The Relationship between Board Gender Diversity in Brazilian Companies and Adhesion to the Carbon Efficient Index

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Abstract

Objectives: This study investigated the relationship between the presence of women in the Boards of Directors (BDs) and company adhesion to the Carbon Efficient Index (ICO2). Additionally, the study investigated whether company adhesion to the Corporate Sustainability Index (ISE) increases the likelihood of adhesion to the ICO2.

Method: The study adopted the logistic regression method, given that the dependent variable (ICO2) is binary. The sample included Brazilian companies that are part of the BrX100, and the study period was from 2011 to 2021. The study segmented the companies into two sub-samples: one group composed of potentially more polluting companies, and one group composed of potentially less polluting companies.

Results: We found a positive relationship between the presence of women in BDs and adhesion to ICO2 for the group composed of more polluting companies, and when the BD was presided by a woman, this relationship happened in all subdivisions of the sample. The findings also indicated that companies that are more leveraged and have greater liquidity, greater market value, and more assets, are more likely to be part of the ICO2.

Contributions: The major contribution of this study is the classification of the sample into different groups of sectors related to gas emissions. This study is in line with three of the UN Sustainable Development Goals (SDGs): gender equality, innovation and action against climate change. In addition, the study is relevant because it showed that the protagonism of women in BDs leads to sustainable, environmentally efficient practices.

Keywords: Board Gender Diversity; ICO2 Index; Sustainability; Potentially Polluting Sectors.

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Introduction

In a global scenario of growing restrictions to GHG (greenhouse gas) emissions, investors have evolved their methods to identify companies that consider carbon disclosure a competitive advantage and not only a matter of environmental compliance. In this context, global industry leaders have been challenged to focus on incremental action to reduce GHG emissions (Rjiba & Thavaharan, 2022).

According to Konadu, Ahinful, Boakye e Elbardan (2022), environmental issues are multidimensional, resulting from several factors. Among these factors, carbon or GHG emissions are a reason for disquiet among corporations due to the attention given to this issue by many stakeholders. The demand for information on how corporations have been managing the impact of their emissions affects their environmental investments, performance and value, and such information is essential for decision making by investors (Ben-Amar, Chang, & McIlkenny, 2017).

While companies face growing social, economic and regulatory pressure to improve the efficacy of their environmental management and reduce GHG emissions, academic researchers seek to improve the corporate governance (CG) mechanisms that contribute to reducing these emissions (Nuber & Velte, 2021). Companies that adopted good corporate governance practices in recent years have taken on the role of developing strategies to promote the reduction of carbon emissions into the environment, generating benefits for society and for their own performance (Walls, Berrone, & Phan, 2012). A growing body of research has associated various approaches to governance with the green performance of organizations (Fernández-Temprano & Tejerina-Gaite, 2020; Hassan & Marimuthu, 2018; Jitmaneeroj, 2018).

The diversity of the board of directors (BD) is one of the main corporate governance mechanisms indicated as relevant for improving company performance. Research on CG has highlighted that the diversity of the board in terms of age, experience, education, ethnicity and gender tends to improve knowledge, deliberation, and the skillset required to deal with increasingly large and complex companies (Hafsi & Turgut, 2013; Liao, Luo, & Tang, 2015; Tingbani, Chithambo, & Papanikolaou, 2020).

Among the various aspects of board diversity, gender diversity has stood out in the enforcement of ethical conduct and effective monitoring of agents to avoid unsatisfactory returns on investment (Konadu et al., 2022). Women in boards have shown social responsiveness by meeting stakeholder needs more effectively (Glass, Cook, & Ingersoll, 2016; Nuber & Velte, 2021). Gender diversity has become one of the critical components for effective CG practices, since it enables fair and equitable business evaluations and improves company performance (Terjesen, Sealy, & Singh, 2009; Vafaei, Ahmed, & Mather, 2015).

Women's protagonism in BDs and initiatives for carbon emission reduction have drawn the attention of the academy and the capital market (Nuber & Velte, 2021; Konadu et al., 2022), but there are still few studies in Brazil associating these two topics. In addition, Nuber e Velte (2021) found that board gender diversity is usually measured by the ratio between the number of women and total members of the board of directors, by the existence of a specific number of women in the board, or by diversity proxies such as Blau's index (Ben-Amar et al., 2017).

