ORIGINAL ARTICLE

The impact of the board of directors on business climate change management: case of Brazilian companies

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Abstract

The corporate sector is one of the main emitters in the world due to the production process and therefore is identified as a major contributor to climate change. In fact, the productive sector is both one of the major aggregators of the impacts of global climate change and a market actor who can play an important role in reducing, mitigating, and adapting the vulnerability of human and natural systems. The main objective of this study was to verify whether the climate change performance of Brazilian companies is influenced by the characteristics of the composition of the board of directors (BD). The performance here is measured according to company's Carbon Disclosure Project (CDP) score. The score, besides evaluating the quality and comprehensiveness of information provided on climate change mitigation strategies, evaluates the level of concrete and proactive actions, policies, and strategies adopted by companies to mitigate climate change. The study was based on the premise that climate risk management is the responsibility of the board, which is responsible for ratifying important decisions in the company. A multiple linear regression model based on data from the CDP of a sample size equivalent to 72 Brazilian companies, referring to the period among 2014 to 2018, totaling 360 observations listed on the Brazilian stock exchange showed that corporate climate management have significant and positive relationship with the size of the company's BD, number of independent directors of the BD, Business Sustainability Index (ISE) participation, size of firm, profitability, and industry classification. The findings suggest several strategies that could be used to engage firm in climate management, among which the increase in the number of independent directors in the board composition. In other words, we have found that one of the most effective strategies of mitigation and adaptation that can inhibit or pressure companies to become involved in climate management is increasing the number of independent directors on the board of directors. This result, although based on Brazilian companies, can have implications for the rest of the world's companies, since, regardless of country, the BD's role remains the same, ratifying the important decisions in the organization. Therefore, proportion of the number of independent director's increase leads to the improvement of the company's involvement in climate issues. Thus, potential investors, for example, may require such a feature before investing in a particular company. In addition, we found that companies that strive to be part of the ISE developed by the São Paulo capital market have a higher climate performance compared to companies that are not part of it, demonstrating therefore that ISE is a key instrument to get companies to increase their concern about environmental issues, in general, and climate, in particular. Thus, as global recommendations for mitigation/

adaptation strategies, capital markets around the world can also play an important role in the climate mitigation and adaptation process by creating ISE-like instruments and creating incentives for companies to strive to adhere to these instruments.

Keywords Climate change · Mitigation and adaptation strategies · Board of directors · Brazilian stock exchange · Business climate change strategy

1 Introduction

One of the biggest challenges currently faced by humanity and the planet is the global climate change (IPCC 2014, 2007). Global warming is a major consequence of greenhouse gas (GHG) emissions in the atmosphere from human activities and production since the industrial revolution (IPCC 2014). Stern (2006) highlights that the global climate change is the largest and most comprehensive market failure ever seen. Thus, climate change represents a threat to economic development for all continents.

According to Jeswani et al. (2008), due to the growing consensus among scientists and governments to act quickly to avoid the deepening of dangerous impacts of climate change, many industries have begun to respond proactively to carbon restriction. However, these authors emphasize that this proactive response is far from uniform; in other words, each industry responds in a different way. This is perhaps due to the complexity of the problem, its thematic scope, or even the controversies of its causes and consequences. All these characteristics make it difficult to find a single appropriate solution. On the other hand, stakeholders have requested more industry disclosure about the impacts of global warming and its associated risks (Stanny and Ely 2008). Due to pressures from stakeholders, industries have been mobilized to develop actions to address climate change risks.

In the national and international literature dealing with climate change disclosure, it is possible observe that there are several studies that are concerned with highlighting some characteristics of companies that explain the difference between the levels of disclosure with regarding climate change. Thus, studies investigated relationship between a company's specific characteristics and corporate climate change disclosures (Eleftheriadis and Anagnostopoulou 2015; Wegener et al. 2013; Stanny and Ely 2008; Barako et al. 2006). Other studies have investigated the corporate disclosure of climate change strategies and governance (Sullivan and Gouldson 2016; Elshandidy and Neri 2015; Galbreath 2009; Reid and Toffel 2009). Lee et al. (2015) and Stanny (2013) investigated market responses to a firm's voluntary climate change information disclosure and carbon communication.

Other studies have investigated whether institutional investor influence global climate change disclosure practices (Cotter and Najah 2012), and the impacts of social, market, economic, regulatory, and institutional factors on the motivation to voluntarily participate in the 2009 Carbon Disclosure Project (Luo et al. 2012). Hoover and Fafatas (2016) investigated if the political leaning of the state, which a given firm is headquartered, is related to its decision to voluntarily disclose climate change information. Besides, there are records of investigations of CEO characteristics and firm environmental disclosure (Lewis et al. 2014), and the factors that influence the disclosure of climate change risk information (Kouloukoui et al. 2019).

However, studies developed by Ben-Amar and McIlkenny (2015), Amran et al. (2014), and Donnelly and Mulcahy (2008) in Canada, Malaysia, and Ireland, respectively, have shown that the board of directors (BD) has a significant impact on climate change disclosure in these

countries. Considering that climate change is an issue of great importance and that mitigation policies require considerable investment, it is to be expected that any decision regarding this subject will necessarily depend on the approval or consent of the BD. Given this, the central question of this study is: does the BD influence the climate performance of Brazilian companies? This study, therefore, attempts to verify if there is a relationship between characteristics of the composition of the BD and the climate change performance of the company.

There are few studies on this subject, in the Brazilian context. It is interesting to highlight the role of the BD in the involvement of the company in matters of climate, since risk management and reports are the responsibility of the board (Galbreath 2010). For the Carbon Disclosure Project (CDP) (2017), fighting climate change is vital to a sustainable economy. Specifically, improving corporate stewardship through measurement and disclosure is essential for the effective management of carbon emissions and climate change risk. However, in the Brazilian context, no research has sought to highlight the impact of the BD in the disclosure of climate change information. Its main objective was to verify whether the climate change performance of Brazilian companies is influenced by the characteristics of the composition of the board of directors.

