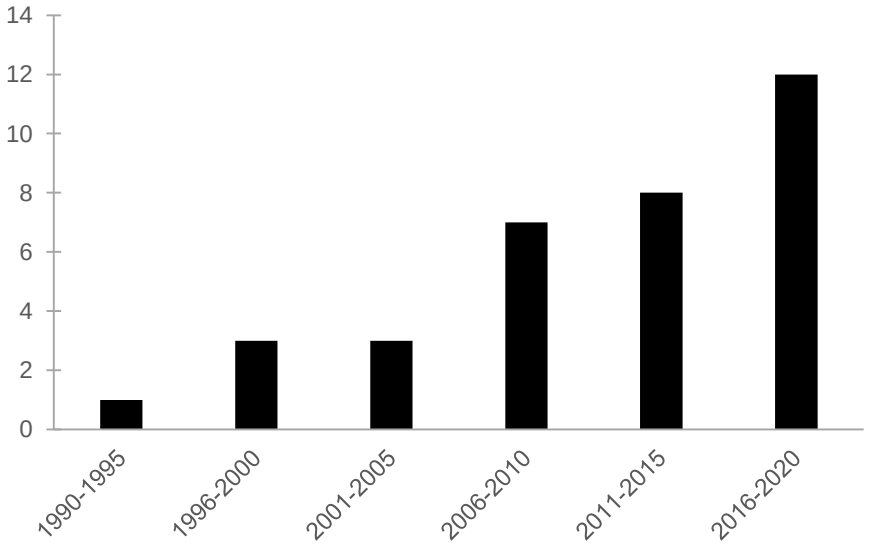

Figure 2: Article distribution by year

Of the 34 articles selected for the literature review, nearly 80% of the articles were empirical articles, while the remaining were either conceptual or experimental research. Most of the studies used a survey methodology for their data collection. Among the survey-based study, most of the studies collected primary data, while nearly 35% of the studies relied on secondary data sources for the analysis. The advantage of using secondary data sources is the greater sample size, which helps generalize the population's results.

4. FINDINGS

Research articles concerning women managers included 21 papers, as presented in Table 2. Nearly half of these papers (11) consider gender as a side issue. For example, Li et al. (2019) discuss how company boards might influence green supply chain strategies that ultimately impact companies' business performance. This paper includes gender as one of the features of the company board while analyzing board composition. So, there is no initiating urge to include gender in the research theme, and hence no conclusion has been addressed to broader gender studies. Among the papers where gender has been one of the goals of the paper/research, we observe that two of them, the study of Pinto et al. (2015) and Takunga & Graham (2006), have started a social discussion on gender. While the former study explicitly targets how stereotypes influence trust views about male or female managers, the latter investigates women's career progress in technical jobs. Both papers adopt a feminist lens to examine the issue.

