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The effect of firm size, foreign ownership, and board diversity on carbon tax in companies listed on the Indonesia stock exchange

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Abstract: In response to increasing global concern over climate change, Indonesia is preparing to implement a carbon tax as part of its strategy to reach net-zero emissions by 2060. This study explores the influence of firm size, foreign ownership, government ownership, and board diversity on carbon tax liabilities among 23 energy sector companies listed on the Indonesia Stock Exchange (IDX) between 2021 and 2023. Using 69 panel data observations, the study applies multiple linear regression models and employs Chow, Hausman, and Lagrange Multiplier tests to determine the most suitable model. The findings reveal that board diversity has a significant negative effect on carbon tax, indicating that companies with more diverse boards may engage in better environmental governance and cost efficiency strategies. In contrast, firm size and foreign ownership show no statistically significant relationship with carbon tax. These results emphasize the importance of board composition in shaping corporate responses to environmental regulation. Despite limitations related to sample size and data availability, the study contributes to the understanding of corporate environmental accountability in emerging markets and suggests implications for both policymakers and corporate leaders.

Keywords: *Carbon tax, Firm size, Foreign ownership, Greenhouse gas emissions, Board diversity.*

1. Introduction

The issue of climate change, widely discussed globally, centers on the rising concentration of greenhouse gases (GHGs) like carbon dioxide (CO_2). These gases trap infrared radiation from the Earth, significantly impacting global temperatures and weather patterns [1].CO_2 was largely emitted through fossil fuel consumption, is the most significant GHG and is widely acknowledged by the scientific community as a contributor to warming in the Earth's troposphere [2, 3].

Addressing global warming requires international cooperation, exemplified by agreements like the Paris Agreement, established in 2015 to limit global temperature increases to below 2°C from pre-industrial levels. Developed nations have pledged to provide updated support information every two years, including public funding projections, with the goal of mobilizing $100 billion annually for climate action in developing countries [4]. Major emitters, including China, the United States, and the European Union, contribute heavily to Global GHG emissions, with the energy sector alone responsible for 76% of global emissions in 2019.

In response to the Paris Agreement, various countries have implemented measures to reduce fossil fuel reliance. For example, South Korea and Indonesia provide subsidies for electric vehicles, with Indonesia reducing VAT for electric cars from 11% to 1%. Additionally, carbon taxes are being adopted as an effective and economical method for reducing emissions [5]. By increasing fossil fuel costs, carbon taxes encourage energy conservation and shift consumption toward renewables [6]. Indonesia's carbon tax policy, initially set from 2022 but was postponed to 2025. The planned rate was ID30,000/tCO_2e ($2)

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for coal-fired plants, remains below the World Bank's recommended level of $35 - $100 for developing countries [7].

Indonesia's carbon tax policy represents a critical step toward aligning national economic strategies with international climate commitments. However, due to regulatory gaps and external geopolitical tensions, notably the Russia-Ukraine conflict, the policy's enforcement has been postponed to 2025. This delay has prompted the government to refine supporting regulations, including those outlined in Presidential Regulation No.98 of 2021 on Carbon Economic Value, which governs emission limits, carbon pricing, and the establishment of supervisory steering committee. Despite this postponement, companies in high-emissions sectors-especially in energy-have begun to prepare for compliance, responding to broader environmental governance trends and increasing pressure from stakeholders. The analysis period of 2021-2023 is thus strategically selected to capture anticipatory behavior by firms prior to the formal application of the carbon tax. This pre-implementation phase provides valuable insight into how companies are adjusting to an evolving regulatory environment.

In addition, Law No.7 of 201 mandates a carbon tax for emissions exceeding the established Upper Emission Limit, with a minimum rate of IDR 30 per kilogram of CO_2 equivalent. Indonesia's carbon trading platform (IDX Carbon) was launched in 2020 to support the carbon tax by facilitating the trading of carbon certificates. Both the carbon tax and trading mechanisms impact corporate profitability by increasing operational costs, thereby encouraging companies to adopt low-carbon technologies and increase renewable energy usage [8].

Indonesia has been a major carbon emitter from over 20 years. According to Indonesia's Meyer, et al. [6] the government aims to achieve net-zero emissions by 2060, targeting a 29% GHG reduction below business-as-usual (BaU) by 2030, or up to 41% with international assistance. The updated Nationally Determined Contribution (NDC) set an emissions reduction goal in the energy sector of 314 million tons of CO_2e by 2030 through domestic efforts and 446 million tons with international support. The energy sector encompasses activities such as oil and gas exploration, production, marketing, and the supply of related equipment and services [9, 10]. Corporate governance is the institutional framework for distributing and exercising power within a company, establishing and exercising power within a company, establishing guidelines for directing and controlling operations. It defines the roles and responsibilities of key stakeholders, such as the board of directors, managers, and shareholders [11]. According to signaling theory, larger companies often produce more emissions but can influence carbon disclosure due to their capacity to demonstrate environmental responsibility and commitment to sustainability [12].

