IJEEP
INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY
EJ EconJournals
ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2025, 15(4), 388-400.

EJ EconJournals

Do Environmental Management Policies Decrease Carbon Emissions? A Probabilistic Analysis of G7 Countries

Monia Chikhaoui*

Higher School of Economic and Commercial Sciences, University of Tunis, Tunisia. Email: monia70chikhaoui@gmail.com

Received: 03 February 2025 **Accepted:** 27 May 2025 **DOI:** https://doi.org/10.32479/ijeep.19664

ABSTRACT

This paper examines the effect of an Environmental Management System (ENVMSB) on carbon dioxide emissions reduction, taking into account the role of Greenhouse Gas emissions taxes (TaxGHG) as well as a Sustainability Committee (CSRSC) in an international sample. To test our hypotheses, we use a sample of 9944 firm-year observations in the G7 countries (Canada, France, Germany, Italy, Japan, United Kingdom and United States) from 2013 to 2022. The econometric approach uses a logistic regression panel data model. The empirical results show that both ENVMSB and CSRSC significantly and positively reduce carbon dioxide emissions. However, we did not find evidence of a significant effect of TaxGHG on carbon dioxide emissions reduction. Moreover, the probabilistic analysis of carbon reduction shows heterogeneity behavior by countries and sectors related to various national policies industrial practices and alignment with international environmental initiatives including United Nations initiatives. These findings have important implications for managers and regulators concerned with firm ecological performance.

Keywords: Carbon Dioxide Emissions, Environmental Management System, Greenhouse Gas Emissions Taxes, Environmental Governance
JEL Classifications: C25, Q41, Q48, Q51, Q56

1. INTRODUCTION

Climate change is a major global problem. It is seen as a challenge for political decision-makers and all third parties. According to the journal Environmental Research Letters of October 19, 2021, 97% of studies published between 1991 and 2012 and updated from 2012 to 2020 support that human activities are responsible for changing the Earth's climate. This new climate perspective has enhanced the discussion and debate about a green economy and how human activities can reduce their emissions and thus be ethically responsible. Numerous international summits have been held in different countries to seek ways to control this behavior. Following the 2015 Paris Agreement, several countries announced the Net-Zero Carbon Emissions initiative and presented their strategies to achieve this goal. This agreement accelerated consensus on the adoption of the Sustainable Development Goals (SDG), announced by the United Nations. This global transformation strategy identified climate protection goals (SDG 6, SDG 7, and SDG 13) and demonstrated a global awareness of climate change.

According to the literature, climate change is an old phenomenon. In 1894, Swedish Nobel Laureate Svante Arrhenius (1859-1927) demonstrated that ice ages are the product of a complex interaction of forces, including oscillations in the Earth's orbit and changes in atmospheric carbon dioxide (CO_2) emissions, confirming that CO_2 emissions are the main factor driving climate change. Recently, the World Meteorological Organization (2022) has emphasized that 2015-2022 were the warmest years on record. The report predicted that by the end of 2022, the global average temperature would be 1.15°C higher than the pre-industrial average.

The causes and effects of CO_2 emissions have been widely discussed in the climate change literature. Early studies have examined the Environmental Kuznets Curve (EKC) hypothesis, first introduced by Kuznets (1955) and further developed by

Grossman and Krueger (1991). This hypothesis postulates an inverted U-shaped relationship between various pollutants and per capita income (Holtz-Eakin and Selden (1995), Tucker, 1995). Later studies have focused on the determinants of carbon dioxide emissions (Friedl and Getzner, 2003) in both developed and emerging economies, using linear and nonlinear regression models in both time series and panel data. The empirical evidence showed that economic growth (Haseeb et al., 2018), Douglas and Thomas (1995), financial development (Zaidi et al., 2019), energy consumption, and technological innovation are significant factors.

However, the obtained results are mixed. This could be explained by the fact that these studies used aggregate data, combining the carbon dioxide emissions of all sectors and all firms. Other studies considered firm-level data and examined the interaction between the carbon dioxide emitted by the firm and different attributes such as performance (Miah et al., 2021), cost of capital, and cost of debt (Garzón-Jiménez and Zorio-Grima, 2021).

To address and reduce the negative impact of carbon emissions, policymakers have introduced new control mechanisms such as carbon taxes and tax incentives for green investments. The tax on carbon dioxide emissions is imposed on polluting energy sources to reduce pollution. Under this perspective, companies have the opportunity to manage the risk associated with carbon emissions and to manage their costs through tax incentives on green investments. Under this perspective, our study focuses on the impact of the environmental management system on CO_2 emissions reduction. This system includes governance functions and IT management of the company's carbon emissions. This includes IT applications and support for reducing carbon emissions as well as IT processes and governance in the processes a company uses to manage its emissions and implement business strategies. Otherwise, we examine the effect of environmental management system (EMS) on carbon dioxide emissions reduction by considering the role of environmental tax as well as environmental governance in a sample of 9944 listed firms in the Group of Seven (G7) countries during the period from 2013 to 2022, using a logistic regression model in panel data.

This paper contributes to the literature in three ways. First, we focus on the Group of 7, which includes the most polluting countries (United States, Japan, and Germany). Second, although previous studies have examined the effect of EMS, environmental taxes, and sustainability committees on carbon dioxide performance, they take each variable separately. In this paper, we study the combined effect of EMS, GHG, and SC on carbon dioxide emissions reduction. Third, we examine whether this effect varies across countries and sectors. In particular, we examine how the adoption of the United Nations Initiative or Sustainable Development Goals (SDG) affects the relationship between the variables of interest. In addition, we investigate the impact of the most polluted sectors.

These findings have important implications for both economists and environmentalists. Indeed, understanding the factors that affect carbon dioxide emissions reduction can help managers identify the internal and external factors that can improve their company's environmental performance. It can also help the authorities to take appropriate decisions.

The rest of the paper is organized as follows: Section 2 reviews the relevant literature and develops the hypotheses. Section 3 presents the data and methodology. Section 4 and Section 5 report and discuss the empirical results and Robustness tests. Section 6 concludes the paper.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

This section reviews the previous literature that examined the links between carbon dioxide performance as measured by carbon dioxide emissions reduction, the environmental management system, the environmental regulation as proxied by environmental taxes and the environmental governance as represented by the environmental committee.

2.1. Carbon Dioxide Emissions Reduction and Environmental Management System (EMS)

An environmental management system (EMS) is a set of processes and practices that enable an organization to develop, implement, manage, coordinate, and monitor its environmental activities (Sayre, 1996). The most commonly used framework for an EMS is that developed by the International Organization for Standardization (ISO) for the ISO 14001 standard. According to Steger (2000), the environmental management system (EMS) is a transparent, systematic, organization-wide process for establishing and implementing environmental objectives, policies, and responsibilities and periodically reviewing its elements. One of the main objectives of an EMS is to reduce negative environmental impacts. Several empirical studies have examined the effect of an ISO 14001-certified environmental management system on carbon dioxide emissions and have produced consistent results. For example, Dunn-Rankin (2011) and Yunus et al. (2016) found that the environmental management system has an effect on the management of greenhouse gas emissions for companies in Australia. Prafitri and Zulaikha (2016) showed that EMS had contributed to greenhouse gas emissions for companies in Indonesia. However, Manurung and Rachmat (2019) stated that ISO 14001 variable had a negative effect on corporate social responsibility disclosure in the Indonesian industry. Using multiple linear regression, Setiawan and Iswati (2019) concluded to no significant relationship between EMS and carbon emissions disclosure in Indonesia from 2013 to 2017. Bearing on this literature, our first hypothesis is formulated as follows:

H_1: Adoption of an environmental management system positively relates to carbon dioxide emissions reduction.

