

Climate Risks and Divestment: Evidence from Cross-Shareholdings*

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This study examines how firms' climate change risk affects cross-shareholder divestment. Using Japan as a laboratory, we explore how business networks and cross-shareholdings influence shareholders' responses to climate-related risks. Employing firm–shareholder matched data, we show that firms with high CO₂ intensity face divestment by business partners. This effect is more pronounced when shareholders have high ESG scores, hold significant ownership stakes, and operate in carbon-intensive industries. In contrast, the climate risk effect weakens when firms are stable, long-term suppliers with substantial market power and maintain reciprocal ownership ties with shareholders. We address endogeneity concerns using instrumental variables, matching methods, and fixed effects. Our findings suggest that shareholders incorporate climate risk of business partners into investment decisions, whereas inter-firm relationships constrain the full reallocation of capital. Overall, this study provides new evidence on how climate risk shapes capital allocation within corporate ownership networks, with important implications for international finance, particularly in markets characterized by relationship-based ownership structures.

Keywords: Climate change risk; Divestment; Cross-shareholding; Business networks; Capital allocation

JEL classification: G30, G32, G34, Q50, Q54

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1. Introduction

The climate-related risk of business partners is becoming an important issue when firms make investment/divestment decisions. After the establishment of the International Sustainability Standards Board (ISSB), firms are required to disclose their own greenhouse gas emissions as well as those of business partners in the supply chain. Firms holding other companies' shares are responsible for the greenhouse gas emissions of their business partners. An increasing number of firms disclose direct CO₂ emissions from their facilities (Scope 1) and indirect emissions from their energy use (Scope 2). However, the number of firms that disclose CO₂ emissions from material procurement and sales within their supply chain is limited because of the difficulty in calculation (Scope 3).

An increasing number of studies have investigated the impact of business partners' climate change risks on firms' own activities.¹ Suppliers' physical climate shocks are transmitted to customers in many ways: disruption of business transactions (Pankratz & Schiller, 2024), delayed payments, and increased default risks. An increase in climate risk within the supply chain decreases trade credit, terminates customer–supplier relationships (Liu et al., 2025), and changes global sourcing (Shu & Fan, 2024). The literature also shows that capital markets and creditors incorporate firms' climate risks as a major source of financial risk that affects institutional investors' portfolio decisions (Krueger et al., 2020) and capital allocation. Firms with high green gas emissions face difficulties in obtaining credit (Javadi et al., 2023) and bank loans (Shikimi, 2025) or pay higher costs of credit (Bolton & Kacperczyk, 2021; Ilhan et al., 2021; Javadi & Masum, 2021; Trinh et al., 2024).

While a growing literature examines how climate risks affect institutional investors' capital allocations, little is known about how firms react to their business partners climate riskiness through cross-shareholdings. This question is particularly important in economies where cross-shareholdings and stable business ties remain prevalent. Many companies hold their business partners' stock shares, forming a business group (Aguilera et al., 2025). Firms holding a large share of their business partners are exposed to the climate risks of their shares. If climate change shocks occur among business partners, they may be transmitted to holding companies. Firms may adjust their shares by anticipating the future risks of their partners. In contrast, cross-shareholding is an implicit long-term contract. Firms in cross-shareholding relationships can make

¹ See the extensive survey of the climate change risk management in supply chain (Ghadge et al., 2020)

decarbonization investments with a longer horizon because they are under less takeover threat and pursue long-term mutual profit maximization. They may not adjust their exposure to partners' climate risk through divestment in the short run. These relationship effects are expected to be profound when firms are indispensable suppliers or customers (Liu et al. 2025) or they are in reciprocal ownership relations. Understanding how climate risks influence divestment within relationship-based ownership structures provides important insights for international finance and markets where business networks and concentrated ownership are common.

This study focuses on the effect of firms' climate riskiness on their business partners divestment behavior through cross-shareholdings. In particular, we investigate three research questions. The first is whether climate riskiness firms experience divestment from their cross-shareholders (climate risk effects). Shareholders concern about climate riskiness of their investment portfolio. They adjust riskiness by reducing their exposure to climate risky firms by divestments (Azar et al., 2021). The second question is that the climate risk effects intensify according to shareholders' climate riskiness and ESG profile (Shareholders' risk effect). The third is that the climate risk effects weaken by the nature of firm-shareholder relationships, including supply-customer ties and reciprocal ownership relations (relationship effects).

To examine the effect of firms' climate risk on cross-shareholdings by their business partners, we use Japan as a laboratory. Japan is famous for its business groups and cross-shareholdings (Miyajima & Kuroki, 2007; Morck & Nakamura, 1999; Yafeh, 2000). Japanese-listed companies disclose the information of their top 30 shareholders, including their names and holdings. Among the top 30, we focus on corporate shareholders and examine the effect of their climate riskiness and ESG profiles on their investments in their business partners. Business groups are not unique to Japan; they are also found in many countries, including European and emerging economies such as China, India, Korea, Taiwan, Latin America, and the Middle East. Our findings have valuable implications for international finance, particularly in economies where cross-shareholding networks and relationship-based finance remain prevalent.

Using Japanese firm shareholder-matched data, we find that firms' climate riskiness affects the divestment behavior of cross-shareholders. We also find that divestment is more pronounced when shareholders are climate-risky, have high ESG scores, are major shareholders, and when both firms and shareholders operate in high greenhouse gas (GHG) emission ("brown") industries. The climate risk effect is moderated or reversed in cases where firms are stable, long-term suppliers with high market power or when firms and shareholders have cross-shareholding relationships. In these cases, shareholders tend to maintain their investments, reflecting long-term commitment. Shareholders in carbon-

intensive industries and with high ESG scores are more likely to terminate their cross-shareholding relationships when firms' climate risks increase. To address endogeneity concerns, instrumental variable approaches and matching analyses are employed, confirming the robustness of the main findings. Fixed effects at the firm-shareholder and industry-year levels help to control for omitted variable bias.

Our study makes several significant contributions to the existing literature. First, it enhances the expanding body of research on climate risk and capital allocation. While prior studies mainly focus on institutional investors' and banks' allocations of credit, we focus on how climate risk influences portfolio adjustments within corporate ownership networks through divestment behavior.

