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MANAGING THE GROWTH OF FEMALE PARTICIPATION IN DATA SCIENCE TECHNOLOGY

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Purpose: The research aims to identify the factors influencing this growth, compare it with men's participation, and provide actionable insights for promoting gender diversity in Data Science.
Design/methodology/approach: This study employs a detailed analysis of the evolution of Data Science and the changing gender dynamics within this field. The study used a literature review, an analysis of foundational data on women's and men's education and careers, and survey research on a large sample of respondents from different countries.
Findings: The study found a notable rise in the number of women pursuing education and careers in Data Science, driven by educational initiatives, support programs, and sociocultural changes promoting gender equality in technical fields. The analysis revealed specific factors that significantly impact this trend, offering insights into effective practices for fostering gender diversity.
Research limitations/implications: The study is limited to data from 2017 to 2021, and further research could extend the timeframe or explore different geographical regions for a more comprehensive understanding. The findings provide a foundation for future research on gender dynamics in other technical fields.
Practical implications: These strategies can support the ongoing growth and balanced gender representation in Data Science.
Social implications: The study underscores the importance of gender equality in technology, emphasizing the role of educational and support programs in empowering women.
Originality/value: This study provides original insights into the growth of women's participation in Data Science, identifying key factors and management practices that can sustain and enhance this trend. The findings contribute valuable knowledge to the discourse on gender diversity in technology and offer practical solutions for fostering an inclusive environment in Data Science.
Keywords: Data Science, technolgy, management, social change, education, women.
Category of the paper: Research paper.

1. Introduction

Data Science, which is an interdisciplinary scientific field, uses mathematical, statistical and computer science techniques to analyse and interpret large data sets. Over the years, these techniques have become an indispensable tool for organisations collecting and processing data, enabling them to extract valuable information from it. Data Science encompasses areas such as knowledge discovery, machine learning and predictive learning, with applications in a wide range of sectors from healthcare to finance and retail (Corea, 2018). The history of Data Science dates back to the early 20th century, when statisticians and engineers began using the first predictive models. Over time, as computer technology developed and data collection and processing capabilities increased, Data Science evolved to integrate elements of artificial intelligence and machine learning (Kotu, 2019). A watershed moment was the birth of the Internet, which significantly increased the amount of data available, and advances in the processing and storage of this data opened up new opportunities for analysts and researchers. Today, Data Science is used in various sectors of life, influencing developments in medicine, energy, manufacturing, as well as entertainment and media. The increase in data generation and the development of cloud technologies and mobile health devices have led to significant improvements in many areas, such as healthcare, where data analysis leads to better diagnoses and personalised patient care (Nielsen, 2015). One of the key aspects of the development of Data Science is data management, which includes both the collection and analysis of data, as well as the identification of patterns and relationships (Wengrow, 2017). In the context of governance, Data Science plays an important role in business process optimisation, risk management and evidence-based decision-making (Mahdavinejad et al., 2018). However, there are also challenges related to data privacy, structural biases and the need to balance opportunities with technological limitations (Thilak, 2018). The future of Data Science seems promising, with a growing demand for skilled professionals and further development of technologies based on artificial intelligence and machine learning (Robinson, Nolis, 2020). Organisations are increasingly investing in advanced analytics systems to better understand and manage data, resulting in increased efficiency and competitiveness (Kelleher, 2018).

The aim of this research was to investigate the factors influencing women's participation in the field of data science, compared to men. The research aimed to identify gender differences in access to education, the labour market, and career achievements in the field of data science.

