Carbon Disclosure and Information Asymmetry

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Abstract

This study is investigated the influence of corporate disclosure of carbon emissions on information asymmetry. The results found that company emissions and disclosure has a positive impact on information asymmetry, but no relationship between carbon emissions and information asymmetry. This discrepancy may be attributed to the lack of carbon-related regulations on government policy during the study period, which affected investors' response to carbon information asymmetry.

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1. Introduction

Carbon emissions, integral to greenhouse gases causing climate change, have prompted global governments to propose carbon reduction policies and targets since the 1997 Kyoto Protocol aimed at stabilizing greenhouse gases. Companies face mounting pressure from stakeholders, including regulatory frameworks and academic studies (Solomon et al., 2011; Matsumura et al., 2014; Bolton and Kacperczyk, 2021), including measure, disclose, and manage emissions. The external costs stemming from a company's emissions are gradually being internalized into corporate expenses, impacting various aspects of corporate operations. However, quantifying greenhouse gas emissions proves challenging due to their connection with diverse assets, liabilities, and intricate organizational structures. Quantitative carbon accounting demands expertise distinct from traditional financial accounting, relying primarily on internal systems for sourcing and tracking (Luo and Tang, 2014). For investors it's difficulty verifying if disclosed emission figures accurately represent a company's actual emissions. Consequently, investigating whether a company's voluntary disclosure of emissions can effectively supplement investors' carbon risk information is a noteworthy research topic.

The costs or liabilities arising from a company's emissions have become an unavoidable burden, potentially leading to significant information asymmetry between the company and its shareholders. According to Akerlof (1978) and Diamond and Verrecchia (1991) emphasized that information disclosure can mitigate such asymmetry, reducing transaction costs. Firms generally experience smaller information asymmetries when reporting on their physical risks (Schiemann and Sakhel, 2019). However, the investors selectively reporting only positive information while neglecting negative aspects diminishes the usefulness of disclosed information (Kolk, Levy, and Pinkse, 2008).

As sustainability gains public attention and companies adapt, carbon reduction becomes pivotal for attracting continued investor interest. The foundation of carbon reduction lies in accurately determining a company's actual emissions. Proactive non-financial information disclosure aims to minimize information asymmetry between companies and stakeholders. Historically, Taiwanese companies lacked laws mandating emission disclosure, leading to inconsistent measurement standards that could hinder investor information processing. Deliberate attempts to present a misleading, greenwashed image of emission data not only fail to bridge the information gap and enhance transparency but may also yield adverse effects. Consequently, this study attempts to examine whether carbon emissions and disclose are value information for investors from the perspective of examining how emissions and disclose affect the information asymmetry that exists between company insiders and external investors. The purpose of this study is to investigate whether the disclosure of emissions by Taiwanese listed companies can alleviate the degree of information asymmetry affect sustainable development.

This study adopts a two-stage econometric technique to examine the influence of

voluntary carbon emissions disclosure on information asymmetry by analyzing the bid-ask spread of corporate stocks. Carbon emission data is sourced from sustainability reports, and stock price and financial data are obtained from the "Taiwan Economic Journal" (TEJ) database of listed companies in Taiwan. The sample period spans from 2017 to 2021.

By exclusively considering firms reporting in the sustainability reports, the study initially conducted a probit regression to estimate the propensity of carbon disclosing in the sustainability reports. The results of the second-stage multivariate analysis provide evidence suggesting no discernible relationship between the disclosure of emissions and the bid-ask spread. This study implies that corporate disclosure of carbon emissions has not demonstrated efficacy in mitigating information asymmetry.

The paper is organized as follows. In Section 2, we review the literature and develop our hypotheses. Section 3 outlines the research design, data, sample selection, and descriptive statistics. Section 4 presents our empirical results. Finally, in Section 5, the paper offered our conclusions.

2. Literature Review and Hypothesis

As the global economy shifts towards achieving net-zero emissions, investors and relevant public interest groups are urging increased carbon information disclosure and transparency from companies. In Taiwan, carbon disclosure regulations were initially introduced by the Taiwan Environmental Protection Agency in 2015 under environmental management laws. To align with climate change adaptation and ensure sustainable development, the concept of total emission control was introduced in 2016. The "Greenhouse Gas Emissions Inventory and Registration Management Measures" were subsequently announced, specifying the sources subject to inventory and registration. In the same year, the declaration and management of greenhouse gas emissions were consolidated into the first batch of inventory and registration objects. This regulation lacks specificity in defining the carbon emissions limit and fails to outline the timeline for implementing "total amount control." Moreover, it is overlooks legal enforcement measures against offenders surpassing the emission limit. Consequently, the efficacy of this new regulation in reducing overall carbon emissions remains uncertain.

