Accounting Research Letters

Article in Press

*Accounting Research Letters*

Volume X, Issue X s

202X

pp. XX-XX

The Accounting and Economic Association of Japan

# The Impact of Tightening Environmental Regulations on Firms' R&D Investment and Dividend Policies: Evidence from Japan

**Kenichi Nagasawa**

**Declaration of Interest**

None

**Data Availability**

The authors do not have permission to share data.

**Funding**

This work was supported by the Japan Society for the Promotion of Science (Grants-in-aid for Scientific Research [24K04944]).

**Acknowledgements**

The authors would like to thank Akitoshi Ito and Takafumi Sasaki for their helpful comments on an early version of this paper. The authors would also like to thank participants in the 2024 Japan Finance Association Annual Conference at Chuo University and the 8th AEAJ Workshop at Okinawa International University for their helpful comments. I am grateful to Editor Hironori Kawase and an anonymous referee for their valuable comments and suggestions.

This work was supported by a Grants-in-Aid for Scientific Research (24K04944). All remaining errors are my own.

Accounting Research Letters

Article in Press
*Accounting Research Letters*
Volume X, Issue X s
202X
pp. XX-XX
The Accounting and Economic Association of Japan

# The Impact of Tightening Environmental Regulations on Firms' R&D Investment and Dividend Policies: Evidence from Japan

**Kenichi Nagasawa**

Shunan University

Submitted: XXXXX XX, 202X; Revised: XXXXX XX, 202X; Accepted: XXXXX XX, 202X;
Available online XXXX XX, 202X

**Abstract**

This study examines how tighter environmental regulations affect the relationship between research and development (R&D) investments and dividend policy. To this end, I implemented a difference-in-differences analysis using the adoption of the 21st Conference of the Parties (COP21) regulations as an external shock. The empirical results indicate that tighter environmental regulations following COP21 led greenhouse gas (GHG) emitting firms to reduce dividends. However, GHG emitting firms with high R&D intensity moderate this decline. The findings align with the signaling hypothesis, which proposes that GHG emitting firms with high R&D intensity mitigate the reduction in their dividend payments in response to COP21 regulations.

**Keywords**: Environmental regulations; dividends; R&D investment; asset beta; Japan
**JEL Classification Codes**: F64; G32; G35

Corresponding Author: Kenichi Nagasawa, Shunan University, 843-4-2 Gakuendai, Shunan-shi, Yamaguchi, Japan 745-8566
Email: nagasawa_k@shunan-u.ac.jp

# 1. Introduction

Reducing greenhouse gas (GHG) emissions is an urgent task. Countries around the world are tightening environmental regulations by imposing additional costs on firms with high GHG emissions (GHG firms). Increases in GHG firms' operating leverage can affect the asset beta, which measures the volatility of individual security returns relative to that of market portfolio returns (Lev, 1974). Previous studies indicate that asset beta increases with heightened environmental regulations (Ito and Nagasawa, 2024). Bankruptcy risks during a recession increase relative to the rise in a firm's operating leverage and asset beta.

Can GHG firms secure investment funds and undertake research and development (R&D) projects as environmental regulations tighten? Sustainable investment activities focusing on R&D as a long-term investment in decarbonization are important to reduce GHG emissions. However, raising funds for R&D investments during a recession is challenging if operating leverage increases in GHG firms with high R&D intensity, and shareholders may withdraw due to concerns that the R&D projects might be suspended.

R&D investment attributes are characterized by outcome uncertainty and significant information asymmetry between firms and investors regarding R&D projects. Most R&D expenditure is allocated on personnel costs (i.e., researchers), and operating leverage tends to be high in R&D-intensive firms. Therefore, such firms prioritize internal financing due to the higher cost of external financing (Brown et al. 2009). Previous research found that GHG firms reduce dividends to ensure financial flexibility following tighter environmental regulations (Balachandran and Nguyen, 2018; Chan et al., 2024). Nevertheless, few studies explore how tighter environmental regulation affects the relationship between R&D investments and dividend policy. For GHG firms, whether to pay dividends to shareholders is a critical issue. Based on this context, this study explores how tighter environmental regulations influence the relationship between R&D investments and dividend policy.

This paper proposes two hypotheses. GHG firms must incur additional costs to reduce emissions in accordance with environmental regulations. As a result, their operating leverage increases, leading to a higher risk of bankruptcy during economic downturn. Consequently, GHG firms may face constraints in accessing both debt and equity financing. Ito and Nagasawa (2024) and Nguyen and Phan (2020) indicate that due to tightening environmental regulations, GHG firms lower their debt ratios to sustain financial flexibility and mitigate bankruptcy risk. Balachandran and Nguyen (2018) suggest that GHG firms also reduce dividends due to increased earnings uncertainty caused by stricter environmental regulations. Thus, GHG firms with high R&D intensity may reduce dividends to mitigate bankruptcy risk and secure funds for future R&D. Based on the above, the following hypothesis is proposed.

