Greenhouse Gas Emissions, Firm Value, and the Investor Base: Evidence from Korea

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This work was supported by the 'BK21 FOUR (Fostering Outstanding Universities for Research)' in 2023.

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Abstract

This paper examines the association between greenhouse gas (GHG) emissions, firm value and foreign ownership for Korean firms. In Korea, firms that emit GHG more than a given threshold have been mandated to disclose the levels of GHG emissions since 2011. We find that firms bound to disclose GHG emissions are likely to be valued less compared to firms without disclosure obligations. In addition, foreign investors' ownership is lower for mandatory-disclosure firms than firms without such requirements. Among mandatory-disclosure firms, GHG intensity is negatively associated with firm value and this association is strengthened after 2015, following the Paris Accords.

Keywords: carbon emissions, greenhouse gas emissions, firm value, foreign ownership, Korea, Paris Accords

JEL classification codes: G32, Q54

1. Introduction

Green finance has recently gotten widespread attention as environmental factors, such as carbon or greenhouse gas (GHG) emissions, are found to significantly affect firm value. A number of prior studies find a negative relationship between carbon emissions and firm value globally (Chapple et al., 2013; Matsumura et al., 2014; Saka and Oshika, 2014; Griffin et al., 2017; Choi and Luo, 2021). On the other hand, Wang et al. (2014) find a positive relationship between GHG emissions levels and the financial performances of firms in Australia. Using Canada as their setting, Griffin et al. (2021) also find a positive association between firm value and GHG emissions. In this study, we investigate how GHG emissions are associated with firm value, as well as the investor base in Korea.

Korea has implemented several efforts to reduce GHG emissions, following developed countries. These efforts include an introduction of the target management system (TMS) and the emission trading system (ETS). The TMS was initiated in 2011 and has been applied to firms whose latest three-year average annual emissions are above a certain threshold. TMS firms are annually designated GHG emissions targets and fined if they fail to meet the target at the end of the year. On the other hand, the ETS, adopted in 2015, takes the form of a cap-and-trade system. Similar to the TMS, firms whose latest three-year average annual emissions are above the threshold are subject to the ETS. More importantly, for the purpose of this study, firms that are subject to either the TMS or ETS are required to disclose GHG emissions regularly to the Ministry of Environment. The disclosure information is verified by a third party every year.

Taking advantage of the abovementioned information on the carbon emissions disclosure system, we study the impact of GHG emissions on firm value and the investor base in Korea. Investigating Korean firms contributes to existing studies for the following reasons. First, by adopting GHG emissions levels that firms are obliged to disclose, a method similar to that employed by Clarkson et al. (2015), our analyses do not suffer from the selection bias problem that prior studies have faced when using voluntary disclosures to the Carbon Disclosure Project (CDP) or corporate reports. Selection bias stemming from the use of voluntarily reported emissions data has been commonly mentioned as a limitation of several prior studies (Busch et al., 2020; Ilhan et al., 2021; and Berg et al., 2022).[1] Second, by analyzing the investor base in Korea, an emerging economy from the perspective of environmental considerations despite significant economic growth, we investigate whether foreign investors consider domestic firms' environmental performances when investing in emerging markets. Foreign investors and foreign direct investment play an important role in emerging economies like South Korea. In fact, various government agencies report that foreign investors have held more than

[1] Matsumura et al. (2014), Saka and Oshika (2014), Griffin et al. (2017), Choi and Luo (2021) and so on. On the other hand, Chapple et al. (2013) is not subject to selection bias because Australia also imposes the mandatory disclosure of carbon emissions for firms in industries with high levels of GHG emissions.

30% of listed equity shares in South Korea since 2020, the majority of which are held by foreign institutional investors from developed countries such as the U.S., the U.K., Luxembourg, and Singapore. Foreign investors in developed countries are known to prioritize environmental, social, and governance (ESG) issues when making investment decisions (Chapple and Moon, 2005; Oh, Chang, and Martynov, 2011). Thus, we add to the literature by examining whether or not foreign investors indeed consider carbon emissions when making investments in emerging economies.