2. Literature research

For many years, research has been conducted to explain gender roles and the inequalities that exist between them. Some of the gender differences in human behaviour have been attributed to selection pressures associated with inter-sexual selection and intra-sexual competition (Zhu, Chang, 2019). Challenges include identifying reproductively valuable partners for both sexes, reducing paternity uncertainty for males and inducing parental investment in offspring for females (Geary, 2000). Males and females face different challenges due to higher rates of reproduction in males, resulting in gender differences in parental investment (Buss et al., 2001). Despite the many differences in theories of evolutionary psychology, all maintain that sex differences ultimately arise through selection for inherited traits rather than non-genetic processes such as social learning. According to Wood and Eagly's biopsychosocial model, men achieve higher status through a monopoly on 'warfare, agriculture and productive activities', which generate far more material wealth than domestic labour (Wood, Eagly, 2012). However, in contrast to the theories of evolutionary psychology, the biopsychosocial model assumes that gender mating preferences result from socially constructed patriarchal systems and not from sexual selection (Wood, Eagly, 1999). In human society, it has been shown that unpredictability (e.g. disasters, violence, famine and disease), through its indirect effects on families, 'accelerates' the life history of individuals as manifested by earlier physiological, sexual maturation and earlier reproduction (Ellis, Essex, 2007). All these factors effectively serve to prolong the reproductive career of females and ultimately maximise the current reproductive success of both sexes (Wood, Eagly, 2012). In this way, the chance of an individual leaving at least one offspring before being affected by disease or dying in an unsafe environment may increase (Figueredo et al., 2009). Although both sexes benefit from a reproductive strategy, women bear a much greater cost of such a strategy (Buss, Schmitt, 2011). Reproductive activities such as pregnancy, breastfeeding and childcare are major barriers to women's participation in most economic production activities (Alexander, 1999; Roudsari et al., 2023). The relative vulnerability of women at critical times also increases their dependence on male provisioning even in traditional societies where women and men contribute similarly to subsistence (Clark, Thorpe, 2023; Puts, 2010). Moreover, due to imbalances in initial parental investment in mammals (including humans), mothers are predisposed to provide direct care for their offspring to a greater extent than fathers (Betzig, 2012, Koch, Narum, 2021). A consequence of external risk is also increased competition between males and social competition (Henrich, Gil-White, 2001). It allows successful individuals to control resources and/or offspring without frequent chenges from subordinates leading to status hierarchies (Snyder et al., 2008). Dominance hierarchies shaped by different forms of competition favour males more often. Sexual dimorphism in terms of physical strength, aggressiveness and psychological competition favours men in combat and in posing

threats (Jozifkova et al., 2022). Male-dominated power hierarchies reinforce traditional gender roles, which maximises men's reproductive success by monopolising (numerous or younger) female partners (Brooks et al., 2022). Polygynous societies, limit women's access to all resources (Micheletti, Mace, 2024). Women usually prefer to be one of several spouses of a wealthy man rather than the only wife of a poor one. Social rivalry (competition) based on skills and altruism can also have reproductive benefits for individuals with high prestige (Furnham, Cuppello, 2024). Based on the study, women preferred men with high prestige and low dominance in long-term relationships, but men with high dominance were preferred in short-term relationships. These analyses can lead to many predictions about gender roles and gender inequality. In societies that are dangerous and unstable, but lacking strong competition, the traditional gender division of labour may prevail (Matriano et al., 2022). Women may enjoy similar social status to men. On the other hand, in safe, stable and competition-oriented societies, modernised gender roles and equal values are promoted (Pfefferman et al., 2022). When external risks are combined with social rivalry, reproductive goals focused on the present are prioritised which contributes to traditional gender roles (Cassar, Rigdon, 2023). Male competition in difficult and unpredictable environments can promote a male monopoly on resources and a dominance-based social hierarchy that favours men and perpetuates gender inequality (Naiman, 2020). In societies that are stable and secure but non-competitive, men may seek to fulfil their reproductive potential by setting reproductive goals focused on the present while women may prefer lower reproductive costs by setting reproductive goals focused on the future (Desai, 2023). A compromise may lead to a moderate segregation of gender roles and the male-dominated social hierarchy would allow for a degree of gender equality (Ebirim et al., 2024).

According to what we were able to find in the literature, there is no research addressing and reporting on how modern technology, globalisation and social change affect gender roles and gender inequalities. The authors potentially add to the literature by conducting an analysis of the factors influencing women's participation in the field of data science, compared to men.

3. Methods

The aim of this study was to investigate the factors affecting women's participation in the field of data science compared to men. The study aimed to identify gender differences in access to education, the labour market and professional achievement in the field of data science.