H1: GHG firms with high R&D intensity reduce dividend payments in the presence of tighter environmental regulations.

A previous study shows that tighter environmental regulations increase the systematic risk, or asset beta, of GHG firms (Ito and Nagasawa, 2024). A higher asset beta raises the cost of equity capital and can negatively impact firm value. Firms may increase dividends to reassure investors and stabilize their market valuation (Grullon et al., 2002). Accordingly, GHG firms with high R&D intensity may mitigate the reduction in their dividend payments following regulatory tightening to enhance their reputation in the stock market, mitigate stock price declines, and prevent a rise in their cost of capital.

H2: GHG firms with high R&D intensity mitigate the reduction in dividend payments in the presence of tighter environmental regulations and a higher asset beta.

The empirical results of this paper support H2: GHG firms with high R&D intensity mitigate dividend reduction following tighter environmental regulations. The rest of this paper is organized as follows. Section 2 describes the validation methodology. Section 3 provides the data and model. Section 4 provides the analysis results, and Section 5 concludes.

## 2. Difference-in-Differences (DID) Methodology

### 2.1. Exogenous Shock in DID Analysis

Endogeneity issues in relationships between R&D investments and dividend policy must be considered. Thus, I conducted a difference-in-differences (DID) analysis using COP21 adoption as an external shock.

### 2.2. Treatment and Control Groups

The "Greenhouse Gas Emission Calculation, Reporting and Publication System" (Publication System) determines the treatment and control groups. Japan's Ministry of the Environment established a publication system following the Law on the Promotion of Measures to Cope with Global Warming on April 1, 2006, to curb GHG emissions by business operators. This system defines businesses that emit a certain amount of GHG as "specified emitters," obliging them to calculate and disclose their GHG emissions.[1] Since COP21, the Japanese government has tightened environmental regulations, increasing compliance and GHG reduction costs for high GHG emitting firms. Hence, specified emitters are most likely to be affected by the adoption of COP21, whereas non-specified emitters are less affected. Following this argument, I define the treated firms as

[1] The specific reporting requirements are available at the following URL. https://policies.env.go.jp/earth/ghg-santeikohyo/about.html (Accessed August 14, 2025)

those that were required to report in all years between 2012 and 2015 and the control firms as those that had not reported during the same period.[2] That is to say, firms that reported in any year between 2012 and 2015 but did not report in at least one other year within the same period are excluded from the sample (e.g., firms that reported in 2012 but not in 2013). This is done to clearly distinguish between the treated and control firms.

## 3. Data and Model

### 3.1. Data and Sample

This study's data were obtained from the Astra Manager of Quick Corp. The sample includes Tokyo Stock Exchange-listed manufacturing firms (Sections 1 and 2, Mothers, and JASDAQ). The analysis period was a seven-year sample from 2012 to 2018 for the independent variables and from 2013 to 2019 for the dependent variables; with a one-period lag.

Firms in the treatment and control groups were randomly assigned to control for endogeneity using DID analysis. I used propensity score matching to select firms in the control group with attributes like those of firms in the treatment group. The nearest neighbor and caliper methods were used in matching. Calipers were calculated by multiplying the standard deviation of the propensity score by 0.25. Propensity scores were calculated using probit regression analysis. The dependent variable in the probit regression model was "*Treatment*"; the explanatory variables were the control variables described in Section 3.2. I performed matching based on firm attributes in years that did not reflect the impact of COP21. Thus, matching was performed in 2012, the first year of the analysis period.

### 3.2. Variable Definition

Table 1 presents the definition of variables. The main independent variables are a triple interaction term, *Year15_18*×*Treatment*×*LOGRD,* and a double interaction term *Year15_18*×*Treatment*. The variable *Year15_18* takes a value of 1 from 2015 to 2018 (affected by adopting COP21) and 0 otherwise. *Treatment* equals 1 if a firm is a "specified emitter" (as shown in Section 2.2) throughout the entire period from 2012 to 2015, and 0 otherwise. *LOGRD* represents the logarithm of R&D expenditure. For robustness, *RD_A* (R&D expenditure divided by total assets) is employed as an alternative to *LOGRD*. The main dependent variables, following Fama and French (2001), are the ratio of dividends to sales (*DIV_S*) and the ratio of dividends to total assets (*DIV_A*). For robustness check, the *DIV_per* variable (dividend per share) is also adopted.[3] Dividend policy may be influenced by firm size, cash flow conditions, profitability, growth opportunities, firm maturity,

[2] Nguyen and Phan (2020) used a similar publication system for Australia's DID analysis.

