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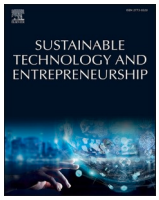

Full Length Article

Cross-country analysis of sustainable innovation and female entrepreneurship and their influence on the presence of women in managerial positions

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ABSTRACT

Despite the global increase of women in business, there is still a very small proportion of female business leaders, although the distribution varies greatly by region and sector. Considering innovation, in its many forms, as well as female entrepreneurship, both considered as a path towards sustainability, the question arises as to whether this drive for sustainability leads to a greater presence of female CEOs. Current studies predominantly examine the impact of women's presence on a company's economic and financial performance, as well as any potential effects on its innovation strategy. However, the examination of factors that help understand the economic and business context influencing the presence of women in leadership roles is often overlooked. This empirical study fills this gap by exploring the micro and macro context influencing the presence of female CEOs in innovative firms worldwide stressing the influence of female owners. The sample comprises 107,026 companies from manufacturing and service industries in 118 countries, from 2007 to 2023, data obtained from the World Bank Enterprise Surveys. The econometric model applied is logistic regression with clustered standard errors. The study contains six estimations generating strong evidence supporting most of the formulated hypotheses. Findings suggest women CEOs are likely to lead women-owned firms which promote (sustainable) innovation through developing new products for new markets, allocating less investment in R&D, product innovation and business processes, although with some nuances. Other important factors to consider are productivity, sales strategy, firm size, sector, and socio-economic context with a gender focus.

Introduction

Sustainable innovation is closely linked to entrepreneurship, as both serve as catalysts for societal change, originating from individual mindsets. Sustainable innovation extends beyond the transformation of technologies and products to reshape markets and assist entrepreneurs in identifying new business opportunities (Larson, 2000). Schaltegger and Wagner (2011), although addressing to a large global market, argue that sustainable innovation provides a framework for sustainable entrepreneurship, as both – sustainable innovation and entrepreneurship– seek to introduce novel solutions that address unmet social and environmental needs. Sustainable entrepreneurs aim to integrate social and environmental progress with economic viability, leading to the development of sustainable business models characterized by their proactive nature and multi-stakeholder focus (Geissdoerfer et al., 2018). Sustainability, when intertwined with innovation, development, and entrepreneurship, cannot be discussed without reference to the Sustainable Development Goals (SDGs) outlined in the 2030 Agenda (UN, 2015), which call for both individual and collective contributions toward a more just and prosperous world.

One significant transformation emphasized by both sustainable innovation and sustainable entrepreneurship, and highlighted in the 2030 Agenda, is the increased inclusion of women in all business sectors. The SDG 5, Gender Equality, specifically calls for the empowerment of all women and girls to reduce gender disparities. A key target under this goal –"Ensure women's full and effective participation and equal

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opportunities for leadership at all levels of decision-making in political, economic, and public life"– underscores the need to foster female entrepreneurship and promote women into senior and middle management positions. Moreover, research in business and management suggests that gender diversity in corporate decision-making correlates with positive outcomes. As indicated by Foss et al. (2022), there is a positive association between gender diversity in management and innovation. This relationship is bidirectional, as firms led by women tend to be more innovative (Khushk et al., 2023). Similarly, the interplay between entrepreneurship, particularly sustainable entrepreneurship, and female leadership highlights that women in executive roles contribute to fostering sustainable business ventures (Criado-Gomis et al., 2020).

According to the latest Global Entrepreneurship Monitor (GEM) report (2024), the rate of nascent entrepreneurship among women worldwide has increased by four percentage points between 2021 and 2023 compared to two decades ago. The proportion of established women-owned businesses has also risen, though by just over one and a half percentage points. However, in advanced economies, female entrepreneurial activity is declining. Despite improvements in women's perceptions of business opportunities and their entrepreneurial skills, fear of failure has significantly increased. In terms of female leadership in managerial roles, Deloitte's latest report (2024) indicates that there are now more women in senior management positions globally than three or five years ago. However, these advancements remain concentrated in specific industries, particularly in the services sector, and in regions such as North America, Europe, and Asia-Pacific. Despite these gains, the overall number of women in managerial positions remains low. Barriers to promotion and appointment to leadership roles may stem from motherhood, work-life balance challenges, and the absence of female mentors (Hurley & Choudhary, 2016). Additionally, the attitudes of male executives, the scarcity of female role models, and lack of confidence among women may further hinder career advancement (De Mascia, 2015).

Cultural perceptions also influence the representation of women in leadership roles, particularly in certain industries. In some regions, female business leaders are perceived as lacking essential skills. Historically, analytical and technical competencies were primarily associated with male-dominated roles (Heilman & Okimoto, 2007). As a result, women were often viewed as less suitable for careers in science, technology, engineering, and mathematics (STEM) (Reuben et al., 2014). However, this gender gap is narrowing in some regions. Indeed, as Han et al. (2019) suggest, the capabilities demonstrated by male and female business leaders, including Chief Executive Officers (CEOs), are increasingly similar.

In the corporate context, two key concerns arise regarding female senior executives, both linked to a company's long-term sustainability. The first relates to innovation, which involves leveraging technology, knowledge, and processes creatively to generate value and competitive advantage (Horn, 2005; Singh & Aggarwal, 2022). Studies indicate that female leadership has a positive impact on innovation (Prabowo & Setiawan, 2021), although high risk aversion among women may act as a barrier to adopting aggressive innovation strategies (Faccio et al., 2016; Hoang et al., 2019; Tian & Wang, 2014). The second concern pertains to corporate performance. Research suggests that gender diversity at the executive level is positively correlated with financial performance (Havran et al., 2020; Mohsni et al., 2021; Valls & Rambaud, 2019) and that female leadership is associated with greater business stability (Bernile et al., 2018). However, Wang et al. (2018) argue that firms led by female CEOs tend to be less prestigious and exhibit weaker market-based performance, with national culture acting as a moderating factor. Nevertheless, beyond cultural considerations, the socio-economic context, particularly gender equality regulations, plays a more critical role.

Overall, existing literature does not adequately explore the contextual factors influencing the presence of women in top management on a global scale. While numerous studies highlight determinants such as perceived gender equality within firms (Yesilirmak et al., 2023), organizational culture and practices, societal norms, official regulations, and the political-economic landscape (Guerrero-Ochoa et al., 2023), as well as personal traits (Saitova & Di Mauro, 2023), stereotypes (Alameeri et al., 2023), and professional networks (Ramos et al., 2022), little attention has been paid to firm-level (economic and financial), sector-specific, or country-level variables that may facilitate or hinder women's advancement into executive roles. Furthermore, discussions on innovation and business efficiency often fail to distinguish among different types of innovation, which is not solely about investment in research and development (R&D), a variable frequently used as a proxy for innovation (Foster et al., 2020). Existing analyses typically assume that female managers are less inclined to support innovative or high-tech projects due to their higher risk aversion. Similarly, studies on firm performance often rely on a single financial metric, such as annual revenue, without considering broader performance indicators. Additionally, research on female CEOs frequently focuses on single-country data or specific company types, likely to mitigate heterogeneity issues rather than addressing them through robust methodological models (Han et al., 2019; Hurley & Choudhary, 2016; You, 2019).

This study addresses these gaps by employing global microdata from the World Bank Enterprise Survey (WBES), covering over one hundred economies across six regions. The objective is to analyze micro- and macro-level factors influencing the likelihood of a firm having a female CEO while accounting for data heterogeneity across countries and time periods. Our analysis consists of four stages: (1) a comprehensive descriptive examination of the curated sample; (2) estimation of the main model using logistic regression with clustered standard errors by country and year; (3) additional estimations based on various classifications within the sample; and (4) robustness checks through different tests.

This study is structured as follows: Section 2 presents a review of the relevant literature; Section 3 details the methodology, sample, and variables; Section 4 presents the results; Section 5 discusses the findings in relation to recent empirical evidence; and Section 6 provides the main conclusions.

Literature review

Innovation in relation to female CEOs

Innovation management is a complex process requiring long-term strategic planning and resilience (Lv et al., 2018). Given its inherent uncertainty (Luthfa, 2019), examining the decision-making processes of female senior managers is particularly compelling. While innovation management is often considered gender-neutral (Lipovka et al., 2021), research suggests that female participation in corporate decision-making positively influences innovation. In particular, Fuentes-Fuentes et al. (2023) highlight that women's involvement fosters inclusive or social innovation, which aims to generate positive societal impact, especially through the development of products targeted at economically vulnerable populations. Although increased female representation on boards and in senior management is generally linked to enhanced firm innovation (Griffin et al., 2021), findings regarding female CEOs present a more nuanced picture (Quintana-García et al., 2022). It is also important to take into account that, while Chief Technology Officers (CTOs) play a more direct role in the innovation process by utilizing and developing company technologies, CEOs are crucial in shaping overall corporate strategy, including innovation-related initiatives (Wu et al., 2021).

Female senior managers may exhibit initial resistance to innovation due to the high risk associated with uncertain outcomes (Tian & Wang, 2014). Agency theory, a cornerstone of business organization literature, posits that managers, in general, tend to be more risk-averse than business owners (Jensen & Meckling, 1976; Jensen & Murphy, 1990). Consequently, managers are not necessarily expected to be strong

advocates of innovation. While incentives could theoretically mitigate this issue, they appear to be less effective for female executives. Women in leadership roles receive fewer monetary incentives related to innovation and are generally less responsive to such measures, resulting in a stronger focus on short-term outcomes and greater risk aversion (Albanesi et al., 2015). This idea is further supported by behavioral agency theory, which suggests that equity-based incentives do not significantly increase risk-taking among female managers (Baixauli-Soler et al., 2015; Larraza-Kintana et al., 2007). Dawson (2023) attributes this to women's heightened perception of negative outcomes in stock market investments, reinforcing their tendency toward conservative decision-making (Faccio et al., 2016).