Second, this study advances research on the effect of investors' climate risk awareness on investees' climate performance. Research has identified the positive effects of institutional investors' ownership on firms' ESG performance (Dyck et al., 2019) and climate risk disclosure (Ilhan et al., 2023). Azar et al. (2021) found that large institutional investors positively influence CO₂ emissions reductions in portfolio firms. Conversely, Böhm et al. (2025) found that environmentally conscious bank shareholders do not affect banks' lending to climate-risky firms or reduce emissions levels. We provide further evidence that cross-shareholdings within business networks are significant for corporate climate performance.

Third, this study engages with the literature on shareholders' investment horizons and decarbonization. Studies have indicated that long-term investors and those with higher ESG portfolio shares exhibit greater concern about climate risks than short-term investors (Krueger et al., 2020). Family firms emit less carbon than non-family firms because of long-term ESG investments over a long-term horizon (Borsuk et al., 2024). Firms owned by nonprofit foundations show superior ESG performance. Firms owned by nonprofit foundations show superior ESG performance compared to those with non-foundation ownership (Schröder & Thomsen, 2025). These studies suggest that decarbonization investments are long-term, and firms under less takeover pressure engage more in such investments. Research has found that insiders with long-term contracts exhibit better CSR performance (Shackleton et al., 2025). Our study focuses on cross-shareholders because of their long-term relationship.

Fourth, our research contributes to the literature on climate-related downside risk management in inter-firm relationships. Research has shown that downstream firms with greater bargaining power pressure upstream firms to reduce CO₂ emissions (Deng et al., 2025). We demonstrate that stable supplier–customer relationships weaken the effect of firms' climate risk on investors' divestment, depending on the indispensability of business partners and mutual shareholdings.

2. Data and Methodology

We use Japanese firm-shareholder data from the Quick Astra Manager database for this analysis. It contains the names of the top 30 shareholders and their holdings for listed firms. There is variation in the type of owners, such as financial institutions, industrial firms, the government, foreign companies, and individuals. The most common shareholders are firms (industrial firms), followed by trust banks, individuals, and other banks (Appendix Table A1). Industrial firms comprise 29.9% of the top 30. Their average shareholding ratio is 6.22%. We restrict our sample to corporate shareholders because our research question is whether shareholders' awareness of climate change risks affects their investment behavior toward their business partners.² Our sample represents one-third of Japanese firm owners' behavior; however, their effect is relatively large compared to other shareholders because of their large shareholding ratio. After excluding erroneous data and missing values, we match firm-shareholder data with firms' financial and CO₂ emission data. Corporate shareholders without financial data, CO₂ emission data, and foreign corporate shareholders are excluded. We obtain firm financial data from the Quick Astra Manager database and firms' CO₂ emissions data from the Japanese Ministry of Environment. Our sample consists of firms listed on the Japanese stock markets from fiscal years 2007 to 2023 because CO₂ emissions data are available after 2006. We exclude the financial industry from our analysis. After excluding erroneous data, our total sample consists of 19,985 firm-shareholder-year observations.

2.1 Climate-risk variables

Firms' climate risk is measured by $\ln(\text{CO}_2 \text{ emissions})$ and $\ln(\text{CO}_2 \text{ intensity})$. CO₂ intensity is defined as CO₂ emissions per sales (Bolton & Kacperczyk, 2021). The former variable captures firms' total emissions. Larger firms are more likely to emit more than smaller firms. To eliminate the firm size effect, we use $\ln(\text{CO}_2 \text{ intensity})$.³ We obtain firms' CO₂ emissions data from the Japanese Ministry of Environment. Firms with

² We exclude government and public organization, financial product dealers, foreign corporations, and individual owners.

³ We use $\ln(\text{CO}_2 \text{ intensity})$ because it is more resilient to outliers.

substantial greenhouse gas (GHG) emissions must report them to the government annually. Based on the amended law concerning the promotion of measures against global warming (the Global Warming Prevention Law), from April 1, 2006, entities that emit large amounts of GHG (specified emitters) are required to calculate and report their GHG emissions to the government. The GHG categories include CO₂ emitted from the use of fuel or the use of electricity or heat supplied by others and other non-energy-origin carbon dioxide stemming from coal, crude oil, and natural gas production, waste incineration, and industrial wastewater treatment. These categories cover Scope1 and Scope2 emissions. We test whether corporate shareholders are sensitive to their business partners' GHG emissions (Scope 3). We assume that the GHG emissions of business partners are equal to their Scope1 and Scope2 emissions.

2.2 Shareholders' ESG profile

We use firms' ESG scores and the sub-component scores of the environment. In Japan, the disclosure of corporate sustainability information was not mandatory until 2023. We obtain the ESG score and its sub-component information from the S&P ESG score database⁴. Owing to data availability, the analysis of the ESG profile is limited to 2014–2023.

2.3 Firm characteristics

Firms' cross-shareholding ratios are affected by their own demand and their business partners' supply effects. To control for firm demand, we include $\ln(\text{total assets})$, $\ln(1 + \text{firm age})$, ROA, cash plus securities/total assets, debt/total assets, and Tobin's q . Accounts receivable-to-sales and accounts receivable-to-sales are included to control for firms' dependence on trade credit. We also include the ownership structure variables of shareholders, including shares held by banks and foreigners, to control for agency cost problems.

2.4 Firms' shareholders (business partners) characteristics

Shareholders' investment behavior may be driven by agency cost motives and other factors rather than by ESG concerns. On the one hand, firms with high cash flows are more likely to invest in related firms. In contrast, prior studies have shown that financially weak firms dissolve their cross-shareholdings (Miyajima and Kuroki, 2007). To control for the shareholders' supply effect, we use the same measures of firm

⁴ Refinitive database also contains information on firms' ESG score. ESG information is available from 2002 but the number of firms with those information is limited to about 475 in 2021.

characteristics for shareholders.

2.5 Summary statistics

Panel A of Table 1 presents the summary statistics of the variables used in the analysis, all of which are winsorized at the 1% level. Appendix Table A2 presents the definitions of the variables. The average shareholding ratio by business partners is 8.2%. Shareholders are larger, more profitable, and more leveraged than firms. Their CO2 intensity is also higher. Panel B shows the shareholders' structure. The total shares held by corporate shareholders among the top 30 are relatively high. Almost one-fifth are held by corporations, ranging from 0.1% to 97% of total shares. The average number of shareholding relationships is 4.4. The top 1 corporate shareholder holds 13.23% of the company's shares, on average. These statistics show that business relationships are relatively concentrated. Panel C presents the industry distribution of the sample.⁵ Firms in the manufacturing industry comprise 71.6% of the total sample. Approximately 61.1% of shareholders are also in manufacturing industries. The ratio of firms that belong to the same industry as the shareholders is 30%.

