Does Corporate Environmental Information Disclosure Mitigate the Cost of Bank Loans: Evidence from TWSE-Listed Companies

Che-Ming Chang

College of Technology Management, National Tsing Hua University

Jianqiang Chen

School of Economics, Ocean University of China

Pei-Fang Hsieh*

College of Technology Management, National Tsing Hua University

Bank loan lenders charge a significantly lower interest rate to firms with high-quality environmental information disclosures as measured by the carbon emission disclosure from the CSR report. We find that the firms with scope 3 emissions disclosure have 8.6 basis points significantly lower bank loan rates relative to firms without scope 3 emissions disclosure. To address endogeneity, we provide the DID method for the implementation of the GHG reduction plan and emissions control actions by the EPA of Taiwan in 2018. The results consistently present the lower cost of bank loans for firms with scope 3 emissions disclosure. We find that the lower bank loan rates built through firms that disclose more environmental information lessen their credit risk and improve ESG performance, particularly those with lower information asymmetry and financial constraints.

Key Words: Environmental Information Disclosure, Bank Loan, Carbon Emission, Scope 3 Emissions.

「政策與管理意涵」

本文發現台灣公司高環境揭露品質（以企業社會責任報告中範疇三碳排放揭露情況衡量）將降低其銀行貸款利率。同時這個現象在台灣環境署公告減碳方案之後尤為明顯。公司高環境揭露品質通過降低公司信用風險以及提升其 ESG 績效從而影響其貸款利率。

Che-Ming Chang   Jianqiang Chen   Pei-Fang Hsieh

1. Introduction

Environmental protection, especially related to carbon emissions and climate change, is becoming a major concern for society. It is an explicit firm characteristic of good corporate social responsibility (CSR) or environmental, social, and governance (ESG) when firms take actions on environmental sustainability such as disclosing and reducing their carbon emissions, as such activities could change shareholders or customers behavior (Weil et al., 2006; Hombach and Sellhorn, 2019). More importantly, if firms do not disclose their carbon emissions and invest in carbon-reducing technologies, their future profits may be hindered by the impact of the EU and US policies related to carbon emissions.[1] Hence, firms with more environmental concerns would increase their cost of capital (Bauer and Hann, 2010; Chava, 2014; Cheng et al., 2014). However, there are few studies that investigate the relationship between the term of bank loans and corporate environmental information disclosure of firms listed on the Taiwan Stock Exchange (TWSE).

In this study, we hand-collect firms' scope 3 carbon emissions information (hereafter scope 3 emissions disclosure) and the detailed illustrations of emissions (hereafter scope 3 emissions detailed disclosure) in their CSR reports as a measure of corporate environmental information disclosure. Scope 3 emissions include all greenhouse gas emissions upstream and downstream except an organization's scope 1 and 2 emissions.[2] In addition to total scope 3 emissions, some firms also further disclose

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1 There are some EU and US mandatory environmental policies, such as carbon tariffs of the EU in 2023 (see: https://www.reuters.com/world/europe/eu-countries-back-plan-world-first-carbon-border-tariff-2022-03-15/) and the US in 2024 (see: https://www.nytimes.com/2021/07/19/climate/democrats-border-carbon-tax.html). Moreover, net-zero emissions will be enforced globally in 2050. See: https://www.un.org/en/climatechange/net-zero-coalition

2 Scope 1 emissions are the firm's direct emissions of greenhouse gas (GHG), for example, emissions associated with fuel combustion in boilers. Scope 2 emissions are indirect GHG emissions from purchased energy (ex. electricity, steam, and heat). Detailed information on scope 1, 2 and 3 emissions is available at: https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard-EReader_041613_0.pdf

detailed scope 3 emissions which consist of the 15 distinct categories of scope 3 emissions such as employee commuting, purchased goods and services, transportation and distribution from upstream and downstream.[3]

We choose to prioritize the disclosure of scope 3 emissions for several reasons. First, scope 3 emissions constitute a significant portion of most companies' overall emissions. Typically, these emissions account for 75% of a company's greenhouse gas emissions. In certain industries that heavily rely on raw materials such as real estate, construction, metals and mining, and agriculture commodities, scope 3 emissions encompass approximately 90-95% of the company's entire value chain.[4] In 2022, the magnitude of scope 3 emissions was found to be 11 times higher than that of scope 1 emissions; however, less than 50% of firms had reported their scope 3 emissions in 2022 to the global environmental data charity CDP.[5] Furthermore, most of the existing literature focuses on the firms' scope 1 and scope 2 emissions (e.g., Palea and Drogo, 2020). In this study, we would like to investigate whether the firms that disclose the scope 3 emissions provide additional environmental information.

Second, the disclosure of scope 3 emissions serves as a valuable tool for managing environmental risks. Firms should be able to track their carbon emissions across the whole supply chain, which is the fundamental characteristic of the scope 3 (detailed) emissions disclosure. To put it another way, the scope 3 (detailed) emissions disclosures are the critical proof of the supply chain's capacity to manage carbon emissions, which is the major obstacle for companies trying to implement net-zero carbon emissions by 2050. For instance, companies can identify emission hotspots, such as carbon-intensive inputs or products, through scope 3 emissions, as well as recognize the parts of their value chain that are particularly susceptible to risks arising from escalating resource

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3 Section 2 provides an example and detailed illustrations of scope 3 emissions detailed disclosure. Greenhouse Gas Protocol provides detailed information about 15 categories: https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf

4 See: https://www.unravelcarbon.com/blog/companies-struggle-scope-3-measurement

5 See: https://www.cdp.net/en/articles/media/companies-failing-to-engage-suppliers-on-nature-and-climate-despite-incoming-regulation

prices and evolving regulatory frameworks, such as carbon taxes and the tightening of efficiency standards.

Finally, there is a growing trend towards the mandatory disclosure of scope 3 emissions because it is widely acknowledged that they provide an extended discourse quality. The 2021 update to TCFD emphasizes disclosing scope 3 emissions, along with scope 1 and 2 emissions.[6] Significant climate risks require quantification of scope 3 emissions to assess financial impacts. In March 2022, the US Securities and Exchange Commission (SEC) proposed requiring public companies to disclose scope 3 emissions when material or related to set targets.[7] The CDP's Global Supply Chain Report indicates increasing pressure on manufacturers for scope 3 emissions reduction.[8] Many companies in Taiwan are involved in original equipment manufacturing (OEM) upstream in the supply chain, necessitating accelerated efforts to develop carbon reduction capabilities to maintain competitiveness. As a result, disclosing environmental information quality becomes crucial as it demonstrates carbon reduction and control capabilities, leading to more stable future operating profits, such as higher expected cash flows, lower cost of capital, and higher firm value (Plumlee et al., 2015). Additionally, firms that disclose scope 3 emissions are generally perceived as having fewer environmental concerns, which can lower their credit risk (Bauer and Hann 2010), a critical consideration for the bank.

Our baseline regressions provide evidence that public firms in Taiwan with involvement in scope 3 (detailed) emissions disclosures have lower bank loan rates. For ruling out endogeneity, we use the difference-in-differences approach based on the *Greenhouse Gas Reduction Action Plan* (the Action Plan) and *Greenhouse Gas Emission*

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6 See: https://www.fsb.org/wp-content/uploads/P141021-2.pdf

7 See: https://www.sec.gov/news/press-release/2022-46

8 Referred to https://www.cdp.net/en/research/global-reports/scoping-out-tracking-nature-across-the-supply-chain

Control Action Program approved by the EPA of the Executive Yuan in 2018.[9] For example, the Action Plan recommends that firms should adopt environmentally friendly and low-carbon supply chain management practices. Additionally, firms should disclose the results of their endeavors to reduce carbon emissions within their supply chain. As a result, financial institution would be more aware of firms' carbon emissions disclosure and incorporate into their loan decisions. Firms with more detailed carbon emissions disclosure, particularly including their supply chain emissions, would result in lower greenhouse gas reduction regulations risk. The comprehensive carbon emission disclosure also lowers the information asymmetry between firms and banks. Our results support that banks strengthen the concern of firms' scope 3 emission disclosures reflecting in lower bank loan rate after the Action Plan.

We provide two possible mechanisms for our baseline results using ordered probit models. The first is that environmental information disclosure lowers the credit risks of reporting firms. We use the Taiwan Corporate Credit Risk Index Rank (TCRI Rank) in TEJ database as measure of firm's credit risk.[10] We find that firms with more comprehensive environmental information disclosures have significantly lower credit risk than others. Secondly, we consider the ESG performance of firms using CDP

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9 In 2018, the Environmental Protection Department formulated the *Greenhouse Gas Reduction Action Plan*, aimed at promoting a comprehensive and inter-departmental national response to reduce greenhouse gas emissions. The plan aimed to establish a partnership mechanism among the central, local, public, and private sectors, with national participation, to implement the national greenhouse gas mitigation policy. Furthermore, sector-specific emission reduction plans, known as *Greenhouse Gas Emission Control Action Programs*, were developed by the nation's various sectors, including energy, manufacturing, transportation, residential and commercial, agriculture, and environmental sectors. These programs, based on the *Greenhouse Gas Reduction Action Plan*, contained greenhouse gas emission targets, timetables, and economic incentives to facilitate the implementation of greenhouse gas reduction measures. See: https://enews.moenv.gov.tw/page/3b3c62c78849f32f/eb92ef3f-e583-4499-a598-418f9cf62fec

10 In TCRI Rank, firms' credit risk ratings are organized into categories from 1 to 9, and Default (10). Credit risk is lower for firms with a lower rank. According to TEJ, the TCRI Rank provides 90 percent accuracy in determining firm credit risk based on 10 financial ratios and expert reviews. See: https://www.tej.com.tw/solution/TCRI%E2%84%A2%20%E5%8F%B0%E7%81%A3%E4%BC%81%E6%A5%AD%E4%BF%A1%E7%94%A8%E9%A2%A8%E9%9A%AA%E6%8C%87%E6%A8%99

Score[11], which is an evaluation score of a firm's performance according of climate change issues. The score asses various factors such as the board's concern on climate change issue, risk management, and climate change disclosure strategy. The CDP Score indicates the firm's internal and external governance tactics for environmental and climate change issue. Our finding supports the idea that firms with more detailed scope 3 carbon emission disclosure result in a higher CDP Score. This result is consistent with firms with higher ESG performance are generally considered to have organizational effectiveness in using resources (Sharfman and Fernando, 2008), better corporate reputation (Turban and Greening, 1997), and lower operational risk (An and Pivo, 2020; Albuquerque et al., 2019). For example, firms could sell products with environmentally friendly features at higher prices (Hilger et al., 2019). Therefore, these two channels ultimately lead to a fall in bank loan rates.

In the final section, we present the heterogeneity test to investigate the quality of environmental information disclosure and which types of firms' scope 3 emissions are more trusted by banks. Goss and Roberts (2011) examine the lenders view the CSR initiatives of low-quality borrowers differently than those of high-quality borrowers. We employ the PIN and KZ index to evaluate the quality of information asymmetry and financial constraints in firms. High-quality firms are defined as having lower information asymmetry (the PIN is below the sample median) and lower financial constraints (the KZ index is below the sample median). Our findings support lenders' increased trust in high-quality borrowers' environmental information disclosure.

Our paper makes several contributions to the existing literature. First, our study adds to the body of knowledge on firms' information disclosure and the cost of capital (Sengupta 1998; Lambert et al., 2006; Gao et al., 2016; Plumlee et al., 2015), particularly in relation to environmental information disclosure and the cost of debt (Jung et al., 2018; Kleimeier

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11 An organization's CDP Score provides a snapshot of its environmental and disclosure practices. An environmentally friendly firm has a higher score. In this study, our focus is solely on the questionnaire score related to climate change, and we do not include the scores from the questionnaires related to water and forest. See: https://www.cdp.net/en/scores/cdp-scores-explained

and Viehs, 2018; Palea and Drogo, 2020; Morrone et al., 2022). While many previous studies use the firm's CDP questionnaire response as a measure of environmental information disclosure, few studies investigate the information content of comprehensive carbon emissions disclosure. We provide evidence that comprehensive scope 3 emission disclosure helps firms reduce their bank loan rates. This disclosure verifies the firms' ability to deal with upcoming carbon taxes and achieve the goal of net-zero carbon emissions. As a result, lenders can anticipate more consistent future cash flow and lower operating risk.