To achieve the research objective, the authors set out to answer three main research questions:

- What factors contribute to the persistent wage gap between men and women in data science, despite the increase in women's educational attainment?
- What are the main reasons for women's lower participation in educational programmes and data science professions and their slower career progression compared to men?
- How does starting a family affect women's careers in data science compared to men?

A variety of research methods were used to comprehensively address the topic of investment in women's education and their role in data science and technology, drawing on a wide range of statistical data, reports, quantitative and qualitative research and case studies.

Statistics on the average educational attainment of women and men in different countries over the years are presented.

Data on the number of women achieving master's and doctoral degrees, as well as their representation in various Data Science fields, were also analysed.

The analysis was also based on the results of quantitative surveys such as 'The Global Survey of Scientists', which examined gender diversity in science worldwide. This was conducted with a sample of over 32,000 respondents from 159 countries. This survey looked at various aspects, including career choices, working conditions and family responsibilities of women in the sciences.

The article also refers to reports from organisations such as UNESCO and the World Economic Forum (WEF). The authors cite the WEF's Global Gender Gap Report, which analyses women's participation in the AI sector and their contribution to industrial innovation.

A comparative analysis method was used to collate data on the education and salaries of women and men and their representation in technical and managerial positions in multinational technology companies.

Specific country and company examples are also analysed to show the progress and challenges of women's education and employment in science and technology.

4. Results and Discussion

Investing in women's education is considered an antidote to the many challenges of the developing world. Both academics and politicians as well as marketing agencies have defended the intrinsic and instrumental value of women's education (Evans et al., 2020). Based on a review of research from the last 15 years, it has been confirmed that investing in girls' education also has high returns in terms of maternal and child health, more stable families, women's empowerment, democracy, income growth and productivity (Herz, Sperling, 2004).

A strong correlation was also found between women's participation in the labour force and education in low- and middle-income countries (Psacharopoulos, Tzannatos, 1989).

In 1960, adult women in North American and Central European countries had an average of 2.6 years of education (Evans et al., 2020). By 2010, this figure had almost tripled to 7.7 years of education. Men's education also increased from 3.5 years of education in 1960 to 8.2 years in 2010. The United Arab Emirates, the country with the largest increase in women's education also started with a low of 0.9 years of education for the average woman and increased to 10 years by 2010 (Bouguen et al., 2018). In most countries, the increase in female education has been accompanied by an increase in male education.

Today, women achieve 60 per cent of all master's degrees and more than half of all doctoral and master's degrees in engineering (DiPrete, 2013). The only significant area of education where women still lag behind men is in participation in science and engineering programmes. However, even in some areas of science, women have made progress, admittedly earning only 25% of engineering degrees, but achieving 52% of master's and doctoral degrees in the natural sciences (Bouguen et al., 2018).

The increase in the number of women in education has not evened out the gender pay gap. Women with higher education still earn less on average than men with the same education (DiPrete, 2013).

However, the rapid increase in the number of women with higher education has certainly contributed to narrowing the gender earnings gap. For more than 100 years, girls have outperformed boys in educational attainment. But back then, women often had to choose between getting an education and starting a family. Women who graduated from university in the first two decades of the 20th century were four times less likely to marry at age 50 than their peers who did not attend university. Among women who did marry, about 30 % never had children (Goldin et al., 2014).

When, in the 1950s, education was treated on a par with family life, a significant proportion of Americans believed that the purpose of education was to make women better wives and mothers, and that a woman's place was in the home. As a result, although more women entered college in those days their percentage was much higher and many women dropped out of college as soon as they became engaged or married (DiPrete, 2013). These norms slowly began to change in the 1960s and 1970s, when the civil rights movement and the women's movement promoted equal opportunities in education and employment for women and minorities. These changes, along with advances in contraception, created an environment more conducive for women to pursue higher education and use their degrees to find work outside the home. The growing wage advantage for workers with higher education was also a strong incentive to work (DiPrete, 2013).