2.2. Carbon Dioxide Emissions Reduction and Environmental Taxes

According to Regulation (EU) No 691/2011 on European Environmental-Economic Accounts, the environmental tax can be defined as a tax whose base is a physical unit (or a proxy for a physical unit) of something that has a proven, specific negative impact on the environment and which is identified as a tax in the European System of Accounts (ESA 2010). It can take various forms, such as carbon taxes, congestion charges, and waste taxes. Previous studies have investigated the impact of environmental taxes on energy consumption and environmental quality (for a literature review, Shahzad, 2020). Agostini et al. (1992) highlighted the effect of introducing a tax on carbon dioxide emissions from combustion processes in OECD European countries. They documented that environmental taxes are a useful policy tool in carbon mitigation. In the same vein, Baranzini et al. (2000) reported strong evidence for carbon taxes reducing CO_2 emissions. Polat (2019) found a negative relationship between environmental taxes and CO_2 emissions in 25 EU countries. He et al. (2019) investigated the impact of energy tax in four Nordic countries and G7 countries from 1994 to 2016 using panel ARDL (AutoRegressive Distributed Lag). Sarıgül and Topcu (2021) examined the effect of environmental tax on CO_2 emissions in Turkey for the 1994-2015 period and found evidence of a negative relationship. Ghazouani et al. (2020) conducted a comparative study among European countries on the implementation of a carbon tax. Bashir et al. (2021) showed that the implementation of environmental taxes helped to minimize energy consumption and energy intensity in 29 OECD countries studied from 1994 to 2018. Doğan et al. (2022) examined the impact of environmental tax on carbon emissions for G7 countries from 1994 to 2014 and found that environmental taxes are effective in reducing CO_2 emissions. Al Shammre et al. (2023) examined the impact of different environmental tax categories (energy, pollution, resource, and transportation) on CO_2 emissions in 34 OECD countries between 1995 and 2019 using dynamic panel threshold regression. Bearing on this literature, we develop the following second hypothesis:

H_2: The presence of environmental taxes positively relates to carbon dioxide emissions reduction.

2.3. Carbon Dioxide Emissions Reduction and Environmental Governance

Environmental governance refers to a set of regulatory processes, mechanisms, and organizations through which political actors solve environmental problems and influence environmental outcomes (Lemos and Agrawal, 2006). It involves the coordination and implementation of actions at various levels, including local, national, regional, and international, to address environmental challenges and ensure sustainable development. Previous studies have examined the impact of the presence of an environmental committee on corporate environmental disclosure and carbon performance. For instance, Peters and Romi (2014), found that the presence of an environmental committee is positively associated with GHG disclosure using a sample of 1238 firms over the period from 2002 to 2006. Utilizing a sample of 215 firms listed on the London Stock Exchange market, Tingbani et al. (2020), explored the effect of environmental committees and gender diversity on greenhouse gas (GHG) voluntary disclosures but they didn't find evidence of a significant relationship between environmental committees and GHG disclosures. Using 1130 firm-year observations of 113 firms listed across five sub-Saharan African countries over the period from 2010 to 2019, Gerged et al. (2022) found that the presence of an environmental committee positively moderates the relationship between board gender diversity and corporate environmental disclosure. With these proposals in mind, we formulate the following third hypothesis:

H_3: The presence of an environmental committee positively relates to carbon dioxide emissions reduction.

3. RESEARCH DESIGN

3.1. The CO_2 Emissions per Capita for G7 Countries

According to the historical databases of WORLD BANK, the Global Carbon Project, and Climate Transparency (Table 1), CO_2 emissions per capita for the G7 countries (2013-2022) are declining from 2013 to 2022. The G7 countries have made varied and significant progress in reducing CO_2 emissions, reflecting the different energy policies of these countries in line with industrial practices and environmental strategies.

The UK has made significant progress, reducing its emissions by 49.1% in 2016 compared to 1971 levels, a decrease primarily due to a sharp reduction in the use of coal and a significant increase in investment in renewable energy. Similarly, Italy has reduced its CO_2 emissions per capita and increased the share of renewables in its energy mix to 15%, the second highest among the G7 countries. In contrast, the United States has significantly reduced its CO_2 emissions thanks to the substitution of coal with natural gas and an increasing diversification towards renewable energies. However, fossil fuel subsidies remained high, averaging $4 billion per year between 2013 and 2014, indicating continued financial support for the fossil fuel industry. Canada has made slight progress in reducing fossil fuel subsidies but is reliant on stable emissions levels due to its heavy use of fossil fuels for power generation. Germany remains heavily dependent on coal, with CO_2 emissions per capita remaining relatively high. Although the country planned to phase out coal subsidies, new public investment in fossil fuels averaged around 3 billion dollars per year. Japan's per capita emissions have increased during this period, partly due to the restart of nuclear power plants and limited support for renewables. Finally, France, which had the lowest per capita CO_2 emissions among G7 countries in 2020, continued to support fossil fuels through consumer subsidies, particularly for diesel.

While some G7 countries have made remarkable progress in reducing emissions through policy changes and investments in renewable energy, other countries have faced a heavy reliance on fossil fuels, which has prevented them from achieving significant reductions in CO_2 emissions.

3.2. Sample Selection and Data Description

Our sample consists of 9944 listed firms in the G7 group countries (United States, Japan, United Kingdom, Germany, France, Italy, and Canada) over ten years from 2013 to 2022[1]. The data (Table 2) are collected from the Thomson Reuters Eikon Assets database. Table 1 describes sample distribution based on year (Panel A), country (Panel B) and GICS sector (Panel C).

Year-level sample distribution shows that 2022 accounts for most of the observation of our sample firms at 14.19% (1411 observations).

1 The firms with missing values have been excluded from the initial sample.

Table 1: CO_2 emissions per capita for G7 countries (2013-2022)

Year and statistics	USA	Canada	JAPON	GER	UK	ITA	FRAN
2013	16.5	15.5	9.2	8.5	7.4	6.0	5.4
2014	16.0	14.8	8.8	8.3	7.2	5.8	5.2
2015	15.5	14.2	8.5	8.0	6.9	5.6	5.0
2016	15.0	13.9	8.1	7.6	6.5	5.4	4.9
2017	14.5	13.5	8.0	7.3	6.1	5.2	4.8
2018	14.0	13.2	7.8	7.1	5.8	5.1	4.7
2019	13.8	13.0	7.5	6.8	5.4	4.9	4.6
2020	13.0	13.6	8.0	7.3	4.6	4.7	3.9
2021	12.8	13.2	7.9	7.0	4.5	4.6	7.8
2022	12.5	13.1	7.7	6.9	4.3	4.5	3.7
Mean	14.36	13.8	8.15	7.48	5.87	5.18	5
STD	1.31	0.77	0.5	0.57	1.08	0.49	1.06
Min	12.5	13	7.5	6.8	4.3	4.5	3.7
Max	16.5	15.5	9.2	8.5	7.4	6	7.8
Total	143.6	138	81.5	74.8	58.7	51.8	50
Classification CO_2 emissions	1	2	3	4	5	6	7

Table 2: Sample distribution

Panel A: Sample distribution-based year			
Year	**N**	**Percent**	**Cum.**
2013	709	7.13	7.13
2014	722	7.26	14.39
2015	733	7.37	21.76
2016	788	7.92	29.69
2017	889	8.94	38.63
2018	961	9.66	48.29
2019	1129	11.35	59.64
2020	1242	12.49	72.13
2021	1360	13.68	85.81
2022	1411	14.19	100.00
Panel B: Sample distribution-based country			
Country	**N**	**Percent**	**Cum.**
Canada	834	8.39	8.39
France	709	7.13	15.52
Germany	576	5.79	21.31
Italy	242	2.43	23.74
Japan	2648	26.63	50.37
United Kingdom	1459	14.67	65.04
United States of America	3476	34.96	100.00
Panel C: Sample distribution-based GICS sector			
GICS sector	**Frequency**	**Percent**	**Cum.**
Communication services	402	4.04	4.04
Consumer discretionary	1208	12.15	16.19
Consumer staples	744	7.48	23.67
Energy	584	5.87	29.55
Financials	1175	11.82	41.36
Health care	518	5.21	46.57
Industrials	2007	20.18	66.75
Information technology	790	7.94	74.70
Materials	1172	11.79	86.48
Real Estate	626	6.30	92.78
Utilities	718	7.22	100.00

Country-level sample distribution indicates that the United States has the majority of observations of our sample firms at 34.96% (3476 observations) followed by Japan (2648 observations) and the United Kingdom (1459 observations). GICS-level sample distribution indicates that the industrial (2007 observations), Consumer Discretionary (1208 observations), and Materials (1172 observations) sectors have the most observations accounting for 20.18%, 12.15%, and 11.79% of total observations respectively.