Nevertheless, female managers often outperform their male counterparts in reaching top executive positions (Prabowo & Setiawan, 2021). Studies indicate a positive relationship between female managers and innovation, particularly in countries with greater fiscal freedom (Audretsch et al., 2022). Owalla et al. (2021) found that in the United Kingdom, women-led small and medium-sized enterprises (SMEs) demonstrate strong support for innovation activities despite industry and firm-size constraints. Similarly, Foss et al. (2022), using data from manufacturing firms in transition economies, argue that this positive association is more pronounced in countries with voluntary gender quotas. However, a comprehensive understanding of this relationship remains elusive. Some studies adopt a more general perspective, suggesting that female participation in corporate decision-making is positively correlated with innovation-related outcomes, particularly in research and development (R&D) activities and expenditures (Arzubiaga et al., 2018; Saggese et al., 2021). This may be attributed to women's tendency to seek extensive information to support decision-making, which enhances the effectiveness of R&D investments. Importantly, support for innovation is not limited to female CEOs; women business owners and other non-managerial female employees often exhibit even stronger support for innovation initiatives (Dohse et al., 2019).

While innovation is frequently associated with R&D, it also encompasses product and process innovation, among other dimensions (Damanpour & Gopalakrishnan, 2001). It is therefore important to analyze the relationship between female CEOs and these broader aspects of innovation. Women's presence on corporate boards has been found to positively impact marketing innovation but not productive innovation (Galia & Zenou, 2012). Beyond introducing innovative marketing methods (Iman et al., 2022; Na & Shin, 2019) or fostering new design strategies, female managers are particularly supportive of sustainable innovation through environmentally friendly business practices (Khushk et al., 2023). However, their involvement in innovation is contingent on factors such as firm size (Prabowo & Setiawan, 2021) and corporate culture (Wu et al., 2021), among others. Process innovation, by contrast, appears to receive greater support from male CEOs, while no significant gender-based differences exist in product innovation (Expósito et al., 2023). In developed economies, gender diversity on corporate boards is positively correlated with product innovation (Attia et al., 2020). In emerging economies, particularly in the manufacturing sector, female senior directors predominantly support marketing innovation, whereas female business owners favor product and service innovations in both existing and new markets while avoiding investment in process innovation (Na & Shin, 2019). In the context of the Association of Southeast Asian Nations (ASEAN), female CEOs have been found to moderate the impact of management practices on product innovation positively (Do et al., 2023).

Given that the existing literature primarily examines the impact of female representation in senior management on corporate innovation, this study seeks to explore the reverse relationship trying to answer the following question: Do innovative companies attract more female CEOs? This leads to the following research hypotheses:

H1a: Companies that invest in R&D activities are less likely to have female CEOs.
H1b: Companies that support product innovation are more likely to have female CEOs.
H1c: Companies that develop new products for new markets are more likely to have female CEOs.
H1d: Companies that promote process innovation are less likely to have female CEOs.

Firm performance in relation to female CEOs

Beyond innovation, the presence of women in top management is linked to business performance. Most research examines the impact of female managers on economic and financial indicators. For instance, a comprehensive literature review by Nguyen et al. (2020) highlights mixed effects of women in top management on business performance. Some studies from the 1980s to 2014 report no significant impact, while others find positive short-term outcomes, particularly in women-owned firms (Beltran, 2019). In countries with a smaller gender gap, women-led firms tend to have higher sales turnover (Hoobler et al., 2018). However, certain studies indicate negative effects on business performance (Allison et al., 2023). Additionally, women-managed firms often exhibit lower labor productivity, especially in developing economies, due to limited capitalization (Islam et al., 2020). Long-term impacts on economic and financial indicators appear to be positive but weak, whereas short-term effects tend to be negative and weak (Jeong & Harrison, 2016). Here, another important question arises: Does this relationship work in reverse? Are female CEOs more or less common in top-performing companies? Based on the literature, the authors propose:

H2: Women CEOs are less likely to be found in companies with high productivity.

Women-led companies generally exhibit higher sales turnover but lower export activity (Quiroz-Rojas & Teruel, 2021). Exporting entails greater risk than selling in domestic markets, and due to higher risk aversion, women are expected to be less engaged in export activities (Marques, 2015). This may also stem from more conservative risk-taking decisions by women (Larraza-Kintana et al., 2007). As a result, female CEOs boost domestic sales but not exports (Bouazza et al., 2023). Various studies indicate that women-led firms—primarily small-sized and service sector-based—show lower export intensity than male-led firms, particularly in OECD countries (Korinek & van Lieshout, 2023). In Estonia, for instance, female-led SMEs focus more on domestic sales due to heightened perceptions of risk or other barriers to internationalization (Lukason & Vissak, 2020). To explore the relationship from the opposite perspective –whether companies with high national and international sales have more female CEOs– the authors propose:

H3a: Women CEOs are more likely to lead companies that focus on national sales.
H3b: Women CEOs are less likely to be found in export-oriented companies.

Other crucial factors to consider are firm size and industry, as women CEOs tend to be more prevalent in certain business environments. Regarding firm size, the literature consistently shows that women are primarily found in smaller companies. In 2019, only 5% of S&P 500 companies had female CEOs (Hurt et al., 2020). In Japan, female representation in non-financial listed firms remains below 1% (Kubo & Nguyen, 2021). Similarly, Luo et al. (2018) found that women CEOs are rare in large private sector firms in China. In Europe, female CEOs predominantly lead smaller firms. According to the European Institute for Gender Equality (EIGE, 2024), only 8% of CEOs in large EU enterprises are women, though with significant variation across countries: Lithuania (21.1%) and Malta (16.7%) have the highest shares, while

Spain, Italy, and Germany range between 2.6% and 3%. Luxembourg and Slovakia report no female CEOs at all. This distribution may reflect the nature of certain industries, such as construction or manufacturing, or the dominance of small and medium-sized enterprises (SMEs), which are often family-run businesses where women serve as both owners and CEOs (Hernández-Nicolás et al., 2022; Óladóttir et al., 2021). Consequently, the following hypothesis is proposed:

H4: There is a higher probability of encountering women CEOs in smaller companies.

Regarding sectoral concentration, research consistently indicates that women are concentrated in the service sector. In the U.S.A, women predominantly work in education, healthcare, general services, financial activities, and hospitality (BLS, 2022). European data distinguishes between male-dominated sectors (*e.g.*, manufacturing, construction, and information and communication) and female-dominated ones (*e.g.*, education, health, social activities, and other services) (Mroczek-Dąbrowska & Gaweł, 2020). In emerging economies, female managers are more likely to work in the service industry than in manufacturing (Elango, 2019). Similar findings are reported by the World Economic Forum (WEF, 2023), which shows that industries such as healthcare, education, and consumer services are heavily dominated by women. Therefore, the authors propose the following hypothesis:

H5: Women CEOs are more likely to be found in service sector companies.

Female entrepreneurship as a lever for women CEOs

The topic of women's participation in business leadership has gained significant interest in recent decades. According to GEM (2024), in 2023, 11% of women globally started a business compared to 13% of men, a trend also reflected in entrepreneurial intentions. Notably, female startup activity is highest in low-income countries. However, the gender gap widens when considering businesses established for over 42 months, with an average of 6.3% among women compared to 10% among men. In some countries, such as South Korea, Saudi Arabia, Lithuania, Puerto Rico, and Thailand, this percentage reaches 10%. Despite these differences, women are more likely than men to establish sustainable businesses, with Poland, South Africa, China, and Canada reporting the highest ratios. As noted by Stefan et al. (2021), this tendency may stem from women's stronger ability to identify social and environmental drivers and integrate them into their business models.

Female entrepreneurship also serves as a significant source of employment and self-fulfillment for women. Self-employment offers a flexible means of balancing income and household responsibilities, a pattern observed since the early 21st century (*e.g.*, Budig, 2006; Chung & van der Lippe, 2020; Gurley-Calvez et al., 2009; Lim, 2017). In many cases, female entrepreneurship functions as a part-time occupation or a response to unemployment (Lawter et al., 2016; Lim, 2019; Patrick et al., 2016). Beyond necessity-driven entrepreneurship, women are motivated to start businesses for various reasons, including autonomy, financial independence, and personal fulfillment, as demonstrated by Cho et al. (2019) in Latin America. Opportunity-driven entrepreneurship is particularly prevalent when women rely on their own resources (Ferrín, 2023). As a result, numerous countries have introduced governmental and non-governmental support programs focused on education, youth, social inclusion, labor, modernization, and trade (Chakraborty et al., 2019; Fackelmann & De Concini, 2021; Johansen, 2016).

Women entrepreneurs, in addition to demonstrating strong financial and organizational management skills, play a key role in social development (Kumar, 2013). These competencies are essential for business leadership, long-term strategic planning, and company growth. Consequently, female entrepreneurs help pave the way for greater representation of women in management positions, either by serving as role models or by ensuring the financial sustainability of their businesses. Indeed, women managers are more commonly found in women-owned companies, as seen in African firms (Charpin et al., 2023). Moreover, female business leaders exhibit entrepreneurial qualities, as senior managers not only oversee daily operations but also embody a company's strategic vision and values (Cannella, 2001). Research indicates that women managers adopt entrepreneurial perspectives within companies. Lyngsie and Foss (2017) highlight that greater gender diversity in top management enhances a company's entrepreneurial character and fosters innovation. The authors further note that improved communication and knowledge-sharing within organizations help identify entrepreneurial opportunities, a leadership trait more commonly associated with female executives. Additionally, in many women-owned businesses, the CEO is often a female owner, particularly in family-run and small firms (Hernández-Nicolás et al., 2022; Óladóttir et al., 2021). In family businesses, in particular, female CEOs are highly valued for their leadership capabilities (Aldamiz-Echevarría et al., 2017).