[3] Using share repurchase as the dependent variable, a panel Tobit DID analysis yields positive but mostly insignificant coefficients on R&D-related variables. See Table A-3 for results and Tables A-1 and A-2 for variable definitions and statistics (Online Appendix).

earnings volatility, and governance conditions (Fama and French, 2001). Therefore, the following control variables are included: *MV_BV, CF_A, BETA LOGAGE, NI_A, F_A, SIZE, RE_K, NI_A_vol, MAIN, and FOR*. Outliers are winsorized at the 1% and 99% levels.

### 3.3. Empirical Model

I divide the sample period for the DID analysis into the years before (2012–2014) and after COP21 adoption (2015–2018).[4] The DID analysis involves fixed effects in the panel data analysis, including firm-specific fixed effects and time-specific fixed effects model. This model calculates *t* values assuming that the error terms are clustered by firm.

## 4. Empirical Results

### 4.1. Matched Sample and Descriptive Statistics

Table 2 presents the propensity score matching balancing test results, showing no statistical significance in the differences between the means of the respective variables in the treatment and

**Table 1 Definition of Variables**

| Variable Name | Variable Definition |
|---|---|
| **Dependent variables** | |
| *DIV_S* | Total amounts of cash dividend divided by one-year lagged total sales. |
| *DIV_A* | Total amounts of cash dividend divided by one-year lagged total assets. |
| *DIV_per* | Dividend amount (in millions of yen) on a payment basis divided by the number of issued shares (in thousands of shares). |
| **Independent variables and control variables** | |
| *LOGRD* | Log (R&D expenses + 1). |
| *RD_A* | R&D expenses divided by the total assets. |
| *Treatment* | A dummy variable which is equal to one if the firm has reported greenhouse gas emissions to the government based on the system of calculation, reporting, and publication of greenhouse gas emissions in all periods 2012-2015, and zero if the firm has not reported for all the same periods. |
| *Year15_18* | A dummy variable which is equal to one from year 2015 to 2018 and zero otherwise. |
| *MV_BV* | Book value of total debt and market value of equity divided by total assets. |
| *CF_A* | Cash flow from operating activities divided by total assets. |
| *BETA* | CAPM $\beta$ relative to the TOPIX over 36 months. |
| *LOGAGE* | Log (firm age+1). |
| *NI_A* | Net income divided by total assets. |
| *F_A* | Net property, plant, and equipment divided by total assets. |
| *SIZE* | Log (Assets). |
| *RE_K* | Retained earnings divided by book equity. |
| *NI_A_vol* | Standard deviation of *NI_A* over four years. |
| *MAIN* | Fraction of shares owned by largest investors. |
| *FOR* | Fraction of shares owned by foreign investors. |
| *ASSET_BETA_d* | A dummy variable which is equal to one if *ASSET_BETA* is above the median in each year, and zero otherwise. |
| *ASSET_BETA* | $\frac{\text{Market Value of Equity}}{\text{Market Value of Equity + Book Value of Debt}} \times \text{Equity Beta}$ The debt beta is very low, so the *ASSET_BETA* is defined under the assumption that the debt beta is zero. Equity beta is defined as the variable *BETA*. |

[4] Approximately 15% of the sample firms have fiscal years ending between September and December. Their firms paid dividends in 2016 after their fiscal year 2015.

**Table 2 Covariate Balance Test**

| | Unmatched | | | Matched | | |
|---|---|---|---|---|---|---|
| | | Mean | | | Mean | |
| Variable | Treatment | Control | t-value | Treatment | Control | t-value |
| *LOGRD* | 7.0965 | 5.4916 | 11.18*** | 6.2838 | 6.1640 | 0.58 |
| *MV_BV* | 0.9260 | 0.9056 | 1.14 | 0.8845 | 0.8861 | -0.07 |
| *CF_A* | 0.0541 | 0.0439 | 3.43*** | 0.0498 | 0.0510 | -0.28 |
| *BETA* | 1.0453 | 1.0143 | 0.87 | 1.0413 | 0.9709 | 1.37 |
| *LOGAGE* | 4.1653 | 3.9184 | 8.78*** | 4.0438 | 4.0897 | -1.10 |
| *NI_A* | 0.0448 | 0.0408 | 1.50 | 0.0415 | 0.0472 | -1.52 |
| *F_A* | 0.1984 | 0.1452 | 10.29*** | 0.1775 | 0.1739 | 0.50 |
| *SIZE* | 11.3870 | 10.0300 | 15.4*** | 10.7820 | 10.6400 | 1.16 |
| *RE_K* | 0.5680 | 0.4215 | 4.84*** | 0.5392 | 0.5591 | -0.59 |
| *NI_A_vol* | 0.0328 | 0.0407 | -4.62*** | 0.0363 | 0.0351 | 0.49 |
| *MAIN* | 0.1679 | 0.1986 | -3.46*** | 0.1845 | 0.1794 | 0.40 |
| *FOR* | 0.1172 | 0.0657 | 7.52*** | 0.0881 | 0.0870 | 0.13 |

This table reports the results of covariate balance test using t-tests for the difference in the mean of each variable between treatment and control groups, before and after propensity score matching. The covariates use values in year 2012 before COP21 is adopted. The definitions of variables are listed in Table 1. *** denote significance at the 1% level.