3.3. Variables Measurement and Model Specification

3.3.1. Variable measurement

The dependent variable is the annual carbon dioxide emissions reduction of the firm (CO_2(-) defined as a binary indicator variable coded 1 if the annual carbon emissions (ACO_2) change reported by a firm is negative (that is the difference between the carbon emissions reported in the current year and past year equals less than zero) and 0 otherwise (Jaffe et al., 2005), Delmas and Toffel (2004), Guthrie and Parker (2014), Lyon and Montgomery (2015), Ibishova et al. (2024).

$$CO2(-) = \begin{cases} 1 \ if \ \Delta ACO2 \prec 0 \\ 0 \quad otherwise \end{cases} \tag{1}$$

Independent variables: To test our three hypotheses, we use three independent variables in a scenario-based estimation (Table 3):

- The first one is ENVMSB, defined as a dummy variable, which takes 1 if the firm has both an Environmental Management System and ISO 14000 certification and zero otherwise.
- Our second independent variable reports to environmental regulation. Then, we consider TaxGHG, which is a dummy variable that takes 1 if the country has a GHG (greenhouse gases) tax and zero otherwise.
- Our third independent variable is environmental governance which is represented by Corporate Social Responsibility and Sustainability Committee (CSRSC). This dummy variable takes 1 if the firm has a CSR and sustainability committee and zero otherwise.

Control variables: In addition to the independent variables, we include several control variables identified in the literature to affect the firm's carbon emissions performance. To reproduce the effect of environmental factors, we consider:

- The sustainable external auditor (CSRSEA), a dummy variable which takes 1 if the firm has a sustainable external auditor and zero otherwise.
- The Sustainable Development Goals (SDG7): The SDG7 is a dummy variable coded 1, if the firm has adopted Sustainable Development Goals (affordable and clean energy) and 0 otherwise.

Table 3: Definition of variables

Variable	Definition	
Dependent variable		
CO_2(-)	A binary variable coded 1 if the annual carbon emissions change reported by a firm is negative (that is the difference between the carbon emissions reported in the current year and past year equals less than zero) and 0 otherwise.	
Independent variables		**Hypotheses to be tested**
ENVMSB	The dummy variable is coded 1, if the firm has EMS and ISO 14000 Certification and 0 otherwise	H1
TaxGHG	The dummy variable coded 1, if the firm has GHG Tax and 0 otherwise	H2
CSRSC	The dummy variable is coded 1 if the firm has a CSR sustainability committee and 0 otherwise	H3
Control variables		
CSRSEA	The dummy variable coded 1, if the firm has a sustainable external auditor, and 0 otherwise.	
SDG7	The dummy variable is coded 1, if the firm has adopted a Sustainable Development Goal (Affordable and clean energy), 0 otherwise.	
EMT	The dummy variable coded 1, if the firm has an environmental management team, and 0 otherwise.	
BSize	Board size.	
BIND	Percentage of the board member independence in the firm board.	
STRGINV	Ownership of strategic investor: Shares held by strategic investor to total outstanding shares.	
FEGD	Percentage of executive female members in the firm.	
FSize	Natural logarithm of total assets.	
Debt	Total debt to total assets.	
ROA	Return on assets.	

- The environmental management team (EMT) is a dummy variable that takes 1 if the firm has an environmental management team and 0 otherwise.

Moreover, we control for corporate governance quality using board size (BSize), defined as the total number of directors on the board, and board independence (BIND) measured by the proportion of independent directors to the total number of directors on the board.

Furthermore, we consider the effect of strategic investors (StrgInv) given by the shares held by strategic investors to total common shares outstanding. We also control for board gender diversity by including the percentage of female executive gender diversity in the firm (FEGD). In addition, we take into account several firm-level characteristics such as firm size (FSize) determined by the natural logarithm of total assets, debt (Debt) defined as long-term debt to total assets ratio, and return on assets (ROA) measured by the percentage of operating profit to total assets.

3.4. Econometric Model

To study the empirical effect of the environmental management system as well as environmental tax and environmental governance on carbon dioxide emissions reduction and to test our three hypotheses, we consider a logistic regression model in panel data. The logit analysis is used to estimate the model and discriminate the sample firms against each other with regard to their diverse environmental management system, greenhouse gas taxes, and carbon dioxide emissions during the process of generating environmental performance. In the logit model, F(Z) denotes the value of cumulative logistic distribution at Z. The index Z is linear in X, while its probability is not $Z = X'\beta$. Where X is the vector of the explanatory variable and β is the vector of the coefficient. The logit specification is

$$P = F(Z) = F\left(X^{'}\beta\right) = \frac{1}{1+e^{-Z}} \quad (2)$$

Logit analysis is employed to estimate a model that distinguishes sample firms based on their varying environmental management systems, greenhouse gas taxes, and carbon dioxide emissions, during the process of generating environmental performance. In the logit model, F(Z) represents the cumulative logistic distribution value at Z. The index Z is linear in X, while its probability is not $Z = X\ '\beta$. Where X is the vector of explanatory variable and β is the vector of coefficient. The logit specification is,

$$P = F(Z) = F\left(X^{'}\beta\right) = \frac{1}{1+e^{-Z}} \quad (3)$$

The model predicts the probability that a firm's environmental performance meets certain criteria, given its characteristics. Here, P is the conditional probability of the even occurring given values of the explanatory variables. Multiply equation by,

$$1 + e^{-z}, (1 + e^{-z})\ P = 1 \quad (3)$$

and divide equation (3) by, P.

$$e^{-Z} = \frac{1-P}{P} \text{ or } e^{Z} = \frac{P}{1-P} \quad (5)$$

take the natural logarithms from equation (5).

$$\ln\left(\frac{P}{1-P}\right) = Z = X'\beta \quad (6)$$

Equation (6) is estimated by the maximum likelihood method. Equation (7) describes the probability of the carbon dioxide reduction, $P = F(Z)$ where,

$$Z = CO2(-)_{it} = \beta_0 + \beta_1 \text{ ENVMSB}_{it} + \beta_2 TaxGHG_{it} + \beta_3 CSRSC_{it} + \beta_4 CSRSEA_{it} + \beta_5 SDG7_{it} + \beta_6 FEGD_{it} + \beta_7 \text{EMT}_{it} + \beta_8 IBM_{it} + \beta_9 BS_{it} + \beta_{10} STRGINV_{it} + \beta_{11} Size + \beta_{12} Debt_{it} + \beta_{13} ROA_{it} \quad (7)$$

The carbon dioxide reduction index Z, which is not directly observable, is created using a dataset that includes all the explanatory variables within the model. The estimated values of this index are then converted into probabilities of reducing carbon dioxide emissions.

4. EMPIRICAL RESULTS

4.1. Descriptive Statistics

Table 4 provides a summary of descriptive statistics of the variables used in the study.

- For Panel A: The board size has a mean of 11 directors with a minimum of 1 director and a maximum of 38 directors. 60.7% of them are independent, which is considerably high. The mean strategic shareholder is 12.5%. The mean percentage of executive female members in the firm is 12.6%. The firm average size is 23.426. The percentage of debt to total assets is <30% (27.1%).

However, the level of firm performance is low: ROA has an average of 3.2% and a standard deviation of 3.5%. It varies between −10% and 10%, indicating a diverse pool of firms in terms of performance.

- Panel B relates to the frequency of dummy variables. For the CO_2(-) variable, frequency of 1 is higher than that of 0, which indicates that most firms are efficient in reducing carbon emissions (59.16%). For the TaxGHG, CSRSC and CSRSEA variables, a frequency of 1 is higher than that of 0. For the ENVMSB and SDG7 variables, a frequency of 0 is higher than that of 1.

Table 5 presents the Pearson matrix coefficients. The first column reports the Pearson correlation coefficient between ENVMSB reduction and other variables. We clearly see that all correlation coefficients are positive except that of taxGHG, StrgInv and ROA. Moreover, no strong correlation was found between the independent variables. Then, no multi-collinearity problem is observed.

4.2. Empirical Examination

4.2.1. Factors of carbon reduction

We notice (Table 6) that the coefficient of ENVMSB ($\beta_1 = 0.181$) is positive and statistically significant at the 10% level implying that the presence of an Environmental Management System induces a reduction of CO_2 emission. Accordingly we accept our first hypothesis H_1.

The coefficient of TaxGHG is not significant. This means that the GHG tax does not contribute to reducing CO_2. This finding is similar to that of Bayar and Sasmaz (2016) who provide evidence of no significant relationship between carbon taxes and CO_2 emissions. However, it is inconsistent with those of numerous studies that found significant relationships between these variables (Ghazouani et al., 2020). Doğan et al., 2022). Consequently, we reject the second hypothesis H_2.

The coefficient of CSRSC ($\beta_3 = 0.104$) is positive and significant suggesting the presence of a sustainability committee that discusses and promotes environmental issues contributes to reducing CO_2 emissions and makes the firm more sustainable. This result is similar to that of Gerged et al. (2022) who observed a positive relationship between the presence of an environmental committee and corporate environmental disclosure with this result, we accept the third hypothesis H_3.