However, reversing the gender gap in education has the potential to undermine the motherhood penalty. When a wife has a higher education than her husband, not only are there chances of her becoming the main breadwinner in the family, but this also offsets the motherhood penalty (Oláh et al., 2023). This phenomenon may occur in countries where it is easier for women to combine a career with parenthood. In Europe, when both partners have a university degree, the proportion of couples in which she earns more than he does is about one-third of childless couples, while among couples with school-age children it is only one-fifth (Cooke et al., 2013; Mortelmans, 2021). In contrast, in the case where the wife has a tertiary education and her husband does not, the percentage of couples in which the wife earns more than the husband is as high as for childless couples with a tertiary education (Lappegård, 2020). Earning potential and work experience may begin to outweigh women's cultural preference to limit their work after having children.

Women's advantage in terms of education or earnings is no longer associated with less marital stability. Historically, such a phenomenon was quite common, but this is now increasingly changing (www.frbsf.org).

One study found that wife employment is still associated with a higher risk of divorce in the USA, but no longer in European countries or Australia. In Finland, Norway and Sweden, wife employment even predicted a lower risk of divorce compared to couples where the wife stayed at home (Cooke et al., 2013).

The prospect of raising children where both mother and father are working people offers a good chance of reducing the gender role gap. Children with such an image are less likely to be influenced by the stereotype, where the father is the head of the family and the main breadwinner and the mother takes care of household chores. Young women, having the image of a working mother, also want to be independent and strive to achieve their own goals and be the best in their profession. Factors such as geographical location, cultural, religious and many other factors lead to this trend being shaken. However, all indications are that the level of awareness among women in personal development, learning and work is increasing.

In an era of globalisation and rapid technological development, the roles of men and women have changed, adapting to modern technology (Beura, 2017). Although women are increasingly studying science, technology, engineering, mathematics and medicine, they are still a minority of executives. They are less likely to be trained in elite research groups, are slower to be promoted and more likely to give up their careers (National Academy of Science, 2006). The group 'The Global Survey of Scientists' examined gender diversity in science worldwide, covering education, working conditions and family responsibilities (Guillopé, Roy, 2020). Conducted between May and December 2018, the research surveyed more than 32,000 people from 159 countries, indicating general trends across disciplines and geographies (Figure 1).

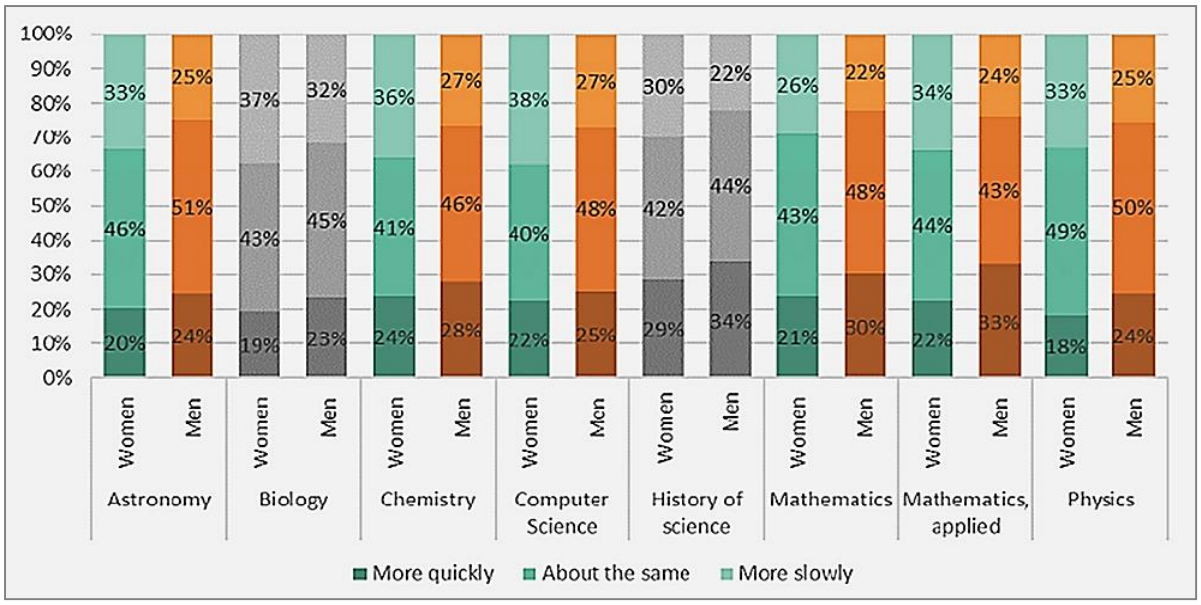

Figure 1. Percentage of respondents comparing their career trajectory with colleagues who graduated at the same time, by discipline (grey colour indicates statistically non-significant differences by gender at the 0.002 level).