**Table 3 Basic Statistics of Main Variables**

| Variables | Obs | Mean | Median | Max | Min | Std.Div |
|---|---|---|---|---|---|---|
| Dependent variables | | | | | | |
| *DIV_S* | 3331 | 0.0131 | 0.0099 | 0.0693 | 0.0000 | 0.0123 |
| *DIV_A* | 3331 | 0.0099 | 0.0083 | 0.0424 | 0.0000 | 0.0077 |
| *DIV_per* | 3331 | 0.0235 | 0.0147 | 0.3312 | 0.0000 | 0.0284 |
| Independent variables | | | | | | |
| *LOGRD* | 3331 | 6.2517 | 6.4536 | 12.1144 | 0.0000 | 2.2959 |
| *RD_A* | 3331 | 0.0212 | 0.0149 | 0.1277 | 0.0000 | 0.0203 |
| *MV_BV* | 3331 | 0.9943 | 0.9075 | 4.0376 | 0.4737 | 0.4441 |
| *CF_A* | 3331 | 0.0586 | 0.0590 | 0.1823 | -0.1697 | 0.0462 |
| *BETA* | 3331 | 0.8363 | 0.8122 | 2.3119 | -0.1146 | 0.4864 |
| *LOGAGE* | 3331 | 4.1199 | 4.1897 | 4.9273 | 1.6094 | 0.4130 |
| *NI_A* | 3331 | 0.0488 | 0.0451 | 0.1766 | -0.1704 | 0.0419 |
| *F_A* | 3331 | 0.1726 | 0.1619 | 0.4369 | 0.0121 | 0.0813 |
| *SIZE* | 3331 | 10.8045 | 10.5848 | 15.2754 | 8.0577 | 1.3426 |
| *RE_K* | 3331 | 0.5503 | 0.6247 | 1.1246 | -2.6714 | 0.3964 |
| *NI_A_vol* | 3331 | 0.0259 | 0.0175 | 0.1331 | 0.0023 | 0.0247 |
| *MAIN* | 3331 | 0.1779 | 0.1238 | 0.6360 | 0.0377 | 0.1403 |
| *FOR* | 3331 | 0.1110 | 0.0754 | 0.4971 | 0.0000 | 0.1126 |
| *ASSET_BETA_d* | 3331 | 0.4575 | 0.0000 | 1.0000 | 0.0000 | 0.4983 |

This table shows the summary statistics of dependent variables for the period 2013-2019 and independent variables for the period 2012-2018.

control groups after matching. This finding suggests that the two groups were adequately matched. Table 3 presents the variables' descriptive statistics; the *LOGRD* variable had a mean and median of 6 and a maximum of 12, indicating no significant bias.

### 4.2. DID Analysis Results

Columns (1)– (4) of Table 4 indicate whether the relationship between GHG firms and dividends changed before and after COP21. Columns (1) and (2) illustrate the results based on the *LOGRD* variable, while columns (3) and (4) present the results based on the *RD_A* variable. For all columns, the coefficients of the *Year 15_18* × *Treatment* variable are negative and statistically significant at the 1% level. In contrast, the coefficients of the *Year15_18×Treatment×LOGRD* (*RD_A*) variables are positive and statistically significant at the 1% to 10% level. The results suggest that while treated firms reduced dividends, GHG firms with higher R&D intensity can mitigate the reduction in dividend payments. This result is consistent with H2.

The control variable results generally align with those of past research (Fama and French, 2001), with the *SIZE* and *RE_K* coefficients illustrating positive signs.

