

A multilevel analysis of greenhouse gas emissions and corporate disclosure in the healthcare sector

Análise multinível das emissões de gases de efeito estufa e divulgação corporativa no setor de saúde

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Abstract

Purpose: This paper aims to investigate what factors can influence the volume of Greenhouse gases (GHG) emissions and firm disclosure of this information from firms in the healthcare sector.

Originality/value: The paper proposes a novel approach to distinguish the total emission of GHG from the disclosure of GHG information while addressing both the internal and external environment of the firm and the link between them in a multilevel analysis comprised of distinct theories (*signaling theory, resource-based view and Varieties of capitalism approach*).

Design/methodology/approach: We run an unbalanced panel with 13,680 observations from a sample of 2,736 firms in the healthcare sector using Feasible generalized least squares (FGLS) and Binary Logit, both in multilevel analysis.

Findings: The paper shows that firms with more financial resources, larger boards and with an increased number of independent board members tend to disclose more information on GHG emissions. In addition, companies headquartered in coordinated capitalism countries are less engaged in the disclosure of GHG information and emit more GHG. We bring attention to how the composition of the board of directors serves as a medium between the internal and external environment of the firm that can influence the disclosure on GHG information to shareholders and stakeholders.

Keywords: healthcare, multilevel analysis, firm disclosure, GHG emissions, GHG disclosure



Resumo

Objetivo: Este artigo tem como objetivo investigar quais fatores podem influenciar o volume de emissões de GEE e a divulgação dessas informações pelas empresas do setor de saúde.

Originalidade/valor: O artigo propõe uma nova abordagem para distinguir a emissão total de GEE da divulgação de informações sobre GEE, ao mesmo tempo que aborda o ambiente interno e externo da empresa e a ligação entre eles numa análise multinível composta por teorias distintas (sinalização, visão baseada em recursos e variedades do capitalismo).

Design/metodologia/abordagem: Executamos um painel não balanceado com 13.680 observações de uma amostra de 2.736 empresas do setor de saúde usando mínimos quadrados generalizados viáveis (FGLS) e logit binário, ambos em análise multinível.

Resultados: O artigo mostra que as empresas com mais recursos financeiros, conselhos de administração maiores e com um maior número de membros independentes tendem a divulgar mais informações sobre as emissões de GEE. Além disso, as empresas sediadas em países com capitalismo coordenado estão menos envolvidas na divulgação de informações sobre GEE e emitem mais GEE. Chamamos a atenção para como a composição do conselho de administração serve como um meio entre o ambiente interno e externo da empresa que pode influenciar a divulgação de informações sobre GEE aos acionistas e partes interessadas.

Palavras-chave: saúde, análise multinível, divulgação firme, emissões de GEE, divulgação de GEE



INTRODUCTION

Research on emissions or disclosure of information on Greenhouse gases (GHGs) has focused on sectors such as farming, agriculture, and fish-farming as they have a big share of responsibility for the emission of GHGs worldwide. This trend leads to a research gap in relation to other economic activities of primary social need, such as healthcare (Uyar et al., 2021), which considers hospitals, pharmaceutical, laboratory analysis, medical device manufacturers, among others (Ahmed et al., 2021).

Recently, the Covid-19 pandemic put the healthcare sector at the center of the spotlight, confirming its position of global relevance in the production and supply chain of essential items. The event exposed society's level of dependence on this sector, which still faces growing challenges such as compliance with increasingly strict environmental regulations (Quitmann et al., 2023). The institutional decision-making environment can also be an influencing factor regarding the disclosure of GHG information, given that coordinated economies present a context for greater environmental regulation and inspection than liberal economies (Bashir et al., 2023). This aspect can impact in different ways on the process of development and maturity of the green industry. In addition to the matter, it is also necessary to make a distinction between the disclosure of GHG information from the actual emission of GHGs.

Combining both problematizations under a single investigation, this research aims to answer the following question: what factors can influence the volume of emissions and firm disclosure of this information from firms in the healthcare sector?

The data employed in this study consist of a sample of 2,736 firms from the healthcare sector in 11 countries obtained from the Thomson Reuters Eikon database for the period of 2016 to 2020. For estimations, we use two econometric models, one being a binary logit and the other being the feasible generalized least squares (FGLS). Each econometric model was presented in the three hierarchical levels, and a group of independent variables representing the correlated body of theories was inserted for each new level.

The study by Cristiano et al. (2024) found that per capita emissions from the healthcare sector increased between 2007 and 2016 in several countries worldwide, including the United States, Japan, and China. The healthcare sector is a major contributor to GHG emissions, particularly during pandemics. Hospitals, for instance, produce and release GHG emissions



through various channels, such as the transportation footprint of staff commuting and fleet management. Despite the significant innovations and social impact of the healthcare sector, research on its GHG emissions remains insufficient.

In this article, a novel approach is proposed when we distinguish the total emission of GHG from the disclosure of GHG information. The justification for this rests on the fact that in some research both are interchangeably used or may overlap, thus generating different results, such as whether greater firm disclosure, under the same explanatory factors, is also due to higher GHG emissions.