In summary, the literature indicates that women and men have different views on sustainability issues due to initial experiences through social interaction (Liu, 2018). Consequently, it is assumed that women are more conscious and concerned about the needs of other stakeholders and are more sensitive to environmental and social issues (Liu, 2018). Female leaders in boards of directors bring different values and characteristics for decision making, which have improved the strategies of firms (Nuber & Velte, 2021).

Considering this scenario, the goal of this study is to investigate the relationship between the presence of women in BDs and company adhesion to the Carbon Efficient Index (ICO2). The study sample encompasses all Brazilian companies integrating the IBrX100 of the B3, and the time interval for the analysis comprised the period from 2011 to 2021.

This study contributes to literature by demonstrating that managers should seek more diverse boards in terms of gender, given this association with the reduction of GHG emissions. In addition, the UN Sustainable Development Goals (SDGs) include a specific goal related to gender equality. This goal provides support for this study as it seeks to ensure the effective participation of women in all decision-making levels in politics, in the economy and in public life. Therefore, regulators seeking to reduce GHG emissions should consider implementing quota policies or incentives for more diverse boards.

In Brazil, measures to promote gender diversity are still fragmented and slow. For investors concerned with sustainability, this study suggests a holistic analysis of corporate governance, since it could help allocate capital or invest in portfolios with low carbon emissions based on board diversity.

In addition, the findings of Lu and Herremans (2019) and Khatri (2023) indicate a positive relationship between

the presence of women in BDs and the environmental performance of companies, particularly in sectors that cause more environmental impact and are more carbon intensive.

To examine the fact that company adhesion to the ICO2 is also influenced by the type of activity sector, this study, based on research by Khatri (2023); Konadu et al. (2022); Valls Martínez, Santos-Jaén, Soriano Román and Martin-Cervantes (2022); Lima, Mota, Prado and Oliveira (2020); Lu and Herremans (2019); Córdova, Zorio-Grima and Merello (2018), and on Law No. 10.165 of December 27, 2000 (Presidency of the Republic, Chief of Staff, Sub-Headquarters for Legal Affairs, 2000), subdivided the activity sectors of the companies in the sample into two subsamples: potentially more polluting sectors (high and moderate GHG emissions) and potentially less polluting sectors (low GHG emissions).

1 Theoretical Framework

1.1 Sustainability and Greenhouse Gas Emissions

In the face of the increasing public perception that climate change and threats to the planet are a reality, academic researchers, professionals and policy makers have been focusing on sustainability (Khlif, Karoui, & Ingley, 2022). More than 200 years of industrial activity have caused a radical change in the global climate system, leading to one of the biggest challenges faced by humanity (Wright & Nyberg, 2017). Global crises such as the Covid-19 pandemic, the devastating effects of forest fires and other extreme climate phenomena created a sense of urgency for change in human behavior, which is seen as the driver of these events (Khlif et al., 2022).

Elkington (1997) observed that a sustainable society would need to fulfill three conditions: (1) its usage rate of renewable resources must not exceed its regeneration rate; (2) its usage rate of non-renewable resources must not exceed the rate at which renewable substitutes are developed; and (3) its pollution emission rate must not exceed the assimilation capacity of the environment.

According to Quadrelli and Peterson (2007), the trend of increasing gas emissions is incompatible with the measures to alleviate the atmospheric concentrations of GHG; therefore, they are ineffective to prevent lasting climate change. In addition, actions taken by most company managers and the government are likely to further aggravate this issue (Rickards, Wiseman, & Kashima, 2014).

In its most recent report, the UN stated that the world would follow a "catastrophic path" towards global warming unless governments apply more effective measures to reduce the effects of GHG emissions, contributing to the well-being of society. The new report by the Intergovernmental Panel on Climate Change (IPCC, 2022) indicates that harmful carbon emissions were the highest in the history of humankind between 2010 and 2019, with increased emissions registered in all major regions of the world.

On the other hand, the sustainability issues caused by economic progress have increased the interest in environmental policy in recent decades (Valls Martínez, Rambaud, & Oller, 2019). In this context, companies, governments and societies have been debating climate adaptation, GHG mitigation, and the introduction of practices such as the Sustainable Development Goals of the United Nations Agenda 2030, the Paris Agreement in 2015, and, more recently, the United Nations Conferences on Climate Change, seeking a more sustainable planet.