## Table 4 Baseline Results: Dividend

| | (1)<br>*DIV_S* | (2)<br>*DIV_A* | (3)<br>*DIV_S* | (4)<br>*DIV_A* |
|---|---|---|---|---|
| *Year15_18×Treatment×LOGRD* | 0.0003*** | 0.0002** | | |
| | (2.96) | (2.15) | | |
| *Year15_18×Treatment×RD_A* | | | 0.0386*** | 0.0217* |
| | | | (2.62) | (1.93) |
| *Year15_18×Treatment* | −0.0030*** | −0.0018*** | −0.0017*** | −0.0010** |
| | (−3.27) | (−2.68) | (−2.78) | (−2.55) |
| *Treatment×LOGRD* | −0.0005 | −0.0006 | | |
| | (−0.87) | (−1.23) | | |
| *Treatment×RD_A* | | | −0.0427 | −0.0233 |
| | | | (−1.12) | (−0.69) |
| *LOGRD* | 0.0003 | 0.0009** | | |
| | (0.80) | (2.06) | | |
| *RD_A* | | | −0.0033 | 0.0444** |
| | | | (−0.15) | (2.36) |
| *MV_BV* | 0.0050*** | 0.0044*** | 0.0050*** | 0.0044*** |
| | (5.57) | (5.72) | (5.53) | (5.72) |
| *CF_A* | 0.0018 | 0.0023 | 0.0016 | 0.0025 |
| | (0.79) | (1.44) | (0.69) | (1.56) |
| *BETA* | 0.0001 | 0.0003 | 0.0001 | 0.0003 |
| | (0.25) | (1.03) | (0.33) | (1.11) |
| *LOGAGE* | 0.0011 | 0.0016 | 0.0001 | 0.0008 |
| | (0.35) | (0.43) | (0.02) | (0.21) |
| *NI_A* | 0.0267*** | 0.0430*** | 0.0265*** | 0.0438*** |
| | (3.77) | (7.40) | (3.66) | (7.27) |
| *F_A* | 0.0075 | 0.0036 | 0.0075 | 0.0035 |
| | (0.88) | (0.98) | (0.87) | (0.94) |
| *SIZE* | 0.0039** | 0.0007 | 0.0039** | 0.0013 |
| | (2.43) | (0.60) | (2.38) | (1.13) |
| *RE_K* | 0.0019*** | 0.0021*** | 0.0020*** | 0.0020*** |
| | (3.13) | (3.96) | (3.12) | (3.55) |
| *NI_A_vol* | −0.0122 | −0.0103* | −0.0122 | −0.0113** |
| | (−1.53) | (−1.89) | (−1.50) | (−2.04) |
| *MAIN* | 0.0011 | −0.0001 | 0.0006 | −0.0002 |
| | (0.26) | (−0.02) | (0.16) | (−0.07) |
| *FOR* | 0.0003 | 0.0015 | 0.0008 | 0.0018 |
| | (0.07) | (0.49) | (0.20) | (0.60) |
| *Constant* | −0.0403* | −0.0145 | −0.0349 | −0.0153 |
| | (−1.89) | (−0.73) | (−1.60) | (−0.75) |
| Firm fixed effect | Yes | Yes | Yes | Yes |
| Year fixed effect | Yes | Yes | Yes | Yes |
| R-squared | 0.245 | 0.353 | 0.244 | 0.352 |
| Observations | 3,331 | 3,331 | 3,331 | 3,331 |

This table reports the estimation results of the DID analysis for the effect of COP21 on the relationship between R&D and dividends. The estimation is based on the fixed effects model. The definitions of variable are shown in Table 1. The sample includes all manufacturing firms listed on the Tokyo Stock Exchange. The sample period for independent variables is from 2012 to 2018, covering 7 years. t-values are shown in parentheses. *, **, and *** denote significance at 10%, 5% and 1% levels, respectively.

### 4.3. Parallel Trend Check

Table 5 shows that the parallel trend assumption must be satisfied for the validation results from the DID analysis to be valid. The coefficients of the *Year 14*×*Treatment*×*LOGRD* (*RD_A*) variables for 2014 prior to COP21 were not statistically significant, suggesting similar trends in the treatment and control groups' main explanatory variables before adopting COP21, indicating that the parallel trend assumption holds.

**Table 5 Parallel Trend Test**

| | (1)<br>*DIV_S* | (2)<br>*DIV_A* | (3)<br>*DIV_S* | (4)<br>*DIV_A* |
|---|---|---|---|---|
| *Year14*×*Treatment*×*LOGRD* | 0.00005 | 0.00005 | | |
| | (0.48) | (0.60) | | |
| *Year15*×*Treatment*×*LOGRD* | 0.0002* | 0.0002** | | |
| | (1.81) | (1.98) | | |
| *Year16*×*Treatment*×*LOGRD* | 0.0002 | 0.00010 | | |
| | (0.96) | (1.33) | | |
| *Year17*×*Treatment*×*LOGRD* | 0.0005*** | 0.0003** | | |
| | (2.85) | (2.55) | | |
| *Year18*×*Treatment*×*LOGRD* | 0.0007*** | 0.0004*** | | |
| | (3.79) | (3.43) | | |
| *Year14*×*Treatment*×*RD_A* | | | −0.0012 | 0.0024 |
| | | | (−0.09) | (0.26) |
| *Year15*×*Treatment*×*RD_A* | | | 0.0343* | 0.0301** |
| | | | (1.70) | (2.05) |
| *Year16*×*Treatment*×*RD_A* | | | 0.0237 | 0.0133 |
| | | | (1.45) | (1.16) |
| *Year17*×*Treatment*×*RD_A* | | | 0.0459** | 0.0267** |
| | | | (2.50) | (2.01) |
| *Year18*×*Treatment*×*RD_A* | | | 0.0536** | 0.0393** |
| | | | (2.49) | (2.54) |
| *Year14*×*Treatment* | −0.0002 | −0.0004 | 0.0001 | −0.0002 |
| | (−0.25) | (−0.87) | (0.15) | (−0.77) |
| *Year15*×*Treatment* | −0.0018* | −0.0014** | −0.0011* | −0.0009** |
| | (−1.80) | (−2.22) | (−1.75) | (−2.25) |
| *Year16*×*Treatment* | −0.0013 | −0.0013* | −0.0008 | −0.0008** |
| | (−1.06) | (−1.95) | (−1.22) | (−1.96) |
| *Year17*×*Treatment* | −0.0039*** | −0.0028*** | −0.0020** | −0.0015*** |
| | (−3.43) | (−3.61) | (−2.51) | (−3.14) |
| *Year18*×*Treatment* | −0.0050*** | −0.0034*** | −0.0021** | −0.0016*** |
| | (−4.09) | (−4.00) | (−2.57) | (−2.94) |
| *Treatment*×*LOGRD* | −0.0006 | −0.0006 | | |
| | (−0.91) | (−1.24) | | |
| *Treatment*×*RD_A* | | | −0.0495 | −0.0276 |
| | | | (−1.34) | (−0.82) |
| *LOGRD* | 0.0004 | 0.0008** | | |
| | (0.84) | (2.15) | | |
| *RD_A* | | | 0.0020 | 0.0439** |
| | | | (0.10) | (2.41) |
| *Control variables* | Yes | Yes | Yes | Yes |
| Firm fixed effect | Yes | Yes | Yes | Yes |
| Year fixed effect | Yes | Yes | Yes | Yes |
| R-squared | 0.273 | 0.350 | 0.270 | 0.347 |
| Observations | 3331 | 3331 | 3331 | 3331 |