Second, we show that scope 3 emission disclosure could enhance firm ESG performance.[12] Improved ESG performance will help firms obtain lower loan rates (Goss and Roberts, 2011; Chava, 2014; Bae et al., 2018), better credit ratings (Attig et al., 2013; Oikonomou et al., 2014) and lower bond spreads (Bauer and Hann, 2010; Eichholtz et al., 2019). Instead of relying on external ratings or data sources like KLD STATS, we employ the firm's scope 3 emissions discourse to examine their concern for environmental protection.

Finally, our study contributes to the understanding of the impact of environmental regulation risk on a firm's cost of capital.[13] We find that firms that disclose more carbon emissions information have significantly reduced loan costs following the implementation of new carbon emission regulations in Taiwan. As a result, these firms are better able to meet the incremental requirements of new regulations.

The remainder of the paper is organized as follows: Section 2 presents and describes the data employed in the analysis and Section 3 shows empirical analysis. Section 4 discusses the mechanisms. Section 5 presents heterogeneity tests. Section 6 focuses on robustness and further tests. Then the paper ends with conclusions.

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12 Scope 3 emission disclosure represents higher quality carbon disclosure and is related to carbon performance. Our study is also relevant to the literature on the relationship between carbon performance and the cost of debt (Caragnano et al., 2020; Al Rabab'a et al., 2023).

13 Seltzer et al. (2022) provide evidence that the announcement of the Paris Agreement results in an increase in bond spreads for firms with poor environmental performance. Chen et al. (2022) show that when a court ruling imposes additional environmental liabilities on firms, it leads to an increase in the costs of debt for the affected firms. Ivanov et al. (2022) show that the introduction of cap-and-trade bills leads to higher interest rates for firms with higher carbon emissions.

2. Data

We collect scope 3 emissions disclosure and scope 3 emissions detailed disclosure data from CSR reports on firms' websites or the Market Observation Post System[14] from 2016 to 2020.[15] TEJ only collects parts information of scope 3 emissions disclosure and does not include scope 3 emissions detailed disclosure, which consists of the 15 distinct categories of sources of scope 3 emissions.[16] Hence, we manually collect 15 categories of scope 3 emissions detailed disclosure from firms by checking the sustainability and environmental parts of their CSR reports. Figure 1 shows an example of scope 3 emissions detailed disclosure. This firm not only reported scope 3 emissions but also reported 7 categories of scope 3 emissions.

After collecting firms' scope 3 emissions data, we define variable *Scope3* as firms with scope 3 emissions disclosure in that year obtaining one and setting it to zero otherwise.[17] We also define variable *Scope3 Detail* as: (a). a firm with a scope 3 emissions disclosure will obtain one; (b). if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. *Scope3 Detail* is a supplementary level of disclosure that goes beyond the realm of scope 3 emissions. Some companies may disclose both their total scope 3

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14 See: https://mops.twse.com.tw/mops/web/t100sb11

15 In Taiwan, firms with share capital that have more than 5 billion NT dollars or belong to specific industries should have CSR reports. Relevant regulation can be referred to: https://cgc.twse.com.tw/pressReleases/promoteNewsArticleCh/694

16 The categories include: (1). purchased goods and services, (2). capital goods, (3). fuel and energy related activities, (4). transportation and distribution (upstream), (5). waste generated in operations, (6). business travel, (7). employee commuting, (8). leased assets (upstream), (9). transportation and distribution (downstream), (10). processing of sold products, (11). use of sold products, (12). end-of-line treatment of sold products, (13). leased assets (downstream), (14). franchises, and (15). investments. Greenhouse Gas Protocol provides detailed information about 15 categories: https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf

17 We also collect scope 1 and scope 2 information from the CSR report and check the data with TEJ as TEJ provides scope 1 and scope 2 information on public firms in Taiwan. We define *Scope1&2* as firms with scope 1 and 2 emissions disclosure in that year obtaining one and setting it to zero otherwise.

emissions as well as the details of those emissions, while others may only disclose their scope 3 emissions without providing further details. To properly account for scope 3 emissions and their details, *Scope3 Detail* should include both the scope 3 emissions information and any additional detailed information. Therefore, we calculate *Scope3 Detail* starting from one to include the information related to scope 3 emissions. Appendix B provides lists of scope 3 emissions disclosure firms.

Figure 1 Example of scope 3 emissions detailed disclosure

Page 68 of Delta Electronics, Inc. 2019 CSR Report.

Available at: https://filecenter.deltaww.com/about/download/2019_Delta_CSR_Report_CH.pdf

Bank loan data and financial data come from TEJ. We focus on Taiwan-listed firms without missing value in bank loans and financial data, and we also eliminate firms in the finance industry. A firm will take out many new loans in a year, so we calculate the firm's average loan rate based on the size of the loan. Then we define *Diff Rate* as the current year's newly issued loan size weighted average loan rate minus the prior year's

size weighted average loan rate.

We also collect data on the CDP Score from the official CDP website,[18] and obtain the TCRI data from TEJ for our mechanism tests in Section 4. Additionally, we calculate the PIN and KZ index for firms for our heterogeneity tests in Section 5. We retain samples that have data records on CDP, TCRI, PIN, and KZ index, and form an unbalanced panel from 2016 to 2020.

Table 1 provides summary statistics of our main variables and on firm other characteristics as our control variables. These traits include *Lnsize* (natural logarithm of the market value of the firm), *Acid* (cash and accounts receivable to its current liabilities), *Leverage* (total debt divided by total asset), *MB Ratio* (market value of the equity divided by the book value of the equity), *OI/Asset* (operating income divided by the total asset), *Tobin's Q* (market value plus long- and short-term borrowings then divided by the total asset), and *Cash Coverage* (EBIT plus depreciation, then divided by interest). Appendix A provides detailed variable definitions. In our final firm-year sample (which includes data records on CDP, TCRI, PIN, and KZ index from 2016 to 2020), nearly 48% of them have scope 1 and 2 emissions information (sourced from TEJ and Firm CSR report). Roughly 40% of them have Firm CSR reports (collected manually), and only 6% of them disclose scope 3 emissions information.[19]

We also check whether the characteristics of firms that disclose scope 3 emissions are not very different from those that do not disclose scope 3 emissions. In Table 2, we delineate firms that disclose scope 3 emissions as follows: A firm is deemed a scope 3 emissions disclosure firm if it provides a disclosure of its scope 3 emissions during any year in our sample period. Notably, some scope 3 emissions disclosure firms in Table 2 may not have continuous scope 3 disclosure information. These firms may report a value

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18 Our focus is solely on the questionnaire score for climate change and does not encompass the scores for water and forest questionnaires. See: https://www.cdp.net/en/scores/cdp-scores-explained

19 The average value of the variable *Scope3 Detail* is 0.24, which is four times the value of 0.06 for the variable *Scope3*. This indicates the magnitude of the incremental contribution of Scope 3 Detail disclosure. When firms disclose information about scope 3 emissions, they tend to, on average, provide details regarding three categories of scope 3 emissions.

Table 1 Summary statistics

This table reports summary statistics of our main variables in regression models. **Diff Rate** is the firm's loan size weighted average newly issued loan rate in year t minus the weighted average loan rate in year t-1. **Scope3** equals one if the firm discloses scope 3 emissions in year t and set it to zero otherwise. **Scope3 Detail** is defined as: a firm with a scope 3 emissions disclosure will obtain one; if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. **Ln Scope3 Detail** is natural logarithm of one plus Scope3 Detail. **Scope1&2** equals one if the firm with scope 1 and 2 emissions disclosure in year t and set it to zero otherwise. **TCRI Rank**, ranging from 1 to 9, with a Default score of 10, assesses the credit risk of firms, where lower ranks signify lower credit risk. **CDP Score**, ranging from 0 to 10, represents a firm's disclosure and environmental performance, with higher scores indicating greater environmental friendliness. For firms holding **ISO 14064** certification in a given year, the variable is set to 1; otherwise, it is set to 0. **PIN** is the average daily absolute value of institutional investors' buy volume minus sell volume in a year, divided by the sum of the buy and sell volume. **KZ Index**, developed by Kaplan and Zingales (1997), measures a firm's financial constraints. **Lnsize** is the natural logarithm of the market value of the firm. **Acid** is a firm's quick asset (cash and accounts receivable) to its current liabilities. **Leverage** is the total debt divided by the total asset. **M/B Ratio** is the market value of the equity divided by the book value of the equity. **OI/Asset** is the operating income divided by the total asset. **Tobin's Q** is market value plus long- and short-term borrowings then divided by the total asset. **Cash Coverage** is EBIT plus depreciation, then divided by interest. Appendix A provides detailed variable definitions.

Variables	Obs	Mean	SD	p10	p50	p90
Diff Rate (%)	2876	-0.09	0.52	-0.52	-0.06	0.32
Scope3	2876	0.06	0.25	0.00	0.00	0.00
Scope3 Detail	2876	0.24	1.36	0.00	0.00	0.00
Ln Scope3 Detail	2876	0.08	0.36	0.00	0.00	0.00
Scope1&2	2876	0.48	0.50	0.00	0.00	1.00
TCRI Rank	2876	5.63	1.64	4.00	6.00	8.00
CDP Score	2876	0.46	1.73	0.00	0.00	1.00
ISO14064	2876	0.19	0.39	0.00	0.00	1.00
PIN	2873	0.53	0.19	0.30	0.50	0.82
KZ Index	2876	-133.33	1491.72	-29.93	-2.65	2.12
Lnsize	2876	22.69	1.42	21.08	22.52	24.48
Acid	2876	1.20	1.01	0.35	1.00	2.14
Leverage	2876	0.49	0.16	0.27	0.49	0.70
MB Ratio	2876	1.76	4.76	0.60	1.15	2.86
OI/Asset	2876	0.03	0.06	-0.03	0.03	0.10
Tobin's Q	2876	1.04	0.71	0.58	0.88	1.63
Cash Coverage	2876	128.97	1516.51	0.84	17.48	99.00

Table 2 Firm characteristics comparison

This table shows the t-test to check if there are any significant differences in the firm characteristics of scope 3 emissions disclosure firms and non-scope 3 emissions disclosure firms. A firm is a Scope3 Firm if it has a disclosure of scope 3 emissions in any year in our sample period. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

	Scope3 Firm	Non-Scope3 Firm	Difference
Lnsize	24.48	22.49	1.99***
Acid	1.18	1.20	-0.02
Leverage	0.50	0.49	0.01
MB Ratio	1.61	1.77	-0.16
OI/Asset	0.06	0.03	0.03***
Tobin's Q	1.10	1.03	0.07
Cash Coverage	44.33	138.46	-94.13

of zero for scope 3 disclosure in certain years and a non-zero value in others. Appendix B provides a list of such firms. In Table 2, we find that most of the variables are not significantly different, except for *Lnsize* and *OI/Asset*. Scope 3 emissions disclosure firms tend to have a higher market value and more operating income. We also conduct propensity score matching (PSM) as a robust check to address concerns regarding the influence of firm size on our results. The results of this analysis can be found in Table C1 and Table C2 of Appendix C.[20]

3. Empirical analysis

3.1 Baseline results

To illustrate that firms with high-quality of environmental information disclosures can affect loan rates, we use the following model:

$$\Delta loan\ rate_{it} = b_0 + b_1 Environmental\ Variable_{it} + Controls_{it} + b_t + b_j + \varepsilon_{it}\ (1)$$

Where i indexes firms, t represents years and j represents industries. The dependent variable, $\Delta loan\ rate_{it}$ (Diff Rate) is the newly issued size-weighted average bank loan rate minus last year of the size-weighted average bank loan rate.[21] $Environmental\ Variable_{it}$ represents relevant disclosures, including *Scope3* (firms with scope 3 emissions disclosure in year t obtain one and set it to zero otherwise) or *Ln Scope3 Detail* (natural logarithm of one plus *Scope3 Detail,* where *Scope3 Detail* is defined in the Section 2 and in

20 Our matching approach involves one-to-one matching for each year. In Appendix Table C1, we observe no significant differences between firms that disclose scope 3 emissions and those that do not after the matching process. Additionally, Appendix Table C2 shows that our baseline results remain consistent when using the matched sample.