The representation of women in top management varies globally due to differing regulatory frameworks. Female inclusion in business decision-making is more pronounced in countries where gender quotas are legally mandated. The global report on women's visibility in business made by Deloitte (2024) analyzed 18,085 companies worldwide, identifying 18,532 women on boards. Between 2018 and 2023, female representation increased across senior management roles: board membership rose by 6.4%, board chairs by 3.1%, CEOs by 1.6%, and CFOs by 4.9%. Notably, companies with women on their boards are more likely to have female CEOs, with 35.3% of female-led boards appointing women as CEOs, compared to just 23% among male-led boards in 2023. Industries with the highest female board representation (between 22.5% and 26.1%) belong to the service sector, including Life Sciences and Healthcare, Financial Services, Energy and Resources, and Technology, Media, and Telecommunications. These industries have seen over 7% growth in female board membership since 2018. Women in managerial positions are more prevalent in industries with a high female-to-male manager ratio (Havran et al., 2020). This phenomenon, known as the sectoral network effect, remains strong despite progress toward gender-neutrality in most sectors (Freeman & Svels, 2022). However, traditional male-dominated industries retain organizational structures that hinder women's advancement into senior management roles (Kräft, 2022).

Geographically, the representation of women on boards varies significantly. Deloitte's (2024) report identifies France, Norway, and Italy as the countries with the highest female representation in top management (above 40%), while Indonesia, UAE, South Korea, Argentina, Kuwait, Saudi Arabia, and Qatar have the lowest (below 10%). The majority of analyzed companies are based in North America (33%) and Asia-Pacific (32%), with North America reporting the highest female board representation (35%). European companies, which constitute 21% of the sample, have nearly 30% female board participation. All regions have seen an increase in female inclusion in senior management, except for the Caribbean and Bermuda, where the number of female CEOs declined between 2018 and 2023. The Middle East and North Africa (MENA) region also experienced a decrease in women chairing boards and leading as CEOs and CFOs. In developing countries, lower female participation may be attributed to the dual burden of domestic and professional responsibilities and cultural norms favoring male leadership (Mohsni et al., 2021).

Given the global trends in female entrepreneurship and top management representation, it is relevant to explore the link between these two aspects within the same organization. Most academic research overlooks the influence of women owners on female senior managers, as it analyzes women-led firms without distinguishing between male- and female-owned businesses, making it difficult to assess the direct impact of female ownership on the inclusion of women CEOs (Chadwick & Dawson, 2018; Luo et al., 2018; Prabowo & Setiawan, 2021). However,

You (2019) suggests that companies with female board members tend to strengthen women's presence in top management, while Han et al. (2019) find that female CEOs are more likely to work in women-owned firms. Additionally, in such companies, female top managers often enhance their business management skills (Beltran, 2019) and benefit from mentorship provided by female owners (Martínez-Zarzoso, 2023). The combination of a female owner and a female CEO also increases the likelihood of business innovation (Prabowo & Setiawan, 2021). This raises an important question: Are female CEOs more common in companies with female owners? To address this, the authors propose the following hypothesis:

H6: Women CEOs are more likely to be found in companies that have at least one female owner.

Macro socio-economic factors related to women CEOs

In addition to micro-level factors, macro-level socio-economic environments also play a significant role in shaping CEO gender. Several studies have examined the broader socio-economic and regulatory contexts, including gender equality policies that influence women's participation in top management (Han et al., 2019; Skaggs et al., 2012). According to institutional theory, organizations tend to align with societal norms (Meyer & Rowan, 1977), an idea reinforced by gender quotas on boards (Carrasco et al., 2015). In countries with narrower gender gaps, there is greater legitimacy associated with having adequate female representation in senior management (Halliday et al., 2021). Consequently, countries with stronger legal frameworks addressing gender equality tend to have a higher number of women-managed firms. However, as Fang et al. (2022) demonstrate in their study of 103 countries, even in countries with smaller gender gaps, female-led firms are generally smaller in size and concentrated in the service sector.

It appears that robust gender equality policies are effective in shifting societal mindsets. McLean et al. (2023) highlight that in the United States, regions with populations originating from countries with higher gender equality tend to have more women in top management roles. The effectiveness of these policies is also reflected in the economic sustainability of companies. As shown by Belaounia et al. (2020), the macro environment of greater gender equality acts as an important moderator in the relationship between the presence of women in top management and firm performance. This idea is similarly supported by Hoobler et al. (2018), who emphasize the connection between gender diversity and corporate financial performance. Based on this, the following hypothesis is proposed:

H7: Women CEOs are more likely to be found in companies located in countries with higher gender equality.

As noted by Adams and Ferreira (2009), advanced economies with high gender equality rates foster greater diversity and more opportunities for women in leadership roles. Elango (2019) further supports this, suggesting that female CEOs have more opportunities not only in countries with greater gender equality but also in wealthier economies. This business practice, which includes greater female representation, tends to originate in more advanced economies and is often referred to as "business feminism," gradually being adopted by less developed countries (Fodor et al., 2019). In developing countries, higher economic output, as by GDP per capita, correlates with an increase in female managers (Amin & Islam, 2014). Therefore, the following hypothesis is proposed:

H8: Women CEOs tend to be found more likely in companies located in more developed economies.

In summary, the proposed hypotheses are outlined in Table 1, highlighting the key contributions from the most prominent authors.

Table 1
Summary of the proposed hypotheses.

	Hypotheses	Proposed sign*	Authors who support
H1a	Companies that invest in R&D activities are less likely to have female CEOs.	-	Tian & Wang, 2014; Baixauli-Soler et al., 2015; Hoang et al., 2019.
H1b	Companies that are leading in product innovation are more likely to have female CEOs.	+	Attia et al., 2020; Do et al., 2023.
H1c	Companies that develop new products for new markets are more likely to have female CEOs.	+	Na & Shin, 2019.
H1d	Companies that promote process innovation are less likely to have female CEOs.	-	Expósito et al., 2023.
H2	Women CEOs are less likely found in companies with high productivity.	-	Jeong & Harrison, 2017; Islam et al., 2020.
H3a	Women CEOs are more likely to lead companies that focus on national sales.	+	Lukason & Vissak, 2020; Bouazza et al., 2023.
H3b	Women CEOs are less likely to lead export-oriented companies.	-	Lukason & Vissak, 2020; Quiroz-Rojas & Teruel, 2021; Bouazza et al., 2023.
H4	There is a lower probability of encountering women CEOs in large companies.	-	Luo et al., 2018.
H5	Women CEOs are more likely to be found in service sector companies.	+	Elango, 2019; Mroczek-Dąbrowska & Gaweł, 2020.
H6	Women CEOs are more likely to be found in companies where at least one of the owners is a woman.	+	Beltrán, 2019; Han et al., 2019.
H7	Women CEOs are more likely to be found in companies located in countries with higher gender equality.	+	Carrasco et al., 2015; Halliday et al., 2021.
H8	Women CEOs tend to be found more likely in companies located in more developed economies.	+	Adams & Ferreira, 2009; Amin & Islam, 2014; Elango, 2019.

Note: Sign refers to the sign of the associated coefficient of the independent variable which is expected to obtain through the analysis of the proposed model.
Source: own elaboration.

Methodology, sample, and variables

This study utilizes data from the World Bank Enterprise Surveys (WBES), which cover a broad range of factors, including firm-level characteristics and broader economic and socio-political conditions. The surveys are completed by senior managers and company owners using a common questionnaire and are conducted through a standardized methodology to ensure consistency and reliability. This methodology employs a stratified random sampling strategy based on firm size, business sector, and country, ensuring that the data is both representative and reliable. As a result, the WBES serves as a robust source for analyzing trends and patterns across various regions and sectors. The database has been extensively used in the literature to examine the performance of women CEOs or to assess the gender gap in entrepreneurship (Bertrand et al., 2022; Birhanu et al., 2022; Fang et al., 2020).

In this study, the initial sample included 154,682 observations from 2007 to 2023 (updated as of February 2023), encompassing a large number of companies across 142 countries. After data curation and removing missing entries, the final sample consists of 107,027 observations from 118 countries from Africa (AFR), Middle East and North Africa (MNA), Europe and Central Asia (ECA), East Asia and Pacific

(EAP), Latin America and Caribbean (LAC), and South Asia (SAR) (see Table 2).

Among the sample, only 14.4% of CEOs are women, indicating a notable gender imbalance in senior business management worldwide. The distribution of female CEOs is geographically uneven: the EAP region has the highest proportion (33.4%), while the MNA region has the lowest (under 5.2%). The Global Gender Gap Index (GGGI), as reported by the World Bank, shows that countries with higher gender parity tend to have more women in top executive positions, with a difference of approximately nine points compared to countries with lower GGGI scores. Additionally, companies in wealthier nations have approximately 8% more female CEOs. Women's representation in top management is also higher in the service (17.2%) than in the manufacturing sector (12.4%). Smaller companies have a higher proportion of women CEOs (15.1%) compared to larger firms (11.5%), though the difference is not substantial. In firms with at least one female owner, the proportion of female CEOs rises to nearly 37%, compared to just 5% in firms with male owners. The WBES data further reveals that female CEOs are generally less common in innovative companies, except for those involved in new product development (see Table 3).