This table reports the results of the parallel trend test on R&D investments before COP21. The estimation is based on the fixed effects model. The sample period for independent variables is from 2012 to 2018. The definitions of variables are shown in Table 1. The sample includes all manufacturing firms listed on the Tokyo Stock Exchange. t-values are shown in parentheses. *, **, and *** denote significance at 10%, 5% and 1% levels, respectively. Control variables are included in all regressions, but their coefficients are omitted from the table due to space constraints. Details are provided in Table A-5 of the Online Appendix.

### 4.4. Additional Analyses

In this section, I conduct additional analyses using dividend per share as the dependent variable. Table 6 presents the results. When using the *LOGRD variable*, the coefficients for the *Year15*×*Treatment*×*LOGRD* variable through the *Year18*×*Treatment*×*LOGRD* variable are positive and statistically significant at the 1% to 5% level, except for the *Year17*×*Treatment*×*LOGRD* variable. Using the *RD_A* variable indicates that the *Year15*×*Treatment*×*RD_A* variable and the *Year16*×*Treatment*×*RD_A* variable have positive coefficients, but only the coefficient for 2015 is statistically significant. These results suggest that while GHG firms with high R&D intensity mitigate the reduction in dividends per share immediately after COP21, they restrained further increases in subsequent years. Given the significant rise in total dividends (Section 4.2), this may reflect a dilution effect due to an increase in issued shares[5]. Note that the significant result for the *Year18*×*Treatment*×*LOGRD* variable may reflect that firms with higher *LOGRD* (i.e., relatively larger firms) increased dividends based on their greater financial capacity. The findings support Hypoth-

**Table 6 Additional Analysis: Dividend per share**

| | (1) | | (2) |
|---|---|---|---|
| (*LOGRD*) | *DIV_per* | (*RD_A*) | *DIV_per* |
| *Year15*×*Treatment*×*LOGRD* | 0.0012** | *Year15*×*Treatment*×*RD_A* | 0.0760** |
| | (2.55) | | (2.36) |
| *Year16*×*Treatment*×*LOGRD* | 0.0013*** | *Year16*×*Treatment*×*RD_A* | 0.0524 |
| | (2.74) | | (1.22) |
| *Year17*×*Treatment*×*LOGRD* | 0.0010 | *Year17*×*Treatment*×*RD_A* | −0.0402 |
| | (1.63) | | (−0.61) |
| *Year18*×*Treatment*×*LOGRD* | 0.0016** | *Year18*×*Treatment*×*RD_A* | −0.0892 |
| | (2.28) | | (−1.00) |
| *Year15*×*Treatment* | −0.0070** | *Year15*×*Treatment* | −0.0012 |
| | (−2.57) | | (−1.12) |
| *Year16*×*Treatment* | −0.0079** | *Year16*×*Treatment* | −0.0008 |
| | (−2.44) | | (−0.41) |
| *Year17*×*Treatment* | −0.0061 | *Year17*×*Treatment* | 0.0006 |
| | (−1.38) | | (0.21) |
| *Year18*×*Treatment* | −0.0077 | *Year18*×*Treatment* | 0.0037 |
| | (−1.48) | | (0.97) |
| *Treatment*×*LOGRD* | −0.0027 | *Treatment*×*RD_A* | −0.1346 |
| | (−1.11) | | (−1.22) |
| *LOGRD* | 0.0011 | *RD_A* | 0.0316 |
| | (0.85) | | (0.53) |
| *Control variables* | Yes | *Control variables* | Yes |
| Firm fixed effect | Yes | Firm fixed effect | Yes |
| Year fixed effect | Yes | Year fixed effect | Yes |
| R-squared | 0.266 | R-squared | 0.264 |
| Observations | 3331 | Observations | 3331 |