The study has demonstrated, through empirical evidence, that BD can play a very important role in the process of climate mitigation and adaptation. In fact, in order to improve and encourage companies to engage more in climate management, it is necessary, for investors, to require the disclosure of information of this nature, and especially requiring that the composition of the BD is high quality with the characteristics suggested by the findings in the present study (independent directors). The present study contributes to the advancement in these discussions about what strategies can be adopted to involve all companies in climate management by discovering, some potential variables that can trigger, boost, and inhibit the involvement of companies in climate issues.

2 Literature review

According to Charreaux (2000), although the field of governance is widely used in literature and it has become important recently, it is important to remember that it emerged initially from the analysis of professors Berle and Means (1932). In fact, these authors found management unfavorable to shareholders in large listed companies, because the separation between shareholders, who take the risk, and managers, who make decisions in their place (Charreaux 2000). For that author, excessive decision-making by managers (agents), due to the insufficient control of the shareholders (principal), was supposed to be the cause of the poor performance of companies. Therefore, there was a need for discipline, as this fact would later contribute to the creation of the agency theory, which takes its name from the agency relationship that should link managers to shareholders.

The theorists Jensen and Meckling (1976) published studies focusing on US and British corporations, mentioning the principal agent problem that gave rise to firm theory or agent-principal theory. According to this theory, executives hired by shareholders would tend to act in a way that maximizes their own benefits (higher wages, greater job stability, more power, etc.), thus acting in their own interests and not in the interests of the company. It is important to emphasize that in a share-based society, shareholder participation in the management of the company is limited to its share of the capital provided. In fact, agency theory analyzes the conflicts and costs resulting from the separation of ownership and control of capital (Fama

1980). The agency relationship can be understood as a contract in which one or more (principal) people employ another person (the agent) to perform some service or work in their favor, involving the delegation of some decision authority to the agent (Jensen and Meckling 1976). According to these authors, considering that both parties are utility-maximizing, and if there is an information's asymmetry between them, there is good reason to believe that the agent will not act in the interests of the principal.

In order to mitigate the problem, companies and their shareholders should adopt a series of measures to align the interests of those involved, aiming, above all, for the success of the company. To this end, measures were proposed that included practices of monitoring, control, and wide disclosure of information. This set of practices is called Corporate Governance (Jensen and Meckling 1976). One of the tools of corporate governance is the BD. The monitoring carried out by the BD is one among several instruments developed in modern corporations to mitigate the agency conflicts between the principal and the administrator. Thus, for scholars, such as Fama (1980), Fama and Jensen (1983), and Lipton and Lorsch (1992), the BD is a key tool of the organization's internal control system that sets the rules of the game for managers and executives.

The agency theory assumes that, to ensure the efficiency of the organization control system, the BD must be of high quality or efficient. An efficient BD is characterized by high participation of external independent directors to the entity, avoiding duality—the distinction between the functions of Chief Executive Officer (CEO) of the company and chairman of the board, and finally a small number of BD.

The research developed by Ben-Amar and McIlkenny (2015) in Canada analyzed the relationship between the effectiveness of the BD and the level of voluntary disclosures of climate change. The authors assumed that, in considering that risk management and reporting are the responsibility of the board, they related the effectiveness of the board to the company's decision voluntarily respond to the annual CDP questionnaire, as well as the quality of risk disclosures and strategies to mitigate climate change in these reports. The results showed a positive association between the effectiveness of the board and the company's decision to respond to the CDP questionnaire, as well as to the quality of carbon disclosure.

Similarly, in Malaysia, Amran et al. (2014) developed research that aimed to analyze some of the generic determinants of company attributes and corporate governance variables and whether there is any relationship with reporting on the strategy of climate change. The results revealed that, although the level of disclosure of climate change data in some emerging Asia-Pacific countries is still low, increasing the proportion of independent non-executive board members encourages companies to separate the chairman of the board of directors and the company's chief executive. They concluded that firm practices to obtain and maintain environmental certification would directly increase the disclosure of climate change data in its sustainability reports.

In the USA, Hoover and Fafatas (2016) also investigated whether the political inclination of the state in which a particular company is based is related to the company's decision to voluntarily disclose information about climate change. They studied the S&P 500 companies with respect to the CDP and found that companies based in states that are more democratic are more likely to disclose carbon emission information to the CDP.

The study developed by Kouloukoui et al. (2018) had investigated the climate risks disclosed by the 100 largest companies in the world, according to the Bloomberg and Price Waterhouse Coopers. The preliminary results shown by the content analysis suggested that, in general, there is still a low level of disclosure about climate risks by these companies. The final

results indicated that the size of the company or the fact that corporations belongs to developed countries do not necessarily explain the level of information disclosed. However, the activity sector, the continent, and the efficiency of the BD are factors that strongly explain the level of climate risk disclosure. They concluded that more effort are needed to encourage an engaging attitude from corporations to develop actions, policies, and strategies to mitigate climate change risks and threats. In addition, the world's largest companies should make a greater investment in climate risk disclosure.

In South Korea, Lee (2012) conducted a study that examined corporate carbon strategies in developing and developed countries, where climate change regulation is widespread and market uncertainty is relatively high. The paper presented a framework for identifying the corporate carbon strategy. The cluster analysis of 241 Korean companies indicates six types of corporate carbon strategy: "wait-and-see observer," "cautious reducer," "product enhance," "all-round enhancer," "emergent explorer," and "all-round explorer." In fact, the study empirically examined whether there are differences between these types of carbon strategies in terms of industry, firm size, and company performance.