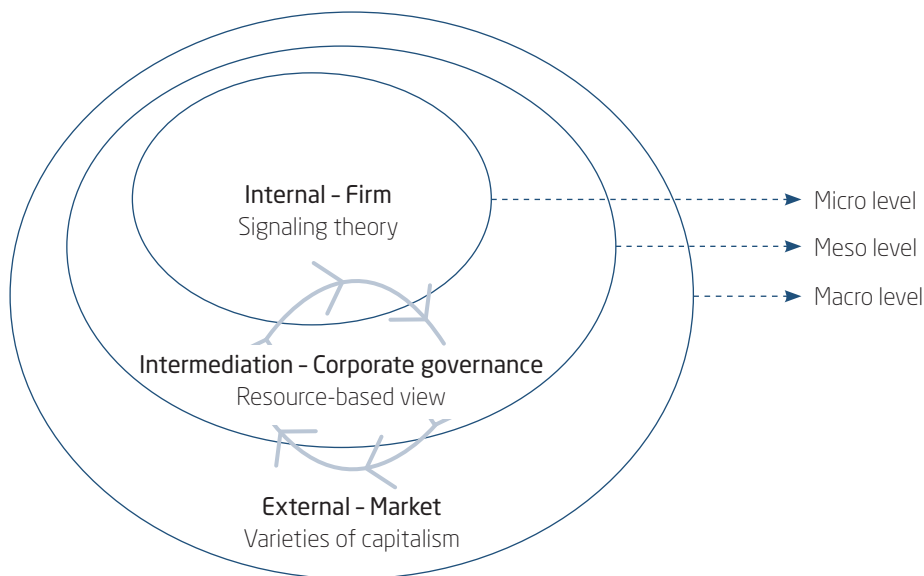
Research findings indicate that: i) larger firms with more financial resources tend to send more signals to the market about their GHGs emissions; ii) the size of the board positively affects GHGs emissions; iii) board diversity positively affects the disclosure of GHGs information; and iv) companies under coordinated capitalism emit more GHG and are less likely to disclose GHG information than companies under liberal capitalism. These results have significant implications for theory, management, and even government policy.

THEORETICAL BACKGROUND AND HYPOTHESES

The research hypotheses were developed considering three levels of interaction of firms with the disclosure and emission of GHGs, as illustrated in Figure 1.

At the micro level (Signaling Theory), the company manages its internal resources, particularly financial performance, to disclose information about its GHG emissions. At the meso level (Resource-Based View), the company's corporate governance structure helps align the interests of both internal and external stakeholders. At the macro level (Varieties of Capitalism), GHG disclosure and emissions are shaped by the institutional characteristics of the country in which the company operates.

Figure 1
Theoretical model



Micro level: signaling theory

Signaling Theory (ST) states that the signals emitted by a firm increase its corporate transparency and may also improve its corporate image. According to this theory, there are three important actors: the sender (the firm), the receiver (parties interested in the company's activities) and the signal (which may be the financial and sustainability information disclosed) (Taj, 2016). Thus, firms are constantly sending signals to the market, which reduces the information asymmetry between them and external stakeholders (Datt et al., 2019).

Since sufficient financial resources are needed for the disclosure of more complete sustainability reports, López-Santamaría et al. (2021) claim that firms releasing the clearest and most complete signals have more financial, human, and technological resources. Managers and executives who work in more profitable firms obtain information about organizational performance and prepare an annual or social responsibility report to inform their stakeholders about the company, which can also facilitate the arrival of foreign investments (Omar & Alkayed, 2021).

Past research (e.g., Ben-Amar and McIlkenny, 2015; Charumathi and Rahman, 2019; Choi and Luo, 2021) has found a positive relationship



between financial performance and GHG emissions. Firms that have better financial performance are more likely to have more opportunities to invest in environmental issues. Furthermore, López-Santamaría et al. (2021) argue that larger firms have a greater number of stakeholders and therefore should also consider environmental performance during their decision-making process.

One way a healthcare company can effectively address societal needs, rather than solely focusing on shareholders, is by sending a clear signal about its performance through transparency regarding its GHG emissions (Sun et al., 2019). Based on this, we propose Hypotheses 1 and 2, along with their respective alternative hypotheses:

- **H1a:** Larger firms disclose more information on GHG emissions.
- **H1b:** Larger firms emit more GHGs.
- **H2a:** Firms with better profitability disclose more information on GHG emissions.
- **H2b:** Firms with better profitability emit more GHGs.

Meso level: resource-based view

The traditional definition of corporate governance emphasizes the importance of the board of directors in creating value for shareholders without neglecting the interests of other stakeholders, such as employees, community, and media (Tibiletti et al., 2021) by being an intermediary between the country's institutional issues and financial performance needs (Crifo et al., 2019). Furthermore, Zaman et al. (2020) note that the boards of healthcare companies are cognizant of institutional pressures and the need for digital transformation. Therefore, the board in this sector acts as an intermediary between the firm's internal context and the macroeconomic environment.

A rare and valuable asset, a good governance structure favors a greater competitive advantage. Therefore, under the resource-based view theory, the corporate board of directors is considered a human resource to the firm because it takes part on strategic issues, including environmental policies, the disclosure of GHGs, and the implementation of strategies that respond to social and legal changes (Crifo et al., 2019).

Larger boards are related to greater diversity in experiences and technical knowledge (Harun et al., 2020) and tend to expand organizational boundaries, providing access to external resources and information, which is critical to the company's strategy (Cancela et al., 2020). Crifo et al. (2019)



consider that larger boards increase organizational efficiency, with members being more likely to bring up additional issues, such as disclosure of GHGs, to be discussed in meetings. Earlier studies (Crifo et al., 2019; Cancela et al., 2020) have found that larger boards positively influence environmental issues. Therefore, we propose hypothesis 3 and its respective alternative hypothesis:

- **H3a:** Larger board of directors disclose more information on GHG emissions.
- **H3b:** Firms with larger board of directors emit more GHGs.