This table reports the estimation results of the DID analysis for the effect of COP21 on the relationship between R&D and dividends per share. The estimation is based on the fixed effects model. The definitions of variable are shown in Table 1. The sample includes all manufacturing firms listed on the Tokyo Stock Exchange. The sample period for independent variables is from 2012 to 2018, covering 7 years. t-values are shown in parentheses. *, **, and *** denote significance at 10%, 5% and 1% levels, respectively. Control variables are included in all regressions, but their coefficients are omitted from the table due to space constraints. Details are provided in Table A-6 of the Online Appendix.

[5] Using log issued shares as the dependent variable, the coefficients of *Year15_18*×*Treatment*×*LOGRD* (*RD_A*) are positive and statistically significant at the 5% and 10% levels, respectively. See Table A-4 for results and Tables A-1 and A-2 for definitions and statistics (Online Appendix).

## Table 7 Channel Analysis: Asset-beta

| | (1) DIV_S | (2) DIV_A | (3) DIV_S | (4) DIV_A |
|---|---|---|---|---|
| *Year15_18×Treatment×LOGRD×ASSET_BETA_d* | 0.0003*** | 0.0002** | | |
| | (3.07) | (2.57) | | |
| *Year15_18×Treatment×RD_A×ASSET_BETA_d* | | | 0.0434** | 0.0245* |
| | | | (2.58) | (1.89) |
| *Year15_18×Treatment×LOGRD* | 0.0001 | 0.0001 | | |
| | (0.94) | (0.59) | | |
| *Year15_18×Treatment×RD_A* | | | 0.0090 | 0.0048 |
| | | | (0.63) | (0.45) |
| *Year15_18×Treatment* | −0.0025** | −0.0015** | −0.0016*** | −0.0010** |
| | (−2.52) | (−2.07) | (−2.68) | (−2.45) |
| *Treatment×LOGRD* | −0.0006 | −0.0007 | | |
| | (−0.93) | (−1.25) | | |
| *Treatment×RD_A* | | | −0.0458 | −0.0258 |
| | | | (−1.18) | (−0.75) |
| *Treatment×ASSET_BETA_d* | −0.0011* | −0.0006 | −0.0006 | −0.0004 |
| | (−1.81) | (−1.63) | (−1.21) | (−1.03) |
| *LOGRD×ASSET_BETA_d* | −0.00001 | 0.00001 | | |
| | (−0.11) | (0.20) | | |
| *RD_A×ASSET_BETA_d* | | | −0.0102 | −0.0008 |
| | | | (−0.72) | (−0.10) |
| *LOGRD* | 0.0003 | 0.0009** | | |
| | (0.79) | (2.04) | | |
| *RD_A* | | | 0.0003 | 0.0445** |
| | | | (0.01) | (2.27) |
| *ASSET_BETA_d* | 0.0007 | 0.0002 | 0.0009* | 0.0004 |
| | (0.86) | (0.46) | (1.95) | (1.30) |
| *MV_BV* | 0.0049*** | 0.0044*** | 0.0049*** | 0.0044*** |
| | (5.49) | (5.60) | (5.40) | (5.57) |
| *CF_A* | 0.0018 | 0.0023 | 0.0016 | 0.0025 |
| | (0.76) | (1.44) | (0.68) | (1.56) |
| *LOGAGE* | 0.0011 | 0.0015 | 0.0004 | 0.0010 |
| | (0.35) | (0.42) | (0.14) | (0.26) |
| *NI_A* | 0.0265*** | 0.0427*** | 0.0259*** | 0.0432*** |
| | (3.71) | (7.30) | (3.53) | (7.14) |
| *F_A* | 0.0078 | 0.0037 | 0.0078 | 0.0036 |
| | (0.91) | (1.03) | (0.91) | (0.98) |
| *SIZE* | 0.0037** | 0.0006 | 0.0038** | 0.0013 |
| | (2.31) | (0.54) | (2.32) | (1.14) |
| *RE_K* | 0.0019*** | 0.0021*** | 0.0020*** | 0.0020*** |
| | (3.18) | (3.96) | (3.10) | (3.52) |
| *NI_A_vol* | −0.0120 | −0.0097* | −0.0124 | −0.0111** |
| | (−1.54) | (−1.82) | (−1.56) | (−2.03) |
| *MAIN* | 0.0012 | −0.00002 | 0.0008 | −0.0002 |
| | (0.30) | (−0.01) | (0.18) | (−0.06) |
| *FOR* | −9.52E−06 | 0.0011 | 0.0005 | 0.0015 |
| | (−0.002) | (0.36) | (0.11) | (0.48) |
| *Constant* | −0.0377* | −0.0131 | −0.0354* | −0.0160 |
| | (−1.81) | (−0.67) | (−1.66) | (−0.80) |
| Firm fixed effect | Yes | Yes | Yes | Yes |
| Year fixed effect | Yes | Yes | Yes | Yes |
| R-squared | 0.249 | 0.356 | 0.247 | 0.353 |
| Observations | 3331 | 3331 | 3331 | 3331 |

