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The Effect of Top Management Team Gender Diversity on Climate Change Management: An International Study

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Abstract: The aim of this research was to assess the effect of top management team gender diversity on firms' effective commitment to climate change management from two new perspectives: a more detailed analysis of gender diversity in corporate management and an international analysis of the phenomenon. Broadening climate change management assessment through selected CDP qualitative metrics for governance, risk management and strategy provides a more in-depth view of climate change managerial practices. Even though a growing body of academic literature highlights the potential positive impact of gender diversity, this empirical research based on a sample of 836 firms from 16 developed countries provides mainly inconclusive results. These results may be explained first by a still insufficient and below critical mass, percentage of women within top management teams; and second, by a selection bias, as only the best performers disclose their climate change management data. This also calls for companies to improve their gender diversity among the top management team, and for regulators to further extend compulsory climate change management reporting.

Keywords: carbon disclosure project; climate change management; corporate social responsibility; gender diversity; top management team

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1. Introduction

The recent Intergovernmental Panel on Climate Change (IPCC) report [1] illustrates that global warming may have catastrophic effects on the Earth, and consequently, human activities. Corporations, as the main economic actors, will be held accountable for the fight against global warming and should therefore consider any managerial practices and behaviours that could be helpful to reduce their carbon footprint. A growing body of academic literature is highlighting the potential positive impact of gender diversity, i.e., the composition of an organisation in terms of gender [2], on climate change management, even though the results are still ambiguous [3,4]. This positive potential impact of gender diversity is mainly based on the resource dependence theory, which argues that women have different human capital to men, and can thus bring diversity in top management team in terms of human capital, which improves decision making; moreover, psychological studies have shown that women have different traits and values than men [5]. This also leads to the assumption that women are more likely to support environmentally responsible practices than men are [3,6,7].

The aim of this study was to assess the effects of top management teams gender diversity on the firms' effective commitment to climate change management from two new perspectives: a more detailed analysis of gender diversity in corporate management, and an international analysis of the phenomena. To the best of our knowledge, most of the previous empirical literature has focused on board gender diversity (e.g., for the likelihood of voluntary carbon disclosure [3–5,8–15]) while very few studies address CEO sex and gender diversity among managerial staff. This research attempts to fill this gap by broadening the scope of gender diversity beyond the boards of directors: chief executive

officer (CEO) sex, chairman of the board (COB) gender, gender diversity of operational and non-operational managers. In addition, most previous empirical literature has only focused on one country, which weakens the generalisation of their results. This research based on a sample of 836 firms from 16 developed countries also addresses this issue.

This research also broadens the climate change management assessment provided by the carbon disclosure project (CDP) database. CDP score has been extensively used in the previous empirical literature as a proxy for carbon disclosure quality [9,16–18]. However, CDP qualitative metrics for climate change management regarding governance, risk management and strategy have also been added to provide a more in-depth vision of climate change managerial practices.

Multi-level modelling tests the hypothesis regarding the influence of top management team gender diversity on these different metrics representing climate change management, including CDP score. The sample description highlights the still very low gender diversity within the top management team, with the exception of board membership and the absence of differences between female and male leaderships in terms of climate change managerial practices. Consequently, the results of multi-level modelling are mostly inconclusive and do not show a significant impact of gender diversity, whatever the position in the top management team and the type of climate change management practices. However, some specific and interesting influences have been identified.

2. Literature Review

2.1. Gender Diversity

Gender diversity can be measured at different levels of organisation. The most obvious level is that of the employees [2], or the one of managers [19]. However, many previous papers that study the effects of gender diversity on organisational outcomes have focused on gender diversity within boards [4,20–22], whilst others have paid attention to gender diversity among CEOs [6,23]. The rationale behind this is that boards and CEOs can make a difference in organisational choices and strategies.

In particular, the presence of women on boards has given rise to an extensive body of literature, which can be due to the fact that some countries such as France adopted a coercive approach, requiring companies to increase the feminisation rate of board members, whereas others let companies freely appoint women or not on boards [9]. However, this literature yields contradictory results, for example, regarding the effect of the presence of women on boards on organisational performance [21,24]. This is mostly due to differences in the way gender diversity and organisational performance are measured. Notably, some authors argue that researchers should pay attention to the presence of women on board committees (and not only the overall representation of women on boards) [3]. Others show that there exists a "critical mass", or a threshold of women representation, below which the presence of women cannot have the same effects as a level above [5,9,25,26].

The literature that deals with the effect of gender diversity on organisational outcomes commonly uses the resource dependence theory, which argues that women have different human capital than that of men, and can thus bring diversity to board's human capital, which improves decision making; moreover, psychological studies have shown that women have different traits and values than men [5]. This so-called "female leadership" has given rise to numerous studies [27]. Notably, women are supposed to be more transformational and more participative leaders than men [9,27]. Previous research has also shown that female managers engage in more coaching behaviour than their male counterparts [28]. However, the eventual incongruence between expectations about women and expectations about leaders can have detrimental effects on women managers [29] and might prevent women from playing an important role in boards or in every leadership situation [27].

2.2. Gender Diversity and Green Management

Previous research about the relationship between gender diversity and climate change management has explored different dimensions and has brought ambiguous results [3,4].

Many studies are interested in the relationship between board gender diversity and carbon disclosure. In Canada, it has been shown that the presence of women on board committees increases the likelihood of voluntary climate change or carbon disclosure [3]. A similar result has been found in Australia [10–12], Canada [9], France [8], Spain [5] and the UK [14,15], no significant relationship in Turkey [13], and a contradictory result for Italy [4].