Past literature indicates three reasons why companies choose to disclose information. First, disclosure aims to alleviate information asymmetry and reduce capital costs (Easley and O'Hara, 2004). Second, disclosure serves to address agency conflicts (Healy and Palepu, 2001). Third, companies may disclose information as a response to regulatory requirements in order to mitigate political costs (Deegan and Gordon, 1996; Chi et al., 2009). Healy and Palepu (2001) argue that companies enhancing the disclosure of both financial and non-financial information can diminish information asymmetry between managers and external shareholders, facilitating more informed investment decisions. Amir and Lev (1996) and Hughes (2000) indicate that the disclosure of non-financial information is also

relevant to value. Information disclosure allows investors to reevaluate the company's worth, potentially enhancing stock liquidity (Heflin, Shaw, and Wild, 2000).

Cormier, Magnan, and Van Velthoven (2005) argue that companies disclosing emissions may diminish information asymmetry between managers and capital providers, potentially leading to a reduction in the company's capital costs when compared to those not disclosing emissions. However, Clarkson, Li, Richardson, and Vasvari (2008) contend that carbon disclosure might not accurately reflect a company's actual carbon performance, and companies may choose not to report negative, inappropriate, or unethical behaviors.

Measuring emissions is a highly intricate task, requiring diverse knowledge and expertise, primarily sourced and tracked from the company's internal systems. Investors face challenges in verifying a company's disclosure of emissions, raising questions about the accuracy of these figures reflecting the actual emissions. Consequently, the impact of company disclosure of emissions on information asymmetry becomes an empirical testing issue. This study expects that if the transparency in a company's information environment is improved through emissions disclosure, investors can better understand potential future liabilities or costs, thereby reducing corporate information asymmetry. Conversely, if a company fails to effectively communicate potential future liabilities or costs related to emissions through disclosure, it may widen the information gap between internal and external stakeholders, which may undermine the company's effectiveness in disclosing emissions to investors.

Taiwanese government lacks stringent regulations and restrictions concerning corporate emissions and information disclosure. Consequently, most companies have not undertaken carbon emissions inventory and disclosures, leading to significant variations in measurement standards and low comparability of emissions. Taken together, it is unclear whether investors will view emissions disclosure as incrementally information. Hence, this study formulates the null hypothesis to establish the following hypotheses:

H1: Ceteris paribus, there is no significant relationship between corporate emissions disclosure and information asymmetry.
H2: Ceteris paribus, there is no significant relationship between corporate emissions and information asymmetry.

3. Empirical Methodology

3.1   Sample Data and Sample Description

In order to examine whether carbon disclosure affect stock bid-ask spreads, and taking into account the Taiwan Stock Exchange's requirement to provide the time point for the preparation and filing of sustainability reports and the applicable GRI standards, this study uses 2017 as the starting year of the study. The data source is obtained from the Taiwan Economic Journal (TEJ) database to obtain financial and

stock price data of Taiwan listed companies from 2017 to 2021. And manually collect the carbon emissions data from the sustainability reports announced by the company from 2018 to 2022.

The sample selection process and distribution are shown in Table 1. There is a total of 1,516 firm-year observations with disclosing emissions and 2,549 firm-year observations with non-disclosing emissions in Panel A. Panel B shows the data distributions for firms in various industries. There is considerable cross-industry variation in the sample, The paper data include industry controls in my regression model. Panel C shows that emissions disclosure have an increasing trend over time, which means that as the public discusses carbon emissions more, companies are more likely to disclose their emissions.

3.2 Empirical models

This purpose is to investigate whether the Emissions disclosure reduces the information asymmetry then affected the sustainable development on the companies. The study changes in the bid-ask spread during the period surrounding the announcement of a sustainability reports are examined, and used the bid-ask spread as a proxy for information asymmetry, which has widely been done in previous studies (e.g., Leuz and Verrecchia, 2000). First, I estimate the models for testing H1 are presented in Eq. (1).

$$SPREAD_{i,t+1} = \alpha_0 + \alpha_1 EMISSION1(EMISSION2)_{i,t} + \alpha_2 SIZE_{i,t} +$$
$$\alpha_3 PROFIT_{i,t} + \alpha_4 SHARE_{i,t} + \alpha_5 VOLUME_{i,t} + \alpha_6 TRANS_{i,t} + \alpha_7 VOLAT_{i,t} +$$
$$\alpha_8 LEV_{i,t} + \alpha_9 IMR_{i,t} + \alpha_{10} YEAR_y + \alpha_{11} IND_y + \varepsilon_{i,y} \tag{1}$$

where *SPREAD* is calculated as the mean daily bid minus the mean daily ask, scaled by the midpoint of the bid and ask prices surrounding announcement date in year *t*+1.