Foreign investment also impacts emissions in developing countries, often leading to increased pollution due to weaker regulatory standards. Many multinational corporations relocate production to countries with looser environmental controls, benefiting from lower ecological standards [13]. Studies indicate that foreign ownership can reduce GHG growth as companies adopt measures to manage their environment impact, although foreign direct investment (FDI) in some countries, like china, initially raises emissions before moderating as energy intensity processes evolve [14].

The issue of gender diversity on corporate boards has gained global attention, with more woman holding executive roles, contributing positively to company performance. Studies show the gender-diverse board of positively correlated with higher ESG scores, particularly in countries with weaker stakeholder and environmental regulation [15]. A higher proportion of female directors is associated with improved ESG performance, as women tend to prioritize environmental and social issues, influencing decision-making related to emissions and sustainability initiative [9].

Prior studies have largely focused on carbon taxation in jurisdictions where policies are already in effect, often neglecting transitional economies or the preparatory behavior of firms during regulatory uncertainty. This study fills the gap by analyzing firm-level factors-namely firm size, foreign ownership, and board diversity-that may influence how companies approach prospective carbon liabilities. By situating this analysis in the context of Indonesia's ongoing regulatory evolution, this paper contributes to literature on corporate environmental accountability and offers practical implications for policy makers and business leaders operating in emerging markets.

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This study aims to examine the factors influencing carbon tax, utilizing independent variables that include firm size, foreign ownership, and board diversity. The dependent variable in this study is the carbon tax. The research population consists of energy sector companies listed on the Indonesia Stock Exchange (IDX) from 2021 to 2023. Data analysis conducted through classical assumption testing, which includes tests for normality, multicollinearity, autocorrelation, and heteroscedasticity. Following this, multiple linear regression analysis will be performed. Hypothesis testing will be conducted using the F-test, T-test, and R^2 test. This paper is organized as follows: the next section reviews that relevant literature and theoretical background; the third section describes the research design and methodology; the fourth section presents the results and discussion; and the final section concludes with key findings, implications, and suggestions for future research.

2. Literature Review

2.1. Legitimacy Theory

Legitimacy Theory suggests that companies seek to maintain legitimacy by aligning with societal values and norms, particularly through environmental practices, to uphold an implicit social contract with their communities [16]. The relationship between sustainability performance and disclosure remains unclear. Voluntary Disclosure Theory proposes a positive relationship, while Legitimacy Theory suggests a negative one; under the latter, companies with poor sustainability performance may provide low-quality disclosures to obscure true outcomes and protect their Legitimacy [17]. Research indicates the companies respond to legitimacy threats from negative media coverage with high-quality assurance measures, supported by independent boards, to reinforce corporate legitimacy [18].

2.2. Signaling Theory

Signaling Theory posits that companies use certain actions or decisions to convey information to external parties, such as investors, regulators, or the public. In a study on the effects of carbon tax, capital expenditure, and company size on carbon emissions disclosure on the Indonesia Stock Exchange, Signaling Theory was applied to examine the influence of company size. The findings indicated the company size did not significantly impact carbon emissions disclosure, suggesting a neutral effect [12]. The essence of Signaling Theory lies in the information asymmetry between stakeholders, where informed parties signal their actions or decisions, and recipients interpret these signals to make informed decisions.

2.3. Sustainable Development

Sustainable Development emerged to address environmental and social impacts of industrial growth, aiming to balance current needs with future resources [19, 20]. Defined by the WCED in Cleveland and Morris [1] it promoted economic growth, resource conservation, and equitable development, as emphasize at the 1992 Rio Earth Summit [19]. This approach is essential in resource-intensive sectors like energy, requiring significant investment in sustainable technologies and low-carbon initiatives to mitigate environmental impact [21, 22].

2.4. Green Economy

A Green Economy is a economic model prioritizing sustainability, environmental protection, and social well-being through clear technologies, renewable energy, and circular practices [21]. While Green Economy focuses on eco-economic relations, Sustainable Development is broader, encompassing all aspects of economic, social, and environmental welfare [23]. Popularized by UNEP and UNEEC, the Green Economy promotes well-being and equity while reducing environmental risks. Studies highlight a "Green Recovery" post-COVID-19 as a strategic shift towards clean energy and resource efficiency [24].