2.6 Methodology

To investigate the effect of firms' climate riskiness and shareholders' climate riskiness or ESG profile on shareholders' divestment behavior, we employ the following estimation model:

$$\Delta Share_{i,j,t} = \alpha_1 Risk_{i,t-1} + \alpha_2 Risk_{j,t-1} + \alpha_3 Risk_{i,t-1} \times Risk_{j,t-1} + \alpha_4 Firm_{i,t-1} + \alpha_5 Shareholder_{j,t-1} + \gamma X_{i,j,t-1} + \mu_i + \pi_j + \varphi_{i,j} + Industry_{i,t} + \varepsilon_{i,j,t},$$

(1)

where $\Delta Share_{i,j,t}$ denotes the growth of the share of firm i held by shareholder j in year t . $Risk_{i,t-1}$ is firms' climate risks, while $Risk_{j,t-1}$ is firm shareholders' climate riskiness or ESG profiles. $Firm_{i,t-1}$ are the firms' control variables. $Shareholder_{j,t-1}$ denotes the shareholders' control variables. $X_{i,j,t-1}$ signifies the other control variable, including shares of firm i held by shareholder j in the previous year to account for adjustment. μ_i, π_j , and $\varphi_{i,j}$ is firm, shareholder, and firm-shareholder fixed effect, respectively to be included to mitigate omitted variable bias. $Industry_{i,t}$ is industry-year fixed effect to control for time-varying industry conditions including

⁵ Appendix Table A3 presents the detailed industry distribution of the sample.

industry demand.

We expect $\alpha_1 < 0$ when climate-risky firms experience divestment (climate risk effects). α_2 captures the effect of shareholding firms' own climate riskiness on their divestment behavior from other business partners. The main focus is on α_3 , which captures the heterogeneous effect of climate risks according to investors' climate riskiness or their compliance with their ESG policies. If they do so, the expected sign of α_3 is negative because they are reluctant to retain climate-risky business partners' shares (shareholders' risk effects).

Furthermore, we investigate whether the climate risk effects weaken according to firm-shareholder relationships, such as supply-customer and reciprocal ownership relations (relationship effects). To empirically assess the relationship effects, we estimate the following model:

$$\begin{aligned} \Delta Share_{i,j,t} = & \beta_1 Risk_{i,t-1} + \beta_2 Risk_{j,t-1} + \beta_3 Risk_{i,t-1} \times Relation_{i,j,t-1} + \beta_4 Firm_{i,t-1} \\ & + \beta_5 Shareholder_{j,t-1} + \gamma X_{i,j,t-1} + \mu_i + \pi_j + Industry_{i,t} + \varepsilon_{i,j,t}, \end{aligned} \quad (2)$$

where $Relation_{i,j,t-1}$ equals one when firm i is suppliers (customers) of shareholder j . We expect β_3 is positive if firms are indispensable suppliers (customers) of shareholders.

3. Results

3.1 Basic results of climate risk effects

First, we investigate whether shareholding firms disinvest in firms with high CO₂ intensity. Table 2 shows the results. We first examine shareholders' divestment decisions using a logit model. The dependent variable in Model 1 is a dummy that takes a value of one if the growth of the share of firm i held by shareholder j is negative and zero otherwise. The explanatory variables are one-year lagged values to avoid simultaneity. We include industry-year fixed effects to control for time-varying industrial effects arising from decarbonization demand and pressure. High-climate-risk firms experience divestment from their business partners. The coefficient of CO₂ intensity is positive and significant at the 1% level. The coefficient on shareholders' CO₂ intensity is also positive and significant ($p < 0.05$), suggesting that shareholders with high CO₂ intensity divest. In

Models 2–3, we replace the dependent variable with the growth of the share of firm i held by shareholder j in year t . We estimate the models using OLS. We include firm-shareholder fixed effects to control for time-invariant unobservable firm-shareholder effects, such as stable business relationships, in addition to industry-year fixed effects.⁶ As expected, the CO₂ intensity in Model 2 is significantly negative at the 5% level, indicating that climate-risky firms experience divestment from other firms. A 10% increase in CO₂ intensity decreases the growth of the shareholding ratio by approximately 1.6 percentage points. Shareholders' CO₂ intensity is also significantly negative ($p < 0.1$). In addition to climate riskiness, firms with high debt ratios experience a decrease in investments from their cross-shareholders. Larger firms show an increase in shareholdings by their business partners. Regarding firms' ownership structures, firms with large bank ownership shares experience divestment. Regarding shareholder characteristics, larger and high-leverage firms decrease their investments.

Next, we explore whether shareholders' attitudes toward firms with high CO₂ intensity differ depending on their own climate riskiness. We include the interaction terms of firms' CO₂ intensity and shareholders' CO₂ intensity in Model 3. The result is negative but insignificant. Firms' CO₂ intensity and shareholders' one are still significant.

3.2 Shareholders' ESG policy

Previous studies indicate that investors' ESG awareness affects their investment decisions and firms' climate riskiness (Azar et al., 2021; Hoepner et al., 2024; Houston & Shan, 2022). We examined whether ESG-conscious shareholders disinvest more in climate-risky firms than ESG-unconscious shareholders do. We replace shareholders' CO₂ intensity with shareholders' ESG and environmental scores. The sample firms are limited to those with these scores. The results are presented in Table 3. Climate-risk firms experience divestment when their shareholders' ESG scores or environmental scores are high. As expected, the interaction term was negative and highly significant. These results indicate that ESG-conscious shareholders are more cautious about their investments in business partners.

⁶ Firm-fixed effects and shareholder fixed effects are absorbed in firm-shareholder fixed effects.