TABLE 2. Literature review papers on the women and management topic

Reference	Research question (RQ) & findings related to gender	Gender focus; managerial theme
Attah-Boakye, et al., 2020	RQ: The relationship between boardroom gender diversity and corporate innovation. Finding: Local factors such as national norms, cultural values, and country-level institutional quality affect boardroom gender diversity, level of investment in research and development (R&D), and corporate innovation.	Main issue; innovation
Xie et al., 2020	RQ: The effect of gender diversity on the innovation performance within R&D teams. Finding: Gender diversity in R&D teams can promote innovation efficiency by providing informational and social benefits throughout the innovation process.	Main issue; innovation
Triana et al., 2019	RQ: The impact of senior management gender diversity on strategic change. Finding: A gender-diverse senior management positively impacts strategic change, which ultimately improves firm performance.	Main issue; strategy
Li et al., 2019	RQ: The links between green supply chain and companies' business performance. Finding: A greater board size and female proportion in the board tend to affect a company's green supply chain decision-making negatively.	Side issue; strategy
Martínez-León et al., 2018	RQ: The organizational strategies to retain employees in engineering professionals. Finding: None.	Side issue; HRM
Frank, et al., 2015	RQ: The influence of innate consumer innovativeness to adapt the marketing mix. Finding: female gender affects negatively Innate willingness to pay for innovations.	Side issue; consumer
Kenney & Patton, 2015	RQ: The gender and nationality of the top management teams & board directors. Finding: Women are under-represented in all functional positions.	Main issue; strategy
Pinto et al., 2015	RQ: The role of stereotyping of female managers in the case of a male-dominated project manager position. Finding: Contrary to expectations, there were no significant gender differences in job candidates' trust and likeability.	Main issues; Stereotypes
Ryan, 2014	RQ: The effect of work motivation on the research performance of research scientists. Finding: Differences in research performance across age and gender were identified. Also, no gender differences were found in the motivational profile of scientists.	Side issue; academia
Wood& Hoeffler, 2013	RQ: The impact of the social benefits of a product on consumer adoption. Finding: Stronger benefits accrue for women than for men.	Side issue; consumer
Schmidt, et al. 2012	RQ: The impact of age and sex on consumers' evaluations of new products &services. Finding: Women evaluate new services significantly more favorably than men.	Side issue; consumer
Gaughan & Corley , 2010	RQ: The role of institutional structures at universities on faculty career management. Finding: Male university research center-affiliates enjoy a slightly greater advantage than female center-affiliates in their industrial involvement.	Side issue; academia
Kowtha, 2008	RQ: The organizational tactics facilitating the new engineer's adjustment to organization. Finding: Gender-moderated the effects of investiture, serial, and fixed tactics on role clarity and work group integration.	Side issue; HRM
Libaers, 2007	RQ: The performance of foreign-born scientists and researchers in R&D system. Finding: Male foreign-born researchers are more productive than their female peers in an unusually multidisciplinary research environment, except in the federal laboratory system.	Side issue; academia

Rhoten & Pfirman, 2007	RQ: The professional results from the participation of women and minorities in interdisciplinary science. Finding: Gender effect on engaging in interdisciplinarity (cross-fertilization, team-collaboration, field-creation, and problem-orientation) showed a higher propensity of females to be engaging in interdisciplinarity compared to males.	Main issue; academia
Sawng et al., 2006	RQ: The relationship between R&D group characteristics & knowledge management activities. Finding: The degree of knowledge creation is high when the group size is small, the female ratio is high and group cohesiveness is high. Whereas knowledge sharing is more activated when work duration is long, and the female ratio is high.	Side issue; Knowledge man.
Morris et al., 2005	RQ: The role of gender and age as moderators of user perceptions and individual adoption and sustained use of technology in the workplace. Finding: Old stereotypes that portray "technology" as a male-oriented domain may disappear-particularly among younger workers.	Main issue; consumer
Chen et al., 1999	RQ: The role of diversity in organizational rewards in R&D organizations. Finding: Members of different ethnic groups and genders held different beliefs about the utility of several rewards. Compared with their male colleagues, female R & D professionals perceived greater organizational benefits in collective rewards, but they did not perceive less organizational benefits in individual rewards.	Main issue; HRM
Tokunaga & Graham, 1996	RQ: The relationships of gender and race with career progress in technical jobs. Finding: Work-related variables, primarily organizational tenure, could explain gender differences in promotions.	Main issue; HRM
Cordero R., DiTomaso N., Farris G.F.. 1996	RQ: The relationship of the gender and race/ethnic composition of workgroups with R&D performance. Finding: Male professionals appear to be more likely to remain in their laboratories in predominantly male workgroups, while female professionals appear to find more job satisfaction in predominantly female workgroups.	Main issue; HRM
DiTomaso N., Farris G.F., Cordero R., 1993	RQ: The impact of work climate on gender and immigrant. Finding: Women report less technical control, fewer communication contacts, more time on a major project, less dedication, less perceived similarity, and less workgroup cohesiveness in newer groups than do men.	Main issue; HRM

HRM- human resources management

When we analyzed the papers' management-related topics, we found out that human resources management issues constitute 28% of the papers, followed by academic-related issues (19%) and consumer concerns (19%). Human resources management issues refer to retaining talent and features of work climate from a company perspective. Except for the work of Takunga & Graham (2006), they do not count as an attempt to understand and contribute to the understanding of how these organizational settings could reduce the gender gap for the benefit of women.