Our results are as follows. First, we find that firms mandated to disclose GHG emissions are on average valued lower compared to firms without such obligations. This result suggests, as investors learn that firms bound to disclose GHG emissions are the ones that emit GHG above the normal level, investors' valuations of the heavy carbon emitters are lower than that of the other firms. We also find that foreign investors' ownership is lower for mandatory-disclosure firms, suggesting that foreign investors avoid investing in heavy carbon emitters. Within the sample of firms with a mandatory requirement, we find that GHG intensity is negatively associated with firm value. We further confirm that such negative association between GHG intensity and firm value is pronounced after 2015. This result is consistent with prior studies, which argue that investors have become more aware of environmental issues after the Paris Accords, and thus the association of GHG emissions with firm value and environmental risk becomes more significant since 2015 (Monasterolo and De Angelis, 2020; Bolton and Kacperczyk, 2021; Degryse et al., 2023; Seltzer et al., 2022).

This study contributes to the literature that examines the association between the amount of GHG emissions and firm value. Chapple et al. (2013) find a negative relationship between carbon emissions levels and firm value among 58 firms entitled to the Australian carbon ETS in 2007. Matsumura et al. (2014) examine S&P 500 firms subject to voluntary CDP disclosure, while Saka and Oshika (2014) focus on Japanese firms and provide evidence of a negative association between carbon emissions levels and firm value. Griffin et al. (2017) find a negative association between stock price and GHG emissions among the U.S. S&P 500 firms, regardless of voluntary CDP disclosure. More recently, Choi and Luo (2021) find a negative association between carbon emissions and firm value analyzing 500 global firms across 28 countries. They also argue that the negative association is more pronounced for firms in countries with an ETS nation-wide and strict environmental regulations. On the other hand, Wang et al. (2014) find a positive relationship between GHG emissions levels and the financial performances of 69 Australian firms and explain this phenomenon using the nature of Australia's dependence on a mining industry. Griffin et al. (2021) also find a positive association between firm value and GHG emissions in Canada. They also observe that this positive association is amplified for high-GHG-intensity firms. They emphasize that Canada differs in important characteristics from Australia, Europe, and the U.S. One characteristic that distinguishes Canada from Australia, Europe, the U.S. is that the latter depends to a lesser extent on fossil fuels to generate electricity. Korea, however, depends heavily on fossil fuels in energy production, much like the U.S.,

as can be seen in Figure 1.[2] As such, due to the diverse range of major industries on which a country depends, there can be variations in the way a firm's GHG emissions are related to its value. We add to the above-mentioned studies by investigating the relationship between GHG emissions and firm value in Korea, a country arising to recognize and pay attention to global warming. Our results suggest that the association between GHG emissions and firm value is negative in Korea and is amplified after the Paris Accords.

[Insert Figure 1 Here]

This paper is also related to the studies that analyze the association between foreign institutional investors and corporate social responsibility (CSR). Several studies find a positive association between foreign ownership and CSR. Dyck et al. (2019) show that foreign institutional investors from countries with strong involvement in better environmental and social practices affect firms' CSR performances. Marshall et al. (2022) find that firms which comply with the CSR mandate in India have a greater number of foreign institutional investors, providing evidence that applications of CSR can positively affect foreign ownership. Yu and Zheng (2020) argue that the mandatory reporting of CSR increases investment by foreign institutional investors in China. Based on these findings, we expect firms that emit large levels of GHG would be less attractive to foreign institutional investors. Consistent with our expectation, we find that foreign ownership is lower for firms obligated to disclose GHG emissions, suggesting that foreign investors avoid holding stocks of firms that are widely-known to emit high amounts of GHG. This finding is closely related to that of Bolton and Kacperczyk (2021), who document institutional investors' divestment of stocks based on GHG emissions globally, especially of foreign company stocks.

This paper is composed of six sections. Section 2 explains the institutional backgrounds of the TMS and ETS in Korea. Section 3 develops hypotheses and Section 4 describes data and regression models with variables. We report empirical results in Section 5 and conclude in Section 6.