For the control variables. We notice that the coefficients of CSRSEA. SDG7 and FEGD are significant and positive. This means that the environmental variables lead to a reduction in CO_2 emissions. However, the coefficient of EMT is not significant. The coefficient of FEGD is positive and significant indicating that female directors tend to display more awareness about environmental sustainability than male directors who may be more

Table 4: Descriptive statistics

(a) Panel A: Continuous variables						
Variable	**Mean**	**STD**	**Minimum**	**Median**	**Maximum**	**N**
BSize	11.344	3.374	1	11	38	9944
BIND	0.607	0.281	0	0.688	1	9944
StrgInv	0.125	0.181	0	0.038	0.978	9944
FEGD	0.126	0.134	0	0.1	1	9944
FSize	23.426	1.646	18.554	23.211	28.951	9944
Debt	0.271	0.166	0	0.258	0.957	9944
ROA	0.032	0.035	−0.100	0.033	0.1	9944

BSize is Board size. BIND is board independence measured by the percentage of the board member independence in the firm board. StrgInv is Ownership of strategic investor: Shares held by strategic investor to total outstanding shares. FEGD Percentage of executive female members in the firm. FSIZE is the firm size measured by the Natural logarithm of total assets. Debt is the total debt to total assets. ROA is Return on assets

(b) Panel B: Frequency of dummy variable			
Variable	**0 (%)**	**1 (%)**	**Total**
CO_2(-)	4061 (40.9)	5883 (59.1)	9944
ENVMSB	9477 (95)	467 (5)	9944
TaxGHG	4349 (43.7)	5595 (52.3)	9944
CSRSC	1401 (14)	8543 (86)	9944
CSRSEA	4961 (49.8)	4983 (50.1)	9944
SDG7	8204 (82.5)	1740 (17.5)	9944
EMT	2570 (25.8)	7374 (74.2)	9944

CO_2(-) is the decrease of CO_2 emission (1 if yes and otherwise), ENVMSB if the firm has both Environmental Management System and ISO 14000 certification. TAXGHG dummy variable that takes 1 if the country has a GHG tax and zero otherwise. CSRSC is a dummy variable that takes 1 if the firm has a sustainability committee and zero otherwise. CSRSEA is a dummy variable that takes 1 if the firm has a sustainable external auditor and zero otherwise SDG7 is a dummy variable coded 1, if the firm has adopted Sustainable Development Goals (affordable and clean energy) and 0 otherwise, EMT is a dummy variable which takes1 if the firm has an environmental management team and 0 otherwise.

Table 5: Pearson's correlation matrix

	ENVMSB	*TaxGHG*	*CSRSC*	*CSRSEA*	*SDG7*	*FEGD*	*EMT*	*BIND*	*BSize*	*StrgInv*	*Debt*	*FSize*	*ROA*
ENVMSB	1.000												
TaxGHG	−0.077	1.0000											
CSRSC	0.042	0.052	1.000										
CSRSEA	0.108	0.129	0.249	1.000									
SDG7	0.017	0.038	0.106	0.134	1.000								
FEGD	−0.042	−0.247	0.061	−0.001	0.051	1.000							
EMT	0.051	−0.004	0.294	0.224	0.056	−0.019	1.000						
BIND	−0.033	−0.533	0.028	−0.112	0.011	0.449	−0.003	1.000					
BSize	0.181	−0.047	0.118	0.254	−0.027	−0.037	0.128	−0.175	1.000				
StrgInv	0.060	0.176	−0.001	0.092	0.045	−0.141	−0.012	−0.379	0.115	1.000			
Debt	0.029	−0.162	0.034	0.015	0.047	0.078	0.008	0.156	−0.015	−0.087	1.000		
FSize	0.108	−0.108	0.186	0.306	0.07	0.102	0.131	0.097	0.472	−0.079	−0.018	1.000	
ROA	−0.012	−0.019	−0.025	−0.024	−0.055	−0.010	0.032	−0.023	−0.068	−0.006	−0.088	−0.170	1.000

Table 6: Estimation results of LOGIT regression using all countries and all sectors

Variables	HYP sign	LOGIT fixed regression		LOGIT Random regression		Mean different test	
		Coeff	z	Coeff	z	Mean different	t
Constant	+/-	−2.064***	−5.890	−1.946***	−5.248	−0.018	−0.33
ENVMSB	+/-	0.181*	1.760*	0.309*	1.78	−0.128	−0.73
TaxGHG	+	0.054	1.050	0.084	0.96	−0.03	−0.34
CSRSC	+	0.104*	1.630*	−0.174	−1.59	0.278	2.55
CSRSEA	+	0.097**	2.090	0.166*	2.10	−0.069	−0.87
SDG7	+	0.518***	8.860	0.879***	8.94	−0.36	−3.68
EMT	+	−0.061	−1.200	−0.092	−1.06	0.031	0.36
BSize	+	−0.007	−0.920	−0.012	−1.00	0.005	0.41
BIND	+	0.003***	2.440	0.004**	2.41	−0.001	−0.58
StrgInv	+	−0.283**	−2.280	−0.480***	−2.26	0.197	0.92
FEGD	+	0.011***	6.110	0.018***	6.12	−0.007	−2.33
FSize	+	0.103***	6.490	0.176***	6.53	−0.073	−2.7
Debt	+	−0.251**	−1.950	−0.478**	−2.16	0.227	1.02
ROA	-	−0.033***	−5.510	−0.055**	−5.39	0.022	2.2
N		9944		9944			
LR Chi^2		327.68		530.17			
Prob $>Chi^2$		0.000		0.000			
Model		Fixed effect		Random effect			

CO_2(-) is the decrease of CO_2 emission, ENVMSB if the firm has both an Environmental Management System and ISO 14000 certification. TAXGHG if the country has a GHG tax. CSRSC if the firm has a sustainability committee. CSRSEA if the firm has a sustainable external auditor. SDG7 if the firm has adopted Sustainable Development Goals (affordable and clean energy), EMT if the firm has an environmental management team . BSize is Board size. BIND is board independence. StrgInv is Ownership of strategic investor. FEGD Percentage of executive female members in the firm. FSIZE is the firm size. Debt is the Total debt to total assets. ROA is Return on assets.
***,** and *indicate significance at the 1%. 5% and 10% levels respectively (bolded values)

concerned about financial performance. This result is consistent with those of previous studies that concluded to the positive effect of board gender diversity (Nadeem et al., 2020); Tingbani et al., 2020; Gerged et al., 2020). Both coefficients of debt and ROA are negative and significant implying that firms use their assets and debts efficiently for monitoring purposes.

4.2.1 Probabilities of carbon dioxide emission reductions

4.2.1.1. Probabilities of carbon dioxide emission reductions in G7 countries by years

According to the G7 countries' results (Table 7). We can deduce a number of important conclusions about the likelihood that carbon dioxide emissions will decline in each of these countries: With the strongest tendency of decline, the UK stands out. In addition to having the highest maximum value (0.9216), the UK ranks 5th in the overall classification, but comes in at number five in the classification. This implies that the UK has put in place sensible policies and plans that have resulted in steady drops in CO_2 emissions over time. It also shows significant advances between 2013 (0.6187) and 2022 (0.7014). Germany comes in second position, with a maximum value of 0.8684 in 2019, showing distinguished drops, particularly between 2013 and 2022. Its mean, however, is a little lower (0.6271) placing sixth overall. It suggests that over time, there has been some variation in the emission reductions.

Canada and Italy are also among the top performers in terms of emissions reduction. Canada's mean value (0.6719) ranks it second, while Italy is ranked first with a very high max value of 0.8669 (near the top of the list). These two countries have moderately ameliorated their performance, suggesting that their policies have been steady in reducing emissions. Japan has the lowest average reduction (mean = 0.5966) across the entire period ranking it least position. While Japan shows a significant reduction in 2021 (0.6621) and 2022 (0.6800). It also has the lowest minimum value (0.3950) recorded in 2015 indicating that Japan's emissions reduction trajectory has been less consistent and slower than other G7 countries. France, with a mean of 0.6583 is slightly behind the UK and Canada in terms of average reduction. However, France's max value (0.8783) suggests that the country has had periods of rapid emissions reduction even though these periods are not as frequent or consistent as the UK's.