Since the objective of this study is to assess the probability of having a female CEO, this variable is labeled as the dependent variable Y. It is binary: 1 if a company has a female CEO and 0 otherwise:

$$Y = \begin{cases} 1 \ \textit{if the CEO is female} \\ 0 \ \textit{otherwise} \end{cases}$$

Y is modeled as a function of a set of explanatory variables included in the vector X, which encompasses factors such as firm size, sector of operation, productivity, domestic and international sales, type of corporate innovation, and macroeconomic variables. The probabilistic model used to determine the likelihood of a female CEO is a logit model (Agresti, 2012; Dobson & Barnett, 2018) defined in Eq. (1):

$$\begin{aligned} logit[P(Y=1|X)] = {} & \alpha + \beta_1 RD\_Invest + \beta_2 New\_Product \\ & + \beta_3 New\_Product\_nm + \beta_4 Improved\_Process \\ & + \beta_5 Productivity + \beta_6 National\_Sales \\ & + \beta_7 Direct\_Exports + \beta_8 Size + \beta_9 Sector + \beta_{10} Owner \\ & + \beta_{11} GGGI + \beta_{12} GDP\_cap \end{aligned} \quad (1)$$

Where Y is the dependent variable, defined as above mentioned, and α is the constant term. The explanatory variables of the Eq. (1) are the following: *RD_Invest, New_Product, New_Product_nm*, and *Improved_Process*. As per Nguyen and Jaramillo (2014), they are related to innovation promoted by a company. In this study, they are codified as binary:

RD_Invest: 1 if the company invested in R&D, 0 otherwise.
New_Product: 1 if new/improved products/services were introduced, 0 otherwise.
New_Product_nm: 1 if new/improved products/services were introduced in a new market, 0 otherwise.
Improved_Process: 1 if new/improved business processes were introduced, 0 otherwise.

Additionally, the explanatory variables include *Productivity, National_Sales*, and *Direct_Exports*, detailed as follows:

Productivity: a quantitative variable measuring the productivity of the sampled companies as firm's global annual turnover to the total number of employees (Muhammad et al., 2022), using its logarithm for normalization (interpreted as elasticity).
National_Sales: percentage of company's domestic sales.
Direct_Exports: percentage of the company's exports (Audretsch et al., 2022).

In addition, several control variables are considered to reflect the

Table 2
Data distribution by country.

Country	N	Country	N	Country	N	Country	N
Albania	678	Egypt	6914	Liberia	150	Russia	4058
Argentina	1470	El Salvador	681	Lithuania	545	Rwanda	356
Armenia	668	Estonia	546	Luxembourg	153	Saudi Arabia	1385
Austria	571	Eswatini	117	Madagascar	317	Senegal	421
Azerbaijan	377	Ethiopia	1241	Malawi	317	Serbia	626
Bahamas	35	Finland	714	Malaysia	1986	Sierra Leone	152
Bangladesh	2315	France	1441	Mali	148	Slovak Republic	575
Barbados	66	Gambia	147	Malta	226	Slovenia	612
Belarus	827	Georgia	775	Mauritania	104	South Africa	1040
Belgium	564	Germany	1481	Mexico	1076	Spain	1026
Belize	72	Ghana	538	Moldova	621	Sri Lanka	534
Benin	140	Greece	583	Mongolia	678	Suriname	236
Bhutan	237	Guatemala	533	Montenegro	227	Sweden	1027
Bolivia	356	Guinea	70	Morocco	1235	Turkey	2344
Bosnia and Herzegovina	286	Honduras	361	Mozambique	592	Tajikistan	493
Bulgaria	923	Hungary	963	Myanmar	581	Tanzania	431
Burundi	151	India	18,083	Namibia	285	Thailand	810
Cóte d'Ivoire	266	Indonesia	1281	Nepal	464	Timor-Leste	329
Cambodia	306	Ireland	568	Netherlands	774	Trinidad and Tobago	115
Cameroon	330	Israel	431	Nicaragua	416	Tunisia	1068
Chad	145	Italy	695	Nigeria	1833	Uganda	457
Chile	695	Jamaica	101	North Macedonia	640	Ukraine	1839
Colombia	1591	Jordan	787	Pakistan	1807	Uruguay	519
Costa Rica	262	Kazakhstan	1546	Panama	62	Venezuela	61
Croatia	717	Kenya	1506	Paraguay	402	Vietnam	910
Cyprus	207	Kyrgyz Republic	522	Peru	1519	Yemen	253
Czech Republic	693	Lao PDR	655	Philippines	1034	Zambia	1151
Denmark	904	Latvia	546	Poland	1054	Zimbabwe	1141
Dominican Republic	370	Lebanon	958	Portugal	962		
Ecuador	459	Lesotho	133	Romania	1252	**Total**	**107,027**

Source: own elaboration.

Table 3
Descriptive statistics on Female CEO of the sample.

Female and male CEOs of the sample: number of firms (N) and % over total.			Distribution by **sector**, in number of firms (N) and in % over total.			
			Manufacturing		Services	
CEO, gender	**N**	**%**	**N**	**%**	**N**	**%**
Female	15,407	14.4	7719	12.4	7688	17.2
Male	91,620	85.6	54,489	87.6	37,131	82.8
Total	107,027	100	62,208	100	44,819	100
			χ-squared		475.97 ***	

Distribution by **region**, in number of firms (N) and in % over total of each region.

Regions	**AFR**		**EAP**		**ECA**		**LAC**		**MNA**		**SAR**	
CEO, gender	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Female	2244	16.4	2865	33.4	6285	17.2	1679	14.7	689	5.2	1645	7.0
Male	11,435	83.6	5705	66.6	30,338	82.8	9779	85.3	12,568	94.8	21,795	93.0
Total	13,679	100.0	8570	100.0	36,623	100.0	11,458	100.0	13,257	100.0	23,440	100.0
χ-squared		4738 ***										

Note: AFR – Africa; EAP – Eastern Asia and Pacific; ECA - Europe and Central Asia; LAC – Latin America and Caribbean; MNA – Middle East and North Africa; SAR - South Asia.

Distribution by **gender ownership**, in number of firms (N) and in % over total.					Distribution by **firm size**, in number of firms (N) and in % over total.			
	Woman-owned		Male-owned		SME (≤100 employees)		Large (>100 employees)	
CEO, gender	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Female	11,578	36.9	3829	5.1	13,130	15.1	2277	11.5
Male	19,840	63.1	71,780	94.9	74,039	84.9	17,581	88.5
Total	31,418	100	75,609	100	87,169	100	19,858	100
χ-squared		18,199 ***			χ-squared	169.74 ***		

Distribution by **new product development (NP)**, in number of firms (N) and in % over total.					Distribution by **new product for new markets (NP_NM)**, in number of firms (N) and in % over total			
	NP (Yes)		NP (No)		NP_NM (Yes)		NP_NM (No)	
CEO, gender	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Female	5201	15.0	10,206	14.1	3524	15.3	11,883	14.2
Male	29,535	85.0	62,085	85.9	19,584	84.7	72,036	85.8
Total	34,736	100	72,291	100	23,108	100	83,919	100
χ-squared		13.92 ***			χ-squared	17.47 ***		

Distribution by **R&D investment**, in number of firms (N) and in % over total.					Distribution by **improved processes development**, in number of firms (N) and in % over total.			
	R&D investment (Yes)		R&D investment (No)		Improved process (Yes)		Improved process (No)	
CEO, gender	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Female	2532	13.5	12,875	14.6	4434	14.0	10,973	14.6
Male	16,244	86.5	75,376	85.4	27,193	86.0	64,427	85.4
Total	18,776	100	88,251	100	31,627	100	75,400	100
χ-squared	15.31 ***				χ-squared	5.14 **		

Distribution by **gender equality index**, in number of firms (N) and in % over total.					Distribution by **GDP**, in number of firms (N) and in % over total.			
	High GGGI (over μ)		Low GGGI (below μ)		High GDP (over μ)		Low GDP (below μ)	
CEO, gender	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Female	10,312	18.8	5095	9.8	9642	17.7	5765	11.0
Male	44,544	81.2	47,076	90.2	44,801	82.3	46,819	89.0
Total	54,856	100	52,171	100	54,443	100	52,584	100
χ-squared	1770.3 ***				χ-squared	988.06 ***		

Source: own elaboration.

firm-, micro- and macro-level context. Firm- and micro-level variables include *Size, Sector*, and *Owner*. *Size* measures firm size as the number of employees. *Sector*, a dichotomous variable, indicates the belonging of the sampled companies to the manufacturing or service industries. *Owner* is dichotomous, indicating the presence of a female owner as 1 and 0 otherwise. Macro variables include *GGGI* and *GDP_cap*:

GGGI: Global Gender Index Gap, published by the World Economic Forum (WEF), indicating gender equality on a scale from 0 (minor gender equality) to 1 (greater gender equality), assessing economic participation, education, health, and politics (Bertrand et al., 2022).
GDP_cap: the economic level of a country, measured in GDP per capita (USD), widely used in other studies, like Minniti (2010).

The variables *GGGI* and *GDP_cap* undergo a logarithmic transformation to enhance their interpretability.

Table 4 shows the descriptive statistics of the above-mentioned variables.