3.3 Heterogeneity by industry

Industries with high GHG emissions are more likely to be affected by regulatory changes in climate policy. Therefore, the effect of firms' climate riskiness on shareholders' divestment behavior is expected to be more profound in high GHG-emitting industries. We split the sample into two groups: industries with GHG emission levels above the median and those below it. The results are presented in Table 4. The effect of CO₂ intensity on the growth of shareholdings is found in high-GHG-emission industries in Panel A. Climate-risky firms in brown industries experience divestment from climate-risky shareholders. The interaction term of firms CO₂ intensity and that of shareholders is negatively significant ($p < 0.1$) in Model 1. We find similar results when we divide the sample by shareholders' industries climate riskiness in Models 3 and 4. Panel B splits the sample by the combination of firm and shareholder industry GHG emission levels. As expected, the results are confirmed among brown-brown industries, suggesting that shareholders in brown industries are under higher pressure to reduce their exposure to climate-risky firms.

3.4 Large shareholders vs. small shareholders

Shareholders' with large stakes could be incentivized to reduce their exposure to climate-risky firms. We test whether the divestment behavior of shareholders differs depending on whether they are the top1 shareholder. The results of Models 1 and 2 in Table 5 indicate that the top 1 shareholder is more concerned about their business partners' climate risk than other shareholders. Other non-top 1 shareholders disinvest when their climate risk is high, indicating that top1 shareholders concern their business partners' climate riskiness whereas the divestment behavior of non-top 1 shareholders is determined by their own climate riskiness. Models 3 and 4 compare large and small shareholders. We define large (small) shareholders as those with a shareholding ratio above (below) the annual median. We confirm the results obtained in Model 1. Furthermore, the negative effect of firms' climate riskiness is larger when shareholders' climate riskiness increases (Model 3: $p < 0.1$), indicating that they have less room to add more risk from their business partners.

4. Relationship effects

4.1 Supplier-customer relationships

Previous studies argue that large customers are more concerned about the climate riskiness of their suppliers because of their reputation in the market and contribute to lower GHG emissions of their suppliers. (Deng et al., 2025). We test whether shareholder divestment behavior is more profound when target firms are major suppliers. We obtain supplier information from annual reports. To mitigate endogeneity bias, we measure supplier relationships prior to the sample period. The results are presented in Table 6. Contrary to expectations, the effect of firms' climate riskiness is mitigated when they are shareholders' suppliers. The interaction terms of firms' CO₂ intensity and supplier dummy in Model 1 are positive ($p < 0.1$), indicating that shareholders may have a longer horizon in decarbonization policy when target firms are their long-term, stable suppliers. Shareholders are expected to maintain current supply-customer relationships when they face difficulties in finding alternative suppliers. To explore this possibility, we divided the sample by suppliers' market share. Following Deng et al. (2025), we measure the suppliers' market share by the ratio of firms' sales to total sales of all firms in the same industry. Firms with market shares above the annual industry median are categorized as having high market shares. As expected, the effect of firms' climate riskiness is mitigated when suppliers have more market power (Model 3, $p < 0.05$). These results indicate that shareholders (customers) value a long-term relationship with their suppliers, even if they are climate risky, because the switching costs are relatively high. We find similar results when we include the customer dummy variable.

4.3 Reciprocal ownership relationships

Firms hold shares with business partners to guard themselves against hostile takeovers and pursue long-term mutual benefits. Shareholders with reciprocal ownership relationships with target firms may not disinvest in them in the short term. Although most firms are in cross-shareholding relationships, we define firms as being in a reciprocal ownership relationship when their shareholders list the target firm's name as one of their top 30 shareholders. We include the interaction terms of the reciprocal ownership dummy and firms' CO₂ intensity. The results in Model 1 of Table 7 show that the effect of firms' climate riskiness is reversed when they have reciprocal ownership relationships. The interaction term of firms' CO₂ intensity and reciprocal ownership is positive and significant ($p < 0.01$). Climate-risky shareholders invest more when they are in reciprocal ownership relationships. The interaction term of shareholders' CO₂ intensity and reciprocal ownership is positively significant ($p < 0.01$, Model 2). However, the effect of reciprocal ownership is reversed when shareholders' environmental scores are high in Model 4, suggesting that they are concerned about their market reputation and committed

to taking on social responsibility.

5. Robustness

5.1 Termination of relationships

Previous studies have found that climate change uncertainty affects customer–supplier relationships (Liu et al. 2025). In this regard, we examine whether firms dissolve their cross-shareholding relationships when their business partners’ climate risk deteriorates. We regress the relationship termination variable on the change in firms’ CO₂ intensity, a proxy for the deterioration of climate riskiness, and other control variables. Deterioration in CO₂ intensity is a value of one if the growth in CO₂ intensity is positive and zero otherwise. We measure deterioration for one year as the shortest and five years as the longest to capture the possibility that shareholders take a long-term evaluation of firms’ climate risk evolution. To measure relationship termination, we use a dummy variable that takes a value of one when firms no longer list the business partners’ names among the top 30 shareholders and zero otherwise.

Table 8 shows the results. Shareholders terminate relationships when firms’ CO₂ intensity deteriorates in the last year. The coefficient on Deteriorate, t-2 to t-1, is positive and significant ($p < 0.05$, Model 1). This result is confirmed for high-GHG industries but not for low-GHG industries (Models 2 and 3). When we split the sample by shareholders’ industries, shareholders in high-GHG industries are sensitive to firms’ deterioration of climate riskiness, but those in low-GHG industries are not (Models 4 and 5). These results are consistent with those in Table 4, which shows that shareholders in CO₂-heavy industries disinvest in high emitters. We also find that shareholders are more likely to terminate relationships when their suppliers or customers show a deterioration in climate risk in the long run (Models 6 and 7). The marginal effect of the deterioration of suppliers’ climate riskiness for the last five years is 2.3 percentage points, whereas that for the last one year is 1.4 percentage points. The results indicate that shareholders are less likely to terminate their business relationships in accordance with the deterioration of their partners’ climate risks in the short run in customer–supplier relationships, supporting the results in Table 5. Finally, we consider shareholders’ ESG awareness. Shareholders with ESG profiles terminate their relationships with firms; the effect is slightly larger for shareholders with ESG scores above the median. In summary, we find a significant effect of the deterioration of climate risks on firm–shareholder relationships.