4.2.1.2. Probabilities of carbon dioxide emission reductions in G7 per GICS sector

According to Table 8, Energy (ENER) and Financials (FINA) are among the top CO_2 emission reductions. The lowest average scores were in Financials with 0.7265 followed by Energy with 0.6586. These probabilities are evidence that both sectors are attempting to decline their carbon emissions, likely as the result of new regulations, investments in clean energy, and better practices of managing and measuring emissions. Industrials (IND) and Health Care (HEAL) are showing similar steps to reduce emissions. Health Care had a score of 0.6677, showing it's been cutting down its CO_2 emissions over the years. In contrast, the Real Estate sector isn't doing as well, scoring just 0.6459. While it has made some progress, its score still points to the high carbon footprint that comes with real estate development, especially in urban areas. Furthermore, there's still a push towards greener building standards.

5. ROBUSTNESS TESTS

We do two robustness tests to verify the sensitivity of the acquired results.

- The first is to examine how adopting a *UN program or sustainable development goals* affects the decrease of carbon dioxide emissions.
- The second test is *Examining the impact of the polluted sector*

In these tests, we check whether the effect *UN program or sustainable development goals* and the *polluted sector* on carbon dioxide emissions reduction varies across firms. To do so we include a dependent variable. A dummy variable coded 1 if the firm adopts the United Nations Initiative or Sustainable Development Goals (SDG) zero otherwise. The same works for the second variable related to the polluted sector. In the second step we explore the effect of the most polluted sectors which are energy. Industrial and materials sectors. For that, we add a dummy variable coded 1 if the firm belongs to polluted sectors using the GICS code.

Table 7: Probabilities of carbon dioxide emission reductions in G7 countries by years

Year and statistics	Canada	France	Germany	Italy	Japan	UK	USA
N	834	709	576	242	2648	1459	3476
2013	0.6528	0.6273	0.6070	**0.6611**	0.5616	0.6187	0.6418
2014	**0.6630**	0.6324	0.5991	0.6613	0.5584	0.6288	0.6460
2015	**0.6736**	0.6344	0.6091	0.6684	0.5564	0.6281	0.6506
2016	0.6621	0.6340	0.6143	**0.6640**	0.5597	0.6282	0.6501
2017	0.6471	0.6313	0.6036	**0.6629**	0.5624	0.6263	0.6399
2018	**0.6580**	0.6387	0.6080	0.6576	0.5727	0.6286	0.6384
2019	**0.6466**	0.6449	0.6148	0.6449	0.5843	0.6357	0.6389
2020	**0.6886**	0.6864	0.6321	0.6778	0.6212	0.6619	0.6730
2021	0.6948	0.6913	0.6505	**0.6964**	0.6621	0.6807	0.6771
2022	0.6993	**0.7094**	0.6763	0.6939	0.6800	0.7014	0.6903
Mean	0.6719	0.6583	0.6271	**0.6725**	0.5966	0.6483	0.6601
Classification	2	4	6	1	7	5	3
Max	0.8947	0.8783	0.8684	0.8669	0.8446	**0.9216**	0.8786
Min	0.4568	0.4558	**0.3684**	0.4153	0.3950	0.4077	0.4021
STD	0.0825	0.0805	**0.0973**	0.0845	**0.0797**	0.0915	0.0782

The bolded values indicate the highest probabilities associated with the reduction of CO_2 emissions

Table 8: Probabilities for carbon dioxide emission reductions in G7 per GICS sector

Year and statistic	COMM	CONS DIS	CONS STA	ENER	FINA	HEAL	IND	INFO	MATE	REAL	UTIL
N	402	1208	744	584	1175	518	2007	790	1172	626	718
2013	0.6353	0.5903	0.5851	0.6370	**0.7120**	0.6146	0.5930	0.5824	0.5750	0.5966	0.6447
2014	0.6354	0.5931	0.5865	0.6392	**0.7104**	0.6124	0.5915	0.5853	0.5814	0.6000	0.6432
2015	0.6393	0.5975	0.5860	0.6737	**0.7078**	0.6150	0.5876	0.5835	0.5828	0.5910	0.6456
2016	0.6430	0.5870	0.5882	0.6687	**0.7101**	0.6105	0.5897	0.5839	0.5886	0.6168	0.6396
2017	0.6431	0.5943	0.5927	0.6419	**0.7098**	0.6105	0.5855	0.5886	0.5796	0.6084	0.6376
2018	0.6383	0.5982	0.5952	0.6281	**0.7093**	0.6125	0.5975	0.5969	0.5894	0.6095	0.6441
2019	0.6382	0.6059	0.6126	0.6380	**0.7033**	0.6239	0.6005	0.6085	0.6047	0.6160	0.6465
2020	0.6564	0.6523	0.6446	0.6975	**0.7374**	0.6254	0.6312	0.6320	0.6333	0.6578	0.6900
2021	0.6815	0.6591	0.6637	0.6740	**0.7554**	0.6418	0.6474	0.6572	0.6578	0.6818	0.7203
2022	0.6973	0.6774	0.6805	0.6872	**0.7659**	0.6525	0.6620	0.6775	0.6711	0.6097	0.7356
Mean	0.6553	0.6233	0.6217	0.6586	**0.7265**	0.6677	0.6147	0.6173	0.6130	0.6459	0.6715
Class	5	7	8	4	1	3	10	9	11	6	2
Max	0.8633	0.8468	0.8350	0.8723	0.9216	0.8480	0.8549	0.8364	0.8572	0.8618	0.8605
Min	0.4558	0.4153	0.4370	0.4568	0.4656	0.4309	0.3684	0.4087	0.3950	0.4077	0.4458
STD	0.0782	0.0817	0.0849	0.0778	0.0784	0.0787	0.0776	0.0809	0.0787	0.0795	0.0782

The bolded values indicate the highest probabilities associated with the reduction of CO_2 emissions

We use the following logistic regression:

$CO2(-)_{it} = \beta_0 + \beta_1\ ENVMSB_{it} + \beta_2\ TaxGHG_{it} + \beta_3\ CSRSC_{it} + \beta_4\ CSRSEA_{it} + \beta_5\ SDG7_{it} + \beta_6\ FEGD_{it} + \beta_7\ EMT_{it} + \beta_8\ BIND_{it} + \beta_9\ BSize_{it} + \beta_{10}\ STRGINV_{it} + \beta_{11}\ FSize + \beta_{12}\ Debt_{it} + \beta_{13}\ ROA_{it} + \beta_{14}\ Robust\ Test_{it} + \xi_{it}$ (8)

- We found (Table 9) that the coefficient of the dummy variable UNinitiative (β_{14} = 0.410) is positive and significant at the 1% level indicating that the adoption of the United Nations Initiative or SDG leads to reducing carbon dioxide emissions.
- We notice also (Table 9) that the coefficient of the dummy variable Industry Pollution (β_{14} = −0.264) is negative and significant at the 1% level indicating that the firms belonging to the most polluted sectors do not reduce carbon dioxide emissions.

Table 9: The estimation results of the Logit regression model including the United Nation Initiative and SDG and polluted sector

Variables	HYP sign	Robust test 1 (UN initiatives)		Robust test 2 (polluted sector impact)	
		Coeff.	*z*	*Coeff.*	*z*
Constant	+/-	**−2.541*** **	−7.110	**−1.445*** **	−3.940
ENVMSB	+/-	**0.191***	1.850	**0.199** **	1.930
TaxGHG	+	0.042	0.810	0.069	1.340
CSRSC	+	−0.072	−1.120	**0.106***	1.650
CSRSEA	+	**0.081***	1.750	**0.100** **	2.150
SDG7	+	**0.409*** **	6.800	**0.515*** **	8.800
EMT	+	−0.036	−0.710	−0.027	−0.520
BSize	+	−0.004	−0.580	−0.003	−0.420
BIND	+	0.002	1.550	**0.003*** **	2.600
StrgInv	+	**−0.340*** **	−2.730	**−0.367*** **	−2.940
FEGD	+	**0.010*** **	5.750	**0.010*** **	5.480
FSize	+	**0.111*** **	6.970	**0.078*** **	4.760
Debt	+	**−0.295** **	−2.290	**−0.246** **	−1.910
ROA	-	**−0.032*** **	−5.290	**−0.035*** **	−5.800
UN initiative	+	**0.410*** **	7.820		
Polluted Sectors	-			**−0.264*** **	-5.870
N		9944		9944	
LR Chi^2		**388.93**		**362.08**	
Prob >Chi^2		0.000		0.000	
Model		LOGIT Fixed effect		LOGIT Fixed effect	