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2.5. Carbon Emissions

Greenhouse Gases (GHGs), including H_2O, CO_2, O_3, and N_2O, trap heat in the atmosphere, regulating Earth's temperature. This natural greenhouse effect is essential for life, but excessive GHG emissions for human activities, especially CO_2, from fossil fuels and deforestation, are driving climate change [25]. Each GHG has a unique heat-trapping potential and atmospheric lifespan. Sectors like transportation contribute significantly to GHG emission, and electric vehicles (EVs) are seen as sustainable alternatives, potentially reducing emissions by up to 40% if charged with renewable energy [26]. Reducing GHG emissions is crucial to counter global warming and environmental degradation [27, 28].

2.6. Carbon Tax

Taxation, essential for government revenue, funds public services such as infrastructure, safety, health, and education [29]. A Carbon Tax, levied per ton of emissions, targets greenhouse gases to drive a shift toward renewable energy and aligns with the polluter-pays principle by raising the cost of carbon-heavy fuels, thereby promoting sustainable energy use and conservation [30]. Carbon taxes are core climate policy tool, commonly known as "Green Taxes" or "Pigouvian Taxes" While they effectively price emissions, the exact reduction outcomes can vary [31]. Countries like Sweden, Ireland, and Switzerland have progressively raised carbon tax rate to meet climate goals, demonstrating a global trend in emissions regulation [30].

2.7. Hypothesis

2.7.1. Firm Size's Impact on Carbon Tax

Total assets, representing a company's resources, including both fixed and current assets, indicate its production capacity. Larger firms, with greater operational scale, tend to produce more carbon emissions. Paying for these emissions signals the company's commitment to environmental responsibility, demonstrating a willingness to incur additional costs and enhancing its competitive standing. Research shows that company size positively and significantly impacts carbon emissions disclosure [32, 33]. According to the given description, the theory put forward is a follow:

H_1: Firm Size as a significant positive impact on carbon tax.

2.7.2. Foreign Ownership's Impact on Carbon Tax

Companies with higher foreign ownership often face increased pressure to maintain social legitimacy, as multinational companies are typically influenced by foreign investors from developed countries with ESG policies. These investors prefer companies with strong environmental performance, which can lead to better tax compliance and competitiveness. Foreign ownership may reduce greenhouse gas emissions, enhancing competitiveness [13]. Additionally, both government and foreign ownership positively impact carbon emissions disclosure in mining companies [34]. Therefore, the company is likely to report more accurate carbon emissions, influencing carbon tax. According to the given description, the theory put forward is a follow:

H_2: Foreign Ownership has a negative impact on carbon tax.

2.7.3. Board Diversity's Impact on Carbon Tax

The presence of woman at the top levels of a company is linked to a more collaborative, inclusive, socially responsible, and long-term-oriented leadership style, which enhances management quality and risk management. Woman are perceived as more transparent and accountable, making carbon emission reporting a priority. Gender diversity in management, especially when woman play prominent roles outside the company, has a stronger impact on mitigating climate change. Studies show that companies by 5% more than those with male-dominated leadership [35] and have lower emissions overall [36]. According to the given description, the theory put forward is a follow:

H_3: Board Diversity has a negative impact on carbon tax.

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3. Methodology

This study focuses on companies listed in the Energy sector on the Indonesia Stock Exchange (IDX) during the period of 2021-2023. A total of 87 companies will be included in the sample, based on specific criteria, which exclude companies that were delisted between 2021 and 2023 and companies that did not provide complete reports on carbon emissions for specified period. The inclusion criteria are as follows:

1. Companies listed on the IDX in the Energy sector during 2021-2023.
2. Companies that have published complete financial reports for the years 2021-2023.
3. Companies that have reported their carbon emissions for the period 2021-2023.

Table 1.
Research Sample.

No.	Description	Total
1	Companies listed on IDX in the Energy sector during 2021-2023.	87
2	Companies that did not provide their financial report consecutively for 2021-2023.	0
3	Companies that did not provide a consecutive report needed in the report 2021-2023.	-64
Number of Companies Included in the Sample		23
Observation Period		3
Number of Companies Analyzed		69

To gather the required company data, this study will utilize the LSEG (Refinitiv) tool, which will be instrumental in retrieving and verifying the relevant data for the analysis.