This study is in line with the UN Sustainable Development Goals (SDGs) and its Agenda 2030. The UN Agenda 2030 encompasses the environmental, economic and social dimensions of sustainable development, as well as good governance at all levels in an integrated and interrelated way. There are 17 Sustainable Development Goals (SDGs) and 169 global action targets to be achieved by 2030. This research is related to goal 5 (Gender Equality), goal 9 (Industry, Innovation and Infrastructure), and goal 13 (Action against Global Climate Change)

Naciti, Cesaroni and Pulejo (2022) found a significant increase in the number of publications on CG and sustainability in recent years. Van Eck and Waltman (2017) analyzed publications from 1999 to 2019 and observed the major foundations of CG and sustainability. The authors identified a transition from abstract concepts, such as "society", "ethics" and "accountability", to more tangible terms, such as "board size", "independent board" and "directors". In their analyses, Naciti et al. (2022) indicated that CG and the literature on sustainability have evolved from a rather conceptual approach into more strategic and practical studies, while their theoretical roots may be associated with a series of studies grounded on Stakeholder Theory, Agency Theory and Voluntary Disclosure Theory.

Human Capital Theory relates the presence of women in boards to an increase in the amplitude of board capital in different dimensions (Charumathi & Rahman, 2019). In addition, Critical Mass Theory states that boards with three or more directing women tend to influence decision making (Silva, 2020), which results in ample environmental disclosure (Charumathi & Rahman, 2019).

The participation of women in corporate boards has been increasing considerably (Charumathi & Rahman, 2019), given that organizations with boards composed of directing women are more likely to approach emerging strategic matters in climate change (Prudêncio, Forte, Crisóstomo, & Vasconcelos, 2021), improve the strategy for disclosing

GHG emissions, and communicate sustainability actions to stakeholders (Konadu et al., 2022; Tingbani et al., 2020; Vall Martínez, et al., 2019; Charumathi & Rahman, 2019).

1.2. Initiatives for Disclosing Greenhouse Gas Emissions

Research carried out in the past decade has identified the factors determining the disclosure of information related to GHG emissions (Córdova et al., 2018). The authors highlighted that there is a growing demand for information by a portion of the capital market, as well as pressure from stakeholders concerned about climate change.

In response to social, economic and regulatory pressure on companies to improve the efficacy of CG and the mechanisms to reduce GHG emissions (Luo, Lan, & Tang, 2012), a growing number of organizations has established strategies to mitigate and disclosure their carbon indices (Gallego-Alvarez, Segura, & Martíinez-Ferrero, 2015).

In this context, carbon disclosure is evidenced through voluntary or mandatory reports of GHG emissions and other quantitative and qualitative information using structures such as the Carbon Disclosure Project (CDP), the Climate Disclosure Standards Board (CDSB), and the Task Force on Climate-related Financial Disclosures (TCFD) (Goloshchapova, Poon, Pritchard, & Reed, 2019).

Differently, the Carbon Performance (CP) index shows GHG emissions that are real or oriented by a company's results. The CP index is more associated with the carbon intensity on the underlying assets and with the resulting transition risk, which has been increasingly priced as a risk premium (Clark, 2019).

Some studies use Bloomberg CDP scores (Hahn, Reimsbach, & Schiemann, 2015; Velte, Stawinoga, & Lueg, 2020), while others use CP, whose indices are results-oriented (Haque, 2017; Qian & Schaltegger, 2017). In addition, there has been research on various factors associated with carbon disclosure and performance, such as governance factors specific of a country (Peng, Sun, & Luo, 2015), while other studies use CG actors such as characteristics of the board, ownership concentration and stakeholder influence (Haque, 2017).

Another important raking is Standard & Poor's 500 Carbon Efficient Index, or S&P 500 CEI, which was designed to measure the performance of companies in the S&P 500 and whose methodology weights companies that have lower or higher levels of carbon emissions per unit of revenue (S&P 500, 2022).

In the Brazilian market, there is an important corporate index focused on this issue, the B3 Carbon Efficient Index (ICO2), which is similar to S&P 500 CEI. Created in 2010,

the purpose the ICO2 has had from its inception is to be an instrument to induce discussions on climate change in Brazil. Companies adhering to this index demonstrate their commitment to transparency regarding emissions, which anticipates views on how they are preparing for a low-carbon economy (B3, 2022).

1.3. The Importance of Gender Diversity for Sustainable Development

The current scenario of interest in sustainability has prompted a growing debate on climate change, and some researchers have focused explicitly on studies associating gender diversity with environmental results (Birindelli, Iannuzzi, & Savioli, 2019; García Martín & Herrero, 2020; Haque & Jones, 2020).