5.2 Endogeneity

This subsection investigates the potential endogeneity between CO₂ intensity

and shareholdings. For example, firms with larger investments from shareholders may make GHG emission-reducing investments, leading to reverse causality. An instrumental variable method was used to mitigate this possible endogeneity bias. We used the two-digit industry mean and standard deviation of firm CO₂ intensity (shareholders' CO₂ intensity), excluding relevant firms (shareholders), as instruments. The results in Table 9 align with those in Table 2. We also conducted an entropy balancing matching analysis with treatment and control groups based on CO₂ intensity levels and similar characteristics (Table 3). Table 10 reveals that climate-risky firms experienced a decrease in investments by their shareholders in Model (1), yielding a robust finding. We also find that shareholders with high CO₂ intensity invest less in firms ($p < 0.05$, Model 2), which is aligned with the results in Table 2.

To address the omitted variable bias, firm-shareholder fixed effects and industry-year fixed effects are incorporated, yielding robust findings.

5.3 The effect of shareholders' divestment on firms' future performance

This subsection examines whether shareholders' divestment behavior impacts firms' financial and climate performances. Firms' future performance is regressed on the predicted average growth of the shareholding ratio obtained from Model 2 in Table 2. The results in Table 11 show that shareholders' divestment has a positive effect on leverage in the following year and cash holdings in the following two years, implying that firms face difficulties in market financing and accumulate internal funds, whereas it does not have a significant effect on financial performance, ROA, or q . It also has a significantly negative impact on firms' market share and climate performance, suggesting that firms that experience divestment from their shareholders on average lose market share in the industry in the following year and curb the growth of total CO₂ emissions in the long run.

6. Conclusion

Controlling CO₂ emissions in firms' own businesses and supply chains is a significant challenge for businesses. Recent literature shows that investors and creditors incorporate firms' climate risks as a major source of financial risk that affects portfolio management and capital allocation (Krueger et al., 2020). This study focuses on firms' cross-shareholdings because, in many cases, firms invest in their business partners. We examine how climate risk affects investor divestment within cross-shareholding networks. We find that firms with high CO₂ intensity experience divestment by their business partners. Shareholders' divestment behavior toward climate-risky firms is more profound when shareholders' own climate riskiness is higher, they are large shareholders, they have higher ESG scores, and both firms and shareholders are in high GHG emitter industries.

The effect of firms' climate riskiness is reversed when firms are shareholders' suppliers with high market power and are in cross-shareholding relationships. These results indicate that shareholders with cross-shareholding relationships and indispensable suppliers are incentivized to pursue long-term mutual benefits and take a long stance in the decarbonization of business partners.

Overall, the results highlight the importance of considering the nature and structure of inter-firm relationships when designing policies and strategies aimed at achieving a net-zero society. While shareholders actively incorporate climate risk considerations into their investment decisions, their responses are nuanced by the complexity of business ties, emphasizing the need for tailored approaches to climate risk management within corporate networks.

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Table 1 Summary statistics

Panel A. Summary statistics of variables				
	Mean	Std. dev.	Min	Max
Shareholding ratio $i_{j,t-1}$ (%)	8.197	14.216	0.05	83.24
Growth of shareholding ratio $i_{j,t-1}$	0.003	0.298	-3.68	3.83
Termination	0.144	0.351	0	1
Termination after three years	0.243	0.429	0	1
<i>Firms' climate risk variables</i>				
ln (CO2 intensity)	-0.666	1.384	-6.664	5.721
CO2 intensity	1.224	2.479	0.006	36.088
ln (CO2)	10.276	1.549	4.111	18.365
Deteriorate	0.401	0.49	0	1
<i>Shareholder' climate risk variables</i>				
Shareholder's ln (CO2 intensity)	-1.351	2.086	-6.575	4.924
Shareholder's CO2 intensity	1.628	4.111	0.006	36.088
Shareholder's ln (CO2)	11.477	2.181	6.931	18.365
Shareholder's ESG score	40.636	24.661	0	90
Shareholder's environment score	47.239	28.056	0	98
<i>Firm characteristics</i>				
ln (firm total asset)	11.132	1.29	6.917	16.992
ln (1+firm age)	4.205	0.383	1.386	4.92
Tangible fixed assets/assets	0.305	0.168	0	0.935
Firm's ROA	4.319	3.982	-38.36	34.988
Firm's q	1.052	0.44	0.352	8.475
Firm's cash to asset ratio	0.109	0.091	0	0.805
Firm's debt to asset ratio	0.487	0.187	0.039	1.82
Bank ownership share	0.213	0.115	0	0.498
Foreigners' ownership share	0.1	0.1	0	0.54
<i>Shareholders' characteristics</i>				
ln (firm total asset)	13.223	1.733	7.886	16.992
ln (1+firm age)	4.307	0.324	1.099	4.963
ROA	4.966	3.847	-15.43	34.988
q	1.292	0.604	0.402	11.231
Cash to asset ratio	0.099	0.087	0	0.705
Debt to asset ratio	0.53	0.198	0.035	0.984
Bank ownership share	0.316	0.103	0.001	0.498
Foreigners' ownership share	0.218	0.119	0	0.549

Table 1 Summary statistics (Continued)

Panel B. Summary statistics of corporate shareholders' structure				
	Mean	Std. dev.	Min	Max
Total shares held by corporations (%)	19.47	16.76	0.1	97.43
Number of corporate shareholders	4.38	2.761	1	17
Shares held by Top1 corporate shareholders	13.23	14.48	0.06	97.43
Panel C. Industry distribution				
	Firms		Shareholders	
Manufacturing	71.59%		61.07%	
Non-manufacturing	28.44%		38.93%	
The ratio of firms that belong to the same industry with shareholders		30.00%		

This table shows the summary statistics. Panel A presents the summary statistics of the variables used in the regression analysis. The sample consists of 19,985 firm-shareholder-year observations. Panel B shows the summary statistics of the corporate shareholders' structure. Panel C presents the industry distribution.