Byron and Post (2016) state that gender diversity is one of the characteristics of the board that can lead the firm to greater social performance. The authors found that more women in the board have a positive effect on social responsibility, explaining that they are more focused on socially responsible activities. In addition, women are concerned not only with commercial decisions, but also with the well-being of the entire community affected by the company's activities (Crifo et al., 2019), as well as influencing the quality of the processes of governance, and effecting sustainability and corporate creativity (Field et al., 2020). Previous research (e. g., Fernandez-Feijoo et al., 2014; Gallego-Álvarez and Pucheta-Martínez; 2020 Gaio and Gonçalves, 2022) has found that firms with greater gender-diversity boards are more engaged in environmental issues. Therefore, we present hypothesis 4 and its alternative hypothesis:

- **H4a:** Board of directors with greater gender diversity disclose more information on GHG emissions.
- **H4b:** Firms with greater gender-diversity boards emit more GHGs.

Independent directors reinforce the board's monitoring and control function to ensure that shareholders' interests are protected (Hussain et al., 2018). In for-profit hospitals, the controlling owner appoints independent board members, highlighting that the role of independent board members is a sensitive issue in the healthcare industry (Jamali et al., 2010). Crifo et al. (2019) suggest that boards with greater independence focus less on short-term decisions, as independent directors tend to make decisions by also analyzing the context external to the firm. Thus, it is more likely that board of directors with greater independence are interested in environmental issues, as this can increase the investment and visibility of the company, in addition to favoring a positive corporate image to shareholders and other interested parties (Tibiletti et al., 2021). Past studies (e. g., Cucari, et al.,

2018; Crifo et al., 2019) has found that board independence has a positive effect on environmental issues. However, there may be greater compromises needed for keeping a balance between the interests of shareholders and stakeholders. Therefore, we present hypothesis 5 and its alternative hypothesis:

- **H5a:** Board of directors with greater independence disclose more information on GHG emissions.
- **H5b:** Firms with more independent directors in the board emit more GHGs.

Macro level: Varieties of capitalism approach

A recent approach to the Institutional Theory, the Varieties of Capitalism (VC) perspective, developed by Hall and Soskice (2001), is concerned with understanding and analyzing how firms behave and how they interact with institutional structures (Benney, 2019). Under VC, firms will behave according to the type of capitalism of its country. In countries with a coordinated market economy, the financial system is centered on large banks, governance is more decentralized, and decision-making processes are shaped by consideration for all stakeholders' interests (Hall & Thelen, 2009).

The coordinated context of the market economy favors the cooperation between firms, which form alliances to develop joint research, thus generating greater cooperation between industries, suppliers, customers, and employees (Hall & Soskice, 2001). Also, the attention given to environmental issues aim to maintain social order and dialogue with different stakeholders. In these economies, companies in the healthcare sector recognize the importance of stakeholders, not just shareholders (Pucheta-Martínez et al., 2019).

Recently, Gallego-Álvarez and Pucheta-Martínez (2020) showed that financial firms headquartered in coordinated capitalist economies are more likely to have greater environmental and social disclosure, which may not lead to lower GHGs emissions due to pressures to coordinate and maintain established business relationships.

Waqas et. al (2023) indicated that collaborations, partnerships, information sharing and strategic definitions with suppliers in the logistics chain of the healthcare sector are key success factors, being factors with strong dependence and driving power. These factors connect with the premise of coordination prescribed by economies under coordinated capitalism and expose a larger and more complex chain of actors exerting pressure on corporations in the healthcare sector. Based on the aforementioned, we present hypothesis 6 and its alternative hypothesis:



- **H6a:** Firms headquartered in a coordinated market economy capitalism disclose more information on GHG emissions.
- **H6b:** Firms headquartered in a coordinated market economy capitalism emit more GHGs.

DATA AND METHOD

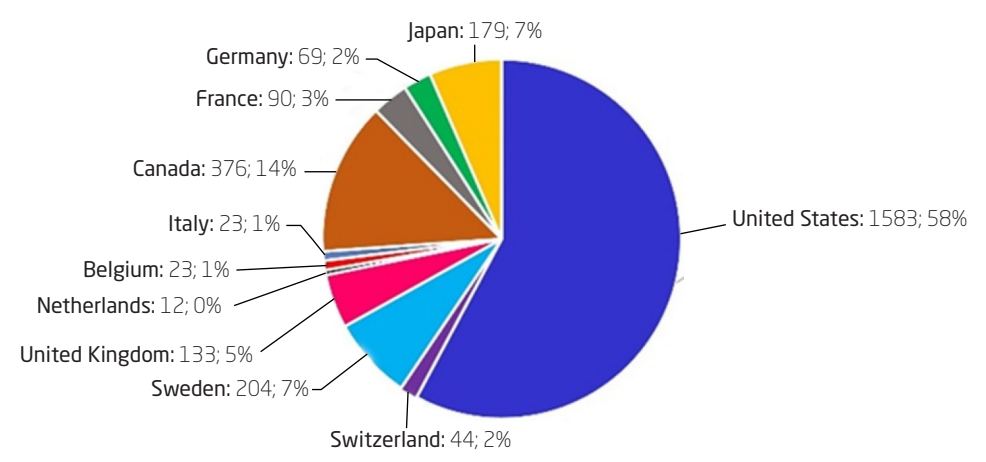
To construct our sample, we retrieve firm information from Thomson Reuters Eikon database, a robust data source for environmental, social, financial, and governance information on firms around the world. An unbalanced panel was structured with 13,680 observations from a sample of 2,736 firms in the healthcare sector. The sample period is between 2016 to 2020. The chosen period was due to the signing of the Global Compact in 2015. Firms included in the sample are headquartered in countries members of the Group of Ten (G10), until the year 2010.