Source: Own elaboration based on: Mei-Hung Chiu and Mark Cesa, A Global Approach to the Gender Gap in Mathematical, Computing and Natural Sciences: How to Measure It, 2020.

In every profession and in every field, men dominate among those who have achieved their professional goals faster and advanced their careers faster. They achieve success much faster than women, especially in sciences such as chemistry, mathematics, astronomy and physics (Figure 2).

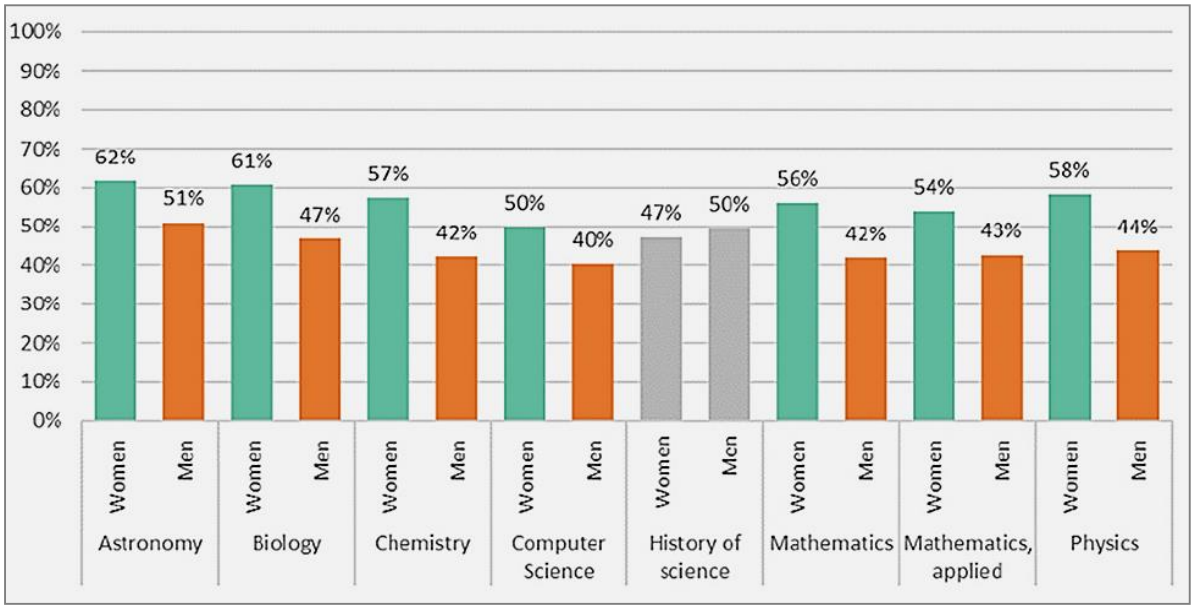

Figure 2. Percentage of respondents indicating that their career had influenced their decisions regarding children, marriage or long-term partnership by occupation (grey colour indicates statistically non-significant differences by gender at the 0.002 level).

Source: Own elaboration based on: Mei-Hung Chiu and Mark Cesa, A Global Approach to the Gender Gap in Mathematical, Computing and Natural Sciences: How to Measure It, 2020.

When it comes to the influence of a professional career on the decision to start a family, marriage or a long-term relationship - a slightly, but higher percentage of respondents are women. Such results show that to a greater extent women subordinate their professional life to their family, private life (Figure 3).