Institutional theories indicate that reaching economic success is not enough for a company to survive, since it must also obtain legitimacy through compliance with the law (DiMaggio & Powell, 1983; Meyer & Rowan, 1977). The issue of legitimacy is emphasized by the Resource Dependence Theory (Pfeffer & Salancik, 1978), which is used to provide grounds for the presence of women in boards. According to this theory, the board of directors provides companies with advice, legitimacy, and access to communication channels (Hillman, Shropshire, & Cannella Jr., 2007; Hillman, Withers, & Collins, 2009).

Atif, Hossain, Alam and Goergen (2021) found a positive relationship between the presence of women in the board and the consumption of renewable energy. Hasan, Kobeissi, Liu and Wang (2018) examined the impact of gender diversity on violations of corporate environmental policies, and found a reduction in the frequency of such violations related to a larger presence of women in the board. In addition, the authors showed that more diversity improves a company's environmental policy, leading to a lower risk of disputes and conflicts.

Based on extensive discussion on regulation and business practices, according to Nuber e Velte (2021), the presence of women in the board is one of the most important CG and sustainability proxies since the 2008-2009 financial crisis triggered by the housing bubble in the United States. The studies by Dawar e Singh (2016) and Velte (2017) indicated a positive relationship between the presence of women and sustainable mechanisms. Though a meta-analysis of 87 studies, Byron and Post (2016) found a positive impact related to the presence of women in the board and sustainability performance.

Studies on this topic show a positive impact associated with the participation of women in the board on indicators related to environmental issues (Baalouch, Ayadi, & Hussainey, 2019), environmental processes (Liu, 2018), biodiversity issues (Haque & Jones, 2020), carbon emissions (Elsayih, Tang, & Lan, 2018; Liao et al., 2015;

Tingbani et al., 2020), and on the innovation of green products (He & Jiang, 2019).

Burkhardt, Nguyen and Poincelot (2020) and Galia, Zenou and Ingham (2015) found a positive impact associated with the presence of women in the boards of companies in France. These positive results are supported by the Chinese (Elmagrhi, Ntim, Elamer, & Zhang, 2019) and the North-American (Li, Zhao, Chen, Jiang, & Shi, 2017; Lu & Herremans, 2019) capital markets.

Regarding carbon disclosure, Tingbani et al. (2020) and Ben-Amar et al. (2017) found a positive influence related to the proportion of women in the boards. In addition, since directing women are considered more active in the relationship with stakeholders, environmental and political concerns regarding climate change are promoted by them. Consequently, companies with a higher female participation in the board naturally incur lower carbon emissions (Nuber & Velte, 2021).

Tauringana and Chithambo (2015) found a positive relationship between CG practices and carbon information in the period from 2008 and 2011. The authors analyzed a sample of 215 companies in the Financial Times-Stock Exchange 350 index in London and developed a GHG disclosure index, concluding that CG variables such as board size and ownership concentration affect the extent of carbon disclosure. With another sample of companies in the United Kingdom, Liao et al. (2015) examined the impact of the characteristics of corporate boards in the voluntary disclosure of GHG emissions, and found a positive relationship between gender diversity (measured as a percentage of women in the board) and the likelihood of disclosing initiatives related to GHG emissions.

In turn, the research findings of García-Sánchez, Monteiro, Piñeiro-Chousa and Aibar-Guzmán (2023) for a data sample of 3,928 companies in the period from 2010 to 2020 indicated that companies with a higher representation of women in the board are more efficient in terms of investment in climate change. In the same line, Toukabri and Jilani (2022), based on the sample of North-American companies, found that the presence of women in the board positively affects carbon and climate change disclosure; in addition, Wang, Tang and Guo (2023) found that gender diversity promotes corporate carbon proactivity.

2.4. Formulation of Hypotheses

Based on the literature analyzed (Liao et al., 2015; García-Sánchez, Monteiro, Piñeiro-Chousa, & Aibar-Guzmán, 2023; Toukabri e Jilani, 2022; Wang et al., 2023), this study formulated the following hypotheses:

H1: The presence of women in boards of directors is associated with a higher adhesion of companies to the Carbon Efficient Index (ICO2).

H2: When held by a woman, the presidency of the board is associated with a higher adhesion of companies to the Carbon Efficient Index (ICO2).