Another body of research is interested in the relationship between gender diversity and green innovation and climate change management [26]. He and Jiang [26] show that green innovation, assessed by green patents and environmental management certification, is related to female board representation in China. In the US, Nadeem et al. [30] found a positive and significant association between board gender diversity and environmental innovation, as measured by process and product innovation. In France, Galia et al. [31] noted a positive association between environmental innovation and board gender diversity on a sample of innovative firms. In Asia, Rehman et al. [32] observed that the adoption of an environmental management systems (EMS), as measured by firms' ISO14000 certification, is more likely in companies with higher board gender diversity, whereas there is no significant relationship between female CEO and EMS implementation. In the US, it has been shown that firms with three or more female directors on boards exhibit more environmental corporate social responsibility [33]. Atif et al., (2021) also documented a positive impact of gender board diversity on renewable energy consumption in the US but with the requirement of two or more women on the board and preferably independent (vs. executive).

Lastly, there is a stream of research on the relationship between board gender diversity and carbon emissions per se, with the ultimate goal of green management, environmental and carbon performances. In terms of carbon performance, Nuber and Velte [34] showed a positive relationship with board gender diversity in Europe with a critical mass of at least two women. In the UK, Haque [35] observed a positive association between gender diversity on corporate boards and carbon reduction initiatives but not with carbon emissions themselves. From a broader perspective of environmental performance, a consensus emerged on the positive impact of gender diversity on the boards of directors, regardless of the measure of this performance (multi-criteria measurements from databases such as Asset4, CSRHub, KLD, RKS or Sustainalytics): Elmagrhi et al. [36] in China, García Martín and Herrero [37] in Europe, Li et al. [38], Lu and Herremans [39] and Cordeiro et al. [40] in the US.

Other studies have dealt not only with board gender diversity but also the CEO's sex, and been interested in the different dimensions of green management. Notably, Glass et al. [6] recall that several liminal studies focused on CEOs, because they are responsible for the corporate strategy, including green strategy [41]. In their study, they pay interest to both board gender diversity and the female CEO, but most of the results are inconclusive [6]. Birindelli et al. [42] investigated the banking industry in the EMEA (Europe, Middle-East and Africa) and observe a non-linear relationship between women directors and the environmental performance of banks, and that female CEOs play a strategic role in shaping this relationship.

What these studies have in common is that they are mostly based on the assumption that women are more likely to support environmentally responsible practices than men [3,6,7]. This could be due to differences in socialisation: women are educated to be caring and concerned for others, which could lead women to be more concerned than men about environmental harm [6,14]. For example, a meta-analysis showed that women tend to have a moral orientation slightly more oriented toward care than men [43]. In addition, women are generally shown as more risk-adverse than men, which can make them more preoccupied by environmental risks [3,33]. All this could imply why, for example, among MBA Students, women are more likely to support environmental accountability requirements [44].

As noted earlier, previous research has focused on two main actors of governance: CEO and board. This leads to Hypotheses H1, H2 and H3, which are based on already mentioned previous studies which have shown a positive relationship between female representation and climate change management [9,36–40].

Hypothesis 1 (H1). *There is a positive relation between the fact that the CEO is a woman and climate change management.*

Hypothesis 2 (H2). *There is a positive relation between female representation on board and climate change management.*

Hypothesis 3 (H3). *There is a positive relation between having a chairwoman and climate change management.*

However, this research also assumes that managers can play a role in some aspects of climate change management although, to the best of our knowledge, very few studies have previously investigated this topic. In France, Burkhardt et al. [45] found that firms with more women in top management exhibit higher environmental performance and that women in top management are associated with indicators such as environmental product and process innovation, and commitment to resource reduction targets. In the US, Ciocirlan and Pettersson [46] showed that companies that employ more women tend to exhibit a greater concern for climate change. Hence, this allows us to formulate Hypothesis H4.

Hypothesis 4 (H4). *There is a positive relation between female representation among managers and climate change management.*

Previous research has already brought some interesting results in the debate about the effect of gender diversity on climate change management. However, to our knowledge, some areas remain unexplored. First, most previous research remains focused on one only country with some exceptions (Birindelli et al., 2019, EMEA; García Martín and Herrero, 2019 and Nuber and Velte, 2021, Europe; Rehman et al., 2020, Asia). This is a shame because both the presence of women on boards and the environmental strategy of firms are strongly dependant on national contexts, which would make the national results less generalisable to other countries. To fill this this gap, an international database and multi-level modelling are used to take account for the country effect. Second, most previous research has been based only on the presence of women on boards and does not take into account the gender diversity of operational and non-operational managers, or the CEO's and COB's sex. This database helps to bridge this gap too, because it contains information on gender diversity on the different company levels (operational managers, overall managers, board, COB, CEO).

3. Data and Methodology

3.1. Sample

To address the research questions dealing with the level of development of climate change management practices and the presence of women among boards and top management teams, both qualitative and quantitative information were needed. As integrated financial statements were not yet developed, it was necessary to use two specific and reliable databases to build a sample of 836 firms from 16 developed countries with up-to-date information.

For the information on climate change management practices, the data were from the Carbon Disclosure Project (or CDP) (Refer in 2 December 2021 to https://www.cdp.net/en for details). The CDP sends questionnaires to companies around the world to collect information on GHG emissions and related issues such as emission reduction activities and managerial efforts and derives a score from the responses, the so-called "CDP score". Regarding managerial efforts and incentives, different climate change management indicators are displayed from the CDP Climate Change 2020 database, the majority of which

are binary (no/yes) and indicate the impact of climate-related issues on firm's governance, risks appetite and strategic orientations.