Finally, β_1 to β_{12} are the coefficients that relate the explanatory and control variables to the dependent variable *Y*. To underline the relationship between the regressors and the explanatory variable *Y*, the F statistic is shown for the independence test in which the null hypothesis is rejected in all cases presented, as shown in Table 3.

In summary, the statistical model outlined in Eq. (1) aims to capture the impact of various factors on the likelihood of a CEO being a woman. Given the significant variation in female representation in business leadership across regions, the authors have clustered standard errors by

Table 4
Descriptive statistics of the variables.

Variables	Mean	Std. Deviation	Median	IQR
Productivity	4.42	0.82	4.41	0.98
National_Sales	87.89	26.89	100.00	2.00
Direct_Exports	8.76	23.09	-	-
Size	93.10	433.06	21.00	59.00
GGGI (log)	-0.39	0.08	-0.38	0.11
GDP_cap (log)	3.70	0.52	3.59	0.50

Note: The median and IQR of Direct_Exports are 0 since the majority of the analysed companies indicate no export activity (which takes the value of "0″ in the estimation model). The dependent variable *Y* and the independent variables *RD_Invest, New_Product, New_Product_nm, Improved_Process, Sector* and *Owner* are binary, as explained in the section 3 (Methodology, Sample, and Variables) of the manuscript.
Source: own elaboration.

country and year to account for regional differences and address observational dependency (Galbraith et al., 2010; Zeileis et al., 2020). Clustering the residuals by country and year in a logit model is advantageous, as it enhances the precision of the standard errors, accounts for unobserved heterogeneity, adjusts for temporal and spatial dependencies, and ensures valid inferences. This approach results in a more robust and reliable model. Considering the potential relationships among variables, the Variance Inflation Factor (VIF) is used as a key measure to assess the severity of multicollinearity in logistic regression analysis, helping avoid bias in coefficient estimation (Midi et al., 2010). In this study, the VIF values for the included variables suggest low multicollinearity, which is not of concern. Additionally, to validate and check the robustness of the estimations, the following tests are incorporated: (i) the goodness of fit of the model using pseudo R^2, where values from 0.2 to 0.4 indicate a good fit, and values above 0.4 indicate an excellent fit (McFadden, 1974); the Cox and Snell pseudo R^2, based on the proportional reduction in the likelihood function, where a value between 0.1 and 0.3 is considered acceptable; and the Nagelkerke pseudo R^2 (Nagelkerke, 1991), a standardization of the Cox and Snell statistic, with values between 0.2 and 0.4 indicating a good fit; (ii) the significance of the coefficients (Wald test); and (iii) the predictive, stability and discriminative capacity of the model assessed through cross-validation and the area under the curve (AUC) in the context of the ROC curve. The values of all these indicators are presented in Section 4. Findings, in the corresponding tables. The Receiver Operating Characteristic curve and its associated metric, the area under the curve (AUC-ROC) provide a comprehensive assessment of the model's discriminative ability, independent of the selected classification threshold. Generally, values above 0.7 are considered acceptable, while those above 0.8 are considered good (Hosmer & Lemeshow, 2000). Additionally, to assess the model's performance, cross-validation is employed to ensure the model's stability and generalizability, mitigating overfitting issues (James et al., 2013), with 70% of the data used for training and the remaining 30% for testing. Finally, visual tools, such as effect plots, were generated to help interpret the results by illustrating how the predicted probability of the dependent variable changes with the independent variables.

The model estimations were carried out using version 4.4.1. of the free software R.

Findings

General model

The general model (a) uses the full sample and assesses the probability of having a female CEO within a company based on short-term economic business performance indicators, such as productivity, domestic sales, and international activity through exports, and also innovation metrics which include R&D investment, development of new products for commercialization on existing and new markets and adoption of improved processes (see Table 5).

According to the results, among the firm's innovation metrics, the variables New_product and Improved_process are significant, both with negative coefficients. This suggests that, in women-led enterprises, there is generally limited innovation in new product development and process improvements. These findings support hypothesis H1d but not H1b, as our results point in the opposite direction. Furthermore, there is insufficient evidence to support hypotheses H1a and H1c, as the variables RD_Invest and New_product_NM are not significant.

Regarding the firm's economic performance indicators, Productivity is significant with a negative associated coefficient. This indicates that lower productivity is associated with a higher likelihood of having a woman as the CEO. This finding supports hypothesis H2. However, hypotheses H3a and H3b are not supported, as the variables National_Sales and Direct_Export are not significant. Among the firm-level control variables, Sector and Owner are both significant and positive. This suggests that female CEOs are more likely to be found in service industries and in companies with at least one female owner. These results support hypotheses H5 and H6.

Of the country-level control variables, GGGI is significant and positive, indicating a greater likelihood of finding female CEOs in countries with narrower gender gaps. This finding supports hypothesis H7. On the other hand, the variables Size and GDP_cap are not significant, meaning there is insufficient evidence to support hypotheses H4 and H8. The pseudo R^2 values are relatively high, indicating a good model fit. The Wald test is significant, suggesting that the independent variables, taken together, explain the model well. The AUC and cross-validated accuracy scores also demonstrate excellent model performance, with 0.80 and 0.86, respectively.

To better illustrate the effect of the significant variables on the dependent variable of female CEO in this general model, Fig. 1 is provided.

Additional models

In addition to the general model, further estimations are provided, classifying the sample based on factors such as gender ownership, firm size, sector, gender equality index, and the economic development of the country.

Model (b), with results shown in Table 5, evaluates the likelihood of having a female CEO based on the gender of the firm's owner. Model (b1) includes the results of the sampled companies with at least one female owner ("Female Owner"), while model (b2) includes the results of the rest of the sampled companies ("Male Owner").

According to the results of model (b1), RD_Invest, New_product, and Improved_process are significant, all with negative coefficients. Productivity is also significant and negative, while National_Sales is significant and positive. Size is significant and negative, and Sector is significant and positive. Thus, in woman-owned, SME-sized companies from the service sector, with low innovation through R&D projects, minimal new product development, limited process improvements, low productivity, but higher domestic market sales, there is a greater likelihood of finding a female CEO. These results align with those from the general model (a) and support hypotheses H1a, H1d, H2, H3a, H4, H5, and H6. As in model (a), the results fail to support hypothesis H1b. The pseudo R^2 values are relatively low in this model, which can be explained by the fact that the sample contains a small proportion of women-owned companies (below 30%), with one-third of these having female CEOs. Despite this, the other model fit indicators suggest a good overall fit.

Model (b2) presents different results: RD_Invest is significant, but with a positive sign, which contradicts hypothesis H1a. Unlike model (b1), in male-owned firms, higher investment in R&D is associated with an increased likelihood of having a female CEO. New_product_mn is significant and positive, whereas in previous models, this variable was

Table 5
Estimations results: (a) General model and (b) Model with classification Female *vs.* Non-female owner.

	(a) General model			(b1) Female Owner			(b2) Male Owner		
	estimate	z value		estimate	z value		estimate	z value	
RD_Invest	-0.1234	(-0.9711)		-0.3213	(-3.4043)	***	0.3482	(2.6714)	***
New_product	-0.2099	(-2.5223)	**	-0.2580	(-2.9769)	***	-0.1105	(-0.7042)	
New_product_nm	0.0905	(1.5327)		0.0720	(1.1738)		0.1384	(2.5323)	***
Improved process	-0.1809	(-3.4475)	***	-0.2117	(-3.6967)	***	-0.0965	(-0.7949)	
Productivity	-0.2706	(-3.3542)	***	-0.4005	(-3.6601)	***	-0.0385	(-0.4190)	
National_Sales	0.0013	(1.0905)		0.0043	(3.7884)	***	-0.0051	(-2.3166)	**
Direct_Exports	0.0012	(1.6271)		0.0011	(0.9566)		0.0008	(0.6513)	
Size	-0.0001	(-1.3248)		-0.0005	(-2.2663)	**	0.0001	(0.9440)	
Sector	0.3280	(4.9141)	***	0.2376	(3.7233)	***	0.5061	(6.9542)	***
Owner	24.1024	(20.2702)	***	No			No		
GGGI	28.8461	(2.9594)	***	1.7356	(1.3461)		4.4979	(3.3699)	***
GDP_cap	-0.1261	(-0.7781)		0.0453	(0.3008)		-0.4716	(-2.3904)	**
Intercept	-0.3375	(-0.4246)		1.4763	(1.8475)	*	0.8565	(0.6886)	
Clustered errors	Country and year			Country and year			Country and year		
Pseudo R^2 McFadden		0.21			0.04			0.03	
Cox-Snell		0.16			0.05			0.01	
Nagelkerke		0.28			0.07			0.03	
Wald Test (F-stat)		1220.6	***		136.77	***		74.585	***
AUC		0.80			0.65			0.63	
Cross-validated accuracy		0.86			0.65			0.95	

Note: for each variable its coefficient and Z-value is shown in brackets; *** means a significance level of 1 %, ** means a significance level of 5 %, * means a significance level of 10 %.
Source: own elaboration.