3.1. Operational Variable

3.1.1. Carbon Tax

Carbon Tax is a levy imposed on carbon emissions that negatively impact the environment. It is applied to emissions exceeding a set threshold, as outlined in Presidential Regulation Number 98 of 2021 and detailed in Law Number 7 of 2021 concerning the Harmonization of Tax Regulations. This tax targets Carbon Dioxide (CO_2) and other Greenhouse Gas emissions to reduce carbon output and promote the use of cleaner energy sources [30]. In Indonesia, the Carbon Tax it set at IDR 30 per kilogram of CO_2 equivalent (CO_2e). The formula for calculating the tax is as follows:
CT (Carbon Tax) = Total Carbon Emissions x Tax Rate

3.1.2. Firm Size

Company size refers to the scale of a company, measured by total assets, number of employees, sales or revenue, and market capitalization. Larger companies typically attract greater public attention and possess more substantial resources [37]. The formula for calculating company size is as follows:
FS (Firm Size) = Total Assets

3.1.3. Foreign Ownership

Ownership structure is a key indicator of a company's performance. According to Law Number 25 of 2017 concerning Investment, foreign ownership includes investments mare by foreign individuals, business entities, and foreign governments within the Republic of Indonesia. The formula of calculating foreign ownership is as follow:

$$\text{FO (Foreign Ownership)} = \frac{\text{Total Shares Owned by Foreigners}}{\text{Total Shares Outstanding}} \text{ x } 100\%$$

3.1.4. Board Diversity

The impact of female directors on company carbon emissions may differ from that of male directors due to variations in value and risk preferences. Women are generally considered more pro-social and altruistic, and are more likely to prioritize stakeholder interests, leading to a reduces tendency to make

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decisions driven solely by personal financial gain [38]. The formula for calculating board diversity is as follow:
BD (Board Diversity) = Number of Female Board Members / Total Board Members

3.2. Regression Model
After the collection is done, the data will be analyzed with a regression model as:

$$CT = a + \beta_1 FS + \beta_2 FO + \beta_3 GO + \beta_4 BD + e$$

CT = Carbon Tax
A = Constant
$\beta_1, \beta_2, \beta_3, \beta_4$ = Regression Coefficient
FS = Firm Size
FO = Foreign Ownership
GO = Government Ownership
BD = Board Diversity
e = Error

4. Result

4.1. Statistical Analysis Descriptive

Table 2.
Statistic Test Descriptive Result.

	Obs.	Mean	Std. Dev.	Min.	Max.
Carbon Tax	69	198348.9	321108.8	696.9	1386954
Firm Size	69	2.70e+08	3.56e+08	9890609	1.68e+10
Foreign Ownership	69	27.66326	25.64202	.0638276	97.37926
Board Diversity	69	11.73852	13.34174	0	50

Source: Stata 15 data processing result, secondary data processed (2024).

The total number of observations (N) in this study is 69, following the removal of outliner data. Initially, the dataset contained 111 observations, but after outliner removal, the unable data was reduced to 69, as shown in the descriptive statistical test results table. The investigation into the variables revealed the following findings: The Carbon Tax variable has a mean value of 198,848.9, with a minimum value of 696.9, a maximum value of 1,386,964, and a standard deviation value of 321,108.8. The Firm Size variable has a mean of 2.70e+08, minimum value of 9,890,609, highest value of 1.68e+10, and standard deviation value 3.56e+08. For the Foreign Ownership variable, the mean value is 27.66326, minimum value of 0.0638276, maximum value of 97.37926, and standard deviation value of 25.64202. Lastly, the Board Diversity variable has a mean of 11.73852, minimum value of 0, maximum value of 50, and standard deviation value of 13.34174.

4.2. Normality Test

Table 3.
Normality Test Result.

	Obs.	W'	V'	z	Prob>z
Carbon Tax	69	0.98524	0.993	-0.013	0.50512
Firm Size	69	0.98832	0.786	-0.465	0.67912
Foreign Ownership	69	0.96630	2.268	1.580	0.05708
Board Diversity	69	0.98469	1.030	0.057	0.47740

Source: Stata 15 data processing result, secondary data processed (2024).

The normality test was conducted using the Shapiro Francis W' test method, as presented in Table 3. According to this method, data is considered to have a non-normal distribution if the prob>z value is

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below 0.05. Conversely, data is considered to follow a normal distribution if the prob>z value is above 0.05. The result indicate that the Carbon Tax variable has a prob>z value of 0.50512, the Firm Size variable has a prob>z value of 0.67912, the Foreign Ownership variable has a prob>z value of 0.05708, and the Board Diversity variable has a prob>z value of 0.47740. Based on these findings, it can be concluded that all variables, consisting of total of 69 observations, are normally distributed.

4.3. Multicollinearities Test

Table 4.
Multicollinearities Test Result.