To address the need in terms of gender information, additional data on companies were gathered using another and dedicated database named MERIT500. Powered by Pantelon, a Sweden company, MERIT500 (refer in 2 December 2021 to https://www.merit500.com for details) is a database that monitors, collects and updates board, management and executive management team information concerning the most important companies in different countries.

Information from the CDP database provided a preliminary sample of 1380 firms. After matching with gender data from the MERIT500 database, an original sample of 836 companies from 16 developed countries from western Europe, North America and Australia was obtained. Table 1 depicts the distribution of data by country and database as well as the EPI ranking for each country in 2020 and over the last decade. The Environmental Performance Index (Yale, 2018) (EPI is produced by the Yale Center for Environmental Law and Policy in collaboration with the World Economic Forum—details of which can be found in 2 December 2021 at: https://epi.envirocenter.yale.edu/) or EPI is a global metric for ranking countries on environmental issues. The EPI scorecard is based on 24 performance indicators across ten issue categories covering two policy objectives: environmental health (environmental health is measured across three categories with different weights: air quality (65%), water quality (30%) and heavy metals (5%) whereas ecosystem vitality count seven categories: biodiversity and habitat (25%), forest (10%), fisheries (10%), climate and energy (30%), air pollution (10%), water resources (10%) and agriculture (5%)) (40% of the score) and ecosystem vitality (60%). These metrics provide a gauge of how countries perform environmental policy goals at a world level but also regionally, which is highly relevant.

Table 1. Sample construction.

Countries	Number of Firms in Databases						EPI Rank 2020	EPI 10-Year Change
	CDP		MERIT500		Sample			
	N	%	N	%	N	%		
USA	480	23.2	629	29.0	267	31.9	24	+2.9
UK	201	9.7	328	15.1	123	14.7	4	+9.0
Canada	98	4.7	232	10.7	72	8.6	20	+3.7
France	95	4.6	120	8.0	52	6.2	5	+5.8
Germany	74	3.6	130	6.0	45	5.4	10	+1.2
Sweden	68	3.3	97	5.5	42	5.0	8	+5.3
Switzerland	51	2.5	112	5.2	37	4.4	3	+8.6
Australia	51	2.5	173	4.5	40	4.8	13	+5.5
Spain	48	2.3	61	2.9	30	3.6	14	+8.6
Italy	47	2.3	64	2.8	28	3.3	20	+1.1
Norway	42	2.0	37	2.5	25	3.0	9	+7.6
Finland	40	1.9	31	1.7	22	2.6	7	+6.0
Netherlands	31	1.5	54	1.7	16	1.9	11	+1.5
Denmark	24	1.2	37	1.7	16	1.9	1	+7.3
Belgium	18	0.9	36	1.4	10	1.2	15	+2.1
Austria	12	0.6	29	1.3	11	1.3	6	+5.4
Total	1380	100	2170	100	836	100	-	-

3.2. Variables

To measure how specific data relating to gender diversity at the board and management level affect the practices of climate change management, dependent variables were extracted from the 2020 CDP database and combined with independent variables related to gender diversity and control variables at the firm and country levels. As depicted in Table 2, variables are presented in detail thereafter.

Table 2. Definitions and sources of variables.

Green Management Variables	Definition	Source
CDP score	Score measuring firm's progress and incentive action on climate change, forests and water security (A/B/C/D)	CDP scores database 2020
Governance indicators	G1. Board-level oversight of climate issues (0 = no or 1 = yes) G2. Incentive mechanisms to climate issues (0/1)	CDP climate change database 2020
Risk indicators	R1. Type of process to manage climate-related risks (0/1) R2. Identify climate risks with impact (0/1) R3. Identify climate opportunities with impact (0/1) R4. Frequency of monitoring climate risks (More than once a year; annually; every 2 years or more) R5. Horizon in the future to consider climate risks (up to 1 year; 1 to 3 years; 3 to 6 years; beyond 6 years)	CDP climate change database 2020
Strategic indicators	S1. Climate risks issues integrated in business strategy (0/1) S2. Use of climate risks scenario to inform strategy (0/1) S3. Use of an emission target active (0/1) S4. Use of emissions' reductions initiatives (0/1) S5. Regulation of activities by a carbon pricing system (0/1) S6. Use of internal price on carbon (0/1) S7. Engage with your value chain on climate issues (0/1) S8. Engage for influencing public policy on climate (0/1)	CDP climate change database 2020
Gender Variables	**Definition**	**Source**
CEO sex	Sex of the Chief Executive Officer (CEO)	MERIT500 database
COB sex	Sex of the Chair of the Board (COB) of Directors	MERIT500 database
Women in board	% of women among the Board of Directors (WBD)	MERIT500 database
Women in management	% of women among the management team (WMT)	MERIT500 database
Women in operational management	% of women among the management team with operational functions (WoMT)	MERIT500 database
Firm and Country Variables	**Definition**	**Source**
Sector	Firm's classification into industries	Global Industry Classification Standard
Size	Number of employees for 2020	Financial statements
Revenues	Firm's turnover for 2020	Financial statements
Profit margin	Net income divided by net revenues for 2020	Financial statements
Financial development	Country's classification using the Financial Development Index Database	International Monetary Fund
Legal system	Country's classification using the historical origin of law system	La Porta et al., ii (2008)

3.2.1. Dependent Variables

The first dependent variable is the CDP score. Codified from A to D and numerically from 4 to 0—from best to worst quality—the scoring variable represents the steps a company moves through as it progresses toward environmental stewardship. CDP data have been extensively used in the previous empirical literature as a proxy for carbon disclosure quality and have become an international standard [9,16–18]. The other dependent variables used in this study were extracted from the CDP climate change database and refer to qualitative metrics of green management in the particular fields of governance (G1 and G2 variables), risk management (R1–R5 variables) and strategy (S1–S8 variables).