2. Korea's efforts in reducing GHG emissions: TMS and ETS

The Korean government enacted the Framework Act on Low Carbon, Green Growth in 2010, as a voluntary effort to reduce GHG emissions. In 2011, the Ministry of Environment in Korea adopted the TMS, which requires individual firms to annually report the amount of GHG emissions as well as energy consumption and to set an annual goal to reduce national GHG emissions. If a firm fails to meet

[2] From 2001 to 2015, about 24% of energy in Canada was produced from fossil fuels, such as oil, gas, and coal, while about 66% and 70% of energy, respectively, was produced from fossil fuels in Korea and the U.S.

the annual goal, they are subject to monetary fines. These firms are those of which annual GHG emissions are over 50 kt CO_2-eq in firm-level or 15 kt CO_2-eq in facility-level as of 2014.[3] As shown in Table 1, these thresholds have changed over time since the introduction of the TMS at the end of 2011. These reports are collected, evaluated, verified, and managed by the Ministry of Environment's Greenhouse Gas Inventory Research Center (GIR).

[Insert Table 1 Here]

In 2012, the Korean government enacted the Act on the Allocation and Trading of Greenhouse Gas Emission Permits to adopt the ETS, which began in 2015. Firms emitting over 125 kt CO_2-eq or owning a facility emitting over 25 kt CO_2-eq, on the past three-year-average, are controlled under the ETS. The ETS is an efficient market-based method for GHG reduction. The Korean ETS has become East Asia's first nationwide obligatory ETS and the second-largest carbon market after the EU ETS. Under the ETS, firms partially pay for initial GHG emissions allowances and trade them with other firms while keeping their GHG emissions levels to the remaining allowances. The ETS is conducted in three phases. In Phase 1, from 2015 to 2017, 100% of initial GHG emissions allowances are distributed to corporate for free. During the first phase, around 300 firms participate, which accounts for 60 – 70% of Korea's GHG emissions. In Phase 2, from 2018 to 2020, 97% of the allowances are distributed for free and the remaining 3% of the allowances are acquired in the form of an auction. In Phase 3, from 2021 to 2025, 90% of the allowances are distributed for free, with the remaining 10% of the allowances being purchased by auction. Within the given allowances, a corporate can buy or sell their allowances with other corporates. The corporate's remaining allowances can be transferred to the following year. Similar to the TMS, the corporate is charged a fee if it emits GHG more than its annual allowances.

3. Hypotheses Developments

A number of prior studies find that firms emitting high levels of GHG or carbon are penalized and tend to be valued lower than non-heavy carbon emitters (Chapple et al., 2013; Matsumura et al., 2014; Saka and Oshika, 2014; Choi and Luo, 2021). Korean firms discharging GHG more than a particular level must report their GHG emissions amounts annually from 2011 and the list of such firms are publicly available (see section 4.1). Thus, investors can differentiate between heavy carbon emitters, i.e. mandatory-disclosure firms, and the others, i.e. firms not obligated to disclose GHG emissions. We expect firms required to provide GHG emissions reports to be valued low in the market.

[3] The annual GHG emissions level is calculated as a recent three-year-average.

Hypothesis 1: Firms required to submit a GHG emissions report are valued lower than firms that do not submit a GHG emissions report.

Foreign institutional investors in emerging markets are known to have higher CSR awareness than domestic investors. These investors consider ESG policies especially in environmental aspects of firms in making investment decisions (Dyck et al., 2019; Azar et al., 2021). For example, Yu and Zheng (2020) exploit the enactment of China's 2008 CSR mandatory disclosure requirement and show that firms with mandatory CSR reporting undergo an increase in their Qualified Foreign Institutional Investors ownership percentage. Considering the case of mandated CSR regulation in India, Marshall et al. (2022) show that host firms complying with the CSR mandate attract more foreign institutional investors. As such, in emerging economies, CSR compliance appears to be an important factor in attracting foreign investors.