In addition, we found that the relationship between female presence in the board and sustainability stated in hypotheses H1 and H2 could be more or less intense based on a sectorial analysis, that is: in companies belonging to potentially more polluting sectors, the presence of women in sustainable initiatives could more active. In that regard, Wallace, Naser and Mora (1994) mentioned that different sectors could provide different levels of disclosure due to the unique characteristics of each sector. Reverte (2009) observed that sectors with higher negative impacts on the environment provide more information in environmental reports than other sectors. Lu and Herremans (2019) and Khatri (2023) provided evidence of the relationship between the presence of women in boards and the environmental performance of companies, particularly in sectors that cause more environmental impact and are more carbon intensive. Based on the above, we formulated the following hypothesis:

H3: For potentially more polluting companies, the association between the presence of women in the board of directors and adhesion to the ICO2 is more intense.

2 Methodological Procedures

2.1 Sample and Data Source

The sample involved all companies that compose the Brazil 100 Index (IBrX100) of the Brazilian B3. This index was chosen for two reasons: the fact that it is the indicator for the average performance of the 100 most negotiated and most representative assets in the Brazilian stock market, and the fact that the ICO2 index is a portfolio of assets available exclusively for companies belonging to the IBrX100.

The time interval comprised the period from 2011 to 2021. The starting year for the period was chosen as 2011 because, after that year, there was a conversion of the Brazilian accounting model to fit the International Financial Reporting Standards (IFRS).

The outliers were treated through winsorization of the data with a 2.5% limit in the performance variables used in the analysis. The sample was treated in a general form as well as segmented into potentially more polluting sectors (those related to non-renewable energy generation, transport, industry, agriculture and construction) and potentially less polluting sectors (those related to technology, purchase and sales of goods and services, and similar).

2.2 Research Variables

The dependent, independent and control variables are

shown in Table 1 below.

Table 1 – Research variables and their reference authors

Variable	Acronym	Measure	Expected Count	References
Dependent Variable				
Carbon Efficient Index	ICO2	*Dummy that takes a value of 1 for IBrX100 companies that adhere to the ICO2, or 0 otherwise.*		Konadu et al. (2022) Rjiba and Thavaharan (2022) Lima et al. (2020)
Explanatory Variables				
Sustainability Index	ISE	*Dummy that takes a value of 1 for companies that participate in the ISE, or 0 otherwise.*	+	Freitas, Souza, Fontenele e Rebouças (2018) Teixeira, Nossa e Funchal (2011)
Presence of Women	FemCA	Percentage of women in the BD	+	Peixoto et al. (2022) Konadu et al. (2022) Prudêncio et al. (2021)
Presidency of the board	PresCA	*Dummy that takes a value of 1 when a woman is the president of the BD, or 0 otherwise.*	+	He, Zhou e Yang (2021)
Board size	TamCA	Amount of members in the BD	+/-	Peixoto et al. (2022) Tauringana e Chithambo (2015)
Independence of the board	IndCA	Proportion of independent members in the BD	+/-	Peixoto et al. (2022) He, Zhou e Yang (2021)
Age of board members	IdadeCA	Calculated by the average age of BD members	+/-	Giannarakis (2014) Prudêncio et al. (2021)
Control Variables				
Company size	TamFirma	Natural logarithm of total assets	+/-	Peixoto et al. (2022) Prudêncio et al. (2021) Rjiba e Thavaharan (2022)
Leverage	ALAV	Ratio between gross debt and total assets	+/-	Andrikopoulus e Kriklani (2013)
Return on Assets	ROA	Ratio between net income and total assets	+/-	He, Zhou e Yang (2021) Martínez et al. (2022) Prudêncio et. Al. (2021) Rjiba e Thavaharan (2022)
Stock market liquidity	LIQ	Stock market liquidity	+/-	Konadu et al. (2022) Krishnamurtia e Velayuthamn (2017)
Tobin's Q	QTOBIN	Sum of market value and total debt divided by total assets	+/-	Peixoto et al. (2022) Prudêncio et al. (2021) He, Zhou e Yang (2021) Rjiba e Thavaharan (2022)

Source: elaborated by the authors.