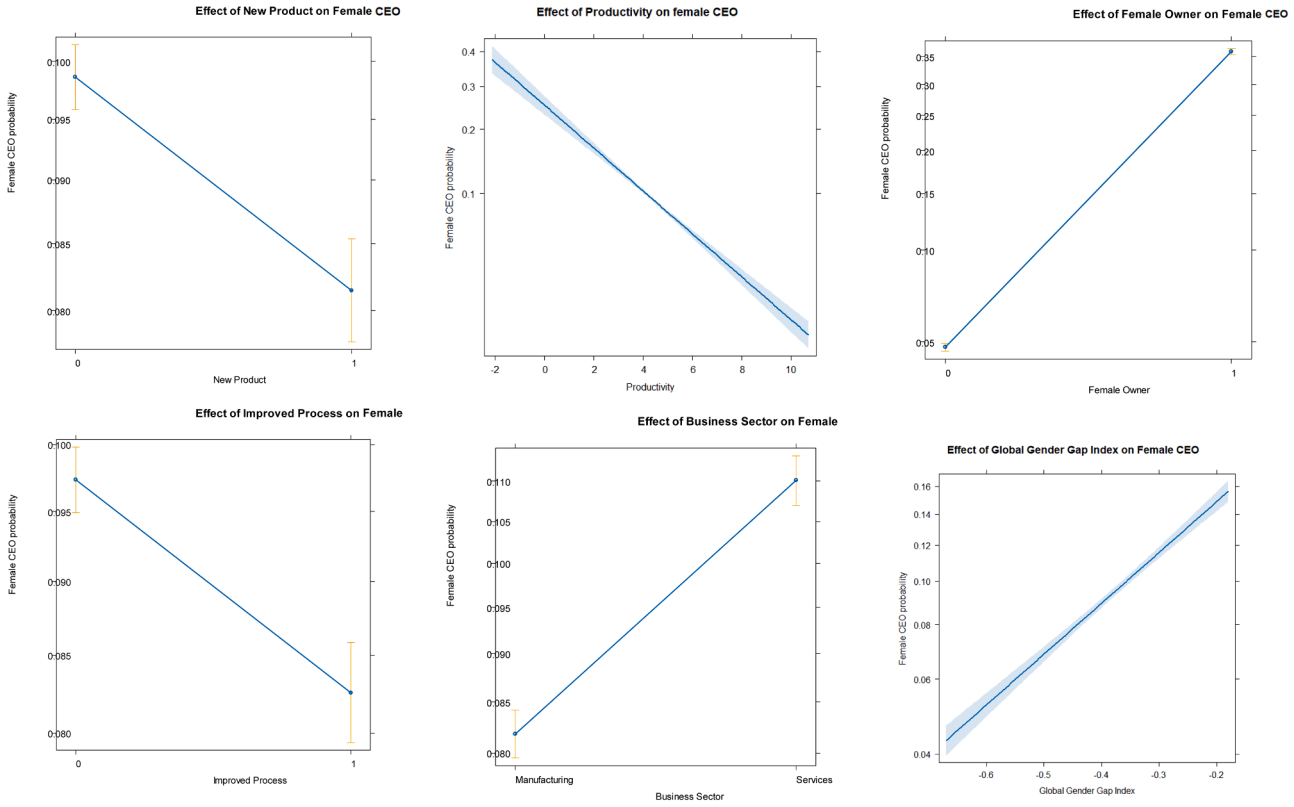

Fig. 1. Effect Plots of significant variables of the estimation of general model (a).

positive but not significant. Thus, in male-owned firms that focus on innovation through the development and commercialization of new products in new markets, the likelihood of having a female CEO is higher. This finding supports hypothesis H1c. The variable National_Sales is significant but, unlike in model (b1), the sign is negative, which contradicts hypothesis H3a. This indicates that, in male-owned companies, the likelihood of a female CEO increases when sales in the domestic market are low. Similar to models (a) and (b1), Sector is significant and positive, suggesting that female CEOs are more likely in male-owned companies in the service industry. This result supports hypothesis H5. GGGI is significant and positive, which supports hypothesis H7. Finally, GDP_cap is significant and negative, which does not support hypothesis H8. Therefore, companies located in countries with lower economic development and a smaller gender inequality gap are more likely to have female CEOs. Model (b2) demonstrates a good fit, despite low pseudo R^2, likely due to the small proportion (3.6%) of male-

owned firms with female CEOs. Notably, the cross-validation accuracy score is an excellent 94%, indicating strong model performance.

Model (c) two estimations: model (c1) analyzes the likelihood of having a female CEO in small and medium-sized enterprises (SMEs) with ≤100 employees, while model (c2) looks at large enterprises with >100 employees. The results are shown in Table 6.

Model (c1) reveals that, as in previous models, New_product and Improved_process are significant and negative, while New_product_nm is significant and positive. Productivity is significant and negative, while National_Sales, as in model (b1), is significant and positive. Size is significant and negative, as in model (b1). The variables Sector, Owner, and GGGI are significant and positive, consistent with earlier results. Therefore, female CEOs are more likely to be found in smaller companies with low productivity, less focus on innovation through new products and process improvements, but a stronger emphasis on domestic sales and innovation through new product development in new markets. These companies are typically in the service industry, owned or co-owned by women, and located in more gender-equal environments. These findings support hypotheses H1c, H1d, H2, H3a, H4, H5, H6, and H7. However, hypothesis H1b is not supported, as the associated coefficient for New_product is negative, contrary to expectations. The pseudo R^2 and other model fit tests indicate a good to excellent model fit.

Model (c2) reveals only two significant variables: National_Sales and Owner. National_Sales, contrary to the results of model (b1), has a negative sign, while Owner remains positive, as in all previous models. Thus, in large companies, the likelihood of having a female CEO is higher when the company is less focused on domestic sales and when there is at least one female shareholder. These findings support hypothesis H6. The model exhibits a good fit, as indicated by pseudo R^2 and the other tests.

Model (d) presents results based on the classification of firms by industry: manufacturing (model d1) and service (model d2). The details are shown in Table 6 previously mentioned.

Model (d1) identifies four significant variables affecting the likelihood of a female CEO: Improved_process and Productivity (both negative), and Owner and GGGI (both positive). These findings support hypotheses H1d, H2, H6, and H7. Model (d2) includes the same significant variables with the same signs as in model (d1), but also shows that New_product is significant and negative, New_product_nm is significant and positive, and GDP_cap is significant and negative. These results support hypotheses H1c, H1d, H2, H6, and H7. Hypotheses H1b and H8 are not supported, as the results point in the opposite direction. Both models (d1) and (d2) demonstrate excellent model fit.

In summary, for firms in both sectors, the probability of having a female CEO increases when firms have lower productivity and are less focused on innovation through process improvement. The probability also increases when there is a female shareholder and when the firm is located in a country with a smaller gender gap. However, in service sector industries, additional factors must be considered. Women are more likely to lead firms that prioritize investment in developing new products for new markets rather than focusing solely on new product development. This trend appears to be more pronounced in countries with less advanced economic development, as also seen in model (b2).

Model (e) includes two estimations: model (e1) for firms in countries with lower gender equality indices (below the sample mean) and model (e2) for firms in countries with higher gender equality indices (above or equal to the sample mean). The results are shown in Table 7.

In model (e1), Sector, Owner and GGGI are significant and positive. Therefore, the probability of having a female CEO increases in female-owned firms and in those belonging to the service sector and located in countries, which tend towards higher gender equality within the low-indexed subsample. These findings support hypotheses H5, H6, and H7. In model (e2) a greater number of variables are significant: RD_Invest, New_product, Improved_process, Productivity, and Size (all negative); National_Sales, Sector, and Owner (all positive). Therefore, in countries with increased gender equality, a wider range of factors influences the likelihood of having a female CEO. This probability is higher in female-owned SMEs in the service industry, located in more gender-equal countries, with lower support for innovation through R&D, new product development, and process improvement, as well as low productivity, but with increased domestic sales. These findings support hypotheses H1a, H1c, H2, H3a, H4, H5, and H6. However, hypothesis H1b is not supported, as the sign is negative, contrary to expectations. Both estimations show good to excellent model fit, with high cross-validation accuracy score (0.82–0.90).

Finally, model (f) presents estimations based on classification by GDP per capita: model (f1) with low GDP per capita (below the sample mean) and model (f2) with high GDP per capita (above or equal to the sample mean). The results are included in Table 7 above mentioned.

Table 6
Estimations results: (c) SMEs *vs.* Large Firms and (d) Manufacture *vs.* Service firms.

	(c1) SMEs			(c2) Large firms				(d1) Manufacture firms			(d2) Service firms		
	estimate	z value		estimate	z value			estimate	z value		estimate	z value	
RD_Invest	-0.1206	(-1.1067)		0.0484	(0.2791)		RD_Invest	-0.1549	(-1.1216)		-0.0666	(-0.5123)	
New_product	-0.2209	(-2.6648)	***	-0.1730	(-1.1948)		New_product	-0.1205	(-1.2919)		-0.3225	(-3.0421)	***
New_product_nm	0.1151	(1.8716)	*	0.0420	(0.4595)		New_product_nm	0.0383	(0.4508)		0.1595	(2.3510)	**
Improved process	-0.1833	(-3.4543)	***	-0.0115	(-0.1177)		Improved process	-0.1857	(-2.8943)	***	-0.1561	(-2.6228)	***
Productivity	-0.2781	(-3.5390)	***	-0.1317	(-1.0838)		Productivity	-0.3309	(-3.9229)	***	-0.2115	(-2.4324)	**
National_Sales	0.0020	(1.8919)	*	-0.0040	(-2.2132)	**	National_Sales	0.0005	(0.4101)		0.0032	(1.5755)	
Direct_Exports	0.0017	(1.6409)		0.0002	(0.1246)		Direct_Exports	0.0006	(0.6171)		0.0023	(1.3898)	
Size	-0.0066	(-4.0032)	***	-0.0000	(-0.5323)		Size	-0.0000	(-0.6701)		-0.0007	(-1.6265)	
Sector (Services)	0.3050	(5.0993)	***	0.2154	(1.0455)		Sector (Services)	No			No		
Owner (Female)	2.6029	(18.9161)	***	1.5464	(9.3991)	***	Owner (Female)	2.4525	(24.0136)	***	2.3662	(15.9000)	***
GGGI	3.3304	(3.6332)	***	0.3024	(0.1885)		GGGI	2.2851	(2.2054)	**	3.5021	(3.5620)	***
GDP_cap	-0.1419	(-0.9019)		-0.1751	(-0.6228)		GDP_cap	-0.0076	(-0.0423)		-0.2514	(-1.5856)	*
Intercept	0.0872	(0.1150)		-1.0821	(-0.9436)		Intercept	-0.7771	(-0.9621)		0.2984	(0.3869)	
Clustered errors	Country and year			Country and year			Clustered errors	Country and year			Country and year		
Pseudo R^2	McFadden	0.24			0.10		Pseudo R^2	McFadden	0.20			0.20	
	Cox-Snell	0.18			0.03			Cox-Snell	0.14			0.17	
	Nagelkerke	0.32			0.12			Nagelkerke	0.27			0.28	
Wald Test (F-stat)		1127.20	***		95.58	***	Wald Test (F-stat)		693.33	***		617.62	***
AUC		0.82			0.71		AUC		0.80			0.80	
Cross-validated accuracy		0.86			0.89		Cross-validated accuracy		0.88			0.83	