Table 2. Climate change risks and divestment from business partners

	(1)	(2)	(3)
	Decrease	Growth of firm <i>i</i> 's shares held by shareholder <i>j</i>	
ln (CO ₂ intensity)	0.122*** (0.027)	-0.016** (0.007)	-0.017** (0.008)
Shareholder's ln (CO ₂ intensity)	0.035** (0.015)	-0.010* (0.006)	-0.010* (0.006)
ln (CO ₂ intensity) × Shareholder's ln (CO ₂ intensity)			-0.001 (0.002)
Shareholding ratio _{<i>ij,t-1</i>}	0.005** (0.002)	-0.030*** (0.001)	-0.030*** (0.001)
Bank ownership share	-0.138 (0.322)	-0.383*** (0.082)	-0.382*** (0.082)
Foreigners' ownership share	0.357 (0.401)	0.080 (0.074)	0.080 (0.074)
ln (total asset)	-0.021 (0.032)	0.069*** (0.019)	0.069*** (0.019)
ROA	0.010 (0.008)	-0.002** (0.001)	-0.002** (0.001)
<i>q</i>	0.364*** (0.062)	-0.008 (0.010)	-0.008 (0.010)
Cash to asset ratio	-0.225 (0.362)	-0.048 (0.053)	-0.048 (0.053)
Debt to asset ratio	1.326*** (0.187)	-0.155*** (0.043)	-0.155*** (0.043)
Shareholder's bank ownership share	-0.083 (0.331)	0.102 (0.087)	0.101 (0.087)
Shareholder's foreigners' ownership share	0.126 (0.332)	0.025 (0.066)	0.025 (0.066)
Shareholder's ln (total asset)	0.072*** (0.025)	-0.045** (0.020)	-0.045** (0.020)
Shareholder's ROA	-0.025*** (0.009)	0.001 (0.001)	0.001 (0.001)
Shareholder's <i>q</i>	0.041 (0.060)	-0.003 (0.008)	-0.003 (0.008)
Shareholder's cash to asset ratio	0.194 (0.375)	-0.048 (0.055)	-0.048 (0.055)
Shareholder's debt to asset ratio	-0.233 (0.188)	-0.085* (0.045)	-0.085* (0.045)

Table 2. Climate change risks and divestment from business partners
(Continued)

	(1)	(2)	(3)
	Decrease	Growth of firm <i>i</i> 's shares held by shareholder <i>j</i>	
Industry-year fixed effect	Yes	Yes	Yes
Firm-shareholder fixed effect	No	Yes	Yes
Number of observations	17819	19985	19985
Log-likelihood	-4970.7381		
Pseudo R2	0.08		
R-squared		0.084	0.084

The dependent variable in Model (1) takes a value of one if the growth of the share of firm *i* held by shareholder *j* is negative, and zero otherwise. The dependent variables in Models (2) to (3) are the growth of the share of firm *i* held by shareholder *j* in year *t*. Standard errors are enclosed in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01

Table 3. Shareholders' ESG profile and divestment

	(1)	(2)
ln (CO2 intensity)	0.014 (0.017)	0.015 (0.017)
Shareholder's ESG score	0.000 (0.000)	
ln (CO2 intensity) $\times$ Shareholder's ESG score	-0.000** (0.000)	
Shareholder's environment score		-0.000 (0.000)
ln (CO2 intensity) $\times$ Shareholder's environment score		-0.000** (0.000)
Shareholding ratio $_{i,j,t-1}$	-0.027*** (0.002)	-0.027*** (0.002)
Firms' characteristics	Yes	Yes
Shareholders' characteristics	Yes	Yes
Industry-year fixed effect	Yes	Yes
Firm-shareholder fixed effect	Yes	Yes
Number of observations	8843	8843
R-squared	0.089	0.089

The dependent variable is the growth of the share of firm i held by shareholder j in year t . Standard errors are enclosed in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01

Table 4. Heterogeneity by industry

Panel A				
	(1)	(2)	(3)	(4)
	GHG emission of firms' industry		GHG emission of shareholders' industry	
	High GHG	Low GHG	High GHG	Low GHG
ln (CO ₂ intensity)	-0.029*** (0.011)	-0.015 (0.015)	-0.024** (0.011)	0.004 (0.017)
Shareholder's ln (CO ₂ intensity)	-0.013 (0.009)	-0.001 (0.013)	-0.012 (0.009)	0.005 (0.013)
ln (CO ₂ intensity) × Shareholder's ln (CO ₂ intensity)	-0.006* (0.003)	0.001 (0.004)	-0.009** (0.004)	0.005 (0.004)
Firms' characteristics	Yes	Yes	Yes	Yes
Shareholders' characteristics	Yes	Yes	Yes	Yes
Industry-year fixed effect	Yes	Yes	Yes	Yes
Firm-shareholder fixed effect	Yes	Yes	Yes	Yes
Number of observations	13885	5943	11591	8297
R-squared	0.101	0.224	0.125	0.158
Panel B				
	(1)	(2)	(3)	(4)
	GHG emission of firms' industry is high		GHG emission of firms' industry is low	
	GHG emission of shareholders' industry is high	GHG emission of shareholders' industry is low	GHG emission of shareholders' industry is high	GHG emission of shareholders' industry is low
ln (CO ₂ intensity)	-0.030** (0.014)	0.000 (0.023)	-0.012 (0.019)	-0.008 (0.028)
Shareholder's ln (CO ₂ intensity)	-0.011 (0.012)	0.001 (0.017)	-0.018 (0.018)	0.004 (0.022)
ln (CO ₂ intensity) × Shareholder's ln (CO ₂ intensity)	-0.014*** (0.005)	0.005 (0.006)	-0.003 (0.007)	0.005 (0.007)

Table 4. Heterogeneity by industry (Continued)

Panel B

	(1) GHG emission of firms' industry is high	(2) GHG emission of firms' industry is low	(3) GHG emission of firms' industry is high	(4) GHG emission of firms' industry is low
	GHG emission of shareholders' industry is high	GHG emission of shareholders' industry is low	GHG emission of shareholders' industry is high	GHG emission of shareholders' industry is low
Firms' characteristics	Yes	Yes	Yes	Yes
Shareholders' characteristics	Yes	Yes	Yes	Yes
Industry-year fixed effect	Yes	Yes	Yes	Yes
Firm-shareholder fixed effect	Yes	Yes	Yes	Yes
Number of observations	8639	5182	2861	3050
R-squared	0.117	0.135	0.266	0.256

The dependent variable is the growth of the share of firm i held by shareholder j in year t . High (Low) GHG refers to industries with GHG emission levels above (below) the industry median. Standard errors are enclosed in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5. Shareholder structures

	(1)	(2)	(3)	(4)
	Top1	Others	Large shareholder	Small shareholder
ln (CO ₂ intensity)	-0.117*** (0.043)	-0.007 (0.007)	-0.040** (0.017)	-0.003 (0.004)
Shareholder's ln (CO ₂ intensity)	0.008 (0.038)	-0.013** (0.006)	-0.016 (0.014)	0.003 (0.004)
ln (CO ₂ intensity) × Shareholder's ln (CO ₂ intensity)	-0.011 (0.010)	-0.003 (0.002)	-0.009* (0.004)	0.001 (0.001)
Firms' characteristics	Yes	Yes	Yes	Yes
Shareholders' characteristics	Yes	Yes	Yes	Yes
Industry-year fixed effect	Yes	Yes	Yes	Yes
Firm-shareholder fixed effect	Yes	Yes	Yes	Yes
Number of observations	3676	16309	9978	10007
R-squared	0.302	0.204	0.151	0.207

The dependent variable is the growth of the share of firm i held by shareholder j in year t .