Regarding the studies about women entrepreneurs, Table 3 presents 13 papers found in the literature review. Slightly over half of the papers have a gender focus. However, only one paper, Foo et al. (2006) stands out as an analysis at the societal level and discusses the mindset needed to become a woman entrepreneur. Another paper written by McAdam et al. (2019) studies women entrepreneurs in Saudi Arabia. However, this paper describes the social context, but its main focus is on understanding digital technologies' role in facilitating women entrepreneurship. Although titled `Wired Mother,` another paper has no feminist lens (Sheng, 2005). Sheng (2005) considers working mothers as consumers and develops suggestions to improve a customer relations management program to attract these consumer moms.

TABLE 3. Literature review papers on the women and entrepreneurship topic

Reference	Research question (RQ) & findings related to gender	Gender focus; ent. theme
Zhang H., & Chen W., 2019	RQ: Investigating the motivation of entrepreneurs using crowdfunding. Finding: The relationship between other-orientation and funding decisions is stronger for women than men, but the relationship for self-orientation is stronger for men than women.	Side issue; funding
Gloor et al., 2020	RQ: The impact of board member composition and board members' social media presence on startups' performance. Finding: Neither board size, nor the presence of more female members, impact significantly the ability to increase sales or generate external funding.	Side issue; board-performance
Mendonça & Reis, 2020	RQ: Differences in user innovation between male and female individuals. Finding: Although men innovate more, females show no clear differences in innovation behavior and characteristics of innovations..	Main issue; innovation
McAdam et al., 2019	RQ: The emergence of digital entrepreneurship in emerging economies. Finding: The paper's framework argues that digital entrepreneurship facilitates the bridging of socio-cultural institutional voids for female digital entrepreneurs.	Main issue; digital entr.
Guzman & Kacperczyk, 2019	RQ: Decomposing the well-established gender gap in entrepreneurship. Finding: There is a funding gap for women, but the residual gap diminishes when stronger growth signals are available to investors for comparable female- and male-led ventures or when investors are more sophisticated.	Main issue; funding
Yu et al., 2018	RQ: The relationship between entrepreneurs' work-family conflict and new venture legitimacy, and the underlying mechanism. Finding: Female entrepreneurs are less likely to choose an effectuation strategy when faced with a high level of interference with work.	Main issue; work-family balance
Bergmann et al., 2018	RQ: The antecedents of a supportive context for entrepreneurship. Finding: University ent. measures positively affect students' climate perceptions, which also depend on students' background and gender. Climate perceptions of male students are more likely to be positively influenced by the prevalence of fellow students who have visited a compulsory entrepreneurship course. At the same time, for females, there is no effect.	Side issue; Student ent.
Marvel et al., 2015	RQ: Exploring the entrepreneur gender-innovation relationship in new ventures. Finding: Male entrepreneurs, compared with a female, are more likely to complete engineering or natural science degrees, maintain heterogeneous interfirm network ties, and locate firms in clustered regions.	Main issue; innovation
Ding & Choi, 2011	RQ: The differences in the profiles of university scientists who have founded or advised companies. Finding: Factors such as gender differ in their effects on the propensity for founding and advising. Human capital, social capital, and institutional characteristics affect founding and advising differently. The gender gap is more significant for founding than for advising.	Side issue; academic ent.
Hsu et al., 2007	RQ: The analysis of major patterns and trends in entrepreneurship among technology-based university alumni Finding: Women alumnae lag their male counterparts.	Side issue; Student ent.
Foo et al., 2006	RQ: Explore the inner processes of the psychological adaptation and changes necessary in the female psyche before a societal, technopreneurial matriarchy may take root. Finding: Female entrepreneurs and managers are affected by left-right brain attributes. This research found that women technopreneurs highly differ from women managers in personal traits and interpersonal and leadership styles.	Main issue; mindset
Sheng, 2005	RQ: Customer relationship management program for women customers. Finding: Different strategies are mentioned for working mothers by connecting them to a world of information technology.	Main issue; Working moms as consumers