Foreign institutional investors play an important role in the Korean stock market due to substantial foreign institutional stock ownership in Korean firms. According to May 2022 statistics released by the Financial Supervisory Service of South Korea, over 30% of corporate shares in Korea are owned by foreign investors, with more than 76% of registered investors being institutional investors. The majority of these institutional investors are from North America or Europe, countries more attentive to ESG issues than Korea (Aggarwal et al., 2011; Oh et al., 2011; McGuinness et al., 2017). In addition, several studies put emphasis on climate change risk in relation to institutional investors. They find that institutional investors actively engage in both the estimation and reduction of firms' carbon emissions and that these investors require a public release of such information (Dimson et al., 2015; McCahery et al., 2016; Kruger et al., 2020).

Based on the above discussions, we expect that foreign institutional investors' ownership is negatively associated with a firm's GHG emissions level because foreign institutional investors avoid investing in firms emitting high levels of GHG.[4] Therefore, we propose that firms bound to submit annual GHG emissions reports, and are known to emit high levels of GHG, are likely to have a low foreign ownership stake.

Hypothesis 2: Foreign investors' ownership is lower for firms required to submit GHG emissions report.

In *Hypothesis 1*, we assume firms mandated to report GHG emissions levels to be valued lower than firms not obligated to disclose GHG emissions levels. We extend our expectation and posit *Hypothesis 3* that among these firms, those emitting higher levels of GHG would be more severely penalized and thus GHG intensity is negatively associated with firm value.

[4] Foreign institutional investors may also push firms to reduce GHG emissions.

In addition, we consider the period before and after 2015 separately to examine how the relationship between GHG intensity and firm value changes. This consideration is meaningful because 2015 is the year when the Paris Accords was settled. Several studies argue that GHG emissions became more significantly associated with firm value and environmental risk after the Paris Accords because investors started to pay more attention to environmental issues since then (Monasterolo and De Angelis, 2020; Bolton and Kacperczyk, 2021; Seltzer et al., 2022; Degryse et al., 2023). Following prior literature, we hypothesize that the negative association between GHG intensity and firm value becomes stronger after 2015.

Hypothesis 3: Among firms required to report GHG emissions, GHG intensity and firm value are negatively associated. This negative association is pronounced after 2015, the year of the Paris Accords.

4. Sample Data and Variables

4.1. Sample Data

We collect Korean firms' financial information from TS-2000 and market information from FnGuide. We collect data on GHG emissions from the website of the National Greenhouse Gas Management System (NGMS). The GIR annually discloses the list of firms with their GHG emissions reports on the NGMS from 2011. Through the NGMS, we can also identify whether firms belong to the TMS or ETS. Some of these firms are publicly traded, while others are private. We match firm names listed in the NGMS to those in the FnGuide to merge financial information and GHG emissions data. From 2011 to 2014, on average, we have about 190 firms reporting GHG emissions annually. Since 2015, we have about 270 firms reporting GHG emissions annually, with 75% of firms being listed in the ETS, in other words, heavy GHG emitters.[5] As seen from Table 2, the number of firms reporting GHG emissions has increased annually.

[Insert Table 2 Here]

The environmental performance data for Korean firms are collected and evaluated by the Korean Corporate Governance Service (KCGS). The KCGS announces the annual ESG ratings of firms that are listed on KOSPI and KOSDAQ.[6] ESG data includes scores in each category (E, S, and G) and its subcategories for every firm. The environmental sector is evaluated within five subcategories: environmental strategy, environmental organization, environmental management, environmental performance, and response to stakeholders. Among these, we select environmental performance

[5] From 2015 to 2020, the average number of firms in the TMS are about 69 (25.6%) and in the ETS are about 201 (74.4%).
[6] The KCGS evaluates all firms listed on KOSPI and some firms listed on KOSDAQ.

subcategory scores to proxy for a firm's GHG responsibility action. This is because the environmental performance subsector includes a firm's effort in the reduction of GHG, the management of major air pollutants, e.g. CO_2, and whether the firm is "eco-friendly"-certified (Byun, 2018). While the KCGS announces the ESG ratings of firms to the public, the numeric scores for each subcategory are not. We obtain these scores for the years 2011 through 2018 from the KCGS.