21 In Table C3 of Appendix C, we show our results hold when change dependent to (a). *Loan Rate/Lag Loan Rate*, which is the current year's newly issued loan size weighted average loan rate over the prior year's; (b). *Ln(Loan Rate/Lag Loan Rate)*, which is the natural logarithm of *Loan Rate/Lag Loan Rate*. In Appendix C, Table C4 presents an analysis of potential variations in the duration of newly issued loans, which may have an impact on our results. Therefore, we introduce a control variable, namely the loan size-weighted average maturity at the firm level, expressed in years (with a maturity of 1 representing a one-year duration). Our study confirms the robustness of our findings even after incorporating this additional variable.

Appendix A).[22] $Controls_{it}$ denotes the list of control variables defined above and in Appendix A: *Lnsize, Acid, Leverage, M/B Ratio, OI/Asset, Tobin's Q, Cash Coverage.* We also control firm scope 1 and 2 emissions disclosure dummy (*Scope1&2*) to test if additional environmental information (scope 3 emissions disclosure) could affect bank loan rates compared to those firms that only have Scope1&2. We include year-fixed effects (b_t) to control for common time-varying effects and industry fixed effects (b_j) to control for time-invariant industry traits. We report standard errors clustered at the firm level.

As shown in Table 3, we find average loan rates dropping significantly (at the 1% level) after firms disclose scope 3 emissions in column (1). Our results hold when including year and industry fixed effects as shown in column (3). Economically, when firms disclose scope 3 emissions, banks would cut about 8.6 bps (6.9 bps) of loan rate compared with firms that do not report scope 3 emissions in column (1) (column (3)). The average loan rate in our sample is 140 bps (1.4%), 8.6 bps (6.9 bps) cut in loan rate means a 6% (5%) of the rate of decline in the average loan rate. In column (2) and (4), we change our key independent to *Ln Scope3 Detail*. The results show that loan rates of firms with more categories of scope 3 emissions detailed disclosure would also decrease statistically significantly. The coefficient in column (2) (column (4)) indicates an increase in categories of *Scope3 Detail* emission disclosure, for example, increasing 1 category to 2 categories, is associated with a decrease in loan rate of about 4.5bps (3.4bps).[23]

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22 In Table C5 of Appendix C, we show that our results hold when using *ISO14064* as the key independent variable. ISO is an indicator that firms declare they followed relevant disclosure principles, and ISO 14064 is an important indicator for carbon disclosure. Firms with ISO 14064 certification in CSR report in that year obtain 1 and set it to zero otherwise.

23 We acknowledge the limitations of our study. The dependent variable in our study is the yearly change of bank loan rate, which is slightly sensitive to most of our firm characteristics control variables. For example, in Taiwan, banks may place more emphasis on the firms' realized profitability when making decisions to change the loan rate for their contracted firms. Therefore, we observe that Tobin's Q is the only significant control variable in our study. For robustness, we incorporate additional control variables based on relevant literature (Sengupta, 1998; Chava et al., 2009; Francis et al., 2005; Zhou et al., 2018; Al Rabab'a et al., 2023) in Appendix C, Table C6. These variables consist of the Altman Z-Score (Altman, 1968), sales growth ratio, interest coverage, return on assets (ROA), firms' CAPM beta, logarithm of firm assets, and logarithm of firm age. The empirical results reveal that sales growth, ROA, and firm age exert statistically significant influence on loan changes in certain columns. These findings suggest that Taiwanese banks may consider factors such as growth potential, profitability, and firm stability when determining adjustments to loan rates.

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Table 3 Regression of bank loan rates against environmental information disclosure

This table displays regression results between the bank loan rates and environmental information disclosure. The dependent variable is Diff Rate, which is the current year's newly issued loan size weighted average loan rate minus the prior year's. Scope3 equals one if the firm discloses scope 3 emissions in year t and set it to zero otherwise. Ln Scope3 Detail is the natural logarithm of one plus Scope3 Detail, where Scope3 Detail is defined as: a firm with a scope 3 emissions disclosure will obtain one; if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. Regressions (3) and (4) include industry and year fixed effects. All regressions include: Scope1&2, Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

Variables	(1) Diff Rate	(2) Diff Rate	(3) Diff Rate	(4) Diff Rate
Scope3	-0.0860***		-0.0687**	
	(-2.7508)		(-2.3629)	
Ln Scope3 Detail		-0.0650***		-0.0493**
		(-2.6657)		(-2.2223)
Scope1&2	0.0242*	0.0226	-0.0014	-0.0025
	(1.6751)	(1.5645)	(-0.0991)	(-0.1795)
Lnsize	0.0084	0.0095	0.0180**	0.0187**
	(1.1423)	(1.2501)	(2.4258)	(2.4437)
Acid	-0.0076	-0.0073	0.0033	0.0035
	(-0.8596)	(-0.8486)	(0.3594)	(0.3837)
Leverage	-0.0456	-0.0439	0.0123	0.0130
	(-0.8352)	(-0.8121)	(0.2381)	(0.2550)
MB Ratio	-0.0028	-0.0028	-0.0012	-0.0012
	(-0.8656)	(-0.8733)	(-0.4643)	(-0.4749)
OI/Asset	-0.0985	-0.0986	-0.2302	-0.2312
	(-0.5806)	(-0.5847)	(-1.3388)	(-1.3490)
Tobin's Q	-0.0335**	-0.0332**	-0.0192	-0.0191
	(-2.2133)	(-2.2001)	(-1.4126)	(-1.4057)
Cash Coverage	0.0000	0.0000	-0.0000	-0.0000
	(1.0021)	(1.0045)	(-0.2532)	(-0.2507)
Constant	-0.2128	-0.2368	-0.4724***	-0.4898***
	(-1.3954)	(-1.5064)	(-3.0366)	(-3.0325)
Observations	2,876	2,876	2,876	2,876
R-squared	0.005	0.006	0.075	0.076
Year FE	NO	NO	YES	YES
Industry FE	NO	NO	YES	YES

Kleimeier and Viehs (2018) use the firm's response to the CDP questionnaire as an indicator of starting to disclose the carbon emissions information (e.g., they use a dummy variable to indicate the initial disclosure). They find that the firms that initially disclose

carbon emissions obtain a lower bank loan rate. On the other hand, in our study, we investigate the scope of a firm's carbon emissions disclosure. We would like to understand the incremental contribution of more detailed carbon emissions disclosure. Therefore, in our sample period, most firms had already disclosed Scopes 1&2, and there was a nearly 60% increase in the number of firms that disclosed Scope 3 from 2016 to 2020.[24]

In Appendix Table C2, we find that Scope 3 and Scope 3 detailed indeed provide an incremental contribution to reducing bank loan rates using the propensity score matching (PSM) sample. For robustness, we investigate these firms, which already disclose Scopes 1&2, and also include Scope 3 in our sample period. The consistent results are shown in Appendix Table C7.

Overall, our findings indicate that environmental information disclosure is associated with a decrease in bank loan rates.

3.2 Endogeneity

In this section, we use the difference-in-differences method to solve endogenous problems. We apply the *Greenhouse Gas Reduction Action Plan* and the *Greenhouse Gas Emission Control Action Program* implemented in 2018 for the regulation shock.[25] The policies unveiled by the government indicate its commitment to enhancing environmental regulations in response to climate change. For instance, the Action Plan

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24 Within our sample, Scope 1&2 disclosures account for 46% of the sample firms in 2016 and 45% in 2020. This indicates that few firms in our sample undertake new scope 1 and 2 disclosures. On the contrary, for scope 3 disclosure, 5% of firms disclosed in 2016, while 8% disclosed in 2020, representing a nearly 60% increase in firms engaging in scope 3 disclosure.

25 The *National Climate Change Action Guidelines* were endorsed by the Executive Yuan on February 23, 2017 and the following year, the Environmental Protection Department developed the *Greenhouse Gas Reduction Action Plan* to promote the reduction of greenhouse gases and initiate a comprehensive and inter-departmental national response. The plan sought to establish a partnership mechanism among central, local, public, and private sectors, as well as national participation, to implement the national greenhouse gas mitigation policy. In the same year, the nation's sectors (energy, manufacturing, transportation, residential and commercial, agriculture, and environmental sectors) commenced developing sector-specific emission reduction plans called *Greenhouse Gas Emission Control Action Programs*. These programs were based on the *Greenhouse Gas Reduction Action Plan* and contained greenhouse gas emission targets, timetables, and economic incentive measures to facilitate GHG reduction implementation. See: https://enews.moenv.gov.tw/page/3b3c62c78849f32f/eb92ef3f-e583-4499-a598-418f9cf62fec

proposes that companies implement green and low-carbon supply chain management practices and disclose the outcomes of their efforts to reduce carbon emissions within their supply chain. Banks would be cognizant of this trend and pay greater attention to firms' carbon emissions and disclosure quality. Firms that effectively disclose their carbon emissions, particularly their upstream and downstream carbon emissions, would be perceived as having a lower risk of coping with current and future GHG reduction regulation risk. Detailed disclosure would also help to reduce information asymmetry between firms and banks. Consequently, their interest rates may decrease. To assess this view, we estimate the following difference-in-differences regression:

$$\Delta loan\ rate_{it} = b_0 + b_1 Environmental\ Variable_{it} \times After2018_t$$
$$+ b_2 Environmental\ Variable_{it} + Controls_{it} + b_t + b_j + \varepsilon_{it} \quad (2)$$

In equation (2), the treatment is the firm with environmental information disclosure (Scope3 or Ln Scope3 Detail). We add an interaction term of $Environmental\ Variable_{it} \times After2018_t$ compared to Equation (1). $After2018_t$ equals one if the year is greater than 2018. To account for the time required to implement the policies, we assign a value of zero to the year 2018 and earlier (2016-2017), and a value of one to all years thereafter.[26] The $Controls_{it}$ are the same as those in Equation (1).

The results reported in Table 4 indicate that loan rates of firms with scope 3 emissions disclosure drops significantly compared with firms without scope 3 emissions disclosure after the year 2018. As shown in columns (1) and (3), the coefficient on $Scope3 \times After2018$ is negative and significantly different from zero when excluding or including the year and industry fixed effects. When we change treatment to $Ln\ Scope3$ $Detail$, the results hold. In columns (2) and (4), the coefficient on $Ln\ Scope3\ Detail \times$ $After2018$ is also negatively significant.

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26 We also make the assumption that policies exhibit delayed effects and are not impactful in the year following their implementation. To further investigate this, we conduct additional analyses, which are reported in Table C8 of Appendix C. Specifically, we define a binary variable, *After2019*, as equal to one for all years after 2019 and zero for all years prior, including the year 2019 and the years 2016 to 2018. We then ran regression models that were similar to those used in this section and find that our results remained consistent.