Wang & Wong, 2004	RQ: The level and determinants of interest in entr. among university students. Finding: Three background factors - gender, family experience with business and educational level - are found to affect entrepreneurial interests.	Side issue; Student ent.

Ent.- Entrepreneurship

Studies given in Table 3 are highly diverse in terms of entrepreneurship topics they belong. Three papers look into student entrepreneurship, while two papers are interested in innovation, and another two are studying funding. Others are related to consumer perspective, board-performance relationship, and individual entrepreneurial features (such as mindset, digital entrepreneurs, and academic).

5. CALL FOR ACTION

Innovation and technologies have been crucial policy elements in advanced countries. Despite their popularity, women's involvement in SET industries either as managers or entrepreneurs has been little researched. There are some studies, particularly in education, around STEM and the gender gap. However, the TM discipline does seem to have an extensive and scientific inquiry into gender inequality in women's career paths. We believe that this should be an agenda for a wide range of disciplines, but in this chapter, we focused on the TM discipline to find out the state of the discipline in this critical topic. Our findings highlight the dearth of research, calling for action for TM researchers.

We conducted a systematic literature review within the TM discipline to understand where TM studies' gender perspective stands. Our findings show that only three articles out of 34 have an intense focus on women's issues. This finding indicates that we need more data and more research to be carried out if we want to reduce the gender gap in SET industries. In other words, we need to better understand and propose fruitful avenues for gender gap issues in TM. Hence, including ourselves, authors of this paper, we have no excuse for not spending time and effort tackling a critical societal problem: gender inequality. If there is no intervention, as the gender inequality report (WEF, 2020) reminds us: it will take 202 years to close the economic gap while it will take 107 years to close the political empowerment. However, more importantly, the risks of being left out of the digital economy will bring risks that cannot be tolerable for anyone, both for women or men.

There is a need for research on a wider geographical area, exploring national, cultural, and local factors that affect women engineers and IT professionals in their entry, retention, and progression in SET industries. Hence, researchers at their respective disciplines need to understand the underlying mechanisms behind the gender gap and propose solutions. Remember, though, we need to apply a feminist perspective and delve into the societal level problems within our research field. Only then can we advance our understanding and come with a better future where policy interventions could be developed to tackle gender gap issues.

Millennium Development Goals are intriguing for us to think out of the box; this is true for the TM discipline. This book discusses all aspects of technology management while drawing attention to gender inequality in technology industries. We hope our chapter could draw colleagues' attention interested in these topics and join the efforts to contribute to the Goal #5. In other words, we can conduct research and reorient our teaching so that we can help reduce the gender disparity and bring equality in opportunities, employment, decision–making, and leadership position in the SET industries.

REFERENCES

Acs, Z., Braunerhjelm, P., Audretsch, D., & Carlsson, B. (2009). The Knowledge Spillover Theory of Entrepreneurship. *Small Business Economics, 32*, 15–30.

Ahl, H. (2006). Why Research on Women Entrepreneurs Needs New Directions. *Entrepreneurship: Theory & Practice, 30*(5), 595–621.

Ashcraft, C., McLain, B., & Eger, E. (2016). Women in tech: The facts. Boulder, CO: National Center for Women and Information Technology.

Atal, N., Gemma Berenguer, G., & Borwankar. S. (2019) Gender diversity issues in the IT industry: How can your sourcing group help? *Business Horizons (2019), 62*, 595—602.