The study by Kouloukoui et al. (2019) investigated the extent and content of climate risks information disclosure provided in the sustainability reports of firms listed on the Brazilian Stock Exchange (BM&FBovespa) and tested whether there were any relationships between the amount of climate risks disclosure and some corporation characteristics. Preliminary results from the content analysis revealed that, although Brazilian companies tend to disclose information on climate risks, the level of this type of disclosure still remains relatively low. This finding is consistent with the results of Kouloukoui et al. (2018) as these authors when investigating the 100 largest companies in the world market capitalization term also found that the level of disclosure of this type of information is still relatively low. The final findings of Kouloukoui et al. (2019) suggest that corporate climate risk disclosures have significant and positive relationships with firm size, financial performance, and country origin. Nevertheless, findings indicate that corporate climate risk disclosures have negative associations with the level of indebtedness.

The study by De Faria et al. (2018) aims to identify which factors are most disclosed in the reports of companies that are members of CDP. To do this, 463 reports submitted by 48 companies between 2014 and 2016 were examined and 32 factors were investigated using the NVivo® software. The results indicate that certain factors—prevention of pollution, prevention of loss, management of environmental assets, the volume of GHG emissions, and climate change strategy—account for 50.03% of the total volume of information disclosed about climate change. The main lesson learned from the study was that climate change mitigation strategy is strongly supported by the disclosure of corporate annual reports, and it has relation with the following determinant factors: pollution prevention, loss prevention, environmental asset management, GHG emissions, and the strategy chosen by the companies to deal with climate change.

The work developed by Brown et al. (2013) analyzed the perceptions of decision-makers and the response of various national, regional, and international institutions to the complex challenges of climate change in the Central African Republic. The results indicate that, although climate change awareness is high, a concrete response is only in the early stages.

In Canada the work conducted by Boiral et al. (2012) proposed an integrative framework for understanding the determinants of business strategies to reduce GHG emissions and the impact of these determinants on performance. The proposed structural equation model is based on a survey of 319 Canadian manufacturing firms. The results actually showed a win-win

relationship between the commitment to reducing greenhouse gas emissions and financial performance.

In South Africa, Vogel (2009) conducted a study that explored emerging perceptions of the need for adaptation and some initial adaptation actions within a "normal" economic mode of operation. Data from semi-structured interviews and scrutiny of reports revealed that there are a number of restrictions that prevent companies from engaging completely in climate change adaptation.

In Pakistan and the United Kingdom, Jeswani et al. (2008) developed a study to understand the effectiveness of the industrial response by analyzing the corporate response in different sectors and different countries. Focusing on the nine most energy and GHG emission intensive industrial sectors, the paper compared corporate responses to climate change in Pakistan and the UK.

2.1 Development of hypotheses

Here, agency theory, more precisely the BD, is used to explain the behavior of firms in addressing the issues of climate change. According to Amran et al. (2014), agency theory has become the dominant force in the theoretical understanding of corporate governance. For them, it has evolved in a way that has become one of the key lessons in addressing the conflicting relationships between owners and managers in large corporations in resolving the growing problem of global warming issues. This research considered the following BD characteristics proposed by the agency theory: (i) BD size, (ii) proportion of independent non-executive directors, and (iii) proportion of women in the BD. In this study, we consider that these characteristics of the board of directors can influence the climate performance.

2.1.1 Size of board of directors

An increase in board size makes it less effective in strategic decision making (Jensen 1993; Lorsch and MacIver 1989). Certain research has shown that the characteristics of the BD structure can positively influence aspects such as involvement in climate change issues (Rose 2007). For example, the study by Amran et al. (2014) investigated whether there is a relationship between the size of the BD and the disclosure of climate change information. From this perspective, the first hypothesis of this study is

> H1: There is a strong statistically significant negative relationship between the size of the BD and climate performance.

2.1.2 Non-executive independent directors

The BD has the designated responsibility of ensuring the alignment of the company's activities with its specific objectives (Amran et al. 2014). Thus, the board has a duty to ensure that senior executives are behaving in ways that provide value to shareholders (Coles et al. 2001). According to the agency theory advocated by Fama (1980) and Fama and Jensen (1983), to be efficient and fulfill its disciplinary role, the BD should preferably be composed mostly of independent directors. The survey conducted by Amran et al. (2014) sought to verify if the number of external non-executive directors influences the level of disclosure of climate change information. Considering that the objective of the shareholders is to optimize the value of the

company in the long term, and that climate change represents a threat to the company's continuity, it is possible to think that a board composed of many NEDI will be more committed to climate issues. Thus, the second hypothesis of this research is

> H2: There is a statistically significant positive strong relationship between the number of independent directors in the BD and climate change performance.

2.1.3 Proportion of women on board

The research conducted by Huse and Solberg (2006) indicated that the diversity of the BD is associated with a greater orientation for corporate social reporting. Also, a study developed by Carter et al. (2003) found empirical evidence of a significant positive relationship between the diversity of the BD, defined as the percentage of women on the board and the value of the firm. Recently, research conducted by Amran et al. (2014) has investigated whether there is any relationship between the proportion of women on the BD and the level of disclosure of climate change information. For them, the female gender is generally more sensitive to global issues, especially social and environmental issues. In fact, gender diversity in the BD leads to decisions that are aligned with the challenges of global warming faced by each organization. According to the authors, gender diversity is aligned with agency theory, whereby it increases the independence of the BD and reduces the conflict between the principal and the agent, providing clear direction to deal with climate change issues. Therefore, the third hypothesis of this research is

> H3: There is a strong positive, statistically significant relationship between the proportion of female directors on the BD and the climate change performance of the company.

In addition to the variables resulting from the characteristics of the BD, we verified whether the fact that a company is part of the Brazilian corporate sustainability index affects their climate change performance.