The selection of countries classified as ‘developed’ aligns with the theory of legitimacy, based on the premise that these nations serve as role models for emerging countries striving to attain ‘developed’ status. By learning from countries with stricter environmental regulations, emerging nations can formulate policies to reduce GHG emissions.

The healthcare sector was selected based on its relevance to the countries’ domestic economy (Campion et al. 2015), contributing significantly to the composition of the gross domestic product. Furthermore, this sector faces the challenge of meeting growing consumer demand and becoming environmentally sustainable (Uyar et al., 2021). The firm sample distribution is shown in Figure 2.



Figure 2
Firm sample by country



Countries were categorized by geographic region and the predominant model of capitalism, as shown in Table 1.

Table 1
Country sample, region, and varieties of capitalism

Nº	Country	Region	Capitalism
1	United States of America	North America	Liberal
2	Switzerland	Europe/Asia	Coordinated
3	Sweden	Europe/Asia	Coordinated
4	United Kingdom	Europe/Asia	Liberal
5	Netherlands	Europe/Asia	Coordinated
6	Belgium	Europe/Asia	Coordinated
7	Italy	Europe/Asia	Liberal
8	Canada	North America	Liberal
9	France	Europe/Asia	Liberal
10	Germany	Europe/Asia	Coordinated
11	Japan	Europe/Asia	Coordinated

Based on data from Figure 2 and Table 1, coordinated capitalism countries total 531 firms (19.41%) and liberal capitalism countries represent 2,205 firms (80.59%).

Two econometric techniques are employed for data examination: Feasible generalized least squares (FGLS) and Binary Logit. In all, six different models were elaborated, being three for each technique. The models were leveled off according to micro (financial performance of the company), meso (characteristics of corporate governance), and macroenvironment criteria (type of capitalism in the given country). The econometric model formulas were prepared by adding new variables at each level and are described in formulas 0 to 6 (0 is the base model, 1 to 3 FGLS and 4 to 6 Logit).

$$GHG = \alpha + \beta Geo_{i,t} + \varepsilon_{i,t} \quad [0]$$

$$GHG = \alpha + \beta Size_{i,t} + \beta ROE_{i,t} + \beta Geo_{i,t} + \varepsilon_{i,t} \quad [1]$$

$$GHG = \alpha + \beta BDS_{i,t} + \beta DivBD_{i,t} + \beta IndBD_{i,t} + \beta Size_{i,t} + \beta ROE_{i,t} + \beta Geo_{i,t} + \varepsilon_{i,t} \quad [2]$$

$$GHG = \alpha + \beta DVC_{i,t} + \beta BDS_{i,t} + \beta DivBD_{i,t} + \beta IndBD_{i,t} + \beta Size_{i,t} + \beta ROE_{i,t} + \beta Geo_{i,t} + \varepsilon_{i,t} \quad [3]$$

$$DGHG = \alpha + \beta Size_{i,t} + \beta ROE_{i,t} + \beta Geo_{i,t} + \varepsilon_{i,t} \quad [4]$$

$$DGHG = \alpha + \beta BDS_{i,t} + \beta DivBD_{i,t} + \beta IndBD_{i,t} + \beta Size_{i,t} + \beta ROE_{i,t} + \beta Geo_{i,t} + \varepsilon_{i,t} \quad [5]$$

$$DGHG = \alpha + \beta DVC_{i,t} + \beta BDS_{i,t} + \beta DivBD_{i,t} + \beta IndBD_{i,t} + \beta Size_{i,t} + \beta ROE_{i,t} + \beta Geo_{i,t} + \varepsilon_{i,t} \quad [6]$$

Formulas 1 and 4 are at the micro level, formulas 2 and 5 are at the meso level, and formulas 3 and 6 are at the macro level. At the micro level, only explanatory variables at business level were included, namely firm size (Size) and profitability (Return On Equity – ROE). At the second level, variables representing characteristics of the Board of Directors were included. At the third level, the variable about the characteristic of the Variety of Capitalism (DVC) was inserted. All models were controlled by firm and year using a dummy variable.

In models 1 to 3, the FGLS technique was used, which allows the adjustment of the beta (β) estimators if the data shows autocorrelation, covariance

or heteroscedasticity. Models 4 to 6 are Binary Logit with dependent variable Disclosure of GHG emissions (DGHG), indicating whether the firm discloses some level of information on emissions of greenhouse gas, can be found in Table 2.

Table 2
Model variables

Type	Variable (Abbreviation)	Proxy	Source
Dependent	Total CO ₂ equivalent emission (GHG)	Continuous, logarithm of disclosed total emission of CO2 and equivalents	Thomson Reuters Eikon Data Base
	Disclosure of GHG emissions (DGHG)	Dummy, if the firm discloses any information about emission of GHG = 1; if not = 0	
Explanatory	Board of Directors Size (BDS)	Discrete, number of board members	
Explanatory	Board of Directors Diversity (DivBD)	Continuous, ratio between the number of female directors and the total number of directors	
Explanatory	Board of Directors Independence (IndBD)	Continuous, ratio between the number of independent directors and the total number of directors	
Explanatory	Type of VC (DVC)	Dummy, if coordinated = 1; if liberal = 0	
Explanatory	Firm Size (Size)	Continuous, natural logarithm of the total asset of the firm	Hall and Soskice (2001)
Explanatory	Profitability (ROE)	Continuous, $\frac{Net\ Income}{Average\ Shareholders'\ Equity}$	
Control	Geographic Region (Geo)	Dummy, if Europe/Asia = 1; If North America = 0	

EMPIRICAL RESULTS

After winsorizing the data and addressing outliers, we began analyzing the adjusted descriptive statistics for the main variables of interest, which are presented in Table 3.