Attah-Boakye, R., Adams, K., Kimani, D., & Ullah, S. (2020). The impact of board gender diversity and national culture on corporate innovation: A multi-country analysis of multinational corporations operating in emerging economies. *Technological Forecasting and Social Change, 161*, 120247.

Bergmann, H., Geissler, M., Hundt, C., & Grave, B. (2018). The climate for entrepreneurship at higher education institutions. *Research Policy*, *47*(4), 700-716.

Cech, E., Rubineau, B., Silbey, S., & Seron, C. (2011). Professional Role Confidence and Gendered Persistence in Engineering. *American Sociological Revie, 76*(5), 641–666.

Cetindamar, D., James, E., Lammers, T., Pearce, A., & Sullivan, E. (2019). "STEM Education and Women Entrepreneurs in Technology Enterprises: Explorations from Australia", in A. Bullough, D. Hechavarria, C. Brush and L. Edelman (Eds.) Programs, Policies, & Practices around High-Growth Women's Entrepreneurship, Edward Elgar. 78-108.

Cetindamar, D. & Beyhan, B. (2019). "Using Women Entrepreneurship in Technology Ventures: Gendered Organization and Gendered Society Interactions", in Francesco P. Appio, Francois Therin and Hyungseok Yoon (Eds.), Handbook of Research on Techno-Entrepreneurial Ecosystems, 3rd Edition, Edward Elgar. With Berna Beyhan.

Cetindamar, D., Phaal, R., & Probert, D. (2016a). Technology Management Activities and Tools, Palgrave/Macmillan.

Cetindamar, D., Phaal, R., & Probert, D. (2016b). Technology Management as a Profession and the Challenges Ahead. *Journal of Engineering and Technology Management*, 41 (July-September): 1-13.

Chen, C. C., Ford, C. M., & Farris, G. F. (1999). Do rewards benefit the organization? The effects of reward types and the perceptions of diverse R&D professionals. *IEEE transactions on engineering management*, *46*(1), 47-55.

Clark-Parsons, R. (2018). Building a digital girl army: The cultivation of feminist safe spaces online. *New Media and Society*, *20*(6), 2125–2144.

Cordero, R., DiTomaso, N., & Farris, G. F. (1996). Gender and race/ethnic composition of technical work groups: relationship to creative productivity and morale. *Journal of Engineering and Technology Management*, *13*(3-4), 205-221.

Cossins, D. (2018) https://www.newscientist.com/article/2166207-discriminating-algorithms-5-times-ai-showed-prejudice/

Credit Suisse. (2014). The CS gender 3000: Women in senior management. Zurich, Switzerland: Credit Suisse.

Davaki, K. (2018). The underlying causes of the digital gender gap and possible solutions for enhanced digital inclusion of women and girls, EU. https://www.europarl.europa.eu/RegData/etudes/STUD/2018/604940/IPOL_STU(2018)604940_EN.pdf

del Carmen Triana, M., Richard, O. C., & Su, W. (2019). Gender diversity in senior management, strategic change, and firm performance: Examining the mediating nature of strategic change in high tech firms. *Research Policy*, *48*(7), 1681-1693.

Dilli, S. & Westerhuis, G. (2018). How institutions and gender differences in education shape entrepreneurial activity: a cross-national perspective. *Small Business Economics, 52*(2)**,** 371–92.

Ding, W., & Choi, E. (2011). Divergent paths to commercial science: A comparison of scientists' founding and advising activities. *Research policy*, *40*(1), 69-80.

DiTomaso, N., Farris, G. F., & Cordero, R. (1993). Diversity in the technical work force: Rethinking the management of scientists and engineers. *Journal of engineering and technology management*, *10*(1-2), 101-127.