Note: for each variable its coefficient and Z-value is shown in brackets; *** means a significance level of 1 %, ** means a significance level of 5 %, * means a significance level of 10 %.
Source: own elaboration.

Table 7
Estimations results: (e) Low GGGI *vs.* High GGGI and (f) Low GDP/capita *vs.* High GDP/capita.

	(e1) GGGI < μ			(e2) GGGI ≥ μ				(f1) GDP/capita < μ			(f2) GDP/capita ≥ μ		
	estimate	z value		estimate	z value			estimate	z value		estimate	z value	
RD_Invest	0.1622	(0.9946)		-0.2726	(-2.9341)	***	RD_Invest	0.1256	(0.6952)		-0.2796	(-3.0362)	***
New_product	-0.1136	(-1.0611)		-0.2431	(-2.4854)	**	New_product	-0.0405	(-0.6487)		-0.2955	(-2.4455)	***
New_product_nm	0.1461	(1.2401)		0.0619	(1.2636)		New_product_nm	0.1760	(1.9131)	*	0.0263	(0.4296)	
Improved process	-0.0719	(-0.4233)		-0.2417	(-4.4184)	***	Improved process	-0.1827	(-2.1025)	**	-0.1636	(-1.8046)	*
Productivity	-0.0916	(-1.4570)		-0.3519	(-3.7247)	***	Productivity	-0.1475	(-2.4041)	**	-0.3815	(-2.9689)	***
National_Sales	-0.0014	(-0.6321)		0.0029	(1.9254)	**	National_Sales	0.0004	(0.2780)		0.0008	(0.6708)	
Direct_Exports	0.0023	(1.3541)		0.0014	(1.0379)		Direct_Exports	0.0022	(1.3681)		0.0007	(0.5611)	
Size	0.0005	(0.5909)		-0.0003	(-1.9772)	**	Size	-0.0000	(-0.5025)		-0.0003	(-1.5071)	
Sector (Services)	0.4406	(7.7092)	***	0.2657	(4.1669)	***	Sector (Services)	0.4494	(7.2131)	***	0.2709	(3.3992)	***
Owner (Female)	2.2673	(30.6422)	***	2.4212	(12.2442)	***	Owner (Female)	2.3286	(24.3784)	***	2.4087	(13.3845)	***
GGGI	8.5351	(3.9536)	***	-1.0238	(-0.5924)		GGGI	2.6115	(2.7965)	***	4.3937	(2.6498)	***
GDP_cap	-0.0205	(-0.0679)		-0.0213	(-0.0112)		GDP_cap	-0.0349	(-0.1068)		-0.9018	(-2.4362)	***
Intercept	0.9865	(0.7775)		-1.7264	(-1.7653)	*	Intercept	-1.4657	(-1.1112)		4.1279	(2.4379)	**
Clustered errors	Country and year			Country and year			Clustered errors	Country and year			Country and year		
Pseudo R^2	McFadden	0.20			0.20		Pseudo R^2	McFadden	0.20			0.22	
	Cox-Snell	0.12			0.18			Cox-Snell	0.13			0.18	
	Nagelkerke	0.25			0.29			Nagelkerke	0.25			0.30	
Wald Test (F-stat)		485.61	***		678.59	***	Wald Test (F-stat)		526.89	***		677.12	***
AUC		0.81			0.80		AUC		0.80			0.81	
Cross-validated accuracy		0.90			0.82		Cross-validated accuracy		0.89			0.84	

Note: for each variable its coefficient and Z-value is shown in brackets; *** means a significance level of 1 %, ** means a significance level of 5 %, * means a significance level of 10 %.
Source: own elaboration.

In model (f1), as in previous estimations, New_product_nm is significant and positive, while Improved_process is significant and negative. Productivity is significant and negative. Sector, Owner, and GGGI are significant and positive. Thus, the likelihood of having a female CEO is higher in firms from the service sector, owned by women, and located in countries with a lower gender gap and less advanced economic development. However, innovation through process improvement and productivity negatively affects the likelihood of having a female CEO, except when a company focuses on developing new products for new markets. These findings support hypotheses H1c, H1d, H2, H5, H6, and H7.

Model (f2) shows similar results to model (f1), with some additions. The variables RD_Invest, New_product, Improved_process, and Productivity are significant, all with a negative sign. Sector, Owner, and GGGI are significant and positive, while GDP_cap is significant and negative. These findings suggest that in less advanced economies, service sector firms, with a female owner or co-owner and located in countries with a lower gender gap, have a higher probability of being led by a female CEO. Similar to other models (a, b1, d2, or e2), innovation strategies through R&D, new product development, and process improvements, as well as productivity, are negatively related to the probability of having a female CEO. Both models (f1) and (f2) show excellent model fit, with high cross-validation accuracy scores (0.84–0.89).

Table 8 summarizes the evidence supporting the hypotheses proposed in this study.

Discussion

Innovation, together with entrepreneurship, is related to the likelihood of having a woman as CEO. However, it is important to differentiate among types of innovation and to consider other factors such as business performance, firm characteristics, and the socio-economic environment. All of these factors collectively contribute to the specific context in which it is easier or harder to find a female CEO.

As indicated in the findings presented in Section 4, lower R&D investments and weaker support for new products generally increase the likelihood of women entering CEO positions. This suggests that women may be more risk-averse, as discussed in the literature (Albanesi et al., 2015; Faccio et al., 2016). If women generally avoid CEO roles in highly innovative environments, even when offered incentives related to the position, it seems that female business leaders are more cautious about risky decisions. This finding aligns with insights from agency and behavioral agency theories (Baixauli-Soler et al., 2015). However, based on the analysis presented in this study, it seems possible that innovative companies themselves may reject female CEOs, primarily due to weak social perceptions about women's suitability to tackle innovative and transformative challenges, as highlighted by Kumar (2013). Stereotypes and prejudices regarding women's risk-taking, technological capabilities, or work-family balance remain common across different regions and sectors. Consequently, female top managers are often not taken seriously and are not given the same opportunities as their male counterparts (De Mascia, 2015).

Similarly, innovation through product design or improvement is often seen as the type of innovation most closely related to the presence of female leadership, as reflected in the literature (Do et al., 2023; Na & Shin, 2019). In this study, as noted in Section 4, product innovation, especially in female-owned and SME-sized firms, tends to decrease the likelihood of a female CEO. Similar results were found in companies from the service sector located in countries with higher gender equality and more advanced economies. This counterintuitive result may be driven by several underlying factors. First, product innovation, a core competitive strategy for many industries, often requires substantial risk-taking, long-term investments, and strong networks –fields traditionally dominated by men, such as technology and manufacturing. Thus, the higher risk aversion among women is a pertinent explanation, as is the case with R&D investment. Second, firms that prioritize product innovation may prefer leadership profiles with extensive technical or engineering backgrounds –areas where female representation is still low. As a result, the pool of candidates for CEO positions in such companies may be biased toward men, further reinforcing gender disparities in top management. Moreover, product innovation, as part of high innovation, is frequently associated with aggressive growth strategies (Dobni, 2010), which are less common in female-owned and small firms (Mitchelmore & Rowley, 2013).

Surprisingly, higher R&D investments correlate with female CEOs only in male-owned firms. One possible explanation may be because women CEOs adopt different behaviors, possibly to outperform their male partners, by choosing riskier strategies, as suggested by Prabowo and Setiawan (2021). Increased innovation, not only through R&D investment but also through product development for new markets,

Table 8
Summary of the evidences which support the proposed hypotheses.

	Hypotheses	Proposed sign*	Obtained sign	Supported / Not supported
H1a	Companies that invest in R&D activities are less likely to have female CEOs.	-	-/+	Partially supported. The positive sign is obtained for male-owned companies.
H1b	Companies that are leading in product innovation are more likely to have female CEOs.	+	-	Not supported: the findings suggest the opposite.
H1c	Companies that develop new products for new markets are more likely to have female CEOs.	+	+	Supported.
H1d	Companies that promote process innovation are less likely to have female CEOs.	-	-	Supported.
H2	Women CEOs are less likely found in companies with high productivity.	-	-	Supported.
H3a	Women CEOs are more likely to lead companies that focus on national sales.	+	+/-	Partially supported. The negative sign is obtained for large and male-owned companies.
H3b	Women CEOs are less likely to lead export-oriented companies.	-		Not supported: the variable is non significate in all models.
H4	There is a lower probability of encountering women CEOs in large companies.	-	-	Supported.
H5	Women CEOs are more likely to be found in service sector companies.	+	+	Supported.
H6	Women CEOs are more likely to be found in companies where at least one of the owners is a woman.	+	+	Supported.
H7	Women CEOs are more likely to be found in companies located in countries with higher gender equality.	+	+	Supported.
H8	Women CEOs tend to be found more likely in companies located in more developed economies.	+	-	Not supported: the findings suggest the opposite.