Table 3
Descriptive statistics

		2016	2017	2018	2019	2020	Period
GHG total emissions	$\bar{x}$	209,163.5	229,416.2	260,748.7	307,686.7	367,288.2	262.880.00
	<i>s</i>	438,909.8	442,666.2	422,838.1	516,854.6	606,188.5	478.019.10
DGHG	$\bar{x}$	0.056	0.052	0.046	0.037	0.031	0.044
	<i>s</i>	0.23	0.22	0.20	0.18	0.17	0.20
Size	$\bar{x}$	7.69	7.56	7.42	7.37	8.34	7.66
	<i>s</i>	1.28	1.35	1.36	1.39	45.30	18.89
ROE	$\bar{x}$	-1.23	1.67	-1.73	-4.60	-0.35	-1.91
	<i>s</i>	7.81	10.56	9.37	127.28	54.44	59.60
BDS	$\bar{x}$	8.03	8.06	8.04	8.16	13.89	8.74
	<i>s</i>	2.31	2.38	2.24	2.16	104.17	35.39
DivBD	$\bar{x}$	22.72	20.08	17.65	15.01	20.39	19.54
	<i>s</i>	12.96	13.36	13.70	12.77	104.60	37.63
IndBD	$\bar{x}$	73.07	73.45	73.10	73.50	78.45	73.85
	<i>s</i>	77.77	19,18	19.58	18.73	102.96	39.39

Over the analyzed period, there was a decrease in the number of firms that disclosed information on GHG emissions, with the beginning of the series at 5.6% and only 3.1% at the end. This may have occurred due to high compliance costs during the 2020 pandemic. In that year, companies may have prioritized survival over GHG disclosure. Contrary to what was observed in the report, the total value of GHG emissions disclosed increased, showing a positive variation of 75.60%. That is, contrary to expectations, which would be the reduction of GHG emissions given the worldwide outcry of society and governments, firms that throughout the period kept some type of report or started reporting information on GHG emissions did so in ascending values. There was a significant increase in demand for healthcare products and services during the peak of the COVID-19 pandemic in 2020,

which led to an increase of the size of the firms and improvements of the profitability index.

Deepening the analyses, a calculation of the Pearson correlation matrix of the continuous variables was conducted, with the coefficients presented in Table 4.

It is observed that the total of CO₂ and equivalents, representative of the GHGs, showed a positive correlation only with the size of the firm, indicating that the larger the higher the GHGs emissions The other GHG emission coefficients did not show statistical significance.

Table 4
Pearson correlation

		1	2	3	4	5	6
1	GHG	1.00					
2	Size	0.629*	1.00				
3	ROE	-0.022	0.006	1.00			
4	BDS	-0.004	0.024	0.990*	1.00		
5	DivBD	-0.015	0.046*	0.932*	0.936*	1.00	
6	IndBD	0.063	0.053*	0.867*	0.867*	0.827*	1.00

Note: Only continuous variables included. *** sig. at 1%; ** sig. at 5%; * sig. at 10%.

Tables 5 and 6 show the results of the econometric model estimates. As a robustness test, we conducted an additional analysis excluding U.S. companies, which have a high representation. This enhances the reliability of the findings and allows us to assess whether U.S. companies are biasing the results.

Table 5
Results of estimations for models 1 to 3 using FGLS

Dep. Var. GHG	Entire Sample			Excluding the USA		
	1	2	3	1	2	3
Size	0.027***	-0.115***	-0.118***	1.136***	1.166***	1.166***
ROE	-0.027***	-0.021**	-0.020**	0.015	0.012	0.012

(continues)

Table 5 (conclusion)**Results of estimations for models 1 to 3 using FGLS**

Dep. Var. GHG	Entire Sample			Excluding the USA		
	1	2	3	1	2	3
<i>Geo</i>	-0.529***	-0.295***	-0.412***	0.204	0.124	0.120
<i>BDS</i>		0.137***	0.138***		0.010	0.010
<i>DivBD</i>		-0.008***	-0.007**		0.001	0.001
<i>IndBD</i>		0.007***	0.006***		-0.005***	-0.005***
<i>DVC</i>			0.162*			0.005
α	4.588***	4.241***	4.251***	-6.662***	-6.707***	-6.703***
Wald Chi ²	86.35	220.7	224.6	909.75	974.77	974.79
F de Chow	0.000	0.000	0.000	0.000	0.000	0.000
Log likelihood	-796.0	-741.1	-739.7	-326.2	-315.8	-315.81
Obs.	600	599	599	380	379	379

Note: *** sig. at 1%; ** sig. at 5%; * sig. at 10%. Homoscedastic models and models without autocorrelation. Control by firm and year.

Results show that the ROE, Geo, and DivBD variables had a negative influence on the total GHG emission values, indicating that firms with better profitability, allocated in Europe/Asia, and with greater gender diversity on the board of directors may have lower total GHG emission values. The IndBD and VC variables have a positive influence, indicating that firms with greater board independence and located in countries with coordinated capitalism tend to have higher total GHG emission values.

However, after excluding US firm from the sample a sign inversion was obtained in the IndBD variable, indicating that more independent boards influence the reduction of total GHG emissions. There is a predominance of the positive influence of the Size variable on the total GHG emission values, indicating that the size of the company influences the increase in the total GHG emission.

Table 6 displays the variations in the beta values and in the relationship of the explanatory variables vis-à-vis the dependent variable in models 1 to 3.