From a governance perspective, the first variable G1 (coded as a dummy variable, yes = 1 and no = 0) identifies companies in which climate-related issues are a direct and explicit subject treated at the highest level of governance of the firm, a board level interest. In the same vein, a second dummy variable of governance, named G2, permits one to

underline specific behaviours in terms of recognition as the incentive for the target variable is equal to 1 (=yes) if the firm provides special incentives (financial or non-financial as recognition) for managers in accordance with the achievement of targets related to green management and climate change-related issues, and 0 otherwise.

In accordance with the politics of risk management, the variable R1 identifies firms regarding their dedicated strategy to manage climate-change risk. R1 takes the value of 1 (=yes) for firms with a specific and independent process to identify, assess and manage climate change-related risks. It is equal to 0 for companies with no specific approach and an integration of climate change risks into multi-disciplinary risk processes. Variables R2 and R3 deal with risks disclosure. The variable R2 identifies firms who declare to have recognised inherent climate-related risks with the potential to have a substantive financial or strategic impact on their business in the future. Symmetrically, the variable R3 is the same but deals with climate-change opportunities' disclosure rather than with risks' disclosure. The variables R4 and R5 give indications about the dedicated time horizons in green management practices. These variables are relative to the frequency of monitoring climate-related risks for R4 and to the horizon in the future to consider climate-related risks for R5.

From a strategic perspective, the variable S1 identifies firms for which climate-related risks and opportunities have been integrated to influence a business strategy. S2 is equal to 1 (=yes) if the company declares to have used climate-related scenario analysis to inform its strategy and 0 (=no) otherwise. The variable S3 identifies firms using (1 = yes) a greenhouse gas emissions target active for business activities during the reporting year, or not (0 = no). The variable S4 identifies firms who declare to have specific and active initiatives in 2020 to reduce greenhouse gas emissions. The variables S5 and S6 are dedicated to climate change management practices in touch with carbon pricing. S5 indicates whether any operations or activities of firms are regulated by a carbon pricing system, whereas S6 identifies organisations using an internal price on carbon in the framework of their current activities. Finally, variables S7 and S8 give details regarding the engagement taken by firms. The variable S7 designates firms that are engaged with their value chain on climate-related issues (suppliers, customers, financial services companies or others). S8 focuses on green engagements that go beyond the main firm's stakeholders, and takes the value of 1 if the firm is engaged in activities (with policy makers, trade associations, funding research organisations) that could influence public policy on climate-related issues.

3.2.2. Independent Variables

Gender-Specific Variables

The first binary variable (labelled CEO) indicates the sex of the chief executive officer of firms, and takes the value of 1 if the CEO in exercise is a female and 0 for a male. Similarly, the sex of the chair of the board (labelled COB) of directors of firms is given by the second gender variable, following the same metrics (1 = female; 0 = male). In addition, three quantitative variables dealing with the representation of women inside the two highest managerial instances, the board of directors and the management team are selected. The percentage of women on the board of directors is calculated by the variable WBD, the percentage of women among the management team by the variable WMT, and the presence of women in charge of operational functions within the management team by the variable WoMT.

Firm and Country-Specific Variables

In addition to gender variables firm-specific variables related to the effects of the sector, firm's size, revenues and profitability are considered. Two dedicated variables in relation to financial development and the legal system are also included. The categorical variable of the sector classifies firms according to the Global Industry Classification Standard (GICS by MSCI). The firm's size is measured by the number of employees for 2020. Revenues are calculated by the firm's turnover as well as the profit margin variable (net income divided

by net revenues in 2020). From a macroeconomic point of view, prior studies have demonstrated that the national context (financial development and legal system) is a relevant explanatory factor [47]. Then, countries are classified into three categories (high, medium and low) according their level of financial development following the Financial Development Index Database published by the IMF (https://data.imf.org/?sk=F8032E80-B36C-43B1-AC26-493C5B1CD33B in 2 December 2021). From a legal and financial perspective [48], it appears that the historical origin of a country's laws is not without consequences on the legal protection of investors and a broad range of regulations, economic outcomes and social practices. Following the distribution of legal origin provided by La Porta et al. [49], countries are classified according to the historical origin of the legal system (common law, French civil law, Scandinavian law and German civil law).

3.3. Methods

In the dataset, companies are embedded in countries, and both the presence of women on boards and the environmental strategy of the firm are strongly dependent on the national context. Therefore, it could be assumed that using simple generalised linear or logistic models would give biased results. That is why multi-level (hierarchical) multiple regressions are used first, as suggested in previous research [50,51]. Indeed, multi-level modelling is particularly adequate when phenomena can be explained at different levels. Specifically, this study is based on two levels of analysis: individuals and countries. SAS software and the mixed and glimmix procedures are used. Thus, 13 models were tested. The first model has the CDP score as the dependant variable. As the CDP score is a continuous variable, this model is a multi-level linear multiple regression. The 12 following ones have the different indexes of green management as dependent variables. Most of them (G1, G2, R1, R2, R3, S1, S2, S3, S4, S5, S6, S7, S8) are binary variables, and multi-level logistic multiple regressions are therefore used. The two other ones (R4 and R5) are continuous variables, and multi-level linear multiple regressions are then used. The indexes G1, S7 and S8 are binary and there are too few companies in one of the modalities. Therefore, the estimation algorithm does not converge. G1, S7 and S8 were not included in the results.