	VIF	1/VIF
Foreign Ownership	1.07	0.932981
Board Diversity	1.07	0.925349
Firm Size	1.00	0.996936
Mean VIF	1.05	

Source: Stata 15 data processing result, secondary data processed (2024).

The multicollinearity test result presented in Table 4, adheres to following criteria: if the tolerance value (1/VIF) is greater than 0.10 and the VIF value is less than 10, it indicates no symptoms of multicollinearity. Conversely, if the tolerance value (1/VIF) is less than 0.10 and VIF value exceeds 10, multicollinearity symptoms are present, and the model fails the multicollinearity test. In this analysis, the Foreign Ownership variable has a VIF value of 1.07<10 and a 1/VIF value of 0.932981, the Board Diversity variable has a VIF value of 1.07<10 and a 1/VIF value of 0.924349, while the Firm Size variable has a VIF of 1.00<10 and a 1/VIF value of 0.996936. The mean VIF is 1.05, indicating that all three variables exhibit no symptoms of multicollinearity.

4.4. Heteroscedasticity Test

Table 5.
Heteroscedasticity Test Result.

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity **Ho : Constant variance** **Variables : fitted values of CT**		
Chi2 (1)	=	105.62
Prob > chi2	=	0.0000

Source: Stata 15 data processing result, secondary data processed (2024)

In the heteroskedasticity test, if the result of Prob > Chi2 is less than 0.05, is indicates the presence of heteroskedasticity in the research data. Conversely, if the value of Prob > Chi2 is grater than 0.05, it suggests that there is no heteroskedasticity. In this study, the Breusch-Pagan test was conducted, yielding a Prob > Chi2 value of 0.0000, which less than 0.05. This indicates that the data analyzed in this study exhibit heteroskedasticity, leading to the rejection of H0. Consequently, a robust standard error test will be performed to provide more valid results despite the presence of heteroskedasticity.

4.5. Autocorrelations Test

Table 6.
Autocorrelations Test Result.

Dublin- Watson d-statistic (4, 69) = 1.885906

Source: Stata 15 data processing result, secondary data processed (2024).

In the autocorrelation test, the Dubin-Watson (DW) test is used. If the value of falls between -2 and +2, it indicates that there is no autocorrelation, and the test is passed. However, if the Durbin-Watson

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value is outside this range, it suggests the presence of autocorrelation. In this study, the DW value is 1.885906, which indicates that there is no autocorrelation in the data.

4.6. Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM)

Table 7.
Common Effect Model Test Result.

	Source	SS	fd	MS	Number of obs	=	69
	Model	2.8135e+12	3	9.3783e+11	F (3, 65)	=	14.52
	Residual	4.1980e+12	65	6.4585e+10	Prob > F	=	0.0000
	Total	7.0115e+12	68	1.0311e+11	R-squared	=	0.4013
					Adj R-squared	=	0.3736
					Root MSE	=	2.5e+05
CT	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**[95% Conf.**	**Interval]**	
FS	0.0005717	0.0000867	6.59	0.000	0.0003984	0.0007449	
FO	870.5418	1244.297	0.70	0.487	-1614.49	3355.574	
BD	247.0241	2388.434	0.10	0.918	-4524.007	5017.056	
_cons	17151.67	63731.44	0.27	0.789	-110128.8	144432.1	

Source: Stata 15 data processing result, secondary data processed (2024)

In the Common Effect Model, the variables Firm Size, Foreign Ownership, and Board Diversity exhibit a positive influence, with coefficient values of 0.0005717, 870.5418, and 247.0241, respectively. However, only the Firm Size variable demonstrates a significant influence, as its probability value is below 0.05, specifically 0.000. In contrast, the other two variables, Foreign Ownership dan Board Diversity, do not have a significant influence, as their probability value are 0.487 and 0.918, respectively, both of which exceed the 0.05 threshold.

Table 8.
Fixed Effect Model Test Result.

Fixed-effects (within) regression					Number of obs.	=	69
Group variable : ID					Number of groups	=	23
R-sq:					Obs. per group:		
Within	= 0.1439				Min.	=	3
Between	= 0.0733				Avg.	=	3.0
Overall	= 0.0614				Max.	=	3
corr (u_i, Xb) = -0.5008					F (3,43)	=	2.41
					Prob > F	=	0.0801
CT	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**[95% Conf.**	**Interval]**	
FS	-0.0001121	0.0001046	-1.07	0.290	-0.0003231	0.0000988	
FO	-361.2961	825.6265	-0.44	0.664	-2026.43	1303.638	
BD	-6902.082	3087.214	-2.24	0.031	-13128.04	-676.1217	
_cons	319617.9	50393.18	6.34	0.000	217990.4	421245.5	
sigma_u	360089						
sigma_2	62874.327						
rho	0.97041427	(Fraction of variance due to u_i)					
F test that all u_i=0: F(22, 43) = 46.32 Prob > F = 0.000							