The variable of interest, *DISC*, is given the value of one if a firm voluntarily discloses its emissions and 0 otherwise. The model developed in this study incorporates multiple controls with a high potential to influence information asymmetry, aligning with previous research findings (Muller et al., 2011 and Cho et al., 2013). *SIZE*, the natural logarithm of total assets, is used to measure firm value. *PROFIT* is profitability, measured by return on assets before interest and taxes, and *SHARE* is stock closing price. *VOLUME* is the daily trading volume of shares, calculated by dividing the daily trading volume of the firm by the total daily trading volume of the market, and *TRANS* is the daily turnover ratio, calculated by dividing the daily trading volume by the number of outstanding shares. I was also control firm risk and leverage by adding *VOLAT* and *LEV*. *VOLAT* is stock price volatility, measured by taking the daily highest trading price minus the lowest trading price, divided by the average of the highest trading price and the lowest trading price. *LEV* is debt ratio, calculated by dividing the total liabilities by the

total assets. This study also used dummy variables to control for the fixed effects of the year and the industry on carbon disclosures.

Table 1: Sample Selection and Distribution

Panel A Sample Selection Process	
Total firm-year observations	4493
Less: Observations with missing financial and stock price data	(313)
Less: Observations with missing emissions data	(115)
Final sample of firm-year observations	4065
Less: Non-disclosing emissions observations	(2549)
Carbon Disclosing observations	**1516**

Panel B Industry distribution			
TEJ	Industry	n	%
01	Cement	25	1.65
02	Food	65	4.29
03	Plastic	63	4.16
04	Textile	62	4.09
05	Electric Machinery	34	2.24
06	Electrical and cable	15	0.99
08	Glass and ceramic	4	0.26
09	Paper and pulp	20	1.32
10	Iron and steel	51	3.36
11	Rubber	33	2.18
12	Automobile	42	2.77
14	Building material and construction	61	4.02
15	Shipping and transportation	56	3.69
16	Tourism	25	1.65
17	Financial and insurance	92	6.07
18	Trading and consumers' goods	25	1.65
20	Other	65	4.29
21	Chemical	110	7.26
22	Biotechnology and medical care	30	1.98
23	Gas and electricity	13	0.86
24~31	Electronic	549	36.21
	Total	**1516**	100.00

Panel C Sample Distribution by year					
Year	2017	2018	2019	2020	2021
n	250	275	301	315	375
%	16.49%	18.13%	19.85%	20.77%	24.73%
Total	**1516**				

To assess whether the impact of carbon emissions on information asymmetry, the first-stage Probit model is used to examine the determinants of the voluntary disclosure-choice model, as depicted in Eq. (2).

$$P(DISC)_{i,t} = \alpha_0 + \alpha_1 SIZE_{i,t} + \alpha_2 PROFIT_{i,t} + \alpha_3 BV_{i,t} + \alpha_4 LEV_{i,t} + \alpha_5 FRSALE_{i,t} + \varepsilon_{i,t} \tag{2}$$

where *BV* is the net assets per share, and *FRSALE* is percentage of foreign sales. Firms with a higher percentage of foreign sales tend to voluntarily provide information related to their carbon emissions.

The second-stage model is designed to test H2 that information asymmetry is associated with emissions Inverse Mills Ratio (IMR) derived from the first-stage Probit model is integrated to mitigate potential endogeneity concerns:

$$SPREAD_{i,t+1} = \alpha_0 + \alpha_1 EMISSION1(EMISSION2)_{i,t} + \alpha_2 SIZE_{i,t} + \alpha_3 PROFIT_{i,t} + \alpha_4 SHARE_{i,t} + \alpha_5 VOLUME_{i,t} + \alpha_6 TRANS_{i,t} + \alpha_7 VOLAT_{i,t} + \alpha_8 LEV_{i,t} + \alpha_9 IMR_{i,t} + \alpha_{10} YEAR_y + \alpha_{11} IND_y + \varepsilon_{i,y} \tag{3}$$

where *EMISSION1* is the natural logarithm of total scope 1 and scope 2 of carbon emissions, and *EMISSION2* is the natural logarithm of total scope 1, scope 2 and scope 3 of carbon emissions.