Table 4 Effect of GHG reduction and emissions control regulations

This table presents regression results of the influence of greenhouse gas reduction and emissions control regulations on firm bank loan rates. The dependent variable is Diff Rate, which is the current year's newly issued loan size weighted average loan rate minus the prior year's. After2018 equals to one when the year is greater than 2018. Scope3 equals one if the firm with scope3 disclosure in year t and set it to zero otherwise. Ln Scope3 Detail is the natural logarithm of one plus Scope3 Detail, where Scope3 Detail is defined as: a firm with a scope 3 emissions disclosure will obtain one; if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. Regressions (3) and (4) include industry and year fixed effects. All regressions include: Scope1&2, Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

Variables	(1) Diff Rate	(2) Diff Rate	(3) Diff Rate	(4) Diff Rate
Scope3 ×After2018	-0.2104**		-0.1965*	
	(-2.0648)		(-1.9236)	
Scope3	0.0463		0.0345	
	(0.8974)		(0.6595)	
Ln Scope3 Detail ×After2018		-0.1788**		-0.1686**
		(-2.2242)		(-2.0837)
Ln Scope3 Detail		0.0607		0.0528
		(1.3824)		(1.1903)
After2018	-0.2316***	-0.2301***		
	(-9.7378)	(-9.7188)		
Scope1&2	0.0181	0.0165	0.0008	-0.0006
	(1.2988)	(1.1920)	(0.0577)	(-0.0423)
Lnsize	0.0119*	0.0117*	0.0163**	0.0161**
	(1.7230)	(1.6600)	(2.2340)	(2.1548)
Acid	0.0045	0.0046	0.0035	0.0037
	(0.5442)	(0.5760)	(0.3844)	(0.4192)
Leverage	0.0099	0.0103	0.0153	0.0158
	(0.1890)	(0.1974)	(0.3000)	(0.3119)
MB Ratio	-0.0011	-0.0011	-0.0012	-0.0012
	(-0.4549)	(-0.4551)	(-0.4777)	(-0.4780)
OI/Asset	-0.2191	-0.2130	-0.2131	-0.2083
	(-1.3804)	(-1.3508)	(-1.2528)	(-1.2315)
Tobin's Q	-0.0187	-0.0187	-0.0191	-0.0191
	(-1.5075)	(-1.5074)	(-1.4364)	(-1.4379)
Cash Coverage	0.0000	0.0000	-0.0000	-0.0000
	(0.1300)	(0.1489)	(-0.1957)	(-0.1691)
Constant	-0.2486*	-0.2445*	-0.4372***	-0.4333***
	(-1.7155)	(-1.6480)	(-2.8417)	(-2.7384)
Observations	2,876	2,876	2,876	2,876
R-squared	0.061	0.063	0.078	0.077
Year FE	NO	NO	YES	YES
Industry FE	NO	NO	YES	YES

We then test the parallel trends assumption of the difference-in-differences approach, which requires that the relative loan rates outcomes of firms with environmental information disclosure and firm without environmental information disclosure would not significantly different before the year 2018. To test the parallel trends assumption, we estimate the following dynamic regressions:

$$\Delta loan\ rate_{it} = b_0 + \sum_{t=2016, t \neq 2018}^{2020} b_t (I_t \times Environmental\ Variable_{it})$$

$$+ b_2 Environmental\ Variable_{it} + Controls_{it} + b_t + b_j + \varepsilon_{it} \quad (3)$$

Where I_t is the year indicator and we take the year 2018 as our base year. The results in Table 5 show that the parallel trends assumption hold. The treatment in columns (1) and (2) are *Scope3* and *Ln Scope3 Detail*, respectively. The difference in loan rates change between treat and control firms is insignificantly different from zero before the year 2018. After 2018, the loan rate changes for the two groups become significantly different.

It is worth acknowledging that the decline in interest rates after 2018 could be attributed to the Central Bank of Taiwan significantly lowering rates to a historic low by 25 basis points in 2020 to counteract the COVID-19 pandemic.[27] However, we believe that this rate reduction will not impact our findings. In Table 5, the coefficient of *Ln Scope3 Detail×Yr2019* is significant, highlighting the importance of the year 2019. Furthermore, the Difference-in-Differences method compares firms with and without Scope3 disclosure. Even though all market companies experienced a rate decrease in 2020, there could still be a significant difference between firms with and without Scope3 disclosure. Additionally, the effect of the overall company loan rate reduction in 2020 has been controlled by year fixed effects.

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27 See: https://www.reuters.com/article/health-coronavirus-taiwan-rates-idUSL4N2BC2Z8.

Table 5 Parallel trend tests

This table tests the evolving differences in the loan rates change by environmental information disclosure and non-environmental information disclosure firms. The dependent variable is Diff Rate, which is the current year's newly issued loan size weighted average loan rate minus the prior year's. Yr2016-Yr2020 is the year dummy for the years 2016 to 2020. Scope3 equals one if the firm discloses scope 3 emissions in year t and set it to zero otherwise. Ln Scope3 Detail is the natural logarithm of one plus Scope3 Detail, where Scope3 Detail is defined as: a firm with a scope 3 emissions disclosure will obtain one; if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. Regressions include industry and year fixed effects and also include: Scope1&2, Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

Variables	(1) Diff Rate	Variables	(2) Diff Rate
Scope3×Yr2016	-0.1207 (-1.2807)	Ln Scope3 Detail×Yr2016	-0.0788 (-1.2911)
Scope3×Yr2017	-0.1005 (-1.1330)	Ln Scope3 Detail×Yr2017	-0.0495 (-0.8191)
Scope3×Yr2018	- -	Ln Scope3 Detail×Yr2018	- -
Scope3×Yr2019	-0.2018 (-1.3916)	Ln Scope3 Detail×Yr2019	-0.1938* (-1.8283)
Scope3×Yr2020	-0.3219** (-2.2198)	Ln Scope3 Detail×Yr2020	-0.2113** (-2.1433)
Scope3	0.1025 (1.1263)	Ln Scope3 Detail	0.0085 (0.1489)
Scope1&2	0.0013 (0.0931)	Scope1&2	-0.0003 (-0.0190)
Lnsize	0.0163** (2.2546)	Lnsize	0.0162** (2.1710)
Acid	0.0035 (0.3946)	Acid	0.0037 (0.4194)
Leverage	0.0160 (0.3134)	Leverage	0.0161 (0.3189)
MB Ratio	-0.0012 (-0.4806)	MB Ratio	-0.0012 (-0.4791)
OI/Asset	-0.2172 (-1.2782)	OI/Asset	-0.2092 (-1.2366)
Tobin's Q	-0.0189 (-1.4274)	Tobin's Q	-0.0191 (-1.4360)
Cash Coverage	-0.0000 (-0.1670)	Cash Coverage	-0.0000 (-0.1552)
Constant	-0.4397*** (-2.8685)	Constant	-0.4358*** (-2.7552)
Observations	2,876	Observations	2,876
R-squared	0.078	R-squared	0.079
Year FE	YES	Year FE	YES
Industry FE	YES	Industry FE	YES

4. Mechanisms

In this section, we provide evidence that environmental information disclosure affects loan rates through mechanisms of (1) lower firm credit risk; (2) higher firm ESG score. First, once firms disclose extra environmental emissions information, their credit risk will decrease. While such a decline in credit risk may decrease their loan rates. Second, firms with scope 3 emissions disclosure may gain an increased ESG score which may result in lower loan rates. Evidence shows that environmental (ESG) performance could lower the cost of debt (Eichholtz et al., 2019). Such firms are considered to have efficient use of resources (Sharfman and Fernando, 2008), better reputations (Turban and Greening, 1997), and lower operational risk (An and Pivo, 2020; Albuquerque et al., 2019).

4.1 Credit risk

We first examine firm credit risk by using the TCRI Rank which is provided by TEJ to access firm credit risk with an accuracy rate of over 90% based on 10 financial ratios and expert reviews.[28] TCRI Rank provides ordered categories of firms' credit risk rating from 1 to 9, and Default (10). The lower the rank, the lower the credit risk of the firm. As the rating is ordinal so we use an ordered probit regression while maintaining a similar regression structure with Equation (1).

In Table 6, we test whether scope 3 emissions disclosure is associated with changes in firm credit risk. Overall, we find that firms with scope 3 emissions disclosure or scope 3 emissions detailed disclosure would have lower credit risk.[29] Estimates in columns (1) and (2) are negative statistically significant at the 1% level, and after we add year and industry fixed effect, coefficients in columns (3) and (4) are still significant at the 1% level and are both large in magnitude (-0.5043 and -0.4924, respectively). The economic

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28 This rank contains profitability, scale, liquidity, risk management, prospect to measure firms with default risk. See:https://www.tej.com.tw/solution/TCRI%E2%84%A2%20%E5%8F%B0%E7%81%A3%E4%BC%81%E6%A5%AD%E4%BF%A1%E7%94%A8%E9%A2%A8%E9%9A%AA%E6%8C%87%E6%A8%99

29 We show similar results with a dependent of ISO14064 in columns (1) and (2) of Table C9 of Appendix C.

magnitude of the effect in column (3) and column (4) implies that once firms disclose scope 3 emissions (column (3)) or one unit increase in *Ln Scope3 Detail* (column (4)), the probability of the TRCI Rank being large than median rank (firm credit risk increase) versus being below the median (firm credit risk decrease) are about 40% lower. The results show that disclosure of environmental information can reduce firms' credit risk.

Table 6 Channel of the environmental information disclosure on bank loan rate – TCRI Rank

This table displays regression results between the TCRI Rank and environmental information disclosure by using ordered probit model. The dependent variable is TCRI Rank, which ranks from 1 to 9, and Default (10). The lower the rank, the lower the credit risk of the firm. Scope3 equals one if the firm discloses scope 3 emissions in year t and set it to zero otherwise. Ln Scope3 Detail is the natural logarithm of one plus Scope3 Detail, where Scope3 Detail is defined as: a firm with a scope 3 emissions disclosure will obtain one; if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. Regressions (3) and (4) include industry and year dummy. All regressions include: Scope1&2, Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

Variables	(1) TCRI Rank	(2) TCRI Rank	(3) TCRI Rank	(4) TCRI Rank
Scope3	-0.5308***		-0.5043***	
	(-3.2659)		(-2.9277)	
Ln Scope3 Detail		-0.4977***		-0.4924***
		(-5.0374)		(-4.7181)
Scope1&2	-0.1991**	-0.2010***	-0.1943**	-0.1927**
	(-2.5511)	(-2.5907)	(-2.3591)	(-2.3506)
Lnsize	-0.6389***	-0.6340***	-0.7024***	-0.6960***
	(-14.9803)	(-14.8296)	(-15.1105)	(-14.8767)
Acid	-0.1146***	-0.1131***	-0.0325	-0.0312
	(-2.8574)	(-2.8347)	(-0.8635)	(-0.8397)
Leverage	1.8806***	1.9029***	2.0210***	2.0434***
	(6.5621)	(6.6256)	(6.6370)	(6.7011)
MB Ratio	0.0258***	0.0256***	0.0306***	0.0302***
	(3.1753)	(3.1808)	(2.9468)	(2.9507)
OI/Asset	-7.8330***	-7.8449***	-8.2094***	-8.2316***
	(-12.1460)	(-12.2106)	(-11.8160)	(-11.9152)
Tobin's Q	0.1332	0.1311	0.1566	0.1534
	(1.5801)	(1.5695)	(1.5918)	(1.5769)
Cash Coverage	-0.0000	-0.0000*	-0.0000***	-0.0000***
	(-1.6118)	(-1.6842)	(-2.6933)	(-2.7700)
Observations	2,876	2,876	2,876	2,876
Pseudo R2	0.249	0.251	0.280	0.283
Year Dummy	NO	NO	YES	YES
Industry Dummy	NO	NO	YES	YES

4.2 CDP score

We next examine whether the decrease in loan rate results from changes in firm ESG score. We obtain CDP Score, an ESG measurement, from CDP. The CDP Score is a snapshot of a firm's disclosure and environmental performance, which includes the board's emphasis on climate change, risk management, and climate change disclosure tactics.[30] While the CDP Score questionnaire includes sections relevant to scope 3 emissions, its primary goal in these sections is to assess the quality of disclosure related to scope 3 emissions based on the TCFD framework, rather than to disclose such emissions. We limit the questionnaire score to climate change issue and exclude the scores of the water and forest issues. The scoring system comprises grades A+, A, B+, B, C+, C, D+, D, F, along with "not scored" and "not available" designations. The "not scored" designation is assigned to firms that submit incomplete material, whereas the "not available" designation is reserved for firms that do not provide any information at all. To normalize the data, a score of 0 is assigned to firms with "not available". a value of 1 is for "not scored" and a value of 2 if for F. Firms that receive an A+ score are assigned a numerical value of 10. Higher scores represent more environmentally friendly firms. We also implement an ordered probit regression in this section.