In the Fixed Effect Model, the variables FS (Firm Size), FO (Foreign Ownership), BD (Board Diversity) exhibit negative coefficients of -0.0001121, - 361.2961, and -6902.082, respectively. Among these, only the variable BD has a significant influence, as it probability value is below 0.05, specifically at 0.031. Conversely, the variables FS and FO do not have a statistically significant effect, with probability values of 0.290 and 0.664, both exceeding the 0.05 threshold.

Additionally, the Prob > F value of 0.0810 indicates that Fixed Effect Model is not significant at the 5% significance level. This implies that the independent variables, collectively, do not have a sufficiently

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strong influence to explain the variability of the dependent variables (Carbon Tax) at the specified level of significance.

Table 9.
Random Effect Model Test Result.

Random-effect GLS regression					Number of obs.	=	69
Group variable : ID					Number of groups	=	23
R-sq:					Obs. per group:		
Within	= 0.0491				Min.	=	3
Between	= 0.0860				avg	=	3.0
Overall	= 0.0847				Max.	=	3
corr (u_i, X) = 0 (assumed)					Wald chi2 (3)	=	4.31
					Prob > chi2	=	0.2299
CT	**Coef.**	**Std. Err.**	**z**	**P>|z|**	**[95% Conf.**	**Interval]**	
FS	0.0000967	0.0000953	1.01	0.310	-0.000901	0.0002836	
FO	-112.7668	856.946	-0.13	0.895	-1791.186	1565.652	
BD	-5193.336	2725.946	-1.91	0.057	-10536.09	149.4194	
_cons	236338.8	76456.98	3.09	0.002	86485.86	386191.7	
Sigma_u	255586.28						
Sigma_2	62874.327						
rho	0.94293704	(Fraction of variance due to u_i)					

In the random effect model, the variable Firm Size (FS) has a positive influence, with a coefficient value of 0.0000967. Conversely, the variables Foreign Ownership (FO) and Board Diversity (BD) exhibit negative influences, with coefficient value of -112.7668 and − 5193.336, respectively. However, all variables demonstrate an insignificant effect, as their probability values exceed the 0.05 significance level. Specifically, the probability values for FS, FO, and BD are 0.310, 0.895, and 0.057, respectively. Furthermore, the Prob > chi2 value of 0.229, which is greater than 0.05, indicates that the null hypothesis cannot be rejected. In other words, where is insufficient statistical evidence to conclude that the independent variable collectively has a significant influence on the dependent variable.

4.7. Chow Test, Hausman Test, and Lagrange Test

Based on the three previously conducted model tests, namely the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM), further testing will be carried out using the Chow test, Hausman test, and Lagrange Multiplier test. These tests aim to determine the most appropriate model for this study.

Table 10.
Chow Test Result.

F (22, 43)	**=**	**46.32**
Prob > F	**=**	**0.0000**

Source: Stata 15 data processing result, secondary data processed (2024).

Based on the result of the Chow Test, the Prob > F value is 0.0000, which is smaller than the significance level of 0.05. This indicate that the null hypothesis (H_0), which states that the Common Effect model is more appropriate than the Fixed Effect Model, is rejected. Therefore, the Fixed Effect Model (FEM) is more suitable for data in this study.

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Table 11.
Hausman Test Result.

	----- Coefficients -----			
	(b)	**(B)**	**(b-B)**	**Sqrt (diag (V_b-V_B))**
	FEM	**REM**	**Difference**	**S.E.**
FS	-0.0001121	0.0000967	-0.0002089	0.0000431
FO	-361.3961	-122.7768	-248.6292	.
BD	-6902.082	-5193.336	-1708.746	1449.176

b = consistent under H_0 and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under H_0; obtained from xtreg
Test: H_0: difference in coefficients not systematic
Chi2(2) = (b-B)'[(V_b-V_B)^(-1)] (b-B)
= -0.72

Based on the results of the Hausman test, where the chi-square value obtained is -0.72, it indicates that the data does not meet the asymptotic assumption required for the Hausman test. Consequently, the test cannot provide valid results due to the negative chi-square value. As a result, it is not possible to determine whether the Fixed Effects Model (FEM), or the Random Effect Model (REM) should be used based on this test.

Table 12.
Lagrange Test Result.