2.1.4 Corporate sustainability index

According to Bovespa (2017), the Corporate Sustainability Index (ISE; in Portuguese: *Índice de Sustentabilidade Empresarial*) seeks to create an investment environment compatible with the demands of sustainable development of contemporary society and stimulate corporate ethical responsibility. ISE is a tool for comparative analysis of the performance of listed companies on the Brazilian stock exchange, based on their corporate sustainability, economic efficiency, environmental balance, social justice, and corporate governance. It also broadens the understanding of companies and groups committed to sustainability, differentiating them in terms of quality, level of commitment to sustainable development, equity, transparency and accountability, product nature, and business performance in the economic, social, and environmental dimensions. A study by Vital et al. (2009) compared performance, through financial indicators, between companies, which are part of the Corporate Sustainability Index and companies, which are not, in order to verify if the adoption of sustainable practices generates value. The present study stands out as it investigates if the companies adhering to the ISE have a greater climate change performance compared to non-ISE companies.

It is understood that the companies of the ISE are companies with a greater commitment or involvement in environmental issues and they are selected based on this criterion. It should be noted that no empirical research was found to verify if there is a relationship between ISE companies and the climate change performance when compared to the climate change performance of non-ISE companies. Therefore, we tried to find out if there was any relationship. Thus, the fourth hypothesis of the research is

H4: Brazilian companies that are part of the ISE have better climate change performance than those, which are not part of it.

3 Method

The main objective of this study was to examine the relationship between the composition of the BD and the climate performance of Brazilian companies. To achieve this, the answers to the CDP questionnaires were used, more specifically the scores obtained from the response to the questionnaire regarding the climate change performance. Thus, the sample in this investigation corresponds to all the companies listed on the Brazilian stock exchange, which answered the questionnaire of the Carbon Disclosure Project referring to the year 2014 to 2018.

We consider 5 years of study because it represents a sufficient period to reach robust and consistent results. When we collected the data from this investigation, the CDP reports for the year 2019 were not yet available. Therefore, we consider the most recent year 2018 and the final year 2014, a period of 5 years. To achieve the proposed objective, this study is based on publicly available CDP data. CDP is a non-profit organization that, on behalf of investors, operates the global disclosure system for investors, companies, cities, states, and regions to manage their environmental impacts (CDP 2018).

When it comes to gathering data from organizations on climate management, the CDP is the most valuable and comprehensive base. CDP collects company data on climate and environmental changes (forests, water, etc.) on a voluntary basis. It asks companies to provide data on their environmental performance. The CDP then transforms this data into detailed analyses of critical risks, opportunities, and environmental impacts. Finally, decision-makers such as investors and climate policymakers use this data to support their decisions, manage risks, and capitalize on opportunities (CDP 2018). The CDP database is generally used by investors and academics for commercial and academic purposes (Hahn et al. 2015) and is rated as one of the most reliable sources of sustainability data by specialists (SustainAbility 2012). In order to collect data, we followed the following step by step:

Step 1—we first accessed the official website of the CDP (https://www.cdp.net/en) in order to collect data from all Brazilian companies that answered the CDP questionnaire from 2014 to 2018. There were some 733 published reports, of which 122, 123, 138, 133, and 222 were, respectively, in 2014, 2015, 2016, 2017, and 2018. Of these companies, 77 provided consistent data that were evaluated by the CDP during the period from 2015 to 2018. At this stage, we collected the scores of the 77 companies. These scores represent the dependent variable of the regression model.
Step 2—we then accessed the official website of each company individually to collect information on the corporate governance structure, specifically information on the

composition of the BD (the list of companies with their respective links to access its official website is available on the official website of the São Paulo Stock Exchange: http://www.b3.com.br/pt_br/). On the stock exchange website, it was also possible to collect information about the activity sector of each company (http://www.b3.com.br/pt_br/). On the official website of each company, we also collect financial information, i.e., Total Assets and Profit (for being listed companies, all made publicly available information: financial information, information on corporate governance, etc.).

Step 3—finally, we accessed the ISE website (http://iseb3.com.br/) where it was possible to identify the companies that answered the CDP questionnaire for 2014 to 2018 and that are part of the ISE.

As can be noted in Table 1, of the 77 companies in the initial sample, we could not access data from five companies. Thus, the sampling procedure resulted in a sample of 72 companies per year totaling 360 observations (72 × 5). Finally, the final sample of this study was composed of 72 companies listed on the São Paulo Stock Exchange. These companies consistently responded to the annual CDP questionnaire and scored between 2014 and 2018.

3.1 Variable description

After receiving company data, the CDP evaluates the answers provided according to predefined criteria. It is worth remembering that the information provided by companies about climate change can be qualitative (political engagement strategies related to climate change issues) or quantitative (for example, number of climate projects implemented, total annual

Table 1 Sample composition

Sector	N
Banks and financial institutions	8
Chemicals	1
Construction and engineering	4
Education services	1
Electric utilities	14
Food, beverage, and tobacco	7
Health care	3
Household and personal products	1
Information technology	1
Insurance	2
Machinery and equipment	1
Metals and mining	2
Oil and gas	3
Other services	2
Paper and forest products	3
Real estate	1
Retailing	5
Telecommunications	2
Transportation	9
Water utilities	2
Firm-year observations (average of the years 2014–2018)	72
Firm-year observations (2014–2018)	360

Source: Created by author based on CDP data (years 2014–2018)

N number of companies

carbon emissions among others). The CDP developed a methodology for evaluating companies' responses, with the contribution of scoring partners, respondents, investors, NGOs, and other partners (CDP 2017).