2.3 Research Econometric Model

The method adopted was logistic regression with panel data (Peixoto et al., 2022). In order to achieve the objective of this study, multivariate modeling techniques were applied, resulting in the following econometric model:

$ICO2_{it} = \beta_0 + \beta_1 \%ISE_{it} + \beta_2 \%FemCA_{it} + \beta_3 FemPR_{it} + \beta_4 TamCA_{it} + \beta_5 IndCA_{it} + \beta_6 IdadeCA_{it} + \beta_7 TamFirma_{it} + \beta_8 ALAV_{it} + \beta_9 ROA_{it} + \beta_{10} LIQ_{it} + \beta_{11} QTobinI_{it} + \varepsilon_{it}$

$$ICO2it = \beta0 + \beta1\%ISEit + \beta2\%FemCAit + \beta3FemPRit + \beta4TamCAit + \beta5IndCAit + \beta6IdadeCAit + \beta7TamFirmait + \beta8ALAVit + \beta9ROAit + \beta10LIQit + \beta11QTobinIit + \varepsilon it$$

The equation above was used to examine all the study hypotheses. The ε represents the error term, while the i represents the business unit, and t represents the point in time.

The Breusch-Pagan, Chow and Hausman tests were applied to define the best models for the regressions. The results obtained in the Hausman test led to the choice of the fixed effects model. The Variance Inflation Factor (VIF) test was performed to determine the existence of multicollinearity problems; the results did not indicate multicollinearity problems. In addition, the Wooldridge test and the Wald test were performed, which demonstrated the non-incidence of heteroscedasticity and autocorrelation. All regressions were performed using White's robust standard error.

3 4 Results and Discussion

3.1 Descriptive Analysis

The final research sample is composed of 97 companies, since 3 of the 100 companies owned 2 assets each in the IBrX100 portfolio.

Table 2 – Descriptive statistics the research variables

Variable	Note:	Mean	Standard Deviation	Min.	Max.
ICO2	1.067	0.2755389	0.4469949	0.00	1.00
ISE	1.067	0.2680417	0.4431469	0.00	1.00
FemBD	1.067	0.0789784	0.1012167	0.00	0.50
FemPR	1.067	0.0328022	0.1782022	0.00	1.00
BDSiz	1.067	7.460169	4.055092	0.00	23.00
IndBD	1.067	0.2853327	.2451189	0.00	1.00
BDAge	888	57.00075	5.737801	33.00	73.56
CompSiz	957	7.423218	0.6073855	6.47	8.90
LEV	957	0.2701254	0.187577	0.00	0.62
TOBINQ	957	1.153062	0.8066774	0.14	3.14
ROA	951	5.87062	4.481329	0.69	16.4
LIQ	862	0.7393283	0.710783	0.01	2.56

Grade: ICO2: B3 Carbon Efficient Index; ISE: B3 Sustainability Index; FemBD: Percentage of women in the board; FemPR: Presidency of the board held by a woman; BDSiz: Board size; IndBD: Independence of the board; BDAge: Average age of board members; CompSiz: Company size; LEV: Leverage; TOBINQ: Tobin's Q; ROA: Return on assets; LIQ: Stock market liquidity.

The result was similar for company adhesion to the ICO2 and ISE indexes, with approximately 27% of the companies in the sample participating in both indexes.

Regarding the governance variables, board size varied from no members to 23 members, with an average of 7 members. The data showed an average board independence of 28%, ranging from no independence to complete independence. The average age of board members was 57 years, ranging from 33 to 73 years. The proportion of women in the boards was 7%, and the proportion of women holding the presidency of the board was 3%.

Regarding the characteristics of the companies, the average company size (logarithm of total assets) was 7.4, with a standard deviation of 0.60, indicating low dispersion. The average leverage (LEV) was 0.27. The average ROA was 5.8% and the average company value (TOBINQ) was 1.15. The average liquidity (LIQ) was 0.73, ranging from 0.01 to 2.56.

3.2 Regression Results

Table 4 shows the regression results divided into 3 columns. Column A shows the estimated regression results including all companies in the sample. Columns B and C show the regressions for the group of companies in more polluting and less polluting sectors, respectively.