Table 7 reports the results of our analysis. Columns (1) and (3) indicate scope 3 emissions disclosure could increase the firm CDP score. Similarly, columns (2) and (4) show that scope 3 emissions detailed disclosure is also positively correlated with CDP score.[31] Specifically, coefficients for columns (3) and (4) are positive significant at 1% level, which indicates the odds of the CDP score being large than median versus the CDP score below the median are around 3 times greater once firms disclose scope 3 emissions information (column (3)) or one unit increase in *Ln Scope3 Detail* (column (4)). The evidence suggests that firms that disclose more information about carbon emissions tend to exhibit higher ESG performance.

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30 See: https://www.cdp.net/en/scores/cdp-scores-explained
31 Similar results are shown with *ISO14064* as the dependent in columns (3) and (4) of Table C9 of Appendix C.

Table 7 Channel of the environmental information disclosure on bank loan rate – CDP Score

This table displays regression results between the CDP Score and environmental information disclosure by using ordered probit model. The dependent variable is CDP Score, which ranges from 0 to 10 and provides a snapshot of a firm's disclosure and environmental performance. The higher the score, the more environmentally friendly the firm is. Scope3 equals one if the firm discloses scope 3 emissions in year t and set it to zero otherwise. Ln Scope3 Detail is the natural logarithm of one plus Scope3 Detail, where Scope3 Detail is defined as: a firm with a scope 3 emissions disclosure will obtain one; if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. Regressions (3) and (4) include industry and year dummy. All regressions include: Scope1&2, Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

Variables	(1) CDP Score	(2) CDP Score	(3) CDP Score	(4) CDP Score
Scope3	1.1694***		1.0991***	
	(7.4503)		(6.2483)	
Ln Scope3 Detail		0.7977***		0.8091***
		(7.2524)		(7.3878)
Scope1&2	0.2849	0.3347	0.3917*	0.4296**
	(1.3246)	(1.5726)	(1.9104)	(2.1075)
Lnsize	0.7922***	0.7827***	0.8505***	0.8366***
	(8.3847)	(8.2544)	(6.8278)	(6.7625)
Acid	-0.0902	-0.0934	-0.2784**	-0.2869**
	(-1.2256)	(-1.3500)	(-2.4144)	(-2.5457)
Leverage	0.5896	0.5094	0.0857	0.0348
	(1.4214)	(1.1923)	(0.1817)	(0.0721)
MB Ratio	-0.4616***	-0.4871***	-0.4712***	-0.4834***
	(-4.6591)	(-4.9437)	(-3.7913)	(-3.7558)
OI/Asset	1.2176	1.0998	1.1827	1.1782
	(1.0916)	(1.0236)	(1.1560)	(1.2085)
Tobin's Q	0.1495**	0.1483*	0.0304	-0.0015
	(1.9834)	(1.8556)	(0.1377)	(-0.0060)
Cash Coverage	-0.0000	-0.0000	0.0000	0.0000
	(-0.5262)	(-0.4194)	(0.1801)	(0.4443)
Observations	2,876	2,876	2,876	2,876
Pseudo R2	0.430	0.433	0.472	0.479
Year FE	NO	NO	YES	YES
Industry FE	NO	NO	YES	YES

5. Heterogeneity

In this section, we study the heterogeneity of the lenders' response for firm environmental information disclosure. We examine differential effects based on firm quality. Goss and Roberts (2011) demonstrate that the quality of borrowers would

influence lenders' trust of their CSR investments. Therefore, we define the firms with scope 3 emissions disclosure as high-quality firms associated with lower information asymmetry and financial constraint. To test this prediction, we measure firm quality using (a). PIN; (b). KZ Index.

We separate the sample into high-quality and low-quality subsamples. If a firm's information-based trading (PIN) is below the sample median, we define it as a high-quality firm. The PIN is to measure the degree of information asymmetry of firms, which is the yearly average of the daily absolute value of institutional investors' buy volume minus sell volume, then divided by the sum of the buy and sell volume. A lower PIN indicates a weaker information asymmetry and better firm quality.

Table 8 reports the results. We find terms, $Scope3$ and $Ln\ Scope3\ Detail$, are statistically significant and negatively correlated with bank loan rates in columns (1) and (3), indicating that high-quality (low information asymmetry) firms are more likely to have lower loan rates when they disclose information on scope 3 emissions. While there are no significant results in columns (2) and (4) for low-quality firms.

We then take the KZ Index as an alternative measure of high-quality firms. A high-quality firm is defined as one whose KZ Index is below the sample median. KZ Index is from Kaplan and Zingales (1997) to measure firm financial constraints. Lower KZ Index firms are less likely to suffer the financial distress and higher firm quality. Here is the KZ index model:

$$KZ\ Index = -1.001909 \times \frac{Cash\ flows}{K} + 0.2826389 \times Q$$
$$+ 3.139193 \times \frac{Debt}{Total\ capital} - 39.3678 \times \frac{Dividends}{K}$$
$$-1.314759 \times \frac{Cash}{K} \tag{4}$$

where $Cash\ flows$ is income before extraordinary items plus total depreciation and amortization. K is last year's property, plant, and equipment. Q is market capitalization plus total shareholder's equity minus book value of common equity minus deferred tax

assets, then dividend by total shareholder's equity. $Debt$ is total long-term debt plus notes payable plus current portion of long-term debt. $Dividends$ included common and preferred stock should be paid. $Cash$ means cash and short-term investments.

Table 8 Heterogeneity tests – difference of information asymmetry

This table displays regression results between the bank loan rates and environmental information disclosure in different firms' quality based on different information asymmetry. High-quality firms (columns (1) and (3)) have PIN that is below the sample median. PIN is the yearly average of daily absolute value of institutional investors' buy volume minus sell volume, then divided by the sum of the buy and sell volume. The dependent variable is Diff Rate, which is the current year's newly issued loan size weighted average loan rate minus the prior year's. Scope3 equals one if the firm discloses scope 3 emissions in year t and set it to zero otherwise. Ln Scope3 Detail is the natural logarithm of one plus Scope3 Detail, where Scope3 Detail is defined as: a firm with a scope 3 emissions disclosure will obtain one; if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. All regressions include industry and year fixed effects. All regressions also include: Scope1&2, Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

Variables	(1) Diff Rate	(2) Diff Rate	(3) Diff Rate	(4) Diff Rate
Subsample	High quality (PIN)	Low quality (PIN)	High quality (PIN)	Low quality (PIN)
Scope3	-0.0721**	-0.0425		
	(-2.0145)	(-0.6233)		
Ln Scope3 Detail			-0.0506**	0.0214
			(-2.0849)	(0.2779)
Scope1&2	-0.0206	0.0112	-0.0220	0.0091
	(-0.7972)	(0.5269)	(-0.8475)	(0.4298)
Lnsize	0.0239*	0.0242	0.0252**	0.0240
	(1.9194)	(1.5804)	(1.9693)	(1.5706)
Acid	-0.0155	0.0102	-0.0148	0.0100
	(-0.8458)	(1.1406)	(-0.8183)	(1.1189)
Leverage	0.0154	0.0468	0.0174	0.0447
	(0.1983)	(0.5950)	(0.2283)	(0.5680)
MB Ratio	-0.0309	-0.0003	-0.0310	-0.0003
	(-1.5722)	(-0.3093)	(-1.5751)	(-0.3065)
OI/Asset	-0.3635	-0.0810	-0.3577	-0.0827
	(-1.4771)	(-0.3087)	(-1.4619)	(-0.3153)
Tobin's Q	0.0329	-0.0118	0.0327	-0.0117
	(0.9897)	(-0.9996)	(0.9811)	(-0.9970)
Cash Coverage	0.0000	-0.0000	0.0000	-0.0000
	(0.5486)	(-0.1392)	(0.5359)	(-0.1253)
Constant	-0.5835**	-0.6419*	-0.6161**	-0.6373*
	(-2.1156)	(-1.9306)	(-2.1636)	(-1.9188)
Observations	1,434	1,442	1,434	1,442
R-squared	0.129	0.041	0.129	0.041
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

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Table 9 reports our findings. High-quality firms' subsamples show negative statistically significant results at least 10% level in columns (1) and (3), which are similar to the previous Table 8 findings. The results indicate that low financial constraint firms have more carbon emission disclosure and obtain lower loan rates from banks.

Table 9 Heterogeneity tests – difference of financial constraints

This table displays regression results between the bank loan rates and environmental information disclosure in different firms' quality based on financial constraints. Firms with KZ Index below the sample median are considered high-quality (columns (1) and (3)). KZ Index is from Kaplan and Zingales (1997) to measure firm financial constraints. The dependent variable is Diff Rate, which is the current year's newly issued loan size weighted average loan rate minus the prior year's. Scope3 equals one if the firm with scope3 disclosure in year t and set it to zero otherwise. Ln Scope3 Detail is the natural logarithm of one plus Scope3 Detail, where Scope3 Detail is defined as: a firm with a scope 3 emissions disclosure will obtain one; if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. All regressions include industry and year fixed effects. All regressions also include: Scope1&2, Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

Variables	(1) Diff Rate	(2) Diff Rate	(3) Diff Rate	(4) Diff Rate
Subsample	High quality (KZ Index)	Low quality (KZ Index)	High quality (KZ Index)	Low quality (KZ Index)
Scope3	-0.1082** (-2.2737)	-0.0152 (-0.5248)		
Ln Scope3 Detail			-0.0597* (-1.8560)	-0.0239 (-0.9016)
Scope1&2	0.0059 (0.2708)	0.0017 (0.0767)	0.0027 (0.1236)	0.0015 (0.0678)
Lnsize	0.0244** (2.2172)	0.0080 (0.8180)	0.0246** (2.1448)	0.0095 (0.9514)
Acid	-0.0002 (-0.0164)	0.0069 (0.6580)	0.0003 (0.0267)	0.0067 (0.6447)
Leverage	-0.0666 (-0.9190)	0.0921 (1.0924)	-0.0636 (-0.8948)	0.0918 (1.0871)
MB Ratio	-0.0009 (-0.3277)	-0.0037 (-1.1441)	-0.0009 (-0.3286)	-0.0039 (-1.2044)
OI/Asset	-0.1933 (-0.7685)	-0.1689 (-0.5848)	-0.1895 (-0.7578)	-0.1734 (-0.6005)
Tobin's Q	-0.0339 (-1.6257)	-0.0115 (-1.0559)	-0.0341 (-1.6315)	-0.0116 (-1.0548)
Cash Coverage	-0.0000 (-0.2309)	-0.0000 (-0.9056)	-0.0000 (-0.1973)	-0.0000 (-0.9055)
Constant	-0.5669** (-2.3581)	-0.3017 (-1.5193)	-0.5748** (-2.2840)	-0.3329* (-1.6512)
Observations	1,438	1,438	1,438	1,438
R-squared	0.121	0.051	0.120	0.052
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

6. Robustness and further tests

We perform several robust checks and additional tests to validate our findings. Our results remain consistent when utilizing propensity score matching (PSM), as indicated in Table C1 for the comparison of post-matching firm characteristics, and Table C2 in Appendix C presents regression results. We confirm the robustness of our results by utilizing various methods of loan rate calculation (*Loan Rate/Lag Loan Rate* and *Ln(Loan Rate/Lag Loan Rate)*), as shown in Table C3. Furthermore, Table C4 presents results that remain robust even after incorporating loan maturity into the regression analysis. The impact of *ISO14064* on bank loan rates is shown in Table C5. To enhance the robustness of our findings, we introduce additional control variables in Table C6 (e.g., *Z-Score, Interest Coverage, and Interest Coverage* et al.). Investigating Scopes 1&2&3 (firms disclosing Scopes 1, 2, and 3 emissions) during our sample period is shown in Table C7. Considering potential delayed effects in policies (using *After2019* rather than *After2018*), as shown in Table C8, we find consistent outcomes. Finally, Table C9 shows the resilience of our channel test results when using *ISO14064*.