At the end of the evaluation, the number of points assigned to a company (the numerator) is divided by the maximum number that could have been assigned (the denominator). The methodology provides two scores for each respondent of the questionnaire: a disclosure score and performance score. Then, the fraction is converted to a percentage multiplying by 100 and rounded to the nearest whole number. The formula for calculating the score is presented in Eq. 1:

$$\text{Disclosure–performance} = \left(\frac{\text{Points achieved}}{\text{Points achievable}}\right) \times 100 \qquad (1)$$

where disclosure is the disclosure score, performance is the performance score, points achieved represent the point reached by the company after the evaluation of the CDP, and points achievable represent the maximum point that could be obtained.

3.1.1 Disclosure score

The *climate disclosure score* evaluates the level of detail and comprehensiveness of a disclosure. The response should clearly show the risks and opportunities related to climate change specific to the company's business, as well as a good management practice for assessing and understanding GHG emissions. Thus, the score of the level of climate disclosure is normalized on a scale of 100 points. Generally, the range in which companies fit in suggests levels of commitment and experience related to carbon transparency (CDP 2017). For those companies that have chosen to make their answers available publicly, this score is available on the CDP website.

However, in this study only the climate *performance score* was considered since the *climate performance* score already covers the *disclosure score*; that is, the *performance score* considers all elements of the *disclosure score* and goes beyond incorporating concrete actions and policies developed companies.

3.1.2 Climate performance score

The *climate performance score* assesses the level of actions, policies, and strategies taken on climate change provided to CDP. The carbon performance variable score is the complement of the climate change variable and can be seen as a tool to recognize companies that are taking concrete measures to mitigate climate change (CDP 2017). It is worth remembering that after calculating the carbon performance score, the CDP converts into one of the six bands: A+, A−, B, C, D, and E. Where the band "A+" represents the highest, indicating "integrated, leading to maturity in climate change initiatives" (CDP 2015). The band "E" for example indicates little evidence of initiatives in climate management. For the purpose of this research, we consider the following climate performance (Table 2) according to the CDP bands:

Recalling that CDP does not give a *performance score* for companies whose climate *disclosure score* is below 50%. For this reason, it is common to see a company respond to the CDP questionnaire, however, not to get any performance score. On the other hand, the performance score from 2016 took into account one of the eight bands: A, A−, B, B

Table 2 Performance score until 2015

Flag	A+	A−	B	C	D	E
Score (%)	100	95	85	60	40	20

−, C, C−, D, and D−. For the operationalization of this work in accordance with the methodology of the CDP (2016), it was considered for the score of the level of climate performance as follows:

Thus, for this study, each flag is converted according to their respective scores as shown in Table 3. As a proxy for the climate performance variable, in this study, we used the scores of the companies' climate performance. These climate performance scores are derived from the CDP's assessment based on information submitted about climate change management. Thus, for the analyses of this study, the present study considered the average performance of 5 years of study (2014 to 2018). It is important to note that CDP's performance scores are not necessarily the best measure of climate performance. Since there is always the likelihood of "creative writing" leading to higher CDP scores even with all the efforts employed by CDP to reduce this fact. However, in this study, we assume that the likelihood of this creative writing happening is the same among all companies; therefore, it will not influence the results. Even so, it is important to emphasize this point since all the statistical analyses in this study are based on these scores. Therefore, this is one of the limitations of this study.

3.2 Statistical analysis

In order to achieve the objective of the study, a multiple linear regression model was used. Here, the climate performance score is a function of the size of the board of directors, the proportion of women on the board of directors, the proportion of the number of non-executive independent director in the board of directors, ISE participation, the size of the company, the level of corporate governance, the activity sector, and financial performance.

The climate change performance obtained from the CDP score represents the response variable. The characteristics of the board and ISE represent the explanatory variables in this study. In addition, there are control variables included: size of the company (see for example Kouloukoui et al. 2019; Amran et al. 2014; Stanny and Ely 2008; Freedman and Jaggi 2005; Patten 2000; Hackston and Milne 1996), the level of corporate governance (see Da Silva Gomes et al. 2017), sector of activity (see Amran et al. 2014; Hackston and Milne 1996; Williams 1999), and financial performance (see Braga et al. 2009; Stanwick and Stanwick 2000; Hackston and Milne 1996). These control variables are used in order to isolate their effects on the dependent variable of this study, and thus to obtain only the influence of the variables relating to the board of directors and ISE participation, the object of this research. This is because these variables have already been identified as potential explanatory factors of the level of environmental and climate change disclosure in the literature. Finally, we constructed the econometric model to follow in Eq. 2:

$$\text{Carbon performance} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \varepsilon \quad (2)$$

where

carbon performance is the performance score of CDP (average of the years 2014–2018), β_0 represents a constant, β_i are coefficients, χ_1 is the size of the BD, χ_2 is the percentage of the non-

Table 3 Climate performance score from 2016

Flag	A+	A−	B+	B−	C+	C−	D+	D−
Score (%)	100	95	85	80	60	40	20	0

executive director independent of the firm, χ_3 is the proportion of women in the BD, χ_4 is the ISE (a dummy variable that assumes values 1, when the company is part of the ISE and 0 otherwise), χ_5 is the size of the company—size (logarithm of the total assets (average of the years 2014–2018)), χ_6 is the level of corporate governance (CG) of the firm (a variable that assumes values 0, when the industry is not part of any CG level (without); 1, when it is inserted in level 1 (N1) of the CG; 2, when it is inserted in level 2 (N2); and 3, when it is inserted in the new market (NM) level), χ_7 is the sector of activity of the company—sector (the industries were classified by activity sector and then each sector is classified according to the Brazilian government's Law 10.165/00, in which the variable assumes value 0 when the industry is not classified in sectors of activity with environmental impact (without); value 1 when it is classified as small environmental impact (small); 2, in the medium impact (medium); and 3, high environmental impact (high)), χ_8 is the profitability of the company (profit/total assets (average of the years 2014–2018)), and ε represents error.

Based on the econometric model, the research model is presented in Fig. 1.