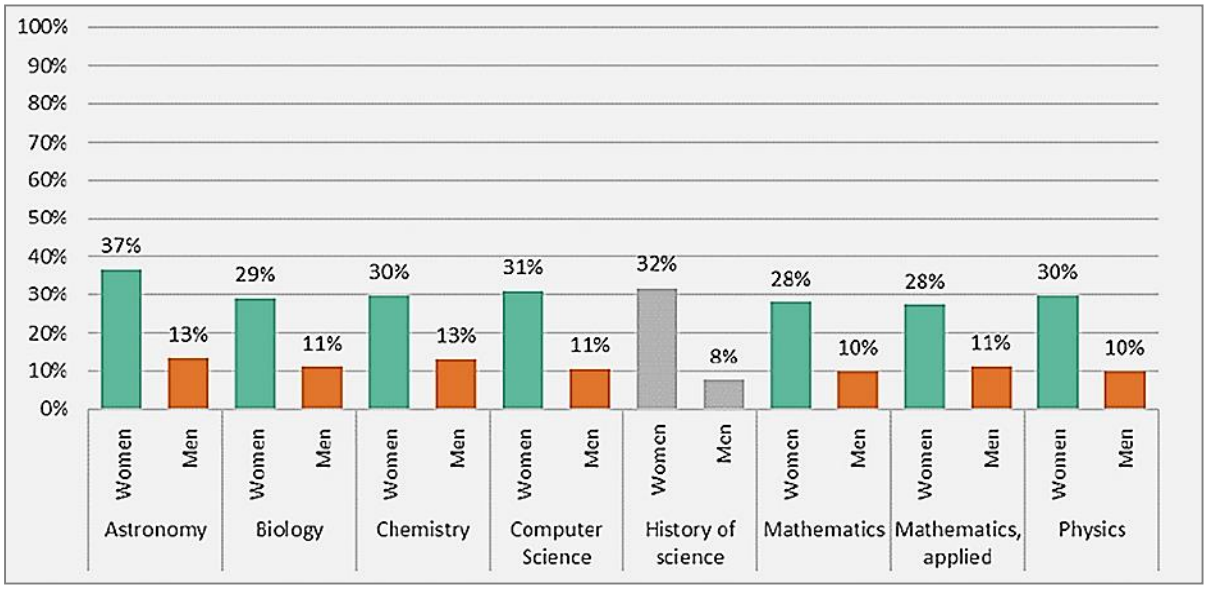

Figure 3. Percentage of respondents indicating that their career or promotion rate slowed down significantly because they became parents by discipline (grey colour indicates statistically non-significant differences by gender at the 0.002 level).

Source: Own elaboration based on: Mei-Hung Chiu and Mark Cesa, A Global Approach to the Gender Gap in Mathematical, Computing and Natural Sciences: How to Measure It, 2020.

A significant career slowdown in women occurs when they become parents. Although the career pace slows down for both genders, this is much more pronounced in women, reaching 30-40% in each field, compared to around 10% in men.

Research has shown that systematic differences between women's and men's experiences continue to exist across all regions, disciplines and levels of development (UNESCO Institute for Statistics, 2021). Women were more likely than men to drop out of education, which negatively affected their professional credibility. More women than men reported that they were discriminated against when assessing or evaluating their performance because of their gender (UNESCO Institute for Statistics, 2021). Fewer women felt they were treated fairly in their work environment, and women were more likely to report lower pay than their male colleagues (Guillopé, Roy, 2020).

In 2019, UNESCO and the Equal Skills Coalition analysed women's participation and contribution to industrial innovation. The fields related to optimisation and automation, key to driving industry, are those in which women are underrepresented in most countries: computer science, physics, mathematics and engineering (UNESCO Institute for Statistics, 2021). In the US in 2015, women made up 57% of professionals, but only 25% of computer scientists. Women are more likely than men to leave the tech industry, most often because of working conditions, lack of access to key creative roles and a sense of professional stagnation

(Ashcraft, 2021). Female engineers earn 84% of what their male colleagues earn, despite their higher level of education; in 2017, 12% of female engineers had a postgraduate degree, compared to 7.4% of male engineers (World Economic Forum, 2018). Women are also underrepresented in the fast-growing AI sector. According to the World Economic Forum, from 2015 to 2017, the number of workers with AI skills increased by 190% (World Economic Forum, 2018). The pay gap in AI is one of the smallest between men and women in the US, with women earning 94% of what men earn (AAUW, 2018) (Figure 4).