7. Conclusion

Using the scope 3 emissions and detailed emissions information from the firm's CSR report of TWSE listed firms, we find that firms with more environmental information disclosures obtain 8.6 basis points lower loan rate than firms without environmental information disclosures. The channels for the lower bank loan rate built through the firms with scope 3 emissions disclosure reduce their credit risk and increase ESG scores.

We also use the DID method for the implementation of GHG reduction and emissions control actions by the EPA of Taiwan in 2018 to alleviate endogenous

problems. Finally, we find that the effect is more pronounced for high-quality firms, which have less information asymmetry and relaxed financial constraints. Our evidence suggests that the disclosure of environmental information reduces firms' cost of debt.

Our study provides the policy implications as follows. Firms should pursue more detailed and meaningful environmental information disclosures such as following the standard and meaningful indicators and guidelines of TCFD. Second, companies need to publicize their emissions information, because the more transparent disclosure would reduce the information asymmetries and send positive signals to the financial market, thereby increasing their corporate value. Third, lenders, such as banks, can lower their default risk by considering the carbon emissions disclosure of firms.
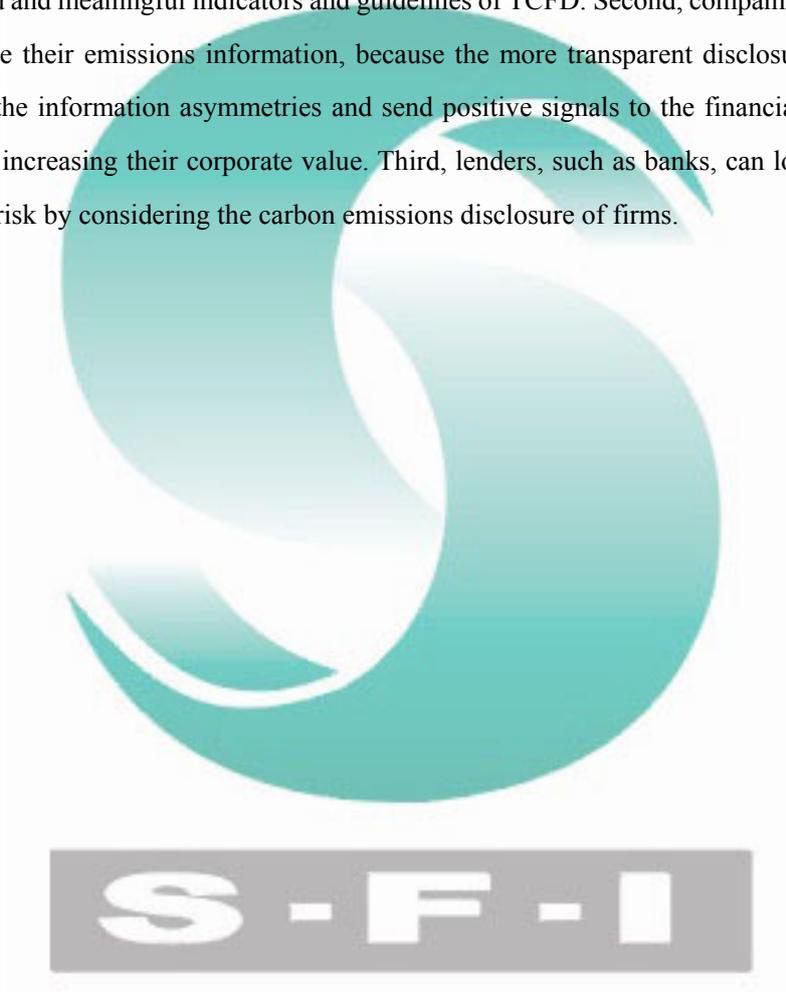
Appendix A Variable descriptions

Variable Name	Definition	Source
Diff Rate	The current year's newly issued loan size weighted average loan rate minus the prior year's.	TEJ
Scope3	Firms with scope 3 emissions disclosure in that year obtain one and set it to zero otherwise.	Firm CSR report
Scope3 Detail	A firm with a scope 3 emissions disclosure will obtain one. If the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one.	Firm CSR report
Ln Scope3 Detail	Natural logarithm of one plus Scope3 Detail.	Firm CSR report
Scope1&2	Firms with scope 1 and 2 emissions disclosure in that year obtain one and set it to zero otherwise.	TEJ/Firm CSR report
Lnsize	Natural logarithm of the market value of the firm.	TEJ
Acid	Quick asset (cash and accounts receivable) to its current liabilities.	TEJ
Leverage	Total debt divided by total asset	TEJ
M/B Ratio	Market value of the equity divided by the book value of the equity.	TEJ
OI/Asset	Operating income divided by the total asset.	TEJ
Tobin's Q	Market value plus long- and short-term borrowings then divided by the total asset.	TEJ
Cash Coverage	EBIT plus depreciation, then divided by interest.	TEJ
TCRI Rank	Ranks from 1 to 9, and Default (10). The lower the rank, the lower the credit risk of the firm. TRCI Rank is provided by TEJ to access firm credit risk based on 10 financial ratios.[32]	TEJ
CDP Score	The CDP Score is a snapshot of a firm's disclosure and environmental performance.[33] The scoring system used in this study includes grades A+, A, B+, B, C+, C, D+, D, F, as well as the designations "not scored" and "not available". The designation "not scored" is assigned to firms that submit incomplete materials, whereas "not available" is reserved for firms that fail to provide any information whatsoever. Firms that receive a rating of "not available" are assigned a score of 0, those labeled as "not scored" are assigned a score of 1, and those that receive an F are assigned a score of 2. Firms that are awarded an A+ are given a score of 10. The higher the score, the more environmentally friendly the firm is.	CDP
PIN	PIN is the yearly average of daily absolute value of institutional investors' buy volume minus sell volume, then divided by the sum of the buy and sell volume.	TEJ
KZ Index	KZ Index is from Kaplan and Zingales (1997) to measure firm financial constraints. Firms with a higher KZ-Index scores are more likely to experience difficulties when financial conditions tighten.	TEJ
ISO14064	Firms with ISO 14064 certification in that year obtain 1 and set it to zero otherwise.	Firm CSR report

32 See: https://www.tej.com.tw/solution/TCRI%E2%84%A2%20%E5%8F%B0%E7%81%A3%E4%BC%81%E6%A5%AD%E4%BF%A1%E7%94%A8%E9%A2%A8%E9%9A%AA%E6%8C%87%E6%A8%99

33 See: https://www.cdp.net/en/scores/cdp-scores-explained

Appendix B Scope 3 emissions disclosure lists

The following table exhibits the firms listed in Taiwan that disclose Scope 3. Alongside, we present the percentage of companies in their respective industries (indicated in parentheses and comprising all listed companies) that have revealed their Scope 3 emissions.

Industry	English Name	Name
Building (1%)	Cathay Real Estate Development Co., Ltd.	國泰建設股份有限公司
Cement (30%)	Taiwan Cement Corp.	台灣水泥股份有限公司
	Asia Cement Corporation	亞洲水泥股份有限公司
Chemical (7%)	Dyaco International Inc.	岱宇國際股份有限公司
	Standard Chem & Pharm CO., LTD.	生達化學製藥股份有限公司
	Qualipoly Chemical Corporation	國精化學股份有限公司
Department Store (6%)	President Chain Store Corporation	統一超商股份有限公司
	Far Eastern Department Stores, Ltd.	遠東百貨股份有限公司
Electrical Machinery (2%)	Hiwin Technologies Corp.	上銀科技股份有限公司
	TECO Electric & Machinery Co., Ltd.	東元電機股份有限公司
Electronic (8%)	Taiwan Semiconductor Manufacturing Company Limited	台灣積體電路製造股份有限公司
	Hon Hai Precision Industry Co., Ltd.	鴻海精密工業股份有限公司
	Delta Electronics, Inc.	台達電子工業股份有限公司
	United Microelectronics Corporation	聯華電子股份有限公司
	ASE Technology Holding Co., Ltd.	日月光投資控股股份有限公司
	Taiwan Mobile Co., Ltd.	台灣大哥大股份有限公司
	Nanya Technology Corporation	南亞科技股份有限公司
	Far EasTone Telecommunications Co., Ltd.	遠傳電信股份有限公司
	Innolux Corporation	群創光電股份有限公司
	AU Optronics Corp.	友達光電股份有限公司
	Unimicron Technology Corp.	欣興電子股份有限公司
	Wiwynn Corporation	緯穎科技服務股份有限公司
	Lite-On Technology Corporation	光寶科技股份有限公司
	Voltronic Power Technology Corp.	旭隼科技股份有限公司
	Wistron Corporation	緯創資通股份有限公司
	Inventec Corporation	英業達股份有限公司
	Powertech Technology Inc.	力成科技股份有限公司
	Acer Incorporated	宏碁股份有限公司
	Chicony Electronics Co., Ltd.	群光電子股份有限公司
	Qisda Corporation	佳世達科技股份有限公司
	Giga-Byte Technology Co., Ltd.	技嘉科技股份有限公司

	King Yuan Electronics Co., Ltd.	京元電子股份有限公司
	MiTAC Holdings Corporation	神達投資控股股份有限公司
	Merry Electronics Co., Ltd.	美律實業股份有限公司
	Wistron NeWeb Corporation	啟碁科技股份有限公司
	Chicony Power Technology Co., Ltd.	群光電能科技股份有限公司
	HTC Corporation	宏達國際電子股份有限公司
	ChipMOS TECHNOLOGIES INC.	南茂科技股份有限公司
	TXC Corporation	台灣晶技股份有限公司
	Primax Electronics Ltd.	致伸科技股份有限公司
	Kinpo Electronics, Inc.	金寶電子工業股份有限公司
	AcBel Polytech Inc.	康舒科技股份有限公司
	Unitech Printed Circuit Board Corp.	燿華電子股份有限公司
	ADLINK Technology, Inc.	凌華科技股份有限公司
	Aten International Co., Ltd	宏正自動科技股份有限公司
	BenQ Materials Corporation	明基材料股份有限公司
Food (7%)	Fwusow Industry Co., Ltd.	福壽實業股份有限公司
Oil & Gas (6%)	Formosa Petrochemical Corporation	台塑石化股份有限公司
Other (7%)	Feng Tay Enterprises Co., Ltd.	豐泰企業股份有限公司
	Pou Chen Corporation	寶成工業股份有限公司
	Sinyi Realty Inc.	信義房屋仲介股份有限公司
	Cleanaway Company Limited	可寧衛股份有限公司
	Taiwan Hon Chuan Enterprise Co., Ltd.	宏全國際股份有限公司
Paper (27%)	Cheng Loong Corporation	正隆股份有限公司
	Chung Hwa Pulp Corporation	中華紙漿股份有限公司
Plastic (12%)	Formosa Plastics Corporation	台灣塑膠工業股份有限公司
	Formosa Chemicals & Fibre Corporation	台灣化學纖維股份有限公司
	Yonyu Plastics Co., Ltd.	永裕塑膠工業股份有限公司
Securities (10%)	President Securities Corporation	統一綜合證券股份有限公司
Shipping (6%)	China Airlines, Ltd.	中華航空股份有限公司
	EVA Airways Corp.	長榮航空股份有限公司
Steel (5%)	China Steel Corporation	中國鋼鐵股份有限公司
	Tung Ho Steel Enterprise Corporation	東和鋼鐵企業股份有限公司
	Chun Yu Works & Co., Ltd.	春雨工廠股份有限公司
Textile Fiber (7%)	Far Eastern New Century Corporation	遠東新世紀股份有限公司
	Eclat Textile Co., Ltd.	儒鴻企業股份有限公司
	Formosa Taffeta Co., Ltd.	福懋興業股份有限公司
	Zig Sheng Industrial Co., Ltd.	集盛實業股份有限公司