To finalize our sample, we exclude financial firms and firms with missing values and limit firms to those listed in KOSPI and KOSDAQ.[7] The final sample yields 14,151 firm-year observations not obligatory to report GHG emissions and 2,115 firm-year observations obligatory to report GHG emissions. Among firms required to report GHG emissions, there are 1,102 firm-year observations listed in the ETS from 2015 to 2020 and 1,013 firm-year observations listed in the TMS from 2011 to 2020. After merging our final sample with data on environmental performance scores, the number of observations drops significantly, especially for the sample of firms that are not required to submit GHG emissions reports, to 7,017 firm-year observations because the data are available only up to 2018 and the ESG ratings database currently includes only large firms.

4.2. Models and Variables

Equations (1) ~ (3) are models to test our hypotheses. Each regression model is identified at the firm-year level, where *i* is a firm and *t* is a year ranging from 2011 to 2020.

Model for Hypothesis 1:

$$Q_{i,t} = \alpha_i GHG\_Dummy_{i,t} + \boldsymbol{\Gamma}_i \boldsymbol{Z}_{i,t-1} \quad (1)$$

Model for Hypothesis 2:

$$FORSHR_{i,t} = \alpha_i GHG\_Dummy_{i,t} + \boldsymbol{\Gamma}_i \boldsymbol{Z}_{i,t-1} \quad (2)$$

Model for Hypotheses 3:

$$Q_{i,t} = \alpha_i GHG\_INT_{i,t} + \boldsymbol{\Gamma}_i \boldsymbol{Z}_{i,t-1} \quad (3)$$

[7] We eliminate financial firms because their firm-level characteristics are not compatible with those of non-financial firms. To eliminate potential outliers, we winsorize continuous variables at the 1% level. For robustness check, we also winsorize the sales growth (*SG*) at the 2% level to further remove outliers and obtain qualitatively similar results.

Z contains variables to control for firm characteristics: size, leverage, cash holdings, cashflow, capital expenditures, sales growth, R&D expenses, advertising expenses, and return on asset. We not only control for year and firm fixed effects but also industry-year fixed effects to address industry trends.[8]

We define two dependent variables in our models. We construct Tobin's Q (*Q*) to proxy for firm value. *Q* is a sum of market value of equity and book value of liabilities divided by book value of total assets. We measure the proportion of foreign ownership (*FORSHR*) as a number of shares held by foreign investors divided by the total number of shares outstanding.

We then construct two explanatory variables. *GHG_Dummy* is a dummy variable equal to one if the firm is required to report GHG emissions levels and zero otherwise. We scale GHG emissions levels by sales to measure the intensity of GHG emissions (*GHG_INT*) (Patten, 2002; Clarkson et al., 2008; Salo and van Ast, 2009; Clarkson, Li et al., 2011; Clarkson, Overell et al., 2011; Sutantoputra et al., 2012; Chapple et al., 2013; Saka and Oshika, 2014; Clarkson et al., 2015; Jung et al., 2018).[9]

Although both absolute and relative measures of GHG emissions have been used in earlier research, we use GHG intensity, the relative measure, because it enables us to compare carbon performance and exposure across firms that vary in size as well as by sector (Salo and van Ast, 2009; Jung et al. 2018). Although penalties associated with the ETS or other regulations are set based on the level rather than the intensity of GHG emissions, the effect of such penalties on firms may be scaled by firm size. Such scaled measures also can more accurately capture practices through which firms switch to less highly polluting or greener technology while controlling for changes in sales or assets. According to Salo and van Ast (2009) and UNEP FI (2013), these two measures are designed to capture multiple dimensions of a firm's GHG profile: absolute emissions are useful for understanding carbon liabilities while relative emissions facilitate comparing the corresponding carbon performance and carbon exposure of firms across sizes and sectors.

We follow prior literature to control for firm characteristics (Hart and Ahuja, 1996; Dowell et al., 2000; Wang et al., 2014). Firm size (*SIZE*) is a natural log of total assets. Leverage (*LEV*) is total debt divided by total assets. Cash holdings (*CSH*) is a sum of cash and short-term investments divided by total assets. We define cashflows (*CF*) as operating income before depreciation divided by total assets in the prior year. Capital expenditures (*CPX*) is a sum of changes in and depreciations of tangibles and intangibles divided by total assets in the prior period. We replace the capital expenditures to zero if the value is negative. Sales growth (*SG*) is sales divided by sales in the prior year. R&D expenses (*XRD*) is R&D expenses divided by total assets in the prior year. Advertising expenses (*AD*) is advertising

[8] To control for time-varying peer effects more directly, we define two industry-adjusted measures: industry-adjusted *GHG_Dummy* and industry-adjusted *GHG_INT*. After replacing these measures in place of our variables of interests, the results in testing all hypotheses do not change qualitatively. We report these results in Appendix C.