Breusch and Pagan Lagrangian multiplier thest for random effects
CT[ID,t] = Xb + u[ID] + e[ID,t]
Estimated Result:

	Var	**Sd = sqrt (Var)**
CT	1.03e+11	321108.8
E	3.95e+09	62874.33
U	6.53e+10	255586.3

Test: Var(u) = 0
Chibar2(01) = 51.19
Prob > chibar2 = 0.0000

Based on the results od the Breusch and Pagan Lagrangian Multiplier test, the chi-square value is 51.19, with a probability value (Prob > chibar2) of 0.0000. This indicates that the result is higher significant at the 1%, 5%, or 10% significance level. Therefore, the test results demonstrade that Random Effect Model is more appropriate to use compared to the Ordinary Least Squares (OLS) model.

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4.8. Hypothesis Test

Table 13.
T Test, F Test, and R^2 Test Result.

Fixed-effects (within) regression					Number of obs.	=	69
Group variable : ID					Number of groups	=	23
R-sq:					Obs. per group:		
Within	= 0.1439				Min.	=	3
Between	= 0.0733				Avg	=	3.0
Overall	= 0.0614				Max.	=	3
corr (u_i, Xb) = -0.5008					F (3,43)	=	2.41
					Prob > F	=	0.0801
CT	Coef.	Std. Err.	t	P>|t|	[95% Conf.		Interval]
FS	-.0001121	.0001046	-1.07	0.290	-.0003231		0.0000988
FO	-361.2961	825.6265	-0.44	0.664	-2026.43		1303.638
BD	-6902.082	3087.214	-2.24	0.031	-13128.04		-676.1217
_cons	319617.9	50393.18	6.34	0.000	217990.4		421245.5
sigma_u	360089						
sigma_2	62874.327						
rho	.97041427	(Fraction of variance due to u_i)					
F test that all u i=0: F (22. 43) = 46.32					Prob > F = 0.000		

Based on several tests conducted, including the Chow test, Hausman test, and Lagrange Multiplier test, this study utilizes a Fixed Effects model for hypothesis testing, specifically the t-test, F-test, and R^2 test. The F-test results show a value of $F(3,43) = 2.41$ with p-value > F = 0.0801, indicating that the overall model is insignificant at the 0.05 significance level. This suggests that the independent variables (FS, FO, and BD) do not jointly explain the dependent variable (CT) well.

For the t-test, the effect of each independent variable on the dependent variable is assessed individually. The result for Firm Size (FS) shows a coefficient of -0.0001121 and p-value of 0.290, indicating the FS does not have a significant influence on CT. The negative coefficient suggests a negative relationship, but the influence is not statistically significant. For Foreign Ownership (FO), the coefficient is -361.2961 with a p-value of 0.664, implying that FO does not significantly affect CT. The negative coefficient indicates a negative relationship, but it is not statistically significant. For Board Diversity (BD), the coefficient is -6902.082 with a p-value of 0.031, suggesting the BD has a significant negative effect on CT at the 5% significance level. The negative coefficient implies that an increase in BD leads to a decrease in CT.

Regarding the R^2 test, the results show $R^2 = 0.1429$, Between $R^2 = 0.0733$, and Overall $R^2 = 0.0614$. This means that approximately 14.39% of the variation in the dependent variable (CT) is explained by the variation in the independent variable (FS, FO, BD) within the group. Only 7.33% of variation between groups in explained by the model, and overall, the model explains just 6.14% of the variation in the dependent variable. The low R^2 value indicates that the model has limited explanatory power.

Table 14.
Hypothesis Testing Result.

No.	Variable Independent	Hypothesis	Coefficient	P-Value	Decision
1	Firm Size (FS)	Firm Size as a significant positive impact on carbon tax	-0.0001121	0.290	Rejected (Not Significant)
2	Foreign Ownership (FO)	Foreign Ownership has a negative impact on carbon tax	-361.2961	0.664	Rejected (Not Significant)
3	Board Diversity (BD)	Board Diversity has a negative impact on carbon tax	-6902.082	0.031	Accepted (Significant)

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5. Discussion

5.1. Firm Size's Impact on Carbon Tax

With a coefficient of -0.0001121, which is a negative value, it indicates a negative relationship between firm size and carbon tax. However, with a p-value of 0.290, firm size has no significant effect on carbon tax. In other words, company size, as measured by total assets, does not directly influence the tax burden paid. According to Signaling Theory, larger companies are typically considered more transparent in financial reporting, aiming to provide positive signals to investors and stakeholders. When the results are not significant, it suggests that the size of a company is not strong enough to serve as a robust signal regarding differences in tax policies or tax management.