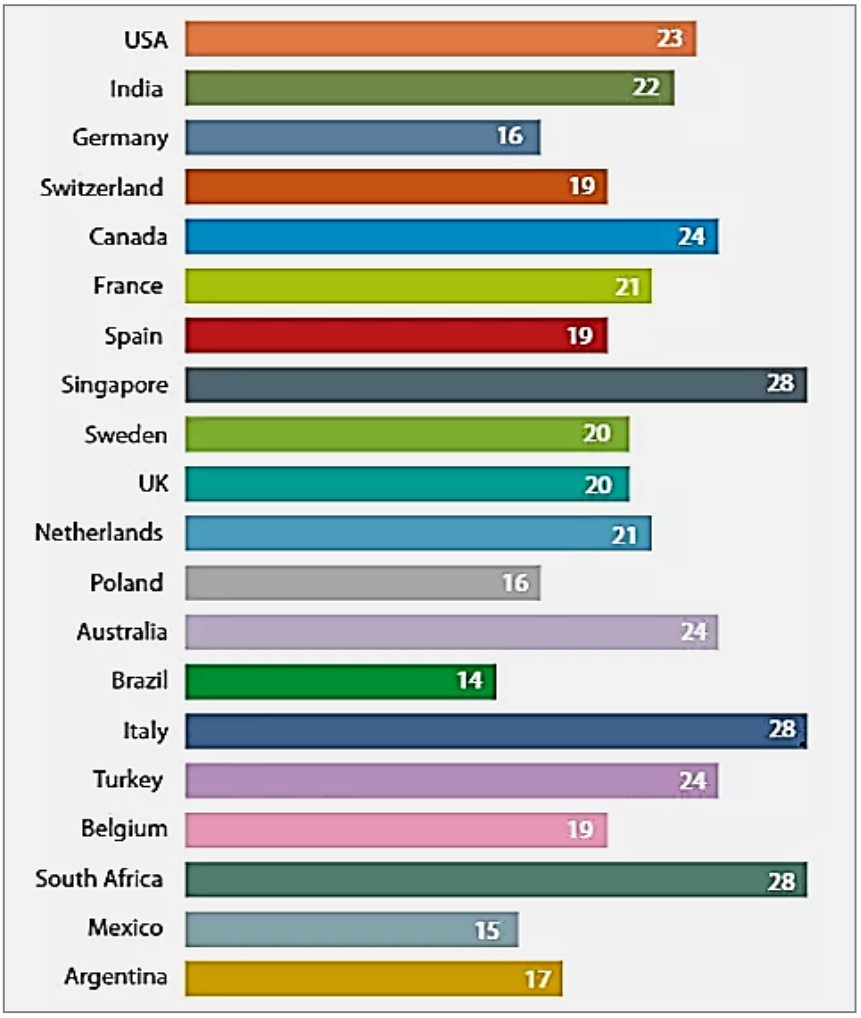

Figure 4. Share of women in the 20 countries with the highest job security for professionals with AI skills in 2017. (%) (In descending order for countries with the highest job security).

Source: Own elaboration based on: WEF, The Global Gender Gap Report 2018, World Economic Forum: Geneva, 2018.

According to data collected and presented in the World Economic Forum's Global Gender Gap Report, only 22% of professionals working in AI worldwide are women. This gap is evident in all 20 countries with the highest concentration of AI workers (Figure 4) and is particularly pronounced in Argentina, Brazil, Germany, Mexico and Poland, where less than 18% of female professionals have AI skills (The Global Gender Gap Report, 2018).

While leading multinational technology companies are making progress, they are still not even close to closing the gender gap in technical and managerial positions. Although there has been some progress at Google in terms of the percentage of female employees, in 2018 less than a quarter of technical positions were filled by women (Figure 5).