[9] We observe that firms with larger assets or sales tend to emit more GHGs. For example, the correlation between the log of GHG emissions level and the log of assets (sales) is 0.619 (0.588) and statistically significant at the 1% level.

expenses divided by total assets in the prior period. Return on Asset (*ROA*) is defined as net income divided by total assets. Lastly, the environmental performance measure (*Log(Env)*) is defined as a natural log of one plus the score for the environmental performance subsector in the environment category assigned by the KCGS.

Summary statistics of our variables are available in Table 3. Summary statistics for firms not required to report GHG emissions are presented in Panel A and those for firms with GHG emissions report obligations are shown in Panel B. *Q, CSH, AD, SG* are smaller for the firms required to give GHG emissions reports. *SIZE, Lev, XRD, CPX*, *ROA*, and *Log(Env)* are larger for these firms compared to non-reporting firms.

[Insert Table 3 Here]

From Table 3, we can infer that, on average, firms obligated to report GHG emissions are valued about 28% less compared to those not required to report. This is consistent with our first hypothesis. In terms of foreign ownership, firms mandated to report GHG emissions have about twice the foreign ownership than those not required to report. This, however, is the opposite of our second hypothesis.[10]

5. Main Results

We first consider a full sample to examine the associations of GHG emissions with firm value and foreign investors' ownership. In Table 4, the main variable of interest is *GHG_Dummy* and the dependent variable is Tobin's Q (*Q*). In column 1, without any controls, the coefficient of interest is statistically significant and negative at the 1% level. A firm obliged to submit a GHG emissions report has *Q* about 0.15 lower than one not obliged to submit a report. After considering relevant controls and year and firm fixed effects, as shown in column 2, we again observe a significant and negative coefficient of interest at the 1% level. In column 3, we add firm and industry-year fixed effects and the *GHG_Dummy* coefficient remains negative and statistically significant at the 1% level, but the economic magnitude is slightly reduced to 0.127. Consistent with Hypothesis 1, since firms obligated to report GHG emissions are considered to be high GHG emitters, these firms on average have *Q* about 0.127 lower than the other firms, that is, non-reporting firms. The magnitude is economically significant as it accounts for 11.8% of the average *Q* among GHG reporting firms in our sample. However, in column 4, for which we additionally control for *Log(Env)*, the coefficient on *GHG_Dummy* loses its explanatory power. Instead, the coefficient on *Log(Env)* becomes negative and statistically significant

[10] Variable definitions are available in Appendix A. Detailed summary statistics and correlations are available in Appendix B.

at the 1% level, with a value of -0.064. This suggests that environmental performance ratings reflect information indicating whether or not a firm is required to disclose GHG emissions. We find signs of control variables to be generally consistent with prior studies.

[Insert Table 4 Here]

In Table 5, we report the results of analyses on the proportion of foreign shares outstanding. In column 1, the coefficient of interest is -0.008 and is statistically significant at the 10% level. With relevant controls and year and firm fixed effects, in column 2, the size of the coefficient of *GHG_Dummy* decreases to -0.007, still significant at the 10% level. However, in column 3, after controlling for industry-year and firm fixed effects, both the economic magnitude and statistical significance of the *GHG_Dummy* coefficient increase. That is, high GHG emitting firms have about a 1 percentage point lower foreign investors' ownership compared to firms that are not mandated to report GHG emissions. This accounts for 8.3% (7.1%) of the mean (standard deviation) of foreign ownership among GHG mandatory-disclosure firms.[11] For column 4, as we control for *Log(Env),* the coefficient of interest remains negative and statistically significant at the 5% level, with a value close to what we observe in column 3. This suggests that *GHG_Dummy* carries additional information that is pertinent to explaining foreign ownership after controlling for environmental performance scores. On the other hand, the coefficient on *Log(Env)* is statistically insignificant. We again find signs of control variables to be generally consistent with prior studies. As such, results in Table 5 support Hypothesis 2.