This first step showed that the country level explains less than 1% of the variation of each score or index. That is why non-hierarchical multiple regressions are used in order to corroborate these results and obtain quality criteria such as adjusted R2 or concordance statistics, which are not accessible through hierarchical modelling. These results were corroborated and the R2 was satisfied (15% for the CDP score for example). The results provided here are for multi-level modelling, but the coefficients are very close for the non-hierarchical modelling.

4. Results and Discussion

4.1. Descriptive Statistics

Descriptive statistics are displayed in Tables 3–6. The sample characteristics by CDP score and gender data are illustrated in Table 3. In aggregate, the panel of 836 firms counts a majority of firms from larger and more advanced countries from North America and Europe. All sectors are well represented with the exception of the telecommunications with only 14 firms or 7% of the panel. More than two-thirds of firms operate in a highly financially developed country and, if the common law system dominates the panel, with a balanced representation of each law system. More than 73% of firms report the best CDP scores, A (39.5%) or B (33.6%), whereas only 7% are classified in the worst score D. Regarding gender data, firms with a woman as chief executive officer or chair of the board represent less than 10% in total—precisely 6.2% for CEO and 9.2% for COB—which shows the glass ceiling that women face [52]. At the notable exception of Sweden (14.3% for CEO and 11.9% for COB), no country presents a percentage higher than 10% for these two prestigious functions—Sweden is known for its high percentage of women among board members [53]. Switzerland is at the opposite of Sweden with 0% for the two variables. The most financially developed countries are not those with the highest percentage of women

in CEO or COB roles. Relatively to the law system classification, the Scandinavian system exhibits the best results in terms of diversity whereas the French and the German civil law systems appear more closed. Finally, diversity appears as strictly decreasing among the boards of directors (WBD, 34.2%), management teams (WMT, 22.4%) and the members of the management teams with operational functions (WoMT, 15.9%). Once again, the case of German civil law countries (Germany, Switzerland and Austria) is particularly noteworthy with, for example, less than 10% of women with operational functions in the management team.

Table 3. Sample characteristics by CDP score and gender data.

Characteristics	Number of Firms		CDP Score (% of Firms)				Gender Data (% of Female)				
	N	%	A	B	C	D	CEO	COB	WBD	WMT	WoMT
Countries:											
USA	267	31.9	36.7	37.8	18.7	6.7	7.1	5.6	30.5	24.6	18.2
UK	123	14.7	32.5	41.5	18.7	7.3	7.3	14.6	37.4	24.3	16.5
Canada	72	8.6	30.6	26.4	31.9	11.1	0.0	16.7	34.3	20.7	13.9
France	52	6.2	61.5	21.2	13.5	3.8	5.8	7.7	43.4	22.3	16.9
Germany	45	5.4	42.2	33.3	15.6	8.9	4.4	8.9	31.2	12.1	5.4
Sweden	42	5.0	28.6	33.3	26.2	11.9	14.3	11.9	40.0	25.3	13.7
Switzerland	37	4.4	48.6	27.0	21.6	2.7	0.0	0.0	29.5	14.1	8.4
Australia	40	4.8	30.0	30.0	25.0	15.0	7.5	12.5	36.9	28.2	16.2
Spain	30	3.6	63.3	26.7	6.7	3.3	0.0	10.0	31.0	19.2	14.6
Italy	28	3.3	64.3	17.9	7.1	10.7	7.1	14.3	38.0	18.0	16.5
Norway	25	3.0	40.0	48.0	8.0	4.0	12.0	2.0	39.3	25.9	19.4
Finland	22	2.6	50.0	31.8	13.6	4.5	13.6	4.5	34.3	25.8	15.8
Netherlands	16	1.9	50.0	6.3	43.8	0.0	12.5	0.0	38.4	26.8	25.9
Denmark	16	1.9	18.8	25.0	50.0	6.3	6.3	0.0	30.0	15.6	12.0
Belgium	10	1.2	30.0	60.0	0.0	10.0	10.0	0.0	38.5	25.8	35.0
Austria	11	1.3	45.5	45.5	9.1	0.0	0.0	27.3	26.7	5.9	6.3
Sectors:											
Financials	185	22.1	40.5	31.4	20.5	7.6	7.6	13.0	34.2	24.2	16.9
Industrials	181	21.7	36.5	33.1	23.8	6.6	3.9	8.3	33.8	19.8	13.6
Cons. goods	93	11.1	51.6	32.3	12.9	3.2	4.3	8.6	36.5	23.1	15.6
Cons. services	82	9.8	37.8	32.9	22.0	7.3	11.0	6.1	36.3	27.3	20.0
Technology	63	7.5	36.5	28.6	23.8	11.1	7.9	1.6	34.4	18.9	14.3
Basic materials	61	7.3	23.0	34.4	29.5	13.1	8.2	14.8	32.8	15.4	10.2
Health care	61	7.3	24.6	47.5	19.7	8.2	6.6	3.3	32.5	27.3	20.6
Utilities	53	6.3	64.2	34.0	0.0	1.9	7.5	9.4	35.1	24.1	17.9
Oil and gas	43	5.1	32.6	37.2	18.6	11.6	4.7	9.3	29.8	20.3	15.8
Telecom.	14	1.7	71.4	28.6	0.0	0.0	0.0	28.6	36.7	25.5	16.2
Financial dev.:											
High	569	68.1	36.7	35.3	20.4	7.6	5.4	9.3	32.9	23.3	16.3
Medium	231	27.6	45.9	27.3	19.5	7.4	8.7	7.8	37.4	20.7	15.0
Low	36	4.3	41.7	47.2	8.3	2.8	8.3	16.7	35.4	19.8	15.4
Law system:											
Common law	502	60.0	34.3	36.5	21.1	8.2	6.2	10.0	33.3	24.3	17.0
French civil law	173	20.7	56.6	23.7	15.0	4.6	4.6	6.4	36.7	20.0	16.5
Scandinavian law	105	12.6	34.3	35.2	22.9	7.6	12.4	8.6	37.1	24.1	15.2
German civil law	56	6.7	42.9	35.7	14.3	7.1	3.6	12.5	30.3	10.8	5.6
CDP score:											
A	330	39.5	-	-	-	-	5.2	8.5	34.8	23.2	16.5
B	281	33.6	-	-	-	-	6.8	10.0	34.5	22.8	16.3
C	164	19.6	-	-	-	-	7.9	11.0	33.6	20.5	14.5
D	61	7.3	-	-	-	-	9.8	4.9	31.7	22.0	14.5
Total	836	100	39.5	33.6	19.6	7.3	6.5	9.2	34.2	22.4	15.9