Top 1 in Model (1) is the top1 shareholder, whereas the others in Model (2) are non-top1 shareholders. A large (small) shareholder is one with a shareholding ratio above (below) the annual median. Standard errors are enclosed in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01

Table 6. Supply chain relationships

	(1)	(2)	(3)	(4)
	Total	Total	Firms with high market share	Firms with low market share
ln (CO2 intensity)	-0.016** (0.007)	-0.016** (0.007)	-0.025*** (0.009)	0.022 (0.019)
ln (CO2 intensity)×Suppliers	0.007* (0.004)	0.007* (0.004)	0.010** (0.005)	-0.007 (0.012)
Shareholder's ln (CO2 intensity)	-0.002 (0.001)	-0.003* (0.002)	-0.005** (0.002)	0.002 (0.003)
Shareholder's ln (CO2 intensity)×Suppliers		0.003 (0.003)	0.004 (0.003)	-0.001 (0.005)
Firms' characteristics	Yes	Yes	Yes	Yes
Shareholders' characteristics	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Industry-year fixed effect	Yes	Yes	Yes	Yes
Number of observations	19890	19890	14580	5272
R-squared	0.115	0.115	0.127	0.170

The dependent variable is the growth of the share of firm i held by shareholder j in year t . Suppliers take a value of one when firms are suppliers of shareholders. Models 3 (4) pertain to firms with market power above (below) the industry median. Standard errors are enclosed in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7. Reciprocal ownership

	(1)	(2)	(3)	(4)
ln (CO2 intensity)	-0.017** (0.007)	-0.018** (0.007)	-0.015** (0.007)	-0.004 (0.013)
Reciprocal ownership	0.128*** (0.035)	0.160*** (0.039)	0.160*** (0.040)	0.354*** (0.119)
ln (CO2 intensity) × Reciprocal ownership	0.049*** (0.019)	0.051*** (0.019)	0.052** (0.021)	0.156** (0.064)
Shareholder's ln (CO2 intensity)	-0.004 (0.006)	-0.004 (0.006)	-0.003 (0.006)	
Shareholder's ln (CO2 intensity)×Reciprocal ownership		0.052** (0.026)	0.051* (0.027)	
ln (CO2 intensity) × Shareholder's ln (CO2 intensity)×Reciprocal ownership			-0.000 (0.010)	
Shareholder's Environment score				0.000 (0.000)
Shareholder's Environment score× Reciprocal ownership				-0.004** (0.002)
Firms' characteristics	Yes	Yes	Yes	Yes
Shareholders' characteristics	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Shareholder fixed effect	Yes	Yes	Yes	Yes
Industry-year fixed effect	Yes	Yes	Yes	Yes
Number of observations	19796	19796	19796	8731
R-squared	0.154	0.154	0.154	0.213

The dependent variable is the growth of the share of firm i held by shareholder j in year t . Reciprocal ownership takes a value of one when firms and shareholders hold each other's shares. Standard errors are enclosed in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8. Termination of business relationships

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total	High GHG	Low GHG	Shareholders' industry is high GHG	Shareholders' industry is low GHG	Firm is supplier	Firm is customer	Shareholders with high ESG score	Shareholders with low ESG score
Deteriorate, t-2 to t-1	0.247** (0.102)	0.419*** (0.129)	-0.146 (0.170)	0.276** (0.132)	0.233 (0.162)	0.218* (0.131)	0.210 (0.131)	0.368** (0.186)	0.351* (0.208)
Deteriorate, t-3 to t-1	-0.172 (0.114)	-0.338** (0.150)	0.013 (0.181)	-0.194 (0.150)	-0.189 (0.181)	-0.143 (0.147)	-0.099 (0.145)	-0.332 (0.217)	-0.108 (0.242)
Deteriorate, t-4 to t-1	-0.113 (0.122)	-0.230 (0.155)	0.213 (0.205)	-0.020 (0.161)	-0.178 (0.192)	-0.240 (0.157)	-0.220 (0.155)	0.134 (0.237)	-0.254 (0.267)
Deteriorate, t-5 to t-1	0.103 (0.133)	0.177 (0.166)	0.024 (0.228)	0.074 (0.177)	0.168 (0.207)	0.350** (0.171)	0.303* (0.170)	0.194 (0.248)	-0.078 (0.281)
Deteriorate, t-6 to t-1	-0.158 (0.120)	-0.237 (0.153)	0.043 (0.202)	-0.186 (0.158)	-0.099 (0.190)	-0.201 (0.154)	-0.196 (0.153)	-0.184 (0.222)	-0.410 (0.256)
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Shareholder controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	12620	8767	3802	7331	5253	6387	6498	3713	3607

The dependent variable is a dummy variable that takes a value of one when firms no longer list the business partner's name within the top 30 shareholders and zero otherwise. Deterioration, t-2 to t-1, takes a value of one if the growth in CO2 intensity from t-2 to t-1 is positive and zero otherwise. *p < 0.1, **p < 0.05, ***p < 0.01

Table 9 Instrumental variable method

Dependent variable	First stage		Second stage
	ln (CO ₂ intensity)	Shareholder's ln (CO ₂ intensity)	Growth of firm <i>i</i> 's shares held by shareholder <i>j</i>
	(1)	(2)	(3)
Industry mean of CO ₂ intensity	0.865 *** (0.009)	0.022 ** (0.009)	
Industry s.d. of CO ₂ intensity	0.129 *** (0.026)	0.201 *** (0.028)	
Industry mean of shareholders' CO ₂ intensity	-0.003 (0.005)	0.985 *** (0.005)	
Industry s.d. of shareholders' CO ₂ intensity	0.048 ** (0.020)	-0.132 *** (0.021)	
ln (CO ₂ intensity)			-0.005 * (0.003)
Shareholder's ln (CO ₂ intensity)			-0.003 *** (0.001)
Firms' characteristics	Yes	Yes	Yes
Shareholders' characteristics	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Number of observations	19911	19911	19911
R-squared			0.012
Partial R-squared	0.3529	0.6893	
Partial F-statistics	2714.15 ***	11020.98 ***	
Anderson-Rubin Wald test: Chi-sq			14.15 ***
Sargan statistic (overidentification test of all instruments)			4.007