$CO_2(-)$ is the decrease of CO_2 emission, ENVMSB if the firm has both an Environmental Management System and ISO 14000 certification. TAXGHG if the country has a GHG tax. CSRSC if the firm has a sustainability committee . CSRSEA if the firm has a sustainable external auditor. SDG7 if the firm has adopted Sustainable Development Goals (affordable and clean energy) , EMT if the firm has an environmental management team . BSize is Board size. BIND is board independence. StrgInv is Ownership of strategic investor. FEGD Percentage of executive female members in the firm. FSIZE is the firm size. Debt is the Total debt to total assets. ROA is Return on assets. ***, ** and *Indicate significance at the 1%. 5% and 10% levels respectively (bolded values)

5.1. Impact of United Nation Initiative and SDG on Probability of Carbon reduction (Table 10)

Over the period from 2013 to 2022 all G7 countries show an overall improvement in the probability of reduction of carbon dioxide emissions. The mean values across the countries indicate a consistent trend of progress in emissions reduction but there are varying rates of improvement. UK stands out as the top performer with the highest mean probability of reduction (0.5214). Reflecting strong progress toward reducing carbon emissions. The UK also has the highest maximum value (0.8510) in 2021. Demonstrating its commitment to climate action. Potentially through policies like the UK's Climate Change Act and its transition to cleaner energy sources. Canada is another strong performer with a mean of 0.5396 and a high maximum value of 0.8137. Canada likely benefited from policy measures such as carbon pricing and the promotion of clean energy technologies. But it still faces challenges due to its energy-intensive industries. Germany and Italy show moderate progress in emissions reductions with mean values of 0.5082 and 0.5489 respectively. While both countries have made significant improvements they face challenges related to their manufacturing sectors which contribute substantially to their carbon footprints. France has a mean value of 0.5291 showing steady progress. France's energy sector. Especially its reliance on nuclear energy. Likely contributed to these reductions although there is still room for improvement in other sectors such as transportation. Japan and Italy are among the lower performers. With mean values of 0.4773 and 0.5489 respectively Japan in particular faces difficulties due to its reliance on fossil fuels after the shutdown of nuclear reactors post-Fukushima. Additionally, Italy could benefit from further policies encouraging sustainable industrial practices. The United Nations Sustainable Development Goal 13 (Climate Action) and the Paris Agreement have played a crucial role in influencing the G7 countries' actions toward reducing carbon

Table 10: The probabilities of reduction of carbon dioxide emissions for G7 (including the united nation initiative and SDG)

Year and statistics	Canada	France	Germany	Italy	Japan	UK	USA
N	834	709	576	242	2648	1459	3476
2013	0.5223	0.5042	0.4991	**0.5486**	0.4477	0.4917	0.5170
2014	0.5323	0.5079	0.4911	**0.5453**	0.4437	0.5030	0.5217
2015	0.5451	0.5086	0.4981	**0.5494**	0.4432	0.5038	0.5272
2016	0.5335	0.5077	0.5027	**0.5439**	0.4466	0.5026	0.5283
2017	0.5185	0.5037	0.4904	**0.5418**	0.4484	0.5024	0.5196
2018	0.5287	0.5111	0.4925	**0.5401**	0.4581	0.5042	0.5169
2019	0.5161	0.5161	0.4936	**0.5244**	0.4689	0.5114	0.5176
2020	0.5545	0.5551	0.5086	0.5525	0.4998	0.5344	0.5482
2021	0.5598	0.5575	0.5235	**0.5633**	0.5314	0.5498	0.5472
2022	0.5625	**0.5736**	0.5471	0.5605	0.5456	0.5690	0.5587
Mean	0.5396	0.5291	0.5082	**0.5489**	0.4773	0.5214	0.5347
Classification	2	4	6	1	7	5	3
Max	0.8137	0.7934	0.7866	0.7787	0.7550	**0.8510**	0.7937
Min	0.3371	0.3364	**0.2909**	0.3256	0.3318	0.2948	0.3155
STD	0.0883	0.0846	0.0982	0.0892	0.0741	**0.0950**	0.0795

The bolded values indicate the highest probabilities associated with the reduction of CO_2 emissions

emissions. The UK with its high ranking and robust climate policies appears to be a leader in these areas.

Canada despite its large energy sector has been aligning with the UN SDGs through initiatives like carbon pricing renewable energy investments and energy efficiency programs which are contributing to its emissions reduction progress. Japan's lower performance may reflect slower transitions particularly after the 2011 nuclear disaster and its reliance on fossil fuel imports. Japan is part of the UN's SDG 7 (Affordable and Clean Energy) but faces challenges in diversifying its energy mix.

Overall all G7 countries are progressing toward the United Nations Climate Action Goals and SDGs but some nations and sectors have more work to do to ensure long-term sustainability and meet the targets set by the Paris Agreement.

5.2. The Probabilities of Reduction of Carbon Dioxide Emissions per GICS Sector (including the United nation Initiative and SDG) (Table 11)

According to Table 12, Financials (FINA) shows the highest average likelihood of reduction, with a mean of 0.6171, revealing robust efforts toward emissions reduction. This could be explained by sustainability finance initiatives such as green bonds and investments in renewable energy projects. Following closely is Utilities (UTIL) with a mean of 0.5461, signifying considerable advancements. The transition to renewable energy sources and the implementation of energy efficiency strategies might account for this, aligning closely with SDG 7 (Affordable and Clean Energy). The Communication Services (COMM) sector ranks next with an average of 0.5301, reflecting substantial progress. This sector probably benefits from the increased focus on digital and communication infrastructure that incorporates sustainability measures and energy efficiency.

Energy (ENER) is sitting in third place with a mean of 0.5316, showing steady growth over time. This is mainly related to the shift from fossil fuels to renewable energy and cleaner practices. The highest value it hit was 0.7751 in 2020, which suggests it had some strong moments. Healthcare (HEAL) with a mean of 0.5091 showed little progress. This modification comes from the healthcare industry's improvement related to greener practices like energy-efficient buildings, and using sustainable supplies. On the other hand, Materials (MATE) has the lowest average for reducing emissions at 0.4851. This shows the tough times in industries that rely heavily on resource extraction and manufacturing. To

Table 11: The probabilities of reduction of carbon dioxide emissions per GICS sector (including the United Nation Initiative and SDG)

Year and statistic	COMM	CONS DIS	CONS STA	ENER	FINA	HEAL	IND	INFO	MATE	REAL	UTIL
N	402	1208	744	584	1175	518	2007	790	1172	626	718
2013	0.5094	0.4677	0.4627	0.5137	**0.6037**	0.4911	0.4714	0.4596	0.4531	0.4670	0.5213
2014	0.5087	0.4725	0.4635	0.5183	**0.6017**	0.4895	0.4700	0.4617	0.4587	0.4721	0.5201
2015	0.5118	0.4751	0.4630	0.5541	**0.6005**	0.4935	0.4680	0.4606	0.4618	0.4701	0.5233
2016	0.5193	0.4653	0.4645	0.5447	**0.6025**	0.4895	0.4700	0.4632	0.4653	0.4879	0.5219
2017	0.5197	0.4718	0.4678	0.5160	**0.6027**	0.4938	0.4675	0.4677	0.4560	0.4829	0.5194
2018	0.5170	0.4762	0.4692	0.5040	**0.6016**	0.5036	0.4785	0.4747	0.4641	0.4839	0.5226
2019	0.5146	0.4883	0.4880	0.5105	**0.5951**	0.5053	0.4802	0.4854	0.4792	0.4909	0.5211
2020	0.5352	0.5253	0.5140	0.5718	**0.6270**	0.5185	0.5051	0.5059	0.5036	0.5250	0.5609
2021	0.5526	0.5238	0.5295	0.5403	**0.6440**	0.5246	0.5174	0.5220	0.5223	0.5421	0.5886
2022	0.5667	0.5402	0.5442	0.5508	**0.6524**	0.5380	0.5282	0.5416	0.5326	0.5575	0.6034
Mean	0.5301	0.4967	0.4937	0.5316	**0.6171**	0.5091	0.4906	0.4909	0.4851	0.5138	0.5461
Class	4	7	8	3	1	6	10	9	11	5	2
Max	0.7597	0.7352	0.7203	0.7751	0.8510	0.7358	0.7445	0.7205	0.7430	0.4746	0.7678
Min	0.3572	0.3256	0.3318	0.3364	0.3315	0.3202	0.2909	0.3288	0.3349	0.2948	0.3524
STD	0.0778	0.0774	0.0797	0.0780	0.0845	0.0769	0.0714	0.0770	0.0732	0.0748	0.0752