Table 4. Governance and risk indicators of green management issues (% of the surveyed population).

Governance (G) and Risk (R) Indicators	All Firms	CEO Gender		Chair Gender	
		Male	Female	Male	Female
G1. Board-level oversight of climate-related issues:					
Yes	98.2	98.2	98.1	98.0	100.0
No	1.8	1.8	1.9	2.0	0.0
G2. Incentive mechanisms to climate-related issues:					
Yes	80.7	80.3	87.0	80.5	83.1
No	19.3	19.7	13.0	19.5	16.9
R1. Type of process to manage climate-related risks:					
Integrated process	85.2	85.0	88.9	85.9	78.7
Specific process	14.8	15.0	11.1	14.1	21.3
R2. Identify climate-related risks with impact:					
Yes	86.6	86.9	81.5	86.3	89.6
No	13.4	13.1	18.5	13.7	10.4
R3. Identify climate-related opportunities with impact:					
Yes	91.1	91.3	88.9	91.4	88.3
No	8.9	8.7	11.1	8.6	11.7
R4. Frequency of monitoring climate-related risks:					
More than once a year	62.0	62.3	58.5	62.1	61.6
Annually	34.5	34.0	41.5	34.9	30.1
Every 2 years or more	3.5	3.7	0.0	3.0	8.2
R5. Horizon in the future to consider climate-related risks:					
Up to 1 year	2.1	2.2	0.0	1.6	6.8
1–3 years	1.4	1.5	0.0	1.4	1.4
3–6 years	34.5	34.0	41.5	34.9	30.1
Beyond 6 years	62.0	62.3	58.5	62.1	61.6

Table 5. Strategic indicators of green management issues (% of the surveyed population).

Strategic (S) Indicators	All Firms	CEO Gender		Chair Gender	
		Male	Female	Male	Female
S1. Climate-related risks issues integrated in business strategy:					
Yes	95.0	94.9	96.3	95.4	90.9
No	5.0	5.1	3.7	4.6	9.1
S2. Use of climate risks scenario to inform strategy:					
Yes	59.9	59.6	63.5	59.5	63.8
No	40.1	40.4	36.5	40.5	36.2
S3. Use of an emission target active:					
Yes	82.7	82.5	83.3	82.4	85.7
No	17.3	17.5	16.7	17.6	14.3
S4. Use of emissions reductions initiatives:					
Yes	91.7	91.5	94.4	91.9	89.6
No	8.3	8.5	5.6	8.1	10.4
S5. Regulation of activities by a carbon pricing system:					
Yes	61.3	61.4	60.4	61.3	61.4
No	38.7	38.6	39.6	38.7	38.6
S6. Use of internal price on carbon:					
Yes	28.1	27.9	32.1	28.9	21.1
No	71.9	72.1	67.9	71.1	78.9
S7. Engage with your value chain on climate-related issues:					
Yes	91.2	91.3	90.7	91.0	93.5
No	8.8	8.7	9.3	9.0	6.5
S8. Engage in activities for influencing public policy on climate:					
Yes	86.5	86.3	88.7	86.2	89.3
No	13.5	13.7	11.3	13.8	10.7

Tables 4 and 5 present descriptive statistics for the climate change management variables. It appears in Table 4 that the quasi-totality of firms (98.2%) report on climate-related issues at the board level. In 8 cases out of 10 (80.7%), there are incentive mechanisms to promote climate change management with a higher proportion in firms with a woman as CEO (87%) or, to a lesser extent, as chair of directors (83%). A large majority of firms (85.2%) declare that they manage climate risks in a global and integrated process without creating a specific process. Interestingly, with variables R2 and R3 in Table 4, more firms identify opportunities (91.1%) associated with climate change rather than risks (86.6%).

Time indicators (R4 and R5) state that monitoring climate risk is a current activity occurring annually (34.5%) or more frequently (62%) and that the horizon in the future to consider climate-related risks is commonly beyond 6 years. Strategic indicators in Table 5 show that 95% of firms have integrated climate risks in their business strategy but only 60% of them use a dedicated scenario for this purpose. The practices of using the greenhouse gas emissions target (82.7%) and gas reduction initiatives (91.7%) are notably widespread, which is less the case for adopting a carbon pricing system (61.3%) and the most advanced practice of using an internal price on carbon (28.1%). Finally, a large proportion of firms use their networks to deal with the green management problematic through their value chain (91.2%) for operational aspects, but also for influencing public policy on the subject (86.5%). No specific effects appear when these statistics are displayed using the sex of the CEO or the chair of the board of directors of firms. Descriptive statistics for econometric issues are presented in Table 6.

Table 6. Descriptive statistics of variables.