Table 6**Results between models, level by level - models 1 to 3 using FGLS**

Dep. Var.	Entire Sample			Entire Sample			
GHG	1	2	3	Model 2 in relation to model 1	Model 3 in relation to model 2		
				Analysis	A	Analysis	A
Size	0.027***	-0.115***	-0.118***	Sign change	-5,26	Same signal	0,026
ROE	-0.027***	-0.021**	-0.020**	Same signal	-0,22	Same signal	-0,048
Geo	-0.529***	-0.295***	-0.412***	Same signal	-0,44	Same signal	0,397
BDS		0.137***	0.138***			Same signal	0,007
DivBD		-0.008***	-0.007**			Same signal	-0,125
IndBD		0.007***	0.006***			Same signal	-0,143
DVC			0.162*				
α	4.588***	4.241***	4.251***				
Wald Chi ²	86.35	220.7	224.6				
Chow's F	0.000	0.000	0.000				
Log likelihood	-796.0	-741.1	-739.7				
Obs.	600	599	599				

Note: *** sig. at 1%; ** sig. at 5%; * sig. at 10%. Homoscedastic models and models without autocorrelation. Control by firm and year. A = beta coefficient variation between models.

When variables from the meso level are inserted into model 1, all three variables from model 1 present a reduction in the strength of influence on the dependent variable. ROE and Geo variables remain with the same sign of relation. The most relevant change is observed in the Size variable, which presents a change in the sign of the relationship and a significant increase in the influence value of its β on the dependent variable (+ 526%).

Thus, the inclusion of the set of variables at the meso level, corporate governance, suggests a modulation of the effect of company size on the quantity of GHG emissions. In turn, the insertion of the variable DVC did not result in high changes in strength, nor in the relation of the variables of the micro and macro level, which suggests that among the two additional levels to model 1, the meso level has a prominent influence in relation to the insertion of the meso and macro levels into model 1.

Table 7 presents the results of the estimations of the econometric models for the Logit technique, which aim to capture the chance of occurrence of the event “dissemination of information on GHG emissions” represented by the DGHG variable.

Table 7

Result of estimations for models 4 to 6 using Binary Logit

Dep. Var. DGHG		Entire Sample			Excluding the USA		
		4	5	6	4	5	6
Size	β	7.700***	6.246***	6.304***	7.023***	5.161***	5.212***
	OR	2209.399***	515.704***	546.654***	1122.477***	174.299***	183.523***
ROE	β	-0.003	-0.0005	-0.001	-0.0331	-0.0328	-0.0335
	OR	0.996	0.999	0.998	0.9674265	0.967	0.967
Geo	β	5.602***	6.910***	9.095***	3.447***	3.958***	5.880***
	OR	271.041***	1001.775***	8.911.268***	31.3987***	52.344***	357.662***
BDS	β		0.085	0.072		0.0822	0.0582
	OR		1.089	1.075		1.085	1.059
DivBD	β		0.068***	0.064***		0.0362*	0.0303
	OR		1.071***	1.066***		1.036*	1.030
IndBD	β		-0.019	-0.017		-0.00215	-1.40e-05
	OR		0.980	0.982		0.997	0.999
VC	β			-3.060***			-2.648***
	OR			0.468***			0.070***
α	β	-77.67***	-64.51***	-4.97***	-68.86***	-51.30***	-51.65***
	OR	1.85e-34***	9.68e-29***	6.08e-29***	1.25e-30***	5.26e-23***	3.71e-23***
Wald Chi ²		72.52	77.25	78.97	62.34	40.11	42.37
F de Chow		0.000	0.000	0.000	0.000	0.000	0.000
Sigma u		4.889	4.404	4.346	4.88	4.53	4.43
Rho		.879	0.855	0.851	0.87	0.86	0.85
LL2		-612.4	-474.0	-467.9	-378.2	-246.8	-242.1
Obs.		8845	3041	3041	4059	792	792

Note: *** sig. at 1%; ** sig. at 5%; * sig. at 10%. Controlled by company and year. Random effects applied. OR = Odds Ratio; LL2 = Log pseudolikelihood.

The Odds Ratio shown in Table 6 expresses the chance of occurrence of the event “dissemination of information on GHG emissions” and its values must be interpreted by its antilogarithm, which, being greater than 1, indicates chances of occurrence of the event, and when less than 1 indicates chances of minor occurrence. The β values indicate the direction of the relationship, whether positive or negative.

Based on Table 7, in all models the variables Size, Geo and DivBD showed a positive relationship, indicating that larger companies, or companies located in Europe/Asia and with gender diversity on their boards, are more likely to disclose information on emissions of GHGs.

The VC variable had a negative value of β , indicating that companies located in countries with coordinated capitalism are less likely to disclose information on GHG emissions. In this case, the chance decreases to 62.50% (antilogarithm of 0.468 = 1.60; $1/1.0 = 0.6250$; $0.6250 \times 100 = 62.50\%$).

The models estimated for the total sample and with the exclusion of US firms did not show differences in results, with two exceptions: the DivBD variable, which had a loss of significance, kept the relationship direction; and the VC variable in which a firm located in a country with coordinated capitalism is 93.24% less likely to disclose information on GHG emissions (antilogarithm of 0.070 = 1.07; $1/1.07 = 0.9324$; $0.9324 \times 100 = 93.24\%$).

Table 8 presents the variations in the beta values, Odds Ratio and if there is a change in the relationship of the explanatory variables vis-à-vis the dependent variable in models 4 to 6.