Before the statistical test itself, we conducted a series of preliminary tests. The data were tested for all assumptions that should be met when performing a multiple linear regression analysis; i.e., there should be no correlation between the independent variables and the variable should be normally distributed, in addition to the preliminary tests like test outliers. All the assumptions have been fulfilled.

4 Results and discussions

4.1 Descriptive statistics

In Table 4, we present the results of the descriptive statistics of the dependent variable, that is, the climate performance score.

The average performance of the first 2 years, 2014 and 2015, remained constant, but there was an increase in 2016, from 46 to 56%, but in 2017 there was a decrease from 56 to 53%;
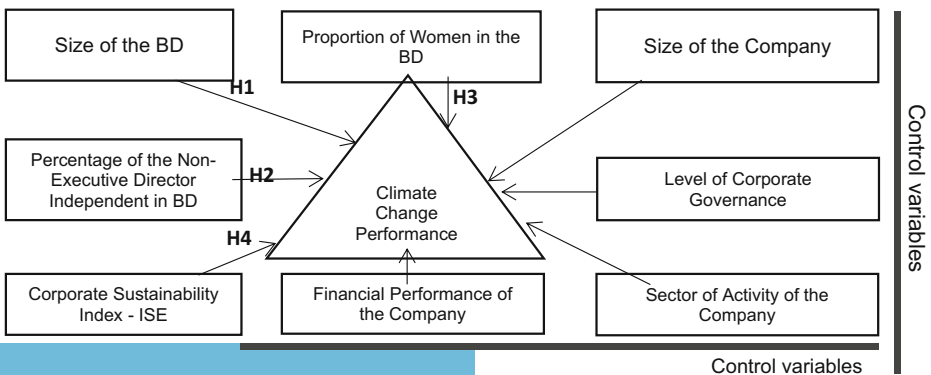

Fig. 1 Research model of the relationship between climate performance and selected independent variables

also, in 2018, there was decrease to 48% in average scores. Finally, the overall average score was 50%.

In Table 5, we present the descriptive statistics of the dummy variables model. The results show that 37 of the sample companies representing 51.4% are part of the ISE and 48% are not part of it. As for the variable sector of activity, ten companies representing 13.9% are from the sector of high environmental impact (for example, oil and gas, mining), 47% of the companies are from the medium environmental impact sector, and 38.9% of the companies are classified as operating in environmental impact activity (for example, banking sector). It is worth noting that although Law 10.165/00 of the Brazilian government classifies these sectors of activity as having no environmental impact does not mean that they do not generate any impact. This only means that these companies operate in sectors that do not directly generate impact through activities that could attack directly the environment. Most of the companies in the sample (59.7%) are from the new market (NM), level of corporate governance of the São Paulo stock exchange, the highest, most demanding level.

Table 6 presents the descriptive statistics of continuous variables of the model. The minimum size of the BD was three members and the maximum were 14 members. It is noted that the sum of all BD members in the sample was 620 members, of whom only 59 were female (9.5%), while 90.4% were male, demonstrating that there is an imbalance of the members of the BD's diversity. The independent members were 219 (35%) better than the percentage of women in the BD. For the size of the company variable, the logarithm (base 10) was applied before statistical modeling.

It is worth remembering that, before doing the modeling, the proportion was calculated for the variable *woman on the BD* (number of women on the BD divided by the number of the total

Table 4 Climate performance score average (2014 to 2018)

Sector	No. of firms	2014	2015	2016	2017	2018	Mean
Banks and financial institutions	8	63	62	76	68	69	67
Chemicals	1	85	95	100	100	100	96
Construction and engineering	4	30	30	30	29	48	33
Education services	1	0	0	0	0	0	0
Electric utilities	14	45	45	59	51	40	48
Food, beverage, and tobacco	7	55	55	68	61	46	57
Health care	3	20	20	33	33	20	25
Household and personal products	1	85	85	85	85	85	85
Information technology	1	20	20	20	20	20	20
Insurance	2	50	50	40	40	40	44
Machinery and equipment	1	60	60	85	60	20	57
Metals and mining	2	63	63	78	78	53	67
Oil and gas	3	68	60	83	77	63	70
Other services	2	20	20	20	20	20	20
Paper and forest products	3	77	60	95	90	90	82
Real estate	1	20	20	20	20	20	20
Retailing	5	28	28	31	40	48	35
Telecommunications	2	40	50	85	73	60	62
Transportation	9	43	46	48	48	47	46
Water utilities	2	30	40	30	30	30	32
Total geral	72	46	46	56	53	48	50

The averages were rounded to the nearest whole value, the values are in percent

Table 5 Descriptive statistics of categorical variables of the model

ISE	Freq.	%	Environmental impact	Freq.	%	Corporate governance	Freq.	%
Yes	37	51.4	High	10	13.9	NM	43	59.7
No	35	48.6	Medium	34	47.2	N2	6	08.3
			Small	0	00.0	N1	11	15.3
			Without	28	38.9	Without	12	16.7
Total	72	100.0	Total	72	100.0	Total	72	100.0

ISE = Corporate Sustainability Index, Freq. = frequency, high = when the industry is classified in sectors of activity with high environmental impact, medium = when the industry is classified in sectors of activity with medium environmental impact, small = when the industry is classified in sectors of activity with small environmental impact, and without = when the industry is not classified in sectors of activity with environmental impact. NM = new market level of corporate governance (CG), N2 = level 2 of CG, N1 = level 1 of CG, and without = when the industry is not part of any CG level

members of the BD) and for the variable *number of independent directors on the BD* (number of directors independent in the BD divided by the numbers of the total member of the BD).

4.2 Hypothesis testing

This section presents the results of the statistical modeling between the dependent variable and the independent variables with the control variables. Thus, to examine whether there was any statistically significant relationship between any of the independent variables and the dependent variable (the climate performance scores), multiple regression was used based on the econometric model of Eq. 2. The modeling results can be seen in Table 7.