Gender Variables	**Mean**	**Std.**	**Min.**	**Max.**
CEO sex (M = 0; F = 1)	0.065	0.245	0	1
COB sex (M = 0; F = 1)	0.092	0.289	0	1
Women in board (%)	0.342	0.101	0	0.667
Women in management (%)	0.224	0.138	0	1
Women in operational management (%)	0.159	0.151	0	1
Firm Variables	Mean	Std.	Min.	Max.
Size (employees)	45,681	112,237	3	2,300,000
Revenues (m$)	18,099	36,510	5.142	559,151
Profit margin (%)	0.091	0.037	−2.115	2.019
Green management Variables	Mean	Std.	Min.	Max.
CDP score (A = 0–D = 3)	0.947	0.939	0	3
G1. Board level interest (0 = no; 1 = yes)	0.982	0.133	0	1
G2. Incentive mechanisms to climate issues (0/1)	0.807	0.395	0	1
R1. Type of process to manage climate-related risks (0/1)	0.148	0.355	0	1
R2. Identify climate risks with impact (0/1)	0.866	0.341	0	1
R3. Identify climate opportunities with impact (0/1)	0.911	0.285	0	1
S1. Climate risks issues integrated in business strategy (0/1)	0.950	0.219	0	1
S2. Use of climate risks scenario to inform strategy (0/1)	0.599	0.490	0	1
S3. Use of an emission target active (0/1)	0.827	0.378	0	1
S4. Use of emissions reductions initiatives (0/1)	0.917	0.276	0	1
S5. Regulation of activities by a carbon pricing system (0/1)	0.413	0.472	0	1
S6. Use of internal price on carbon (0/1)	0.281	0.450	0	1
S7. Engage with your value chain on climate issues (0/1)	0.912	0.283	0	1
S8. Engage for influencing public policy on climate (0/1)	0.865	0.342	0	1

This table reports the summary statistics for dependent and explanatory variables. Statistics for the categorical country (financial development and legal system) and green management (R4 and R5) variables are not reported, see Table 2 for detail.

4.2. Models

Table 7 presents the results of the models.

Table 7. Results of estimates of green management variables.

Variables	CDP Score	G2	R1	R2	R3	R4	R5	S1	S2	S3	S4	S5	S6
Intercept	3.11 ***	2.33 ***	−0.89	3.06 ***	2.45 **	1.20 ***	0.74 ***	1.44 ***	1.06 *	1.79 **	3.21 **	0.50 ***	−0.88
Gender variable													
CEO sex (ref. male)													
Female	−0.16	0.52	−0.58	−0.44	−0.34	−0.00	−0.00	0.01	0.26	0.17	0.51	0.05	0.27
COB sex (ref. male)													
Female	−0.02	0.17	0.67 **	0.45	−0.37	−0.05	0.06	−0.05	0.17	0.11	−0.23	0.00	−0.40
Women in management	0.003	0.002	−0.00	0.02	0.04 ***	−0.00	0.00	0.00	−0.00	0.01	0.02	−0.01 **	−0.01
Women in op. management	0.001	−0.008	0.01	−0.02 *	−0.03 **	0.00	−0.00	−0.00	−0.00	−0.00	−0.01	0.00	−0.00
Women in board	0.005	0.003	−0.01	0.002	0.00	−0.00	−0.00	−0.00	−0.00	−0.00	−0.01	0.00	0.01
Firm variables													
Sector (ref. utilities)													
Basic materials	−0.74 ***	0.08	−2.35 ***	−0.19	0.20	0.13 **	0.11 *	−0.06	−0.38	0.00	−0.54	−0.08	−0.55
Consumer goods	−0.42 ***	−0.81	−0.58	−0.89	0.11	0.13 **	0.10 *	−0.09	−0.17	−0.69	−0.47	0.03	−0.13
Consumer services	−0.69 ***	−1.13 **	−1.59 ***	−0.99	−0.22	0.11 **	0.11 **	−0.10	−0.32	−0.90 *	−0.87	−0.05	0.09
Financials	−0.49 ***	−0.61	−1.44 ***	−0.98	−0.53	0.09 *	0.05	−0.15 ***	0.05	−0.49	−1.04	−0.08	−0.27
Health care	−0.75 ***	−0.64	−1.21 **	−1.29 *	−0.35	0.06	0.09	−0.11	−0.13	−0.82	−0.96	−0.03	0.06
Industrials	−0.64 ***	−0.58	−0.64	−1.03	−0.63	0.08	0.09 *	−0.11 *	−0.31	−0.50	−0.81	−0.05	−0.26
Oil and gas	−0.53 ***	−0.59	−1.35 **	−0.92	−0.44	0.15 **	0.05	−0.16 **	0.25	0.25	−1.28	0.01	−0.88
Technology	−0.66 ***	−1.17 **	−0.63	−1.07	−0.70	0.10 *	0.11 **	−0.18 **	−1.08 ***	−0.84	−1.24	−0.03	−0.39
Telecommunications	−0.15	−1.87 **	−0.05	−2.94 ***	−2.38 ***	0.15 *	0.13	−0.38 ***	−1.69 **	−0.85	−2.16 **	−0.18	−1.67
Revenues	0.00 ***	0.00 ***	0.00 ***	−0.00 ***	−0.00 ***	0.00	0.00	0.00	−0.00 ***	−0.00	−0.00 ***	0.00	−0.00 ***
Profit margin	−0.01	−0.12	−0.02	0.09	−0.12	0.01	0.01	−0.00	−0.05	0.04	−0.06	0.01	−0.04
Size (ref. 5001–15,000)													
0–5000	−0.20 **	−0.09	0.76 **	−0.12	−0.38	−0.06 *	0.01	−0.07 *	−0.41 *	−0.17	0.01	−0.01	−0.28
15,001–45,000	0.17 **	−0.12	0.42	−0.11	−0.53	−0.03	0.02	−0.09 **	−0.23	−0.22	−0.02	−0.04	−0.30
+45,000	0.32 ***	−0.21	0.75 **	0.13	−0.19	−0.03	−0.01	−0.06	0.48 *	0.31	0.39	−0.02	0.08
Country variables													
Financial dev. (ref. medium)													
Low	0.30 *	0.35	−0.14	0.46	1.65	−0.07	0.08	0.09	0.38	1.48	0.84	0.16	0.68
High	0.17	0.93	−0.25	0.66	0.07	−0.05	−0.00	0.15 **	0.51	0.53	0.67	0.20 **	0.77
Legal system (ref. Scand. law)													
Common law	−0.28	−1.28 *	−0.06	−1.12	0.22	0.07	−0.01	−0.20 ***	−0.62	−0.12	−0.43	−0.19 *	−0.94
French civil law	0.11	−0.72	−0.22	−0.22	0.28	0.04	0.05	−0.09	−0.47	0.17	−0.10	−0.06	−0.41
German civil law	0.04	−0.03	−0.86	−0.52	0.26	0.09 *	0.01	−0.03	0.05	1.94 **	−0.03	0.03	0.41