This table presents the results obtained using instrumental variable methods. In the first stage, we regress firms' CO₂ intensity and shareholders' CO₂ intensity on the instruments and control variables from the main regression model in Table 3. The instruments are the two-digit industry mean and standard deviation of firm CO₂ intensity (shareholders' CO₂ intensity) excluding relevant firms (shareholders). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 10 Matching analysis

Dependent variable	Growth of firm i's shares held by shareholder j	
	(1)	(2)
Model		
Average treatment effect of treated: Firms' ln (CO ₂ intensity)	-0.016*** (0.004)	
Average treatment effect of treated: Shareholder's ln (CO ₂ intensity)		-0.010** (0.004)
Number of observations	19272	19272

This table presents the results obtained by matching analysis. Model (1) shows the differences in the growth of the share between high CO₂ emission firms (the treatment group) and other firms with mostly similar characteristics besides CO₂ intensity (the control group). High CO₂ emission firms refer to firms with CO₂ intensity above annual industry median. Model (2) shows the differences in growth of the share between high CO₂ emission shareholders (the treatment group) and other shareholders with mostly similar characteristics besides CO₂ intensity (the control group). High CO₂ emission shareholders refer to shareholders with CO₂ intensity above annual industry median. Entropy balancing is employed. Standard errors are enclosed in parentheses. **p < 0.05, ***p < 0.01

Table 11. Firms' post performance and shareholders' divestment

	(1)	(2)	(3)	(4)	(5)	(6)
	ROA	q	Debt/asset	Cash/asset	Market share	Growth of CO ₂ emission
Decrease, t-1	-0.084 (0.095)	0.002 (0.012)	0.004** (0.002)	0.001 (0.002)	-0.001** (0.001)	-0.003 (0.008)
Decrease, t-2	0.127 (0.096)	-0.002 (0.013)	0.000 (0.002)	0.003** (0.002)	0.000 (0.001)	0.006 (0.008)
Decrease, t-3	0.091 (0.096)	-0.005 (0.013)	0.001 (0.002)	-0.000 (0.002)	0.000 (0.001)	-0.016** (0.008)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm control	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	16016	15468	16016	16013	16013	7677
R-squared	0.034	0.057	0.065	0.036	0.027	0.026

The dependent variables are firms' ROA (Model 1), q (Model 2), debt-to-asset ratio (Model 2), cash-to-assets (Model 4), market share (Model 5), and growth of CO₂ emissions (Model 6). A decrease was set to one if the predicted growth of firms' shares was negative and zero otherwise. *p < 0.1, **p < 0.05, ***p < 0.01

Appendix.

Table A1. Distributions of top 30 shareholders and their shareholding ratio

Ownership type	N	Mean	SD	25th percentile	Median	75th percentile
Firm	215069	6.22	11.18	0.84	1.98	5.63
Bank	85866	2.32	2.07	1.06	1.98	3.33
Insurance	64993	2.07	1.69	0.88	1.57	2.74
Trust bank	111232	3.03	3.20	0.87	1.92	4.15
Foreign companies	60409	1.89	3.70	0.59	1	1.79
Individuals	94790	4.68	8.10	0.71	2.13	4.49
Government	9587	3.87	5.35	1.15	2.41	4.49
Employees	52248	2.95	2.57	1.24	2.22	3.81
Securities	17724	1.29	2.35	0.38	0.71	1.4
Others	4182	4.55	8.44	0.81	1.84	4.17
Other financial institutions	3396	3.02	7.15	0.66	1.15	2.515
Total	719496	3.91	7.36	0.83	1.78	3.8

This table shows the distribution of top 30 shareholders and their shareholding ratio by ownership type. Ownership data covers from 2003 to 2023.

Table A2. Definition of variables

Variable	Definition
<i>Dependent variable</i>	
Growth of the share of firm i held by shareholder j in year t	Growth of the share of firm i held by shareholder j in year t
Termination	1 if firm-shareholder relationships are terminated
<i>Firm characteristics</i>	
$\ln$ (firm total asset, $t-1$)	Logarithm of firm total assets
$\ln$ (1+firm age)	Logarithm of (1+ number of years since firm's foundation)
Firm's ROA, $t-1$	Firm's return on total assets
Firm's q , $t-1$	Tobin's q
Firm's cash to asset ratio, $t-1$	Firm's cash plus securities/total assets
Firm's debt to asset ratio, $t-1$	Firm's debt/total assets
Firm's account payable to sales, $t-1$	Firm's account payable/ sales ($t-1$)
Firm's account receivable to sales, $t-1$	Firm's account receivable/ sales ($t-1$)
Bank ownership share	The ratio of financial institution ownership
Foreigners' ownership share	The ratio of foreign shareholding
$\ln$ (CO ₂ intensity)	logarithm of firm's CO ₂ emission/ sales
<i>Shareholders' characteristics</i>	
Shareholder's $\ln$ (firm total asset, $t-1$)	Logarithm of total assets
Shareholder's ROA, $t-1$	Shareholder's return on total assets
Shareholder's q , $t-1$	Tobin's q
Shareholder's cash to asset ratio, $t-1$	Shareholder's cash plus securities/total assets
Shareholder's debt to asset ratio, $t-1$	Shareholder's debt/total assets

Table A2. Definition of variables (Continued)

Variable	Definition
Shareholder's bank ownership share	The ratio of financial institution ownership
Shareholder's foreigners' ownership share	The ratio of foreign shareholding
<i>Shareholders' ESG profile</i>	
ESG score	ESG score
Environment score	Environment score
Shareholders' ln (CO ₂ intensity)	logarithm of shareholder's CO ₂ emission/ sales
<i>Firm-shareholder relationships</i>	
Supplier	1 if firms are shareholder's stable supplier
Reciprocal ownership	1 if firms hold shareholders' share and their name is listed among the top 30's