4. Empirical results

4.1 Descriptive statistics

According to the Table 2 provides descriptive statistics for the sample companies. Panel A shows the statistics regarding Eq. (3). The mean of ESSION2 is 4.460, which is higher than the mean of ESSION1 (4.412), which implies that companies also voluntarily disclose scope 3 emissions, thus causing a difference between ESSION2 and ESSION1, but the difference is not high. Panel B of Table 2 are shows the descriptive statistics for the disclosure choice model in Eq. (2).

Finally, Table 3 presents the Pearson correlation coefficients on the main variables. In Panel A, I reported the correlation coefficients for Eq. (1). The results show that *DISC* is significantly and negatively associated with *SPREAD*. This means that the emissions disclosure reduced the degree of information asymmetry. It can be also observed that *SIZE, PROFIT, SHARE, VOLUM*, and *TRANS* are significantly and negatively associated with *SPREAD*. And *LEV* is significantly and positively associated with *SPREAD*. In Panel B for Eq. (3), the correlation coefficients show that *EMISSION1* and *EMISSION2* are significantly and positively associated with *SPREAD*. These results suggest that firms with higher carbon emissions have higher information asymmetry.

Table 2: Descriptive statistics

Panel A disclosing firms (N=1516)					
Variable	Mean	S.D.	Min	Median	Max
SPREAD	0.314	0.299	0.100	0.241	5.370
EMISSION1	4.412	1.092	1.100	4.385	7.450
EMISSION 2	4.460	1.128	1.100	4.414	7.991
SIZE	7.574	0.774	5.750	7.423	10.060
PROFIT	5.873	6.649	-23.480	4.706	57.870
SHARE	62.766	120.738	4.170	28.665	1770.690
VOLUME	19.591	49.312	0.020	6.383	741.670
TRANS	185.656	287.647	1.890	76.006	2986.600
VOLAT	0.479	0.275	0.007	0.416	1.720
LEV	46.060	20.059	0.000	46.010	100.000
Panel B voluntary disclosure-choice sample (N=4065)					
Variable	Mean	S.D.	Min	Median	Max
DISC	0.372	0.483	0.000	0.000	1.000
SIZE	7.574	0.774	5.750	6.960	10.064
PROFIT	5.873	6.649	-23.480	4.706	57.870
BV	27.390	36.316	0.000	20.770	1062.000
LEV	46.060	20.059	0.000	46.010	100.000
FRSALE	49.400	40.036	0.000	56.070	100.000

1. *SPREAD* is the firm's information asymmetry calculated as the mean daily bid minus the mean daily ask, scaled by the midpoint of the bid and ask prices. *EMISSION1* is the natural logarithm of total scope 1 and scope 2 of carbon emissions. *EMISSION2* is the natural logarithm of total scope 1, scope 2 and scope 3 of carbon emissions. *SIZE* is the natural logarithm of the firm's assets. *PROFIT* is profitability, measured by return on assets before interest and taxes. *SHARE* is stock closing price. *VOLUME* is the daily trading volume of shares, calculated by dividing the daily trading volume of the firm by the total daily trading volume of the market. *TRANS* is the daily turnover ratio, calculated by dividing the daily trading volume by the number of outstanding shares. *VOLAT* is stock price volatility, measured by taking the daily highest trading price minus the lowest trading price, divided by the average of the highest trading price and the lowest trading price. *LEV* is debt ratio, calculated by dividing the total liabilities by the total assets. *DISC* is the value of one if a firm voluntarily discloses its emissions and 0 otherwise. *BV* is the net assets per share. *FRSALE* is percentage of foreign sales.
2. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 3: Pearson correlation coefficients

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A Correlation coefficients for Eq. (1) (n=4065)										
SPREAD		1.000								
CO2DIS		-0.122***	1.000							
SIZE		-0.233***	0.514***	1.000						
PROFIT		-0.028**	0.071***	0.110***	1.000					
SHARE		-0.257***	0.134***	0.130***	0.277***	1.000				
VOLUME		-0.072***	0.250***	0.373***	0.007	0.131***	1.000			
TRANS		-0.104***	0.005	-.083***	0.093***	0.228***	0.258***	1.000		
VOLAT		0.016	-0.052***	-0.163***	0.096***	0.078***	0.212***	0.602***	1.000	
LEV		0.048***	0.117***	0.467**	-0.075***	-0.226***	-0.076***	-0.090***	-0.018	1.000

1.Variables are defined in Table 2.
2.***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.2 The empirical regression results

According to the Table 4 the regression results of the carbon emissions disclosure on information asymmetry. The result shows that the coefficient of *DISC* is significantly positive, suggesting a significant increase in information asymmetry for emissions disclosing companies. This finding may be explained by the fact that current regulations in Taiwan do not have specific provisions on carbon emissions disclosure. Taiwanese Government will implement carbon tax in 2025.Companies use different boundaries to track emissions, which may make it more difficult for investors to perceive the emissions data. Hence, emissions disclosure significantly increases the degree of information asymmetry.