Table 8
Results between models, level by level - models 4 to 6 using Binary Logit

Dep. Var.	DGHG	Entire Sample			Entire Sample			
		4	5	6	Model 5 in relation to model 4		Model 6 in relation to model 5	
					Analysis	A	Analysis	A
Size	β	7.700***	6.246***	6.304***	Same signal	- 0,189	Same signal	0,009
	OR	2209.399***	515.704***	546.654***		- 0,767		0,060
ROE	β	-0.003	-0.0005	-0.001	Same signal	- 0,833	Same signal	1,000
	OR	0.996	0.999	0.998		0,003		- 0,001
Geo	β	5.602***	6.910***	9.095***	Same signal	0,233	Same signal	0,316
	OR	271.041***	1001.775***	8.911.268***		2,696		7,895

(continues)

Table 8 (conclusion)**Results between models, level by level - models 4 to 6 using Binary Logit**

Dep. Var.		Entire Sample			Entire Sample			
DGHG		4	5	6	Model 5 in relation to model 4		Model 6 in relation to model 5	
					Analysis	A	Analysis	A
BDS	β		0.085	0.072	Without statistical significance		Without statistical significance	
	OR		1.089	1.075				
DivBD	β		0.068***	0.064***	Same signal		- 0,059	
	OR		1.071***	1.066***				
IndBD	β		-0.019	-0.017	Without statistical significance		Without statistical significance	
	OR		0.980	0.982				
VC	β			-3.060***				
	OR			0.468***				
α	β	-77.67***	-64.51***	-4.97***				
	OR	1.85e-34***	9.68e-29***	6.08e-29***				
Wald Chi ²		72.52	77.25	78.97				
F de Chow		0.000	0.000	0.000				
Sigma u		4.889	4.404	4.346				
Rho		.879	0.855	0.851				
LL2		-612.4	-474.0	-467.9				
Obs.		8845	3041	3041				

Note: *** sig. at 1%; ** sig. at 5%; * sig. at 10%. Controlled by company and year. Random effects applied. OR = Odds Ratio; LL2 = Log pseudolikelihood. A = beta coefficient variation between models.

The insertion of variables at the meso level did not affect the sign, but it did modulate the strength of the β ratio of the explanatory variable ROE (-83.33%) and the odds ratio of the Size variables (-76.70%) and the variable of Geo control (+269.60%). The insertion of the third level variable did not change the signs of the relations, but as observed from the effects of the insertion of the second level variables, the β of the explanatory variable ROE increased (+100%) as did the odds ratio of the variable Geo (+789, 50%).

These results indicate the relevance of aspects of corporate governance interacting with other explanatory factors. In turn, the macro factor, variety

of capitalism, has a strong impact on the interaction with the control variable Geo, and on the explanatory variable ROE.

In this context, our analysis concludes that the actions of disclosure and GHG emissions, though individual, should be understood within the broader social context. The various levels of analysis (micro, meso, and macro) interact with different stakeholders to generate corporate outcomes, whether financial or non-financial. Therefore, the decisions and behaviors of companies in the healthcare sector are shaped by the needs and expectations of their environment (e.g., the type of capitalism in their country), as well as their internal capabilities (such as financial resources) and intermediary capabilities (like governance structures).

DISCUSSION AND IMPLICATIONS FOR THEORY AND PRACTICE

Overall, the findings support Hypotheses H1a, H2a, H3a, H3b, H5a, and H5b. However, Hypotheses H6a and H6b yielded results that contradict expectations. Specifically, companies operating in liberal economies disclose more information on GHG emissions and also emit higher levels of atmospheric emissions.

The results show that larger firms tend to have greater environmental transparency when disclosing more information about their greenhouse gas emissions. In line with earlier studies (e.g., Ben-Amar and McIlkenny, 2015; Charumathi and Rahman, 2019; Choi and Luo, 2021), firms with more financial resources disclose more information to the market because they see the signals as a communication between firm (sender) and stakeholders (receiver). Another finding is that more profitable firms emit less GHGs, which was observed in the results of this research. This finding is in line with the premise that the disclosure of GHG information has become increasingly relevant to enhance corporate image, which attracts more investments, thus enabling greater realization of investment opportunities and boosting its profitability margin. Therefore, disclosing information on GHG emissions, especially when the firm emits less GHG than competitors in the same sector, can be a relevant competitive differentiator.

At the meso level (corporate governance), results indicate that board size has a positive influence on GHG disclosure, which is in line with previous studies (Kouloukoui et al., 2018; Crifo et al., 2019; Cancela et al., 2020). A larger board tends to have more trained human resources with different



degrees of education and experience. During board meeting, this technical body tends to raise topics on environmental issues. Notwithstanding firm disclosure of GHG emissions, the totality of emissions of GHG by firms with larger boards is higher than other firms in the same sector (Shaukat et al., 2016).

Concerning board diversity, data reveals that more women on the board may not affect the disclosure of more information on GHG emissions. This contradicts previous studies (e. g., Fernandez-Feijoo et al., 2014; Gallego-Álvarez and Pucheta-Martínez, 2020; Gaio and Gonçalves, 2022). Considering these studies analyzed European firms, ours included firms from different continents, which may explain the difference in findings. Also, this research considers women to be important for greater environmental disclosure if they form a critical mass in the boards (Strydom et al., 2017). Women still make up a small portion of the boards, which can discourage them from expressing their opinions and promoting environmental discussions during meetings.

Still at the meso level, results indicate that firms with a more independent board disclose more information on GHG. The result confirms previous studies (e. g., Cucari et al., 2018; Crifo et al., 2019; Tibiletti et al., 2021). In practice, this means that non-executive directors can bring environmentally concerned ideas to firm. A justification for this finding may be that non-executive directors are not only concerned with shareholders and financial performance but also with all its stakeholders (community, employees, media, and NGOs). Thus, they consider firm disclosure of GHG as a company response to them. However, the pressures and demands of non-executive directors to meet and reconcile the interests of shareholders and stakeholders can result in succumbing to decisions in favor of established business relationships that imply emitting more GHGs than other companies in the same sector.