Eurostat statistics. http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tsdsc480&language=en

EU (2013). Women active in the ICT sector. https://ec.europa.eu/digital-single-market/en/news/women-active-ict-sector

Favaro, K., Karlsson, P.-O., & Neilson, G. L. (2014). The 2013 chief executive study:WomenCEOsof the last 10 years: Strategy&. Available at: https://www.strategyand.pwc.com/media/file/Strategyand_The-2013-Chief-Executive-Study.pdf. Accessed: January 22, 2015.

Fältholm, Y., Abrahamsson, L., & Kallhammer, E. (2010). Academic Entrepreneurship-Gendered Discourses and Ghettos. *Journal of Technology Management & Innovation, 5*(1), 51-63.

Foo, C. T., Wai, L. S., & Lang, T. S. (2006). The mind of a technopreneuress: differentiating the self-leading, entrepreneurial from custodial, managerial female. *Technovation*, *26*(2), 175-184.

Fouad, N. A., Fitzpatrick, M.E., & Liu, J. P. (2011). Persistence of women in engineering: A qualitative study. *Journal of Women in Math, Science and Engineering*, *17*, 69-96.

Frank, B., Enkawa, T., Schvaneveldt, S. J., & Torrico, B. H. (2015). Antecedents and consequences of innate willingness to pay for innovations: Understanding motivations and consumer preferences of prospective early adopters. *Technological Forecasting and Social Change*, *99*, 252-266.

Gaughan, M., & Corley, E. A. (2010). Science faculty at US research universities: The impacts of university research center-affiliation and gender on industrial activities. *Technovation*, *30*(3), 215-222.

GEM, (2012). *GEM 2012 Women's Report*. London: GEM. (Prepared by: D. J. Kelley, C. G. Brush, P. G. Greene, Y. Litovsky and Global Entrepreneurship Research Association). Accessed July 2, (2016) at http://www.babson.edu/Academics/centers/blank-center/global-research/gem/Documents/GEM%202012%20Womens%20Report.pdf

Global Entrepreneurship Research Association (GERA) (2016). Global Entrepreneurship Monitor 2016/17.

Global Entrepreneurship Monitor (GEM) (2019). 2018/2019 Women's Entrepreneurship Report.

Gloor, P. A., Colladon, A. F., Grippa, F., Hadley, B. M., & Woerner, S. (2020). The impact of social media presence and board member composition on new venture success: Evidences from VC-backed US startups. *Technological Forecasting and Social Change*, *157*, 120098.

Guzman, J., & Kacperczyk, A. O. (2019). Gender gap in entrepreneurship. *Research Policy*, *48*(7), 1666-1680.

Hsu, D. H., Roberts, E. B., & Eesley, C. E. (2007). Entrepreneurs from technology-based universities: Evidence from MIT. *Research Policy*, *36*(5), 768-788.

Huang, J., Gates, A. J., Sinatra, R., & Barabási, A. L. (2020). Historical comparison of gender inequality in scientific careers across countries and disciplines. PNAS March 3, 2020 117 (9) 4609-4616; first published February 18, 2020; https://doi.org/10.1073/pnas.1914221117

IFC, 2020, Digital Economy. https://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/Gender+at+IFC/Priorities/Digital_Economy_SA/

ILO (2014). Global employment trends 2014: Risk of a jobless recovery? International Labour Organization (ILO), Geneva, Switzerland, 2014.

Jeong, S. H. & Harrison, D. A. (2017). Glass breaking, strategy making, and value creating: meta-analytic outcomes of women as CEOs and TMT members. *Academy of Management Journa*l, *60*(4), 1219–1252.

Karataş-Özkan, M. & Chell, E. (2015). Gender Inequalities in Academic Innovation and Enterprise: A Bourdieuian Analysis. *British Journal of Management, 26* (1), 109–25.

Kenney, M., & Patton, D. (2015). Gender, ethnicity and entrepreneurship in initial public offerings: illustrations from an open database. *Research Policy*, *44*(9), 1773-1784.

Kowtha, N. R. (2008). Engineering the engineers: Socialization tactics and new engineer adjustment in organizations. *IEEE transactions on engineering management*, *55*(1), 67-81.