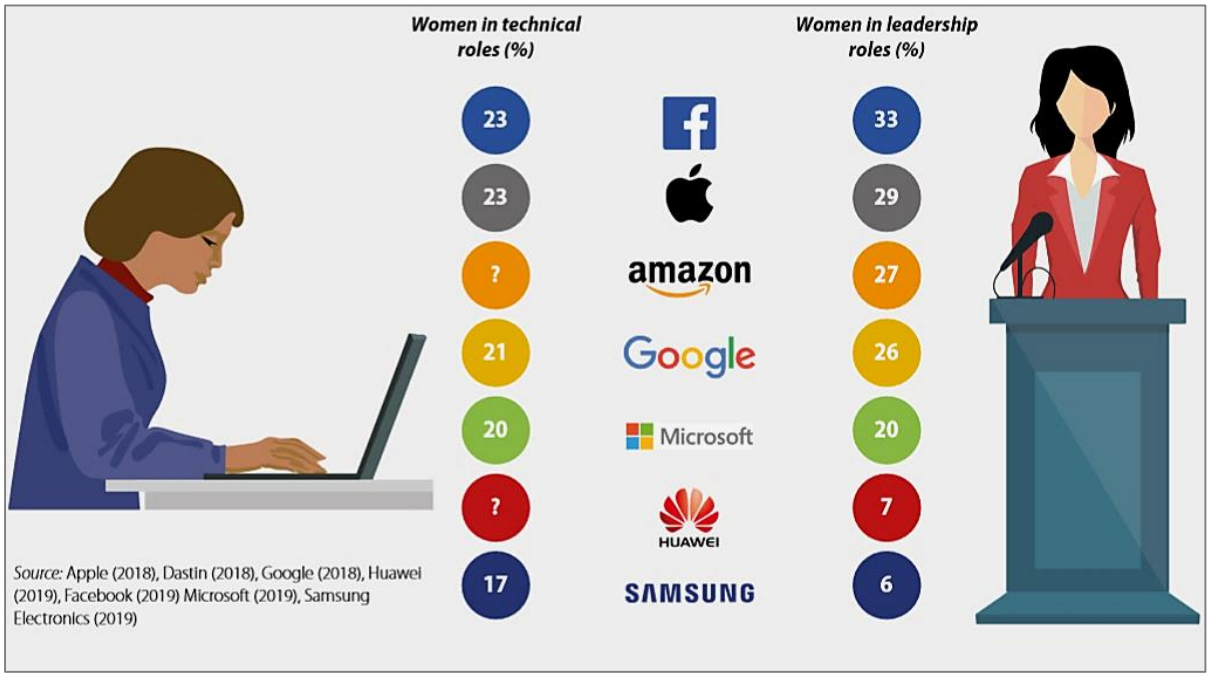

Figure 4. Women in technical and managerial positions at selected leading international technology companies in the years: 2018-2019.

Source: Apple (2018), Dastin (2018), Google (2018), Huawei (2019), Facebook (2019) Microsoft (2019), Samsung Electronics (2019).

Nevertheless, women are approaching equality in science at least in terms of numbers. In higher education, they have reached a gender ratio of 45-55 % at undergraduate and master's level and 44 % at doctoral level (Google diversity annual report, 2018). In many countries, they dominate in the natural sciences but remain a minority in digital computing, physics or mathematics. These fields drive industry and thus will provide many jobs in the future.

5. Summary

The analysis showed that women are more likely than men to drop out of school and to experience discrimination in the assessment of their career achievements. Significant differences between women's and men's career experiences are evident across all regions and disciplines, suggesting that systematic gender barriers still exist.

Women in Data Science were more likely to report lower pay compared to their male counterparts, despite higher levels of education. The research also indicates that women are underrepresented in key technological areas such as computer science, physics, mathematics and engineering, limiting their contribution to industrial innovation.

In the context of managing gender differences, the article highlights the importance of educational initiatives, support programmes and social and cultural changes that promote gender equality in the technical sciences.

The results of this study cannot be considered complete and exhaustive, as some data may be outdated or incomplete, which affects the accuracy of the conclusions.

The study does not fully represent the diversity of women's experiences and perspectives around the world, especially in regions with less access to education and technology.

Taking these limitations into account is crucial for proper interpretation and recommendations.

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