Given these findings for the meso level, the structure of the board of directors of firms is a valuable resource linking financial performance to environmental strategies and policies. In line with the Resource-Based View theory, a firm in the healthcare sector with a larger board and a greater presence of non-executive directors is important for the existence of reporting on GHG emissions.

At the macro level (varieties of capitalism), the results show that companies based in coordinated market economies are less likely to report information on GHG emissions and emit more GHG. Since countries with coordinated capitalism tend to be more concerned with their work and education



system (Hall & Soskice, 2001), firms headquartered in them have greater social responsibility. With this result, we expand the findings of Gallego-Álvarez and Pucheta-Martínez (2020) who analyzed firms in the financial sector.

When we look at the Binary Logit estimates, two new results emerged in the analyses. From them, it can be inferred that firms with greater gender diversity tend to disclose more GHG. This confirms earlier studies (Fernandez-Feijoo et al., 2014; Gallego-Álvarez and Pucheta-Martínez, 2020; Gaio and Gonçalves, 2022) that indicate that more women on the board affect environmental issues, (Field et al., 2020). Still at the macro level, the findings refute the perspective that firms headquartered in countries with coordinated capitalism disclose more information about their GHG emissions. Thus, the results are not in line with the work of Gallego-Álvarez and Pucheta-Martínez (2020).

Bearing in mind that the treatment of GHG is an innovative action publicized by companies to the market, it is salutary to highlight that according to Durst and Leyer (2022) smaller companies are more dependent on institutional aspects than larger companies, and it is necessary to include in the research analysis the context of companies. In models 2 and 3, in which variables related to the context of the company are inserted, the causality sign of company size is inverted, indicating that the size of companies negatively affects the quantity of GHG emissions and reduces the chances of greater disclosure of GHG information.

On the other hand, the context of coordinated capitalism and strong corporate governance practices can contribute to the dissemination of innovative green practices, functioning according to Pratono et al. (2019, p. 1) as an “input from green entrepreneurial orientation and market orientation”.

Theoretical implications

The Signaling Theory indicates that firm’s disclosure of GHG are signals that stakeholders need for legitimizing the actions of firms, as well as improving corporate image. Thus, larger companies must continue to have the responsibility of indicating how their actions have been affecting air quality through their GHG emissions.

According to the resource-based view theory, the findings suggest that boards of directors are both valuable and rare resources. Companies must recognize the significance of their boards, as they serve as a bridge between financial performance for shareholders and environmental performance for



other stakeholders. A larger board, particularly with non-executive directors, can guide the company toward greater GHG disclosure, fostering positive relationships between the company, shareholders, and society.

The indication of the meso level as the group of variables with the greatest capacity to modify the strength and relationship of the other variables reinforces the relevant role of corporate governance practices for greater absorption of the interests of the various stakeholders in the long term. Diversity on the board can act to reduce GHG emissions, by enabling the alignment of interests and promoting the consensus of objectives to be pursued by the corporation through the various pressures of interest groups.

Our results indicate that the institutional level is important for GHG disclosure, however, more academic research is needed on this relationship.

Practical implications

From a managerial perspective, the findings suggest that companies should progressively increase corporate disclosure of GHG, as it tends to translate into financial and social benefits. Firms can also increase the size of their boards by including non-executive directors in corporate decisions. A higher level of board independence can bring an enhanced vision, going beyond the traditional financial vision. Additionally, managers must be aware that the type of capitalism can affect their firm's environmental decisions. To achieve SDGs 7, 12, and 13, companies must recognize that both internal and external factors influence their performance.

The perspective of balancing the number of men and women under management conditions can be a factor to be observed by potential investors when making capital allocation decisions. Likewise, companies that want to stand out in the market can adopt internal policies to promote gender diversity to attract investors and signal to the market through their reports the fulfillment of social demands. In this sense, an alignment is obtained between what is being reported and what is being measured in terms of factual results in the amount of GHG emissions.

A practical way for governments to perform and act as key players between firms and the achievement of GHG reduction targets would be to legislate on the mandatory disclosure of information on GHG derived from economic activities. Yu et. al. (2022) emphasizes the important role of the government as an agent of policies and supervision to encourage and lead companies to the use of renewable energies to reduce GHG generation, not only in a passive posture of demanding compliance, but also providing tools and support (financial, exemptions, subsidies).



CONCLUSIONS

The results of this research suggest that companies with greater financial resources are more likely to disclose information on GHG emissions. Furthermore, companies with more human resources—specifically, larger boards of directors and higher levels of independence—are not only more likely to disclose GHG information but also tend to emit more GHG. Finally, companies headquartered in countries with a coordinated capitalism model are less likely to disclose GHG emissions, whereas companies in liberal economies tend to emit more GHG.

Another interesting finding is the demonstration that the disclosure of information is not necessarily aligned with reducing the amount of GHG emissions. Therefore, our findings call attention for companies to strike a balance between disclosing their emissions and reducing GHG emissions. Healthcare companies must evaluate their genuine contribution to the Paris Agreement and the 2030 Agenda, while also effectively communicating their tangible environmental actions to stakeholders.

Although this research was concerned with the use of metrics that better measure the analyzed variables, it is not free of limitations. This study only examined the healthcare sector, making it difficult to generalize the results to other sectors. Furthermore, the study analyzed a limited period. Future studies should incorporate more recent years, analyze each type of capitalism separately, and compare their findings with ours. Additionally, using a Neural Network model or the Fuzzy-Set Qualitative Comparative Analysis (fsQCA) method could help identify the key factors and pathways for companies to reduce their GHG emissions. New metrics should also be developed to more effectively represent companies' GHG disclosures.

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