Table 7 shows that 55.36% of the variations in the climate performance score are explained by the variations of the model variables. It was also observed that the value of the F statistic was 9.7724, significant at the 5% level and that the predictive power of the model corresponds to 49.70% (R-squared adjusted). Mathematically, the equation of the regression model can be written as

$$\text{Carbon performance} = -98.43 + 2.15x_1 + 26.61x_2 - 26.97x_3 + 16.78x_4 + 13.93x_5 - 0.76x_6 + 8.53x_7 + 32.45x_8 . \quad (3)$$

As shown in Table 7, on the one hand, the results indicate that the size of the BD is significant at the 10% level and positively related to the climate performance score. Therefore, we reject the hypothesis H1 raised in this study that there is a strong statistically significant negative

Table 6 Descriptive statistics of continuous variables of the model

	N	Minimum	Maximum	Sum	Mean	SD
Climate performance score	72	0.0	100,0	3597	50.0	30.00
Size of board of directors (BD)[a]	72	3.0	14,0	620	9.00	2.00
Women on the BD	72	0.0	5,00	59	1.00	1.00
Independent directors on the BD	72	0.0	9,00	219	3.00	3.00
Profitability[a]	72	−0.48	1.61	6.59	0.09	0.23
Size of the company[a]	72	738,248	1,313,892,017	6,779,737,751	94,163,024	262,319,294

SD standard deviation, BD board of directors

[a] Average of the years 2014–2018

relationship between BD size and climate change performance. From this result, we cannot affirm that the fact that the BD is composed of a small number of people justifies its efficiency and, consequently, more disclosure of climate change.

Those findings suggest that contrary to expectations, a large board of directors leads to greater concern about climate issues. Perhaps, due to the fact that with more members, they are likely to have at least one member or more who can defend the need to address climate change and persuade other board members to invest in climate mitigation, which can lead to involvement in climate issues.

On the other hand, it was found that the number of independent directors is significant at the 1% level and positively related to the climate performance score. This finding demonstrates that the increased percentage of independent directors on the BD drives companies to become involved in climate issues. This result is strongly supporting the H2 hypothesis of the finding that there is a statistically significant positive relationship between the number of independent directors on the BD and climate performance. This means that the more independent directors on the board, the greater the company's involvement in climate change issues.

This result is consistent with the assumption of agency theory as this theory suggests that an efficient BD is one that is composed of a larger number (proportion) of independent directors. We conclude that because it is efficient, the BD did not have a biased vision focused only on economic returns, but rather focused more on the three dimensions of sustainability, known as the triple-bottom line. According to the new standard of development, a company is sustainable if it can interact holistically among the three sustainability spheres (economic, social, and environmental aspects). This finding corroborated the findings of Amran et al. (2014), who also discovered the need to increase the number of external directors to improve a company's climate change performance.

The results indicate that, for the period and sample investigated, there is no statistically significant relationship between the proportion of women on the board and the climate performance at the significance level of 5%. Therefore, the hypothesis H3 raised in this investigation is rejected. Therefore, the number of women on the board does not influence the climate performance of the companies investigated. This finding is not

Table 7 Final results of the regression model

Model	Coefficients	Standard error	t Stat	Significance
Constant	− 98.4393*	29.8489	− 3.2979	0.0016
Size of board of directors (BD)	2.1558***	1.2837	1.6793	0.0980
Independent directors on the BD (%)	26.6142**	11.3110	2.3529	0.0218
Women on the BD (%)	− 26.9768	26.2521	− 1.0276	0.3081
ISE	16.7884*	5.5061	3.0490	0.0034
Size of the company	13.9321*	4.2598	3.2706	0.0017
Corporate governance	− 0.7638	2.2864	− 0.3340	0.7395
Sector	8.5332*	2.2835	3.7368	0.0004
Profitability	32.4503*	11.1833	2.9016	0.0051

$R^2 = 0.5536$, $F = 9.7724$ (significant at 5%), R-squared adjusted $= 0.4970$

BD board of directors

*Significant at $p < 0.01$, **significant at $p < 0.05$, ***significant at $p < 0.1$

consistent with Huse and Solberg (2006), who pointed out that the diversity of boards implies a higher orientation for the corporate social report and greater intensity of the social performance.

In fact, we cannot affirm with the support of empirical evidence that gender diversity on the BD leads to decisions that are aligned with the issues of global warming faced by each organization (Amran et al. 2014). According to these authors, gender diversity is aligned with agency theory, whereby it increases the independence of the board and reduces the conflict between the principal and the agent, providing a clear direction to deal with climate change issues. However, it is important to highlight that, concluding that gender diversity does not influence climate management; it seems premature since there are so few women represented in the DB. Thus, based on the characteristics of the sample data, the outcome on the impact of the proportion of women on climate management can be considered preliminary.

The results indicate that, for the period and sample investigated, for the ISE variable, there is a statistically positive relationship with the climate performance at the 1% level of significance. That is, the companies that are part of the ISE tend to achieve a higher score of climate performance. Thus, the fact that the company is part of the ISE leads to greater involvement in issues of climate than a company that is not part. Therefore, we accepted the hypothesis H4 raised in this investigation. In fact, ISE companies are selected based on a strict criterion, considering their commitment to socio-environmental and climate management issues. This result shows that, although ISE is a national evaluation tool, companies that can achieve it also stand out in international assessments such as the CDP evaluation.

In addition, evidence of the relationship between all control variables and climate performance was found in the exception of the variable level of corporate governance. Thus, we found evidence of a statistically significant positive relationship between the variables size of the company, sector, and profitability and the climate performance, at a significance level of 1%, thus indicating that the score of the companies was positively impacted by the size, sector of activity, and financial performance of the company of the sample study.