Table 4 – Logistic regression for all sectors, potentially more polluting sectors, and potentially less polluting sectors

Variable	All Sectors (A)	Potentially more polluting sectors (B)	Potentially less polluting sectors (B)
ICO2 (Dependent)			
ISE	0.6827***	0.8742***	0.1650
	(0.1972)	(0.2611)	(0.3814)
FemBD	1.2489	2.9982**	-3.3191
	(1.0364)	(1.3975)	(2.4174)
FemPR	1.5801***	1.5826**	1.7986**
	(0.5145)	(0.6329)	(0.7143)
BDSiz	0.1057***	0.1313***	0.1658
	(0.0342)	(0.0407)	(0.0918)
IndBD	-0.8561	-0.2557	-0.9227
	(0.4405)	(0.5740)	(0.7552)
BDAge	-0.0015	-0.0695***	0.1158**
	(0.0161)	(0.0219)	(0.0520)
LIQ	0.9193***	0.1787	1.6839***
	(0.1624)	(0.2536)	(0.2938)
CompSiz	0.4105	1.6450***	0.2233
	(0.2492)	(0.3999)	(0.4186)
ROA	-0.0152	0.0346	-0.0725
	(0.0241)	(0.0335)	(0.0446)
TOBINQ	0.1491	0.8076***	-0.3635
	(0.1421)	(0.2050)	(0.2695)
LEV	0.7807	1.8880**	5.4590***
	(0.4766)	(0.7843)	(1.522)
_cons	-5.5640***	-13.0015***	-10.3364
	(2.0866)	(3.0035)	(5.485)
Observations	836	546	290
Year	Sim	Sim	Sim
Sector	Sim	Sim	Sim
R²	0.2079	0.2606	0.3401

Significance: ** p<0.05, *** p<0.01

Table 4 shows a relationship between adhesion to the Corporate Sustainability Index (ISE) and to the Carbon Efficient Index (ICO2) at a 1% significance level, indicating that company adhesion to the ISE increases the likelihood of company adhesion to the ICO2, particularly for companies whose operations generate higher carbon emissions.

This finding is corroborated by Rosa, Guesser, Hein, Pfitscher and Lunkes (2015), who analyzed the determining factors for environmental disclosure in Brazilian companies

and found that the most evident aspects of disclosure are related to atmospheric emissions and other impacts.

Although the results did not indicate a significant association between a female presence in BDs and company adhesion to the ICO2 for the general sample and for potentially less polluting companies, the estimated result with companies in potentially more polluting sectors showed that the presence of women in BDs is positively associated with company adhesion to the ICO2 at a 5% significance level.

Therefore, the findings do not confirm hypothesis 1 completely. However, this finding confirms hypothesis 3, since there is a positive and significant association between the presence of women in BDs and company adhesion to the ICO2 for potentially more polluting companies. This finding is consistent with the research done by Lu and Herremans (2019) and Khatri (2023), who provided evidence on the positive relationship between the presence of women in boards and the environmental performance of companies, particularly in companies with higher carbon emissions.

When the presidency of the BD is held by a woman, the association between the presence of a female president and adhesion to the ICO2 is positive and significant in all subdivisions of the sample, at a 1% significance level for all sectors and 5% for each of the sector groups observed separately. Therefore, hypothesis 2 was also confirmed, which is in line with the evidence found by Nuber and Velte (2021), who associated female leadership with different values and characteristics for decision-making, and with Liu (2018), who found that women have higher sensitivity regarding environmental and social issues.

Regarding board size, a positive relationship with ICO2 was found at a 1% level for the complete sample and for the more polluting sectors, and at a 10% level for the less polluting sectors. Therefore, the findings suggest that larger BDs increase the likelihood of adhesion to the ICO2. This finding is in line with Tauringana and Chithambo (2015), who found a positive relationship between CG and board size and company commitment to initiatives to reduce carbon emissions.

The relationship between BD independence and company adhesion to the ICO2 was negative and insignificant in all subdivisions of the sample. This finding suggest that this characteristic of the board is not associated with adhesion to the ICO2.

The findings indicate other important aspects such as the relationship between the average age of BD members and adhesion to the ICO2. The presence of younger board members increased the likelihood of company adherence to the ICO2 in more polluting sectors; this finding was observed at a 1% significance level. This finding is

corroborated by Hafsi and Turgut (2013), who identified the benefits of the heterogeneity of opinions of young board members. On the other hand, when estimating for less polluting sectors, this relationship is inverse; that is, it is positive and significant at a 5% level, indicating that the presence of more experienced board members increases the likelihood of company adhesion to the ICO2 in this subgroup.

Regarding ROA, its association with company adhesion to the ICO2 is negative and insignificant for all samples. When it comes to the other control variables, the findings corroborate previous research, demonstrating that the decision by companies to adhere to the ICO2 is related to their characteristics, such as company size (Andrikopoulus & Kriklani, 2013; Córdova et al., 2018; Peixoto et al., 2022), liquidity (Krishnamurtia & Velayuthamn, 2017), leverage and sector (Córdova et al., 2018).