Appendix C Robustness and further tests

Table C1 Firm characteristics comparison – after propensity score matching (PSM)

This table shows the t-test to check if there are any significant differences in the firm characteristics of scope 3 emissions disclosure firms and non-scope 3 emissions disclosure firms after propensity score matching (PSM). We perform one-to-one matching of each year of Scope 3 and Non-Scope 3 Firms. A firm is a Scope3 Firm if it has a disclosure of scope 3 emissions in any year in our sample period. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

	Scope3 Firm	Non-Scope3 Firm	Difference
Lnsize	24.04	24.01	0.03
Acid	1.17	1.22	-0.06
Leverage	0.50	0.51	-0.01
MB Ratio	1.56	1.60	-0.05
OI/Asset	0.05	0.06	-0.01
Tobin's Q	1.07	1.06	0.01
Cash Coverage	42.64	41.75	0.89

Table C2 Robustness tests – using matched sample

This table displays regression results between the bank loan rates and environmental information disclosure by using a matched sample. We perform one-to-one propensity score matching (PSM) of each year of Scope 3 and Non-Scope 3 Firms. The dependent variable is Diff Rate, which is the current year's newly issued loan size weighted average loan rate minus the prior year's. Scope3 equals one if the firm discloses scope 3 emissions in year t and set it to zero otherwise. Ln Scope3 Detail is the natural logarithm of one plus Scope3 Detail, where Scope3 Detail is defined as: a firm with a scope 3 emissions disclosure will obtain one; if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. Regressions (3) and (4) include industry and year fixed effects. All regressions include: Scope1&2, Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

Variables	(1) Diff Rate	(2) Diff Rate	(3) Diff Rate	(4) Diff Rate
Scope3	-0.1482***		-0.1181**	
	(-2.8674)		(-2.3589)	
Ln Scope3 Detail		-0.1176***		-0.0773**
		(-3.0692)		(-2.1375)
Scope1&2	-0.0496	-0.0595	-0.1048	-0.1178*
	(-0.7086)	(-0.8826)	(-1.5327)	(-1.7922)
Lnsize	-0.0056	-0.0001	-0.0034	0.0007
	(-0.3841)	(-0.0101)	(-0.2038)	(0.0426)
Acid	-0.0719**	-0.0691**	-0.0500	-0.0458
	(-2.0945)	(-2.1548)	(-1.3860)	(-1.2785)
Leverage	-0.3327*	-0.3086	-0.2599	-0.2418
	(-1.7087)	(-1.6341)	(-1.3393)	(-1.2594)
MB Ratio	0.0489	0.0473	0.0519	0.0508
	(0.8299)	(0.7832)	(0.9412)	(0.8873)
OI/Asset	-0.7164	-0.6003	-1.3307*	-1.2304*
	(-0.9501)	(-0.8186)	(-1.8101)	(-1.6916)
Tobin's Q	-0.1122	-0.1158	-0.0625	-0.0664
	(-1.2248)	(-1.2403)	(-0.7146)	(-0.7330)

Cash Coverage	0.0004	0.0003	0.0004	0.0003
	(0.4353)	(0.3911)	(0.4313)	(0.3951)
Constant	0.4530	0.3149	0.3523	0.2453
	(1.2210)	(0.8790)	(0.8421)	(0.5939)
Observations	430	430	430	430
R-squared	0.046	0.051	0.203	0.202
Year FE	NO	NO	YES	YES
Industry FE	NO	NO	YES	YES

Table C3 Robustness tests of bank loan rate against environmental information disclosure

This table displays regression results of robustness between the bank loan rates and environmental information disclosure. Loan Rate/Lag Loan Rate is the current year's newly issued loan size weighted average loan rate over the prior year's. Ln(Loan Rate/Lag Loan Rate) is the natural logarithm of Loan Rate/Lag Loan Rate. Scope3 equals one if the firm with scope3 disclosure in year t and set it to zero otherwise. Ln Scope3 Detail is the natural logarithm of one plus Scope3 Detail, where Scope3 Detail is defined as: a firm with a scope 3 emissions disclosure will obtain one; if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. All regressions include industry and year fixed effects. All regressions also include: Scope1&2, Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

Variables	(1) Loan Rate/Lag Loan Rate	(2) Loan Rate/Lag Loan Rate	(3) Ln(Loan Rate/ Lag Loan Rate)	(4) Ln(Loan Rate/ Lag Loan Rate)
Scope3	-0.0646***		-0.0729***	
	(-3.0496)		(-3.0622)	
Ln Scope3 Detail		-0.0389**		-0.0432**
		(-2.2847)		(-2.3951)
Scope1&2	0.0049	0.0035	-0.0064	-0.0081
	(0.4317)	(0.3072)	(-0.7210)	(-0.8983)
Lnsize	0.0126***	0.0126***	0.0049	0.0048
	(2.7260)	(2.7181)	(1.0384)	(1.0255)
Acid	-0.0013	-0.0011	0.0020	0.0021
	(-0.2542)	(-0.2314)	(0.3785)	(0.4136)
Leverage	0.0222	0.0223	0.0423	0.0424
	(0.6948)	(0.6996)	(1.4819)	(1.4939)
MB Ratio	0.0005	0.0005	-0.0001	-0.0001
	(0.5088)	(0.5151)	(-0.0894)	(-0.0835)
OI/Asset	-0.3809*	-0.3811*	-0.2619***	-0.2623***
	(-1.7895)	(-1.7912)	(-3.1255)	(-3.1386)
Tobin's Q	-0.0106	-0.0104	-0.0199	-0.0197
	(-1.3846)	(-1.3644)	(-1.3624)	(-1.3468)
Cash Coverage	0.0000	0.0000	0.0000	0.0000
	(0.3258)	(0.3418)	(0.1702)	(0.1923)
Constant	0.7032***	0.7022***	-0.1646*	-0.1639*
	(6.9354)	(6.8862)	(-1.6949)	(-1.6752)
Observations	2,861	2,861	2,849	2,849
R-squared	0.042	0.041	0.112	0.111
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

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Table C4 Robustness tests – taking into account loan maturity

This table presents regression results that examine the relationship between bank loan rates and environmental information disclosure, while also taking into account loan maturity. The dependent variable is Diff Rate, which is the current year's newly issued loan size weighted average loan rate minus the prior year's. Scope3 equals one if the firm discloses scope 3 emissions in year t and set it to zero otherwise. Ln Scope3 Detail is the natural logarithm of one plus Scope3 Detail, where Scope3 Detail is defined as: a firm with a scope 3 emissions disclosure will obtain one; if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. Average Maturity is calculated as the loan size-weighted average maturity at the firm level, expressed in years, with the maturity of 1 representing a one-year duration. Regressions (3) and (4) include industry and year fixed effects. All regressions also include: Scope1&2, Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

Variables	(1) Diff Rate	(2) Diff Rate	(3) Diff Rate	(4) Diff Rate
Scope3	-0.0856***		-0.0680**	
	(-2.7316)		(-2.3277)	
Ln Scope3 Detail		-0.0653***		-0.0493**
		(-2.6753)		(-2.2147)
Scope1&2	0.0244*	0.0229	-0.0012	-0.0023
	(1.6911)	(1.5841)	(-0.0857)	(-0.1622)
Average Maturity	-0.0037	-0.0039	-0.0037	-0.0038
	(-0.9821)	(-1.0508)	(-0.9390)	(-0.9819)
Lnsize	0.0083	0.0094	0.0178**	0.0186**
	(1.1266)	(1.2409)	(2.4025)	(2.4269)
Acid	-0.0076	-0.0073	0.0036	0.0038
	(-0.8594)	(-0.8482)	(0.3946)	(0.4212)
Leverage	-0.0406	-0.0385	0.0175	0.0185
	(-0.7440)	(-0.7136)	(0.3372)	(0.3602)
MB Ratio	-0.0028	-0.0028	-0.0012	-0.0012
	(-0.8698)	(-0.8780)	(-0.4654)	(-0.4767)
OI/Asset	-0.0976	-0.0978	-0.2286	-0.2296
	(-0.5751)	(-0.5795)	(-1.3291)	(-1.3393)
Tobin's Q	-0.0334**	-0.0331**	-0.0192	-0.0190
	(-2.2235)	(-2.2105)	(-1.4166)	(-1.4098)
Cash Coverage	0.0000	0.0000	-0.0000	-0.0000
	(0.9543)	(0.9523)	(-0.3146)	(-0.3170)
Constant	-0.2081	-0.2330	-0.4675***	-0.4856***
	(-1.3584)	(-1.4762)	(-2.9936)	(-2.9970)
Observations	2,876	2,876	2,876	2,876
R-squared	0.006	0.006	0.076	0.076
Year FE	NO	NO	YES	YES
Industry FE	NO	NO	YES	YES

Table C5 Regression of bank loan rate against environmental information disclosure - ISO14064 [34]

This table displays regression results between the bank loan rates and ISO14064. The dependent variable is Diff Rate, which is the current year's newly issued loan size weighted average loan rate minus the prior year's. ISO14064 equals one if the firm with ISO14064 certification in year t and set it to zero otherwise. Regression (3) includes industry and year fixed effects. All regressions include: Scope1&2, Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

Variables	(1) Diff Rate	(2) Diff Rate
ISO14064	-0.0496**	-0.0466**
	(-2.4048)	(-2.3315)
Scope1&2	0.0306**	0.0054
	(2.0248)	(0.3681)
Lnsize	0.0088	0.0187**
	(1.1940)	(2.5566)
Acid	-0.0079	0.0031
	(-0.8617)	(0.3290)
Leverage	-0.0446	0.0157
	(-0.8054)	(0.3018)
MB Ratio	-0.0028	-0.0012
	(-0.8721)	(-0.4744)
OI/Asset	-0.1080	-0.2382
	(-0.6295)	(-1.3772)
Tobin's Q	-0.0339**	-0.0198
	(-2.2063)	(-1.4203)
Cash Coverage	0.0000	-0.0000
	(0.9618)	(-0.2782)
Constant	-0.2191	-0.4888***
	(-1.4363)	(-3.1532)
Observations	2,876	2,876
R-squared	0.005	0.075
Year FE	NO	YES
Industry FE	NO	YES

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34 ISO14064 is a series of standard for Greenhouse Gas verification, it contains risk management, carbon measure, and development plan. See: https://www.bsigroup.com/zh-TW/ISO-14064-Greenhouse-Gas-Emissions/

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Table C6 Robustness tests – adding more control variables

This table displays regression results between bank loan rates and environmental information disclosure by adding more control variables. The Z-Score represents the Altman Z-Score (Altman, 1968), calculated as follows:

$$Z-Score = 1.2 \times \frac{working\ capital}{total\ assets} + 1.4 \times \frac{retained\ earnings}{total\ assets} + 3.3 \times \frac{EBIT}{total\ assets} + 0.6 \times \frac{market\ value}{total\ liabilities} + 0.99 \times \frac{Sales}{total\ assets}.$$

Growth refers to the sales growth rate in percentage. Interest Coverage represents the interest expense plus earnings before taxes over earnings before taxes. ROA stands for the income over total assets of the firm in percentage. CAPM Beta indicates the beta from the CAPM model of the firm for each year. Lnasset represents the logarithm of firm assets. Firm Age refers to the logarithm of the years firms have been public. The dependent variable is Diff Rate, which is the current year's newly issued loan size weighted average loan rate minus the prior year's. Scope3 equals one if the firm discloses scope 3 emissions in year t and set it to zero otherwise. Ln Scope3 Detail is the natural logarithm of one plus Scope3 Detail, where Scope3 Detail is defined as: a firm with a scope 3 emissions disclosure will obtain one; if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. Regressions (3) and (4) include industry and year fixed effects. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