In terms of control variables, *SIZE*, *PROFIT*, and *TRANS* are significantly and negatively associated with *SPREAD*. That mean the larger company, larger profitability and higher stock turnover ratio have the lower information asymmetry. Moreover, *SHARE*, *VOLUM*, *VOLAT*, and *LEV* variables are significantly and positively associated with *SPREAD*.

To correct for self-selection, I was estimated the Eq. (3) jointly with the disclosure choice model (Heckman model). Table 5 presents the results of the regression while controlling for endogenous using the IMR obtained from the first-stage Probit model. The results show that the coefficients of *ESSION2* and *ESSION1* are negative but not statistically significant. I was not found evidence that carbon emissions affect information asymmetry. The results show that higher *SPREAD* is associated with higher *SHARE,* whereas higher *SPREAD* is associated with lower *TRAN*, *VOLATE* and *LEV.*

Table 4: Regression model analysis

Panel A Regression analysis of the influence on voluntary carbon disclosure and Information Asymmetry (N=4056)			
Variable	Coef.	Std.	T value
Intercept	2.513	0.137	18.31 ***
DIS	0.050	0.024	2.04***
SIZE	-0.322	0.021	-15.33***
PROFIT	-0.018	0.002	-11.81***
SHARE	0.0004	0.00008	5.01***
VOLUME	0.002	0.0003	4.56***
TRANS	-0.0003	0.0004	-7.08***
VOLAT	0.114	0.051	2.24***
LEV	0.005	0.0006	7.95***
YEAR	0.075	0.028	2.63***
IND	0.249	0.048	5.15***
R^2	0.142		
F value	55.89***		

1. Variables are defined in Table 2.
2. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 5: Regression model analysis

Panel A Regression analysis of the influence of carbon emission on information asymmetry (N=1516)				
Variable	Coef.	Z value	Coef.	Z value
Intercept	-0.203	-0.68	0.011	0.52***
Emission1	-0.0013	-0.17***		
Emission2			-0.0004	-0.83***
SIZE	0.06000	1.61***	0.0024	0.89***
PROFIT	-0.00058	-0.38***	-0.00003	-0.27***
SHARE	0.00028	3.96***	0.00002	4.02***
VOLUME	0.0003	1.45***	0.00003	2.50***
TRANS	-0.0008	-2.31***	-0.000007	-2.65***
VOLAT	-0.0666	-1.65***	-0.00285	-1.42***
LEV	-0.00139	-2.13***	-0.00008	-1.73***
IMR	0.25000	5.16***	0.0159	4.45***
YEAR	Included			
IND	Included			
Wald Chi-square	67.16		93.94	
Prob > Chi-sq	0.000			
Panel B Self-selection model (N=4056)				
SIZE	1.508	28.88***	1.508	28.88***
PROFIT	0.019	5.09***	0.019	5.09***
BV	-0.006	-5.42***	-0.006	-5.42***
LEV	-0.015	-10.05***	-0.015	-10.05***
FRSALE	0.0024	4.10***	0.0024	4.10***

1. Variables are defined in Table 2.
2. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5. Conclusion

In light of the growing focus on carbon emissions across various sectors, the role of companies' disclosure of such emissions as a signaling mechanism has become increasingly significant. This article aims to investigate whether carbon disclosure and carbon emissions serve as signaling devices to mitigate information asymmetry between insiders and investors in corporate contexts.

To furnish causal evidence regarding the impact of carbon emissions on the capital market, I conducted manual data collection on the carbon emissions of Taiwanese-listed companies from 2017 to 2021. Subsequently, I was analyzed whether emissions disclosure and the level of carbon emissions influence information asymmetry.

The results indicate a significant increase in information asymmetry among companies disclosing emissions. This result may be attributed to the absence of specific provisions on carbon emissions disclosure in current Taiwanese regulations. Companies employ varying boundaries to track emissions, potentially complicating investors' interpretation of emissions data. Furthermore, upon examining the impact of carbon emission levels, no evidence supporting their influence on information asymmetry is found. This result suggests that investors in Asia, particularly those investing in Taiwanese-listed companies, harbor differing perceptions regarding corporate environmental reporting compared to counterparts in Western countries. This study contributes to the extant literature by bridging a gap regarding the informational significance of carbon emissions. It is offers empirical evidence delineating the relationship between carbon emissions of Taiwanese firms and the presence of information asymmetry among firm insiders and investors.

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