In the context of Legitimacy Theory, larger companies tend to maintain their reputation in society by complying with tax regulations. This insignificance may indicate the larger companies have the potential to behave similarly to small companies in terms of tax compliance. These finding constant with previous studies, such as those by Maharani, et al. [32] and Adi Pratama, et al. [33] which found that firm size have a positive effect on carbon emission disclosure because larger companies typically operate a larger scale, which can result in higher carbon emission. Paying for carbon emission serves as a signal to stakeholders that the company is committed to environmental responsibility by willingly bearing the additional. This commitment can enhance the company's competitive advantage over others.

5.2. Foreign Ownership's Impact on Carbon Tax

The coefficient of -361.2961 indicates a negative relationship between foreign ownership and carbon tax. However, with a p-value of 0.664, foreign ownership does not significantly influence the level of carbon tax paid. According to signaling theory, foreign ownership is often associated with higher governance standards to provide a positive signal to the global market. However, the insignificance of this result suggests that foreign ownership alone is insufficient to signal a company's tax strategy. From the perspective of legitimacy theory, companies with foreign ownership are expected to comply with stricter global standards, including taxation.

The lack of significance may indicate that foreign ownership does not directly affect carbon tax compliance or payment. However, it can still play a role in reducing greenhouse gas emissions, enhancing competitiveness [13] and positively influencing carbon emissions disclosures, particularly in mining companies suggesting its indicated impact on environmental and sustainability practices.

5.3. Board Diversity's Impact on Carbon Tax

With a coefficient of -6902.082 and p-value of 0.031, Board Diversity has a negative and significant effect on Carbon Tax. This indicates that the more diverse the board of directors, the lower carbon tax paid by company. Based on Legitimacy Theory, diversity within the board of directors reflects a company's efforts to gain social legitimacy through inclusive representation. Companies with diverse boards tend to focus more on social and environmental issues, including carbon tax, to maintain their reputation and build public trust. The negative effect on carbon tax suggests that companies with diverse board may prioritize direct carbon emission reduction strategies or cost efficiencies, leading to a low carbon tax burden.

In context of signaling theory, board diversity serves as a positive signal to investors and stakeholders, highlighting that the company has good governance, is innovative, and is committed to sustainability issues. However, this negative result implies that board diversity not only serves as a symbolic gesture but also plays a critical role in efficient strategic decision-making social responsibilities, including carbon tax management. The reduced carbon tax payments could signal that companies are actively managing carbon emissions through non-monetary approaches, such as adopting green technologies or implementing sustainability programs.

Previous studies have found that companies with greater gender diversity on the boards reduced carbon emission by about 5% mode than those with predominantly male board [35] and tend to have lower overall carbon emissions [36]. These findings suggest that diverse boards enhance legitimacy and

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send strong sustainability signals while achieving tangible results in reducing carbon footprints. Thus, the negative relationship between board diversity and carbon tax reflects effective board leadership in balancing reputational legitimacy with strategic environmental management.

6. Conclusion

The analysis reveals the board diversity has a significant and negative effect on carbon tax, suggesting that companies with diverse boards prioritize strategies for reducing emissions or improving cost efficiency, which leads to lower carbon tax burdens. In contrast, firm size and foreign ownership show no significant impact on carbon tax, indicating that these factors alone are insufficient to influence tax compliance or payment. These findings highlight the importance of effective governance structures, such as diverse boards, in balancing environmental management with reputational and competitive advantages, in line with both Signaling and Legitimacy Theories.

This study is limited by the small sample size, which may affect the generalizability of the results. Furthermore, the lack of a formal, written mandate requiring carbon emissions reporting has resulted in many companies not disclosing such data, with more than half of the initial sample being excluded from the analysis. This significantly restricts the availability of comprehensive and reliable data. Additionally, the study's reliance on carbon tax as a proxy for environmental responsibility may not fully capture the boarder sustainability initiatives of companies. The use of secondary data also limits the exploration of qualitative factors influencing corporate environmental strategies.

Future research should focus on obtaining a larger and more representative sample to enhance the reliability and applicability of the findings. Policymakers are encouraged to establish clear regulations mandating carbon emission reporting to improve data availability and transparency. Expanding the analysis to include other sustainability metrics, such as carbon reduction targets or green initiatives, can provide a more holistic view of corporate environmental efforts. Finally, incorporating qualitative approaches, such as interviews or case studies, could uncover deeper insights into how board characteristics and ownership structures influence environmental strategies.

Data Availability:

The data of this research are openly available at https://bit.ly/Declarationofopendata

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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