	(1)	(2)	(3)	(4)
Variables	Diff Rate	Diff Rate	Diff Rate	Diff Rate
Scope3	-0.0805**		-0.0591**	
	(-2.5586)		(-2.0142)	
Ln Scope3 Detail		-0.0618**		-0.0430*
		(-2.5440)		(-1.9225)
Scope1&2	0.0206	0.0192	-0.0028	-0.0037
	(1.3867)	(1.2901)	(-0.1958)	(-0.2605)
Lnsize	-0.0090	-0.0076	0.0404*	0.0412*
	(-0.4119)	(-0.3460)	(1.7270)	(1.7564)
Acid	-0.0065	-0.0064	0.0060	0.0061
	(-0.7293)	(-0.7221)	(0.6308)	(0.6515)
Leverage	-0.1226*	-0.1186*	0.0298	0.0314
	(-1.7965)	(-1.7694)	(0.4455)	(0.4756)
MB Ratio	-0.0028	-0.0028	-0.0013	-0.0014
	(-0.8855)	(-0.8950)	(-0.5058)	(-0.5162)
OI/Asset	0.2211	0.2199	-0.0837	-0.0837
	(0.8532)	(0.8492)	(-0.3223)	(-0.3229)
Tobin's Q	-0.0194	-0.0196	-0.0295	-0.0295
	(-1.0552)	(-1.0580)	(-1.2603)	(-1.2593)
Cash Coverage	-0.0000	-0.0000	-0.0000	-0.0000
	(-0.3151)	(-0.2968)	(-1.1905)	(-1.1651)
Z-Score	-0.0068	-0.0062	-0.0062	-0.0060
	(-0.9746)	(-0.9108)	(-0.8862)	(-0.8606)
Growth	-0.0000***	-0.0000***	0.0000***	0.0000***
	(-3.4339)	(-3.4846)	(3.1991)	(3.1755)
Interest Coverage	0.0000	0.0000	0.0000	0.0000
	(1.1208)	(1.1142)	(0.7818)	(0.7673)
ROA	-0.0034**	-0.0035**	-0.0015	-0.0016
	(-2.0605)	(-2.1041)	(-0.9307)	(-0.9600)
CAPM Beta	0.0055	0.0051	0.0279	0.0269
	(0.2414)	(0.2262)	(1.0941)	(1.0557)

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Lnasset	0.0213	0.0210	-0.0266	-0.0267
	(1.0179)	(0.9988)	(-1.1702)	(-1.1738)
Firm Age	-0.0188*	-0.0189*	0.0010	0.0011
	(-1.8306)	(-1.8458)	(0.0976)	(0.1087)
Constant	-0.2224	-0.2483	-0.3725**	-0.3900**
	(-1.3923)	(-1.5073)	(-2.2754)	(-2.2880)
Observations	2,836	2,836	2,836	2,836
R-squared	0.007	0.008	0.078	0.078
Year FE	NO	NO	YES	YES
Industry FE	NO	NO	YES	YES

Table C7 Further tests of bank loan rate against environmental information disclosure

This table displays regression results between the bank loan rates and different types of environmental information disclosure. The dependent variable is Diff Rate, which is the current year's newly issued loan size weighted average loan rate minus the prior year's. Scope1&2&3 is set to one if the firm discloses emissions for scope 1, scope 2, and scope 3 in year t, and it is set to zero otherwise. Scope1&2 is set to one if the firms disclose emissions for scope 1 and 2 in that year, and it is set to zero otherwise. All regressions include industry and year fixed effects. All regressions also include: Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

	(1)	(2)	(3)	(4)
Variables	Diff Rate	Diff Rate	Diff Rate	Diff Rate
Subsample	Full Sample	Full Sample	Matched Sample	Matched Sample
Scope1&2&3		-0.0714**		-0.1413***
		(-2.4184)		(-2.8942)
Scope1&2	-0.0052		-0.1462**	
	(-0.3647)		(-2.2276)	
Lnsize	0.0141**	0.0178***	-0.0032	-0.0119
	(2.1211)	(2.7189)	(-0.1897)	(-0.7774)
Acid	0.0033	0.0033	-0.0459	-0.0536
	(0.3527)	(0.3584)	(-1.2204)	(-1.4965)
Leverage	0.0104	0.0125	-0.2481	-0.2980
	(0.2008)	(0.2421)	(-1.2572)	(-1.5750)
MB Ratio	-0.0010	-0.0011	0.0529	0.0572
	(-0.4020)	(-0.4616)	(0.8950)	(1.0202)
OI/Asset	-0.2246	-0.2296	-1.2439*	-1.3290*
	(-1.2998)	(-1.3371)	(-1.6600)	(-1.7974)
Tobin's Q	-0.0189	-0.0191	-0.0662	-0.0660
	(-1.4074)	(-1.4129)	(-0.7141)	(-0.7456)
Cash Coverage	-0.0000	-0.0000	0.0003	0.0003
	(-0.1339)	(-0.2552)	(0.4225)	(0.3300)
Constant	-0.3867***	-0.4699***	0.3339	0.4959
	(-2.7729)	(-3.3346)	(0.7937)	(1.2457)
Observations	2,876	2,876	430	430
R-squared	0.075	0.075	0.203	0.202
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

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Table C8 Robustness tests of the effect of GHG reduction and emissions control regulations

This table presents regression results of the influence of greenhouse gas reduction and emissions control regulations on firm bank loan rates, while also accounting for the delayed effects of these policies. The dependent variable is Diff Rate, which is the current year's newly issued loan size weighted average loan rate minus the prior year's. After2019 equals to one when the year is greater than 2019. Scope3 equals one if the firm with scope3 disclosure in year t and set it to zero otherwise. Ln Scope3 Detail is the natural logarithm of one plus Scope3 Detail, where Scope3 Detail is defined as: a firm with a scope 3 emissions disclosure will obtain one; if the firm also has scope 3 emissions detailed disclosure, we will add the number of categories of scope 3 emissions detailed disclosure starting from one. Regressions (3) and (4) include industry and year fixed effects. All regressions include: Scope1&2, Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

Variables	(1) Diff Rate	(2) Diff Rate	(3) Diff Rate	(4) Diff Rate
Scope3×After2019	-0.2028**		-0.2085**	
	(-2.2042)		(-2.2522)	
Scope3	-0.0156		-0.0115	
	(-0.5561)		(-0.4039)	
Ln Scope3 Detail×After2019		-0.1066*		-0.1130*
		(-1.8504)		(-1.9412)
Ln Scope3 Detail		-0.0187		-0.0121
		(-0.9424)		(-0.6181)
After2019	-0.2685***	-0.2728***		
	(-10.1051)	(-10.3334)		
Scope1&2	0.0074	0.0055	0.0006	-0.0012
	(0.5325)	(0.3980)	(0.0425)	(-0.0891)
Lnsize	0.0150**	0.0158**	0.0170**	0.0176**
	(2.1512)	(2.1995)	(2.3397)	(2.3479)
Acid	0.0012	0.0013	0.0037	0.0039
	(0.1404)	(0.1595)	(0.4144)	(0.4444)
Leverage	0.0028	0.0022	0.0158	0.0157
	(0.0528)	(0.0413)	(0.3095)	(0.3101)
MB Ratio	-0.0019	-0.0019	-0.0012	-0.0012
	(-0.6729)	(-0.6743)	(-0.4751)	(-0.4766)
OI/Asset	-0.1741	-0.1725	-0.2257	-0.2254
	(-1.0655)	(-1.0595)	(-1.3227)	(-1.3235)
Tobin's Q	-0.0222*	-0.0223*	-0.0186	-0.0189
	(-1.6885)	(-1.6799)	(-1.4129)	(-1.4149)
Cash Coverage	0.0000	0.0000	-0.0000	-0.0000
	(0.3861)	(0.3760)	(-0.2037)	(-0.2095)
Constant	-0.3437**	-0.3589**	-0.4534***	-0.4668***
	(-2.3632)	(-2.3938)	(-2.9647)	(-2.9481)
Observations	2,876	2,876	2,876	2,876
R-squared	0.056	0.056	0.077	0.077
Year FE	NO	NO	YES	YES
Industry FE	NO	NO	YES	YES

Table C9 Channel tests based on ISO14064

This table displays regression results of how ISO14064 affects TCRI Rank and CDP Score using the ordered probit model. TCRI Rank ranks from 1 to 9, and Default. The lower the rank, the lower the credit risk of the firm. CDP Score ranges from 0 to 10 and provides a a snapshot of a firm's disclosure and environmental performance. The higher the score, the more environmentally friendly the firm is. ISO14064 equals one if the firm with ISO14064 certification in year t and set it to zero otherwise. Regressions (2) and (4) include industry and year dummy. All regressions include: Scope1&2, Lnsize, Acid, Leverage, MB Ratio, OI/Asset, Tobin's Q, and Cash Coverage. Appendix A provides detailed variable definitions. We report t-statistics based on robust standard errors clustered at the firm level in parentheses. *** means 1% significance level. ** means 5% significance level. * means 10% significance level.

Variables	(1) TCRI Rank	(2) TCRI Rank	(3) CDP Score	(4) CDP Score
ISO14064	-0.3078***	-0.2836**	0.5114***	0.5266***
	(-2.7041)	(-2.3850)	(3.7473)	(3.6893)
Scope1&2	-0.1611**	-0.1593*	0.2832	0.3946*
	(-2.0121)	(-1.9015)	(1.2565)	(1.8355)
Lnsize	-0.6315***	-0.6972***	0.8042***	0.8838***
	(-14.5179)	(-14.9651)	(8.2930)	(6.8388)
Acid	-0.1161***	-0.0337	-0.1279	-0.3281**
	(-2.8617)	(-0.8940)	(-1.5055)	(-2.5633)
Leverage	1.8829***	2.0359***	0.4654	-0.1294
	(6.5646)	(6.7331)	(1.0542)	(-0.2557)
MB Ratio	0.0255***	0.0305***	-0.4689***	-0.5085***
	(3.1847)	(2.9450)	(-4.4767)	(-4.1047)
OI/Asset	-7.9070***	-8.2632***	1.5346	1.1069
	(-12.1870)	(-11.8900)	(1.1794)	(0.9734)
Tobin's Q	0.1328	0.1561	0.1674**	0.1140
	(1.5821)	(1.5947)	(2.4689)	(0.6054)
Cash Coverage	-0.0000	-0.0000***	-0.0000	-0.0000
	(-1.6272)	(-2.6291)	(-0.5025)	(-0.0438)
Observations	2,876	2,876	2,876	2,876
Pseudo R2	0.248	0.279	0.401	0.451
Year Dummy	NO	YES	NO	YES
Industry Dummy	NO	YES	NO	YES

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Che-Ming Chang   Jianqiang Chen   Pei-Fang Hsieh

企業環境資訊揭露能否降低銀行貸款成本：來自台灣證券交易所上市公司的證據

張哲明　陳堅強　謝佩芳[*]

銀行貸款機構對環境資訊揭露品質較高（以企業社會責任報告中碳排放揭露情況衡量）的企業收取的利率要低得多。我們發現，與未揭露範疇三排放的企業相比，揭露範疇三排放的企業的銀行貸款利率顯著降低 8.6 個基點。為了解決內生性問題，我們利用了台灣環保署 2018 年溫室氣體減量推動方案和溫室氣體排放管制行動方案的實施進行 DID 分析。結果一致表明，揭露範疇三排放的企業的銀行貸款成本較低。我們發現，透過揭露更多環境資訊的公司建立的較低銀行貸款利率可以降低其信用風險並提高 ESG 績效，特別是那些資訊不對稱程度和財務約束較低的公司。

關鍵詞：環境資訊揭露、銀行貸款、碳排放、範疇三排放。