This table reports the estimation results of the DID analysis for the effect of COP21 on the relationship between R&D, dividends and Asset-Beta. The estimation is based on the fixed effect model. The definitions of variable are shown in Table 1. The sample includes all manufacturing firms listed on the Tokyo Stock Exchange. The sample period (of independent variables) is from 2012 to 2018, covering 7 years. t-values are shown in parentheses. *, **, and *** denote significance at 10%, 5% and 1% levels, respectively.

esis 2, showing that high R&D intensity suppresses the decline in dividend payments following the adoption of COP21.

### 4.5. Channel Analysis

I examine whether a higher asset beta affects the dividend policy of GHG firms with high R&D intensity. Specifically, I create a dummy variable (*ASSET_BETA_d*) that equals 1 if the asset beta is above the median in each year, and 0 otherwise. The interaction term *Year15_18*×*Treatment*×*LOGRD*(*RD_A*)×*ASSET_BETA_d*, which serves as the primary variable to analyze how asset beta moderates the relationship between GHG firms with high R&D intensity and their dividend policy, was constructed.

The coefficient of the *Year15_18*×*Treatment*×*LOGRD* (*RD_A*)×*ASSET_BETA_d* variable is expected to be positive. The findings in Table 7 indicate that the coefficient of the *Year15_18*×*Treatment* variable is negative in (1) to (4), and significant at 1% to 5% level. In contrast, the coefficient of the *Year15_18*×*Treatment*×*LOGRD* (*RD_A*)×*ASSET_BETA_d* variable is positive in all models and is statistically significant at the 1% to 10% level. The results suggest that higher asset beta is related to the smaller magnitude in the reduction of dividend amounts for GHG firms with high R&D intensity.

Tables 4 to 7 can be interpreted as follows. After the adoption of COP21, shareholders anticipate higher systematic risks for GHG firms with high R&D intensity, exhibiting concerns over the potential suspension of R&D. Accordingly, these GHG firms have signaled to the stock market that they were reducing business risk by using internal funds to pay dividends to shareholders, strengthening their market reputation.

## 5. Conclusion

This paper examined how tighter environmental regulations affect the relationship between firms' R&D investments and dividend policies. The empirical results were consistent with H2: while treatment firms typically have more incentive to lower dividend amounts due to the adoption of COP21, their incentive weakens for firms with high R&D intensity. My findings suggest that GHG firms may reduce future R&D investments by paying internal funds to shareholders as dividends. This study's contributions are as follows. First, I examine the impact of tighter environmental regulations, adding to the literature on the link between R&D investments and dividend policy. Second, I show that firms' responses to environmental issues may reduce the internal funds available for R&D investments. The findings of this study suggest that for GHG firms to increase their R&D investments, the government must be proactive in providing subsidies and tax incentives for these firms.

## References

Balachandran, B., and Nguyen, J.H. (2018). Does carbon risk matter in firm dividend policy? Evidence from a quasi-natural experiment in an imputation environment. *Journal of Banking and Finance*, 96, 249–267.

Brown, J.R., Fazzari, S.M., and Petersen, B.C. (2009). Financing innovation and growth: cash flow, external equity, and the 1990s R&D boom. *The Journal of Finance*, 64 (1), 151–185.

Chan, Y., He, W., and Mi, L. (2024). Climate risk and payout flexibility around the world. *Journal of Banking & Finance*, 166, 107233.

Fama, E.F., and French, K.R. (2001). Disappearing dividends: changing firm characteristics or lower propensity to pay? *Journal of Financial Economics*, 60 (1), 3–43.

Grullon, G., Michaely, R., and Swaminathan, B. (2002). Are dividend changes a sign of firm maturity? *Journal of Business*, 75 (3), 387–424.

Ito, A. and Nagasawa, K. (2024). Impact of the corporate response to climate risk on financial leverage and systematic risk. *Applied Economics Letters*, 31 (8), 728–731.

Lev, B. (1974). On the association between operating leverage and risk. *Journal of Financial and Quantitative Analysis*, 9(4), 627-641.

Nguyen, J.H. and Phan, H.V. (2020). Carbon risk and corporate capital structure. *Journal of Corporate Finance*. 64, 101713.