Note: Sign refers to the sign of the associated coefficient of the independent variable which is expected to obtain through the analysis of the proposed model.
Source: own elaboration.

appears to attract women CEOs in SME-type firms and those in the service sector, particularly in weaker economies. This fits with the fact that women managers are more commonly found in these companies and sectors, as noted by various authors (Elango, 2019; Fang et al., 2022; Hurt et al., 2020; Kubo & Nguyen, 2021) and reports (Deloitte, 2024; EIGE, 2024). In such firms, faced with growth challenges and lower economic development, innovation is pursued with the higher risks involved, demonstrating strong confidence in assigning female leaders to steer the business. A similar suggestion was made by Owalla et al. (2021), who studied SME-sized firms in advanced economies like the UK. This represents a clear entrepreneurial context, aligned with sustainable innovation, aimed at transforming products and markets and identifying new business opportunities (Larson, 2000). Furthermore, this trend is positively influenced by female top managers, as emphasized in the academic literature (Criado-Gomis et al., 2020; Lyngsie & Foss, 2017).

Regarding sales strategy, the research does not find internationalization through exports to be a critical factor in the likelihood of having a female CEO. Female shareholders, SMEs, and companies in countries with low gender gaps tend to focus more on domestic sales, which appears to be more favorable for female leadership. A similar idea is suggested by other authors, such as Lukason and Vissak (2020) or Bouazza et al. (2023). Additionally, lower productivity is closely linked to the presence of female CEOs, echoing some studies (Allison et al., 2023; Islam et al., 2020) while contradicting others (Hoobler et al., 2018). In large firms, female ownership (which favors female CEO presence) and a domestic sales strategy (which disfavors it) are key factors, contradicting findings by Bruckmüller et al. (2014) and Hurley and Choudhary (2016). In SMEs, various factors influence the likelihood of a female CEO, as described in Section 4. The prevalence of women CEOs in SMEs suggests that both internal and external factors in this context increase or decrease the probability of a female CEO. In contrast, as noted in recent reports, the proportion of female CEOs in large companies globally is still minimal. This suggests that this environment is more globalized, where the gender of the CEO matters less, and all CEOs –male and female– are primarily focused on fulfilling the designed business strategy.

It is also relevant to note that the results of this study highlight the prominence of female CEOs in women-owned companies in the service sector, particularly in countries with higher gender equality. This combination signifies sustainability, aligns with the SDGs, and underscores the importance of joint efforts to increase women's presence in leadership roles. Furthermore, the findings support the literature indicating that female CEOs are more common in firms with at least one female founder (Han et al., 2019). This may be because women feel supported by female owners, who help consolidate managerial skills and provide mentorship (Beltran, 2019; Martínez-Zarzoso, 2023). This combination can lead to more sustainable entrepreneurship and intrapreneurship models, based on informed decision-making by women, often mistakenly interpreted as risk aversion. The role of technology in business can also create new opportunities for female entrepreneurs, and the growth of digital social media facilitates managing communication between work and family (Rajahonka & Villman, 2019). Countries with higher gender equality indices were the first to introduce gender quotas for senior positions, which has led to a new reality in both business (greater pressure for companies to comply with gender norms) and society (increased recognition of women's worth), as highlighted in the literature through the lens of institutional theory (Carrasco et al., 2015).

In some analyses, the economic development of a country emerges as a determinant of the likelihood of having a female CEO. Interestingly, the findings suggest that in male-owned firms, particularly those in the service sector and more advanced economies, a lower GDP per capita (indicating moderate economic development) is associated with a higher likelihood of having a female CEO. It is crucial to note that GDP per capita and the GGGI measure both the economic and social development of a country. Since one of the dimensions in the GGGI is economic development, it may absorb the positive effect of GDP per capita on women's participation in business leadership. The negative coefficient related to GDP per capita (GDP_cap) suggests it applies to countries with developed economies that are not considered top-tier. This idea is also supported by Elango (2019), who found in emerging economies that both gender equality policies and good economic development increase the likelihood of finding female CEOs in firms.

Conclusions

Women's participation in management positions in companies

remains a minority. Despite extensive research on women in senior management, most analyses focus on the influence of women's presence on firm performance and strategies. This study shifts the focus by exploring which firm characteristics, especially the type of innovation, along with other macro-level factors, increase the likelihood of having a female CEO. The aim is to identify which variables within a company and its environment favor the presence of female CEOs globally, emphasizing the role of innovation and female entrepreneurship.

The study uses a sample extracted from the World Bank Enterprise Survey (WBES), with 107,026 curated data from a large number of companies across 118 countries from six global regions, over the period from 2007 to 2023. Due to the nature of data, logistic regression with clustered standard errors by country and year was applied. Twelve ypotheses were proposed, examining the probability of having female CEOs based on corporate innovation strategy, productivity, markets, size, sector, and country socio-economic development. The analysis includes a general model and five additional models based on gender ownership (female *vs.* male-owned), size (SMEs *vs.* large), sector (manufacturing *vs.* service), global gender index (lower *vs.* higher GGGI), and economic development (lower *vs.* higher GDP per capita).

This empirical research supports most of the proposed hypotheses. The main findings suggest that women CEOs are more likely to lead companies that selectively innovate, especially those developing new products for new markets (in male-owned firms, SMEs, service industries, and less advanced economies) and occasionally investing in R&D (only in male-owned firms). In contrast, female CEOs are more common in companies that do not prioritize new product or process innovation and show lower R&D investments, especially in female-owned firms and those located in countries with greater gender equality and economic development. Evidence also reveals that female entrepreneurship strongly contributes to the presence of female CEOs. Thus, answering the main question of this paper, female entrepreneurship, coupled with the innovative character of the company, appears to be a crucial determinant for the greater inclusion of women as CEOs. However, it is necessary to distinguish among the different types of innovation to better understand these dynamics.

According to the additional analysis, the study also suggests that lower productivity is associated with the presence of a female CEO. High domestic sales increase the likelihood of a female CEO in female-owned firms, SMEs, and countries with a narrower gender gap, while low domestic sales do so in male-owned firms and large enterprises. Other crucial factors positively related to the presence of women CEOs include SME-sized companies, the service sector, and socio-economic contexts with smaller gender gaps. All estimations, on average, show good model fit.

From a managerial perspective, identifying the factors that increase the likelihood of having a female CEO provides valuable insights for both public administrations and private companies. Policymakers can use these insights to guide the design of more effective public policies that promote gender diversity in senior management, such as regulatory incentives, gender quotas, leadership development programs, and corporate governance reforms. For private companies, understanding these factors can help shape internal strategies to create more inclusive organizational cultures, implement fair hiring and promotion practices, and establish mentorship and sponsorship programs that support women's leadership pathways.

In line with the above, several practical implications arise. Increasing women's participation in business leadership is crucial for fostering innovation, improving decision-making, and driving sustainable economic growth. However, the inclusion of women in senior management varies significantly across countries due to differences in cultural norms, institutional frameworks, and labor market structures. This heterogeneity underscores the importance of context-specific strategies that align with the socio-economic and regulatory environment of each country. Therefore, continuous analysis is needed to identify the most effective tools and mechanisms for promoting the inclusion of women in executive roles and boardrooms. Future research and managerial efforts should focus on identifying best practices that have successfully reduced gender gaps in leadership, ensuring that firms and policymakers can implement evidence-based strategies to achieve greater gender equity in corporate governance.

The limitations of this study stem from the characteristics of the sample, which provides firm-level information without continuous economic and financial data, partially constraining the processing of data and the models used. While the study accounts for the macro socio-economic environment variable, such as the GGGI, which reflects gender equality in a country, it does not consider temporal changes in gender policies or economic contexts that might influence results over time. Therefore, future research should fill these gaps to enhance our understanding of gender dynamics in business, both from micro and macro perspectives.

Finally, while much of the literature examines how female leadership influences different types of innovation, this study takes a reverse approach by examining how innovation influences the presence of female CEOs. This shift in focus highlights the need for further research into whether structural or cultural biases in innovation-driven firms create barriers to female leadership and what measures could be taken to promote more inclusive executive pathways. Additionally, this study suggests several other avenues for future research. One area, particularly related to technological innovation, is exploring the relationship between digitalization and the gender gap, specifically, whether digitalization helps reduce the gap in companies. Another important avenue is to assess the impact of women's inclusion in technological and financial leadership roles, such as Chief Technology Officer (CTO) and Chief Financial Officer (CFO), on business performance. Given the current statistics on women's representation in these positions, future studies should move beyond the CEO role and focus on how female leadership in these critical areas influences innovation, strategic decision-making, and overall firm success.

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CRediT authorship contribution statement

Inna Alexeeva-Alexeev: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Conceptualization. **Pilar Guaita-Fernandez:** Writing – review & editing, Validation, Investigation, Formal analysis, Conceptualization. **Cristina Mazas-Perez-Oleaga:** Validation, Supervision, Software, Methodology, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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