Significance levels: *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$.

Several findings emerge herein. CEO sex, COB sex, the percentage of women in management and on boards do not play a significant role for a lot of variables: the CDP score, G2 score, R4 score, R5 score, S1 score, S2 score, S3 score, S4 score and S6 score. This would imply that the hypotheses are not validated and would contradict previous research that has tried to show the link between those different gender-related variables and climate change management. However, these results deserve a deeper analysis because some sub-scores seem to be influenced by gender-related variables. Several notable facts can be noted.

First, CEO sex does not influence any of the climate change management scores. This invalidates hypothesis H1 but sustains previous research's results, which brought inconclusive results on the relationship between CEO sex and climate change management [6].

Second, the percentage of women on boards does not influence any of the climate change management scores. This invalidates hypothesis H2 and gives contradictory results with previous research which has underlined the influence of board gender diversity on green management [26,33]. This can be explained by the fact that, contrary to previous studies which concern only specific countries (e.g., China: He and Jiang, 2019; US: Nadeem et al., 2020; France: Galia et al., 2015; . . .), this study was based on an international dataset with multi-level modelling in order to take into account the country effect.

Third, COB sex only influences R1 score: having a female COB is positively associated with defining specific climate-related risk management processes (instead of having an overall risk management process which includes climate-related risk). This partially validates hypothesis H3 and provides an original result, because, to our knowledge, there has been very little research into the relationship between COB sex and climate change management.

Fourth, the percentage of women among managers (including operational and non-operational managers) positively influences (0.05) the R3 score and negatively influences (−0.01) the S5 score. The R3 score corresponds to having identified climate-related opportunities with impact. The S5 score corresponds to the regulation of activities by a carbon pricing system. In addition, the percentage of women among operational managers negatively influences the R2 score (fact of having identified climate-related risks with impact) and R3 score (fact of having identified climate-related opportunities with impact). As noted in the literature review section, previous research has not studied the influence of gender diversity among managers on green management. Therefore, those original results deserve some interpretation. An explanation of those mixed results would be that, at the same level of feminisation of management, a company with a high percentage of women among operational managers would be a company with a lower percentage of women among non-operational managers, which would maybe explain a negative influence on the R2 score and R3 score which seem more influenced by non-operational than operational managers. Finally, hypothesis H4 is partially validated.

5. Conclusions

This study tested four hypotheses about the relationship between gender diversity (CEO sex, COB sex, presence of women in board, presence of women among overall or operational managers) and climate change management (governance, risk and strategic indicators) on an international dataset of 836 companies from 16 developed countries from western Europe, North America and Australia. This yielded mixed results. First, this indicated that CEO sex and the percentage of women on boards do not influence any of the green management scores. Second, we found that the COB sex only influenced the definition of specific climate-related risk management processes. Finally, we obtained original and surprising results about the influence of the feminisation of managerial levels on climate change management. The low percentage of women in leadership positions may also explain the lack of significance of the results. It could be inferred that these low percentages do not really allow gender diversity to produce significant effects until a still unknown critical mass has been reached according to the critical mass theory [54]. For instance, if the CEO is a woman but most of her managerial staff and board is dominated

by men, a positive impact of gender diversity cannot be expected. This assumption calls for future research on the influence of gender diversity within top management team as a whole on managerial practices to determine whether this critical mass exists. Finally, this is also a call for companies to broaden gender diversity in executive positions beyond boards. This is also an appeal to legislators to set up regulations in this area. To date, some countries or states, such as California, France, India, Israel, Kenya and Spain, have set quotas for women on boards following the first country to do so, Norway, in 2003, but excluding senior management positions. However, France passed a new bill in 2021 that requires a quota of at least 30% among senior management by 2027 and 40% by 2030 for the largest companies. The Netherlands have also introduced a new legislation that came into force in January 2022, requiring large companies to set appropriate and ambitious target ratios to improve gender diversity not only within their boards, but also within their senior management.

This study suffers from several limitations. First, there is a selection bias due to the fact that carbon disclosure is made voluntarily by companies, i.e., the worst performers prefer not to answer the CDP Survey. This may also explain the lack of significance of the results, implying that the sample only consisted of the best performers. This is also a call for regulations on compulsory extra-financial reporting, such as those currently examined by the EU. Second, climate change management data correspond to self-reported strategies and processes which may not correspond to reality. However, gender diversity data are not self-reported (they are gathered by the owners of MERIT500), thus avoiding the common method bias.

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