Kraus, S., Breier, M., & Dasí-Rodríguez, S. (2020). The art of crafting a systematic literature review in entrepreneurship research. *International Entrepreneurship and Management Journal*, 1-20.

Krippendorff ,K. (2004). Content Analysis: An Introduction to Its Methodology. Thousand Oaks, CA: Sage.

Kuschel, K., Ettl, K., García, C. D., & 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 (2020) 16*, 1–15.

Libaers, D. P. (2007). Role and contribution of foreign-born scientists and engineers to the public US nanoscience and technology research enterprise. *IEEE Transactions on engineering management*, *54*(3), 423-432.

Li, G., Shao, S., & Zhang, L. (2019). Green supply chain behavior and business performance: Evidence from China. *Technological Forecasting and Social Change*, *144*, 445-455.

Maclaran, P. & Chatzidakis, A. (2020). Feminising (digital) utopias. *Journal of Business Research*, Fortcoming. https://doi.org/10.1016/j.jbusres.2019.01.019

Martínez-León, I. M., Olmedo-Cifuentes, I., & Ramón-Llorens, M. C. (2018). Work, personal and cultural factors in engineers' management of their career satisfaction. *Journal of Engineering and Technology Management*, *47*, 22-36.

Marvel, M. R., Lee, I. H., & Wolfe, M. T. (2015). Entrepreneur gender and firm innovation activity: a multilevel perspective. *IEEE Transactions on Engineering Management*, *62*(4), 558-567.

Mattis, M. (2004). Women entrepreneurs: out from under the glass ceiling. *Women in Management Review*, *19*(3), 154-163.

McAdam, M., Crowley, C., & Harrison, R. T. (2019). "To boldly go where no [man] has gone before"-Institutional voids and the development of women's digital entrepreneurship. *Technological Forecasting and Social Change*, *146*, 912-922.

Mendonça, J., & Reis, A. (2020). Exploring the mechanisms of gender effects in user innovation. *Technological Forecasting and Social Change*, *155*, 119988.

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Annals of Internal Medicine*, *151*(4),264-9.

Morris, M. G., Venkatesh, V., & Ackerman, P. L. (2005). Gender and age differences in employee decisions about new technology: An extension to the theory of planned behavior. *IEEE transactions on engineering management*, *52*(1), 69-84.

Murphy, M. (2020). Inside Google's struggle to control its 'racist' and 'sexist' AI. The Telegraph, 16 January. https://www.telegraph.co.uk/technology/2020/01/16/google-asking-employees-hurl-insults-ai/

Muzio, D., & Tomlinson, J. (2012). Researching gender, inclusion and diversity in contemporary professions and professional organizations. *Gender, Work & Organization*, *19*(5), 455-466.