The bolded values indicate the highest probabilities associated with the reduction of CO_2 emissions

Table 12: The probabilities of reduction of carbon dioxide emissions for G7 (including pollution impact)

Year and statistics	Canada	France	Germany	Italy	Japan	UK	USA
N	**571**	**328**	**253**	**105**	**1322**	**698**	**1844**
2013	0.8087	0.8014	0.6849	**0.7481**	0.5935	0.7581	**0.8141**
2014	**0.8392**	0.7807	0.6538	0.7408	0.5884	0.7968	0.8283
2015	**0.8666**	0.7767	0.6684	0.7822	0.5839	0.7878	0.8383
2016	**0.8512**	0.8125	0.6726	**0.7789**	0.5912	0.7867	0.8509
2017	0.8294	0.8091	0.6741	**0.7613**	0.5951	0.7754	**0.8418**
2018	**0.8362**	0.8070	0.6881	0.7584	0.6074	0.7867	0.8332
2019	**0.8059**	0.8235	0.7266	0.7583	0.6171	0.8173	**0.8385**
2020	**0.8505**	0.8534	0.7404	0.7807	0.6546	0.8194	0.8505
2021	0.8663	0.8594	0.7739	**0.8153**	0.7001	0.8590	**0.8676**
2022	0.8751	**0.8982**	0.8029	0.8124	0.7281	0.8667	0.8798
Mean	0.8444	0.8298	0.7206	**0.7748**	0.6301	0.8096	**0.8505**
Classification	2	3	6	5	7	4	1
Max	0.9999	0.9973	0.9936	0.9862	0.9689	**0.9995**	0.9999
Min	0.4926	0.5006	**0.3918**	0.5201	0.4391	0.4360	0.4165
STD	0.1370	0.1378	**0.1772**	0.1226	**0.0867**	0.1633	0.1312

The bolded values indicate the highest probabilities associated with the reduction of CO_2 emissions

tackle carbon emissions in this area, we need some innovations in materials science to come up with more sustainable options.

Real Estate (REAL) and Industrials (IND) also show moderate progress with means of 0.5138 and 0.4906 respectively. These sectors face significant challenges due to energy-intensive construction processes transportation logistics and manufacturing. Consumer Staples (CONS STA) and Consumer Discretionary (CONS DIS) sectors have similar performances with means of 0.4937 and 0.4967. respectively. These sectors rely on resource-intensive processes, such as manufacturing goods and retail logistics, which could explain their slower pace in emissions reduction. UN SDG Alignment: Sectors like Utilities and Energy contribute directly to SDG 7 (Affordable and Clean Energy) making notable progress toward reducing carbon emissions through investments in renewable energy and energy efficiency.

5.3. Polluted Sector Impact on Probabilities Carbon Reduction by Countries

In the second step we explore the effect of the most polluted sectors which are energy industrial and materials sectors. For that, we add a dummy variable coded 1 if the firm belongs to polluted sectors using the GICS code. Specifically, we consider the following logistic regression:

$$CO2(-)_{it} = \beta_0 + \beta_1 \text{ENVMSB}_{it} + \beta_2 TaxGHG_{it} + \beta_3 CSRSC_{it} + \beta_4 CSRSEA_{it} + \beta_5 SDG7_{it} + \beta_6 FEGD_{it} + \beta_7 \text{EMT}_{it} + \beta_8 IBM_{it} + \beta_9 BS_{it} + \beta_{10} STRGINV_{it} + \beta_{11} Size + \beta_{12} Debt_{it} + \beta_{13} ROA_{it} + \beta_{14} \text{Industry Pollution}_{it} + \xi_{it} \quad (9)$$

The data represents the probabilities of reduction of carbon dioxide emissions for G7 countries (Canada, France, Germany, Italy, Japan, UK, USA) from 2013 to 2022. Each country's performance is recorded with a measure that reflects the likelihood of reduced emissions within a given year including the pollution impact across firm-years. Firm-years Number: This shows the number of firm-year observations for each country in the study. For example, the USA has 1.844 firm-years indicating more data points compared to Canada with 571 firm-years.

Probabilities for years (Table 12): These are the probabilities (ranging from 0 to 1) for each country's success in reducing emissions. Values closer to 1 indicate better performance in reducing emissions. While values closer to 0 indicate less successful reductions. The USA and Canada are the top performers with mean reduction probabilities of 0.8505 and 0.8444 respectively. The USA achieved the maximum value of 0.9999 showing highly effective emissions reduction in some years. Japan shows the least fluctuation (low STD). Meaning its emission reduction efforts although lower overall were relatively steady across the years. Germany and Italy exhibit some fluctuation in performance (high STDs). But Germany achieved high probabilities in 2022 similar to other G7 countries. Overall, all countries have made notable progress in emission reduction. But their efforts are not always consistent. France and Canada stand out for their high-peak performances, but other countries like Germany and Japan had years with significant fluctuations.

5.4. Polluted Sector Impact on Probabilities Carbon Reduction by Sectors (Table 13)

According to the results provided by the Table 13. Which includes probabilities of reduction of carbon dioxide emissions by sector with an emphasis on pollution impact. The Energy sector shows a relatively high mean probability of reducing CO_2 emissions over the years. With a minimum value (0.4835), the energy sector indicates variability. Suggesting that some firms in this sector may struggle with emissions reduction while others are closer to the upper limit. The industrial sector has a lower mean probability compared to Energy but still shows consistent progress in emissions reduction. The sector has a large variation (min value of 0.3918). Indicating substantial differences in the ability to reduce emissions across different firms. The Materials sector is slightly behind the Energy and industrial sectors in emissions reduction with a similar level of variability. The wide range indicates that the sector faces challenges in implementing consistent emissions reduction measures. The Real Estate sector has a good average probability of emissions reduction. However its maximum and minimum values show significant variability suggesting mixed performance among firms. The Utilities sector has the highest mean probability indicating strong progress in reducing CO_2 emissions. It also has a relatively high maximum value (close to 1), signalling that some firms in this sector are near-optimal emissions reduction. The minimum value is slightly higher than that of other sectors. Showing that even the lower-performing firms in Utilities have relatively better emissions reduction probabilities.

The utility sector (0.8442) has the highest mean probability, suggesting the best reducing emissions probability. For the standard deviation, the Industrials sector (STD = 0.1598) and Materials sector (STD = 0.1584) have relatively high variations. Indicating that there are firms within these sectors that are making significant progress and others that are lagging behind. For Minimum Emissions Reduction Probability we find that The Industrials sector has the lowest minimum value (0.3918), indicating that some firms in this sector have a significantly lower ability to reduce emissions compared to others. Which highlights the challenge of achieving consistent progress across the sector.

Table 13: The probabilities of reduction of carbon dioxide emissions per GICS sector (including pollution impact)

Year and statistic	ENER	IND	MATE	REAL	UTIL
N	584	2007	1172	626	718
2013	0.7550	0.7200	0.6776	0.7529	**0.8180**
2014	0.7772	0.7110	0.6956	0.7545	**0.8137**
2015	**0.8334**	0.7011	0.6895	0.7299	0.8056
2016	**0.8096**	0.7226	0.7119	0.7959	0.8055
2017	0.7884	0.7299	0.7107	0.7539	**0.8231**
2018	0.7785	0.7396	0.7254	0.7548	**0.8257**
2019	0.7859	0.7563	0.7493	0.7826	**0.8284**
2020	0.8223	0.7715	0.7814	0.7991	**0.8569**
2021	0.8404	0.8022	0.8073	0.8331	**0.8931**
2022	0.8428	0.8217	0.8359	0.8474	**0.9019**
Mean	0.8040	0.7565	0.7493	0.7978	**0.8442**
Class	2	4	5	3	1
Max	0.9999	0.9995	0.9991	0.9999	0.9994
Min	0.4835	0.3918	0.4391	0.4360	0.4729
STD	0.1438	0.1598	0.1584	0.1621	0.1445

The bolded values indicate the highest probabilities associated with the reduction of CO_2 emissions

The Utilities sector stands out as the leader in emissions reduction across the GICS sectors. With the highest mean probability and strong performance across the board. Energy and Industrial sectors also show good progress. But the wide range of values indicates that some firms are significantly outperforming others. The Materials and Real Estate sectors show also promising potential but face greater variability. Lacking more targeted actions to reduce emissions more consistently across firms. This analysis reflects the varying degrees of success across sectors in reducing CO_2 emissions. Likely influenced by industry-specific factors regulatory environments, and technological advancements.