Several scholars point out the size of the company as a factor that influences climate management. This result suggests that the size of the company influences its level of climate change performance. Our findings are consistent with previous studies (Kouloukoui et al. 2019; Kouloukoui et al. 2018; Amran et al. 2014) that also found evidence of a positive relationship between firm size and climate management.

Another variable widely investigated by scholars as a potential influence of climate management is financial performance since the company depends on significant financial resources to invest in climate issues. Our finding suggested that there is a statistically significant and positive relationship between corporate financial performance and climate change performance.

Regarding the variable sector of activity, results are suggesting that companies in the high environmental impact sector had more proactive climate change performance than companies from other sectors. Finally, the last control variable, level of corporate governance, was not statistically significant. This means that on average and considering the size and characteristics of the sample of this study, companies ranked at a high governance level did not present a statistically significant higher climate performance than those ranked at a low level of corporate governance.

5 Conclusions

The main objective of this study was to examine the relationship between the composition of the BD and the climate management performance of Brazilian companies. To do so, the study was based on data from the CDP of a sample size equivalent to 72 companies, referring to the year 2014 to 2018, totaling 360 observations listed on the Brazilian stock exchange, which answered the questionnaire of the Carbon Disclosure Project referring to the period among 2014 and 2018.

The findings of this study contributed to the advancement of our understanding of which variables have the potential to boost or inhibit the companies' involvement in investing in climate mitigation and adaptation strategies and actions, that is, the need to discover the potential variables that may explain the level of commitment of companies on climate issues. As global recommendations for mitigation/adaptation strategies, this study suggests that the characteristics of the board composition may be an important tool that can be used to improve corporate climate management. The findings have shown that in fact, increasing the size of the board further, particularly increasing the number of independent directors in the BD, leads the company to have a greater commitment to climate issues. This result, although based on Brazilian companies, can have implications for the rest of the world's companies, since, regardless of country, the role of the board of directors remains the same, ratifying the important decisions of the organization.

Based on these results, it appears that one of the effective strategies to engage business in climate management may be increasing the number of independent directors in the board composition. For example, a practical strategy derived from this outcome is that the creators, majority shareholders, or even the body responsible for overseeing the stock exchange may require that companies have a minimum number of independent directors on the board of directors. In doing so, companies naturally became involved in climate change issues.

In addition, we found that companies that strive to be part of the ISE developed by the São Paulo capital market have a higher climate performance compared to companies that are not part of it. Demonstrating therefore that ISE is a key instrument to get companies increasingly worry about environmental issues in general and climate in particular. Thus, another strategy evidenced by the present study is that stock exchanges can also play an important role in the process of mitigation and adaptation, creating, for example, indicators of corporate climate change, so that companies participate and obtain scores. These scores can be based on proactive management of climate change, i.e., the mitigation and adaptation policies, actions, and strategies that the companies have in place to address these issues. Then, the scores can be made available by the body responsible for each stock exchange around the world.

This strategy can radically increase the level of involvement of companies in climate issues as they come from the official body responsible for the stock market, and as a result, investor powers can trust and bring those scores into the investment decision-making process. It is important to emphasize that these recommendations can be valid not only for the Brazilian companies of the sample but also for the other Brazilian companies besides and the companies that are not Brazilian, that is, the rest of the companies of the world. Thus, this study contributed to global recommendations for mitigation strategies or adaptation to global change in the corporate context. Thus, as

global recommendations for mitigation/adaptation strategies, capital markets around the world can also play an important role in the climate mitigation and adaptation process by creating ISE-like instruments and creating incentives for companies to strive to adhere to these instruments. Finally, efforts to promote mitigation and adaptation in Brazil and around the world will require the more active participation of all, including business. In the case of business, this implies the need to find out which strategies are most effective that can be adopted to involve all companies in climate mitigation and adaptation globally. In this way, efforts to promote adaptation and mitigation in Brazil and globally in the corporate context will require, for example, increasing the proportion of the number of independent directors in the board and, secondly, creating or improving mechanisms for the disclosure and sharing of information. In addition, it is important to create best practices and comprehensive metrics for assessing the climate mitigation and adaptation policies, actions, and strategies that companies have in place to deal with its issues.

Moreover, this study contributed to the literature by demonstrating that size, activity sector, and financial performance are potential attributes strongly related to climate management, presenting, however, several limitations that need to be discussed as it opens the way for future research. The first one refers to the sample size, $n = 72$, in the 5-year period, from 2014 to 2018, totaling 360 observations, relatively small. This may limit generalizations, as it needs a large sample size to infer generalizations. Thus, the findings of this study are restricted to the companies investigated. This study considered only the companies that answered the CDP questionnaire and had consistently scored in the 5 years of the study and the companies are listed on the stock exchange of São Paulo. Thus, future research can investigate unlisted companies as well as small businesses.

Secondly, the findings, besides being restricted to the sample studied, are also restricted to the Brazilian context since it investigated only the Brazilian companies. This does not mean that the results of this study cannot serve as a basis for decision-making by managers, investors, and other stakeholders outside Brazil, only to keep in mind that the results are derived from Brazilian companies. Thus, future research should investigate what factors explain the climate management of companies considering other geographical contexts, thus comparing the results with those found in the Brazilian context.

Third, to assume that the CDP score is necessarily a good measure of climate change performance is questionable. Therefore, it is important to recognize that CDP scores are not necessarily the best measure of climate performance. Even with all of CDP's efforts together with its partners, there has always been a problem with creative writing leading to higher CDP scores, particularly when it comes to risk disclosures. However, it could be argued that the likelihood of creative writing is the same across companies, and therefore would not change the results. But it is something to think carefully about. In this sense, future studies may consider the performance of the Global Reporting Initiative (GRI) sustainability report for example and then compare the findings with those of the present study.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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