Neessen, P. C., Caniëls, M. C., Vos, B., & De Jong, J. P. (2019). The intrapreneurial employee: toward an integrated model of intrapreneurship and research agenda. *International Entrepreneurship and Management Journal*, 15(2), 545-571.
OECD (2012). Education at a Glance 2012, Paris: OECD.
OECD (2018). Bridging the Digital Gender Gap. Paris: OECD.
Ozkazanc-Pan, B. & Muntean, S. C. (2018). Networking towards (in)equality: Women entrepreneurs in technology. *Gender, Work and Organization, 25*(4), 379-400.
Petticrew, M. (2006*). Systematic Reviews in the Social Sciences: A Critical Guide*. Malden, MA: Blackwell.
Pinto, J. K., Patanakul, P., & Pinto, M. B. (2015). Gender biases in hiring project managers: perceptions of trust and likeability. *IEEE Transactions on Engineering Management*, *62*(3), 325-334.
Polkowska, D. (2013). Women Scientists in the Leaking Pipeline: Barriers to the Commercialisation of Scientific Knowledge by Women. *Journal of Technology Management & Innovation, 8*(2), 156-65.
Rhoten, D., & Pfirman, S. (2007). Women in interdisciplinary science: Exploring preferences and consequences. *Research policy*, *36*(1), 56-75.
Roztocki, N. & Weistroffer, H. R. (2009). Research trends in information and communications technology in developing, emerging and transition economies. *Collegium of Economic Analysis*, *20*, 113-127.
Ryan, J. C. (2014). The work motivation of research scientists and its effect on research performance. *R&D Management*, *44*(4), 355-369.
Sawng, Y. W., Kim, S. H., & Han, H. S. (2006). R&D group characteristics and knowledge management activities: A comparison between ventures and large firms. *International Journal of Technology Management*, *35*(1-4), 241-261.
Schmidt, J. B., Zayer, L. T., & Calantone, R. J. (2012). Grumpier old men: Age and sex differences in the evaluation of new services. *Journal of Product Innovation Management*, *29*(1), 88-99.
Sheng, M. L. (2005). The wired mother. *Technovation*, *25*(9), 1071-1077.
Sugimoto, C.R., Ni, C., & Lariviere, V. (2015). On the Relationship between Gender Disparities in Scholarly Communication and Country-Level Development Indicators. *Science and Public Policy, 42*, 789–810.
Thongpapanl, N. (2012). The changing landscape of technology and innovation management: an updated ranking of journals in the field. *Technovation*, *32*(5), 257–271.
Tokunaga, H., & Graham, T. (1996). Career progression in a Fortune 500 company: examination of the" glass ceiling". *IEEE Transactions on Engineering Management*, *43*(3), 262-272.
UN (2019). Women and Girls -Closing the Gender Gap, New York: UN. https://www.un.org/en/un75/women_girls_closing_gender_gap
UNCTAD (2019). Digital Economy Report. New York: UNCTAD.
UNESCO (2020). AI and Gender Equality. Paris: Unesco.
van der Hoven, C., Probert, D., Phaal, R., & Goffin, K. (2012). Dynamic technology leadership: the adaptive role of the CTO. *Research-Technology Management*, *55*(5), 24-33.
Wang, C. K., & Wong, P. K. (2004). Entrepreneurial interest of university students in Singapore. *Technovation*, *24*(2), 163-172.
WEF (2020). Global Gender Gap Report. Switzerland.
Woetzel, J., Madgavkar, A., Manyika, J., Ellingrud, K., Hunt, V. & Krishnan, M. (2016). Realizing Gender Equality. McKinsey Global Institute, May. Accessed June 1, 2016 at http://www.mckinsey.com/global-themes/employment-and-growth/realizing-gender-equalitys-12-trillion-economic-opportunity?cid=other-eml-alt-mgi-mck-oth-1605.
World Bank, (2014). Enterprise surveys: Gender. Washington DC: The World Bank. Available at: Http://www.enterprisesurveys.org/
Wood, S., & Hoeffler, S. (2013). Looking Innovative: Exploring the Role of Impression Management in High-Tech Product Adoption and Use. *Journal of Product Innovation Management, 30*(6), 1254-1270.

Wynn, A. (2019). Why Tech's Approach to Fixing Its Gender Inequality Isn't Working. October 11, 2019 UPDATED October 15, 2019. Harvard business review blog. https://hbr.org/2019/10/why-techs-approach-to-fixing-its-gender-inequality-isnt-working

Xie, L., Zhou, J., Zong, Q., & Lu, Q. (2020). Gender diversity in R&D teams and innovation efficiency: Role of the innovation context. *Research Policy*, *49*(1), 103885.

Yu, X., Meng, X., Chen, Y., Chen, Y., & Nguyen, B. (2018). Work-family conflict, organizational ambidexterity and new venture legitimacy in emerging economies. *Technological Forecasting and Social Change*, *135*, 229-240.

Zhang, H., & Chen, W. (2019). Backer motivation in crowdfunding new product ideas: Is it about you or is it about me?. *Journal of Product Innovation Management*, *36*(2), 241-262.