For company size, the findings indicated a positive association with adhesion to the ICO2 at a 1% significance level for all sectors, and at a 5% significance level for more polluting sectors.

The findings also showed a positive relationship between liquidity and company adhesion to the ICO2 at a 1% significance level for the general sample and for the less polluting sectors. For Tobin's Q, the findings indicated a positive relationship happening only for the group of companies in more polluting sectors. This finding suggests a positive association at a 1% level between the market value of companies and adhesion to the ICO2.

Lastly, leverage shows a positive and significant association with adhesion to the ICO2 when observed in the groups subdivided by sector. It was observed at a 5% significance level for companies in potentially more polluting sectors and at a 1% significance level for companies in potentially less polluting sectors.

Final Remarks

This study investigated the relationship between the presence of women in the Boards of Directors (BDs) and the adhesion of Brazilian companies to the B3 ICO2 index. In summary, the research sought to understand whether the participation of women in BDs is related to an increase in the likelihood of companies engaging in activities that minimize GHG emissions. The sample involved companies integrating the IBrX100 of the B3, and the time interval for the analysis comprised the period from 2011 to 2021.

Additionally, the study segmented the general sample into two subsamples, namely potentially more polluting sectors and potentially less polluting sectors in terms of GHG. The logistic regression model was adopted, given that the dependent variable (ICO2) is binary.

The findings showed that there is a positive relationship between adhesion to the ISE and to the ICO2, meaning that companies that are more committed to sustainability are more likely to be more aware regarding GHG emissions. This was even clearer in the subsample of potentially more polluting companies.

Considering the general sample, hypothesis 1 was not confirmed (H1: women's participation in BDs is associated with greater company adherence to the ICO2). However, a positive relationship was found between the presence of women in the board and adhesion to the ICO2 for the group of potentially more polluting companies, confirming hypothesis 3 (H3: for potentially more polluting companies, the association between the presence of women in BDs and company adhesion to the ICO2 is stronger). This result is consistent with previous research (Liao et al., 2015; Bem-Amar et al., 2017; Tingbani et al., 2020) that found an association between the representativeness of women in BDs and higher likelihood of company adhesion to initiatives related to carbon emission reduction.

Another important finding was observed for the relationship between the gender of the president of the board and adhesion to the ICO2. When held by a woman, the presidency of the board is associated with a higher likelihood of company adhesion to the ICO2. That was observed in all samples. This confirms hypothesis 2 (H2: when held by a woman, the presidency of the board is associated with a higher company adhesion to the ICO2) and corroborates Nuber and Velte (2021) and Liu (2018), who found that female leaders are associated with different decision-making values and characteristics.

This study also found that the decision of companies to adhere to the ICO2 is associated with characteristics of the company such as company size, liquidity, market value, leverage and sector, suggesting that companies that integrate the ICO2 are larger and have more liquidity and leverage. These findings are corroborated by previous research (Córdova et al., 2018; Peixoto et al., 2022; Krishnamurtia & Velayuthamn, 2017) associating companies involved in low carbon initiatives with important aspects such as the improvement of stock market liquidity and leverage, higher market values, and

larger assets.

The association between the age of board members and adhesion to the ICO2 is noteworthy, even though this study did not propose a hypothesis for this relationship. This study found that the presence of younger board members increases the likelihood of adhesion to the ICO2 for companies in more polluting sectors, corroborating Hafsi and Turgut (2013).

An important difference and contribution of this study compared to previous studies is the approach to gender diversity in BDs in association with the commitment of companies to sustainable initiatives and with the low carbon economy based on the classification of observation for different sectors related to GHG emissions. We found no other studies in Brazil adopting the approach of subdividing the sample into more polluting and less polluting sectors and analyzing the gender distribution of the board in relation to adhesion to the ICO2, indicating the innovative nature of this study.

One limitation of the study was the sample size. However, it is important to note that the authors carried out similar tests considering all B3 companies and opted to work with the 97 companies in the IBrX100, since the reliability measures of the models showed better results for this more restricted sample. For future research, we suggest analyzing more countries besides Brazil, adopting other proxies for corporate sustainability, and treating the age diversity of board members as a more prominent variable, using it to formulate research hypotheses.

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