6. CONCLUSION

In this paper we have simultaneously examined the effect of the environmental management system greenhouse gas taxes, om 2013 to 2022. The empirical results show a positive relationship between environmental governance and carbon dioxide emissions reduction. We also found a positive relationship between the sustainability committee and carbon dioxide emissions reduction. However, we did not find a significant relationship between greenhouse gas taxes and carbon dioxide emissions reduction. These findings support the theoretical assumption that both an environmental management system and a sustainability committee are practical tools to reduce carbon dioxide emissions. In addition, we perform several robustness tests by examining whether these relationships vary across countries and sectors. The empirical results show that the firms that adopt United Nation Initiative or Sustainable Development Goals reduce carbon dioxide emissions. However, the firms that belong to the most polluted sectors don't reduce carbon dioxide emissions.

The G7 countries have shown various levels of success in reducing carbon dioxide emissions. The USA and Canada lead the charge with high mean probabilities of reduction. While Japan and Germany show more fluctuation. These differences may be related to various national policies. Industrial practices, and alignment with international environmental initiatives. Including United Nations SDGs. The pollution impact is an important factor in evaluating these countries' long-term success in achieving carbon neutrality. This study has implications for policymakers and regulators to take appropriate decisions that contribute to reducing carbon dioxide emissions.

REFERENCES

Agostini, P., Botteon, M., Carraro, C. (1992), A carbon tax to reduce CO_2 emissions in Europe. Energy Economics, 14(4), 279-290.

Al Shammre, A.S., Benhamed, A., Ben-Salha, O., Jaidi, Z. (2023), Do environmental taxes affect carbon dioxide emissions in OECD countries? Evidence from the Dynamic Panel Threshold Model. Systems, 11(6), 307.

Baranzini, A., Goldemberg, J., Speck, S. (2000), A future for carbon taxes. Ecological Economics, 32(3), 395-412.

Bashir, M.F., Benjiang, M.A., Shahbaz, M., Shahzad, U., Vo, X.V. (2021), Unveiling the heterogeneous impacts of environmental taxes on energy consumption and energy intensity: Empirical evidence from OECD countries. Energy, 226, 120366.

Bayar, Y., Şaşmaz, M.Ü. (2016), Karbon vergisi, ekonomik büyüme ve CO_2 emisyonu arasındaki nedensellik ilişkisi: Danimarka, Finlandiya, Hollanda, İsveç ve Norveç örneği. International Journal of Applied Economic and Finance Studies, 1(1), 32-41.

Delmas, M., Toffel, M.W. (2004), Stakeholders and environmental management practices: An institutional framework. Business Strategy and the Environment, 13(4), 209-222,

Doğan, B., Chu, L.K., Ghosh, S., Diep T.H.H., Balsalobre-Lorente, D. (2022), How environmental taxes and carbon emissions are related in the G7 economies? Renewable Energy, 187, 645-656.

Douglas, H.E., Thomas, S.M. (1995), Stoking the fires? CO_2 Emissions and economic growth. Journal of Public Economics, 57(1), 85-101.

Dunn-Rankin, D. (2011), Lean Combustion: Technology and Control. United States: Academic Press.

Friedl, B., Getzner, M. (2003), Determinants of CO_2 emissions in a small open economy. Ecological Economics, 45(1), 133-148.

Garzón-Jiménez, R., Zorio-Grima, A. (2021), Effects of carbon emissions, environmental disclosures and CSR assurance on cost of equity in emerging markets. Sustainability, 13(2), 696.

Gerged, A.M., Chijoke-Mgbame, A.M., Konadu, R., Cowton, C.J. (2022), Does the presence of an environmental committee strengthen the impact of board gender diversity on corporate environmental disclosure? Evidence from Sub-Saharan Africa. Business Strategy and the Environment, 32, 2434-2450.

Ghazouani, A., Xia, W., Ben Jebli, M., Shahzad, U, (2020). Exploring the role of carbon taxation policies on CO_2 emissions: Contextual evidence from tax implementation and non-implementation European countries. Sustainability, 12, 8680.

Grossman, G.M., Krueger, A.B. (1991), Environmental Impacts of a North American Free Trade Agreement. Working Paper.

Guthrie, J., Parker, L.D. (2014), The global accounting academic: What counts! Accounting Auditing and Accountability Journal, 27(1), 2-14.

Haseeb, A., Xia, E., Danish, D., Baloch, M.A., Abbas, K. (2018), Financial development, globalization, and CO_2 emission in the presence of EKC: Evidence from BRICS countries. Environmental Science and Pollution Research, 25, 31283-31296.

He, P., Chen, L., Zou, X., Li, S., Shen, H., Jian, J. (2019), Energy taxes, carbon dioxide emissions, energy consumption and economic consequences: A comparative study of Nordic and G7 countries. Sustainability, 11, 1-17.

Ibishova, B., Misund, B., Tveterås, R. (2024), Driving green: Financial benefits of carbon emission reduction in companies. International Review of Financial Analysis, 96, 103757.

Jaffe, A.B., Newell, R.G., Stavins, R.N. (2005), A tale of two market failures: Technology and environmental policy. Ecological Economics, 54(2-3), 164-174.

Kuznets, S. (1955), International Differences in Capital Formation and Financing, in Capital Formation and Economic Growth. United States: Princeton University Press. p19-111.

Lemos, M.C., Agrawal, A. (2006), Environmental governance. Annual Review of Environment and Resources, 31, 297-325.

Lyon, T.P., Montgomery, A.W. (2015), The means and end of greenwash. Organization and Environment, 28(2), 223-249.

Manurung, D.T.H., Rachmat, R.A.H. (2019), ISO 14001 implementation impact and financial performance on corporate social responsibility disclosure. Journal Management, 23(2), 207-222.

Miah, M.D., Hasan, R., Usman, M. (2021), Carbon emissions and firm performance: Evidence from financial and non-financial firms from selected emerging economies. Sustainability, 13(23), 13281.

Nadeem, M., Bahadar, S., Gull, A.A., Iqbal, U. (2020), Are women eco-friendly? Board gender diversity and eco-innovation. Bus Strategy Environ 29(8), 3146-3161.

Peters, G., Romi, A. (2014), Does the voluntary adoption of corporate governance mechanisms improve environmental risk disclosures? Evidence from greenhouse gas emission accounting. Journal of Business Ethics, 125, 637-666.

Polat, O. (2019), Environmental taxes and carbon dioxide emission in EU countries: A panel VAR approach. Economics Business and Organization Research, 1(1), 20-33.

Prafitri, A., Zulaikha, Z. (2016), Analisis pengungkapan emisi gas rumah kaca. Journal Akuntansi Dan Auditing, 13(2), 155-175.

Sarigül, S.S., Topcu, B.A. (2021), The impact of environmental taxes on carbon dioxide emissions in turkey. International Journal of Business and Economic Studies, 3(1), 43-54.

Sayre, D. (1996), Inside ISO 14001: The Competitive Advantage of Environmental Management. Delray, Beach, FL: St, Lucie Press.

Setiawan, P., Iswati, S. (2019), Carbon emissions disclosure, environmental management system, and environmental performance: Evidence from the plantation industries in Indonesia. Indonesian Journal of Sustainability Accounting and Management, 3(2), 215-226.

Shahzad, U. (2020), Environmental taxes, energy consumption, and environmental quality: Theoretical survey with policy implications. Environmental Science and Pollution Research, 27(20), 24848-24862.

Steger, U. (2000), Environmental management systems: Empirical evidence and further perspectives. European Management Journal, 18(1), 23-37.

Tingbani, I., Chithambo, L., Tauringana, V., Papanikolaou, N. (2020), Board gender diversity, environmental committee and greenhouse gas voluntary disclosures. Business Strategy and the Environment, 29(6), 2194-2210.

Tucker, R.C. (1995), Politics as Leadership: Revised Edition. United States: University of Missouri Press.

Yunus, S., Elijido-Ten, E., Abhayawansa, S. (2016), Determinants of carbon management strategy adoption: Evidence from Australia's top 200 publicly listed firms. Managerial Auditing Journal, 31(2), 156-179.

Zaidi, S.A.H., Wei, Z., Gedikli, A., Zafar, M.W., Hou, F., Iftikhar, Y. (2019), The impact of globalization, natural resources abundance, and human capital on financial development: Evidence from thirty-one OECD countries. Resources Policy, 64, 101476.