[Insert Table 5 Here]

Hypothesis 3 states that, among firms required to report GHG emissions, i.e. high GHG emitters, GHG intensity is negatively associated with firm value, and that this negative association is pronounced after the Paris Accords of 2015. To test the hypothesis, we limit our sample to firms reporting GHG emissions and present the results in Table 6. For Panel A, we do not control for *Log(Env)* and there are 2,058 firm-year observations from 2011 to 2020 in columns 1 and 2. We conduct regression analyses after separating firm-year observations based on 2015: before 2015 in columns 3 and 4, and after 2015 in columns 5 and 6. In columns 1 through 6, the dependent variable is firm value (*Q*) and our main variable of interest is GHG intensity (*GHG_INT*).

[Insert Table 6 Here]

[11] The mean (standard deviation) of foreign ownership for GHG mandatory-disclosure firms is 12% (14%).

In column 1, the coefficient on *GHG_INT*, -0.097, is statistically significant at the 5% level. After including control variables in column 2, the coefficient on *GHG_INT*, -0.078, remains negative and statistically significant at the 10% level. A one-standard-deviation increase in *GHG_INT* decreases *Q* by 0.095. This accounts for 8.8% of average *Q* among GHG reporting firms. As such, we confirm that, among firms that are required to disclose GHG emissions, firms with higher GHG intensity are more likely to be valued less. For control variables, *SIZE* is negatively associated with *Q*, while *LEV*, *CSH*, and *CF* are positively associated with *Q*. This is consistent with what we observed in Table 4, but coefficients on *CPX*, *XRD* and *AD* lose statistical significances.

Columns 3 through 6 show the difference in the explanatory power of *GHG_INT* by separating sample periods based on 2015. In column 3, the coefficient of interest is -0.037 and is statistically significant at the 10% level. After we control for firm characteristics in column 4, however, the explanatory power of the *GHG_INT* coefficient is driven away. This suggests that GHG intensity is not associated with the reduction in firm value prior to 2015. On the other hand, in columns 5 and 6, the coefficient of interest is economically meaningful and statistically significant at the 1% level. The coefficient of interest shown in column 6, -0.146, suggests that, after 2015, a one-standard-deviation increase in *GHG_INT* is associated with a decrease in *Q* of 0.178. This 0.178 decrement is about 1.87 times larger than the decrement of 0.095 in column 2. In summary, what we observed in columns 1 and 2 is mainly driven by the period following the Paris Accords, confirming our third hypothesis.

To examine whether GHG emissions can explain the reduction in firm value even after controlling for environmental ratings, we add *Log(Env)* as a control for Panel B. As we control for *Log(Env)*, we restrict our sample to firms whose environmental ratings are available and the sample size drops accordingly. However, the results remain qualitatively the same as those reported in Panel A, confirming our Hypothesis 3. The results in Panel B suggest that GHG intensity additionally captures information for explaining firm value after controlling for environmental performance evaluations.[12]

6. Conclusion

Since the declaration of the Low Carbon, Green Growth as a new national vision in 2008, Korea has started to pay more close attention to global warming. In November 2009, the Korean government set a goal of reducing GHG emissions levels to 30% lower than business-as-usual by 2020, and enacted the Framework Act on Low Carbon, Green Growth in 2010. Regulations such as the TMS and ETS were introduced to control GHG emissions within the country. Since the Paris Accords in 2015, more countries have taken actions to reduce GHG emissions. In this study, we examine how GHG

[12] The Spearman rank correlation between *Log(Env)* and *GHG_INT* is -0.122, which is statistically significant at the 1% level. This implies that firms that exhibit high-GHG-intensity are likely to be given a poor environmental performance rating. In other words, carbon intensity may be an important characteristic for explaining environmental performance evaluations, which is not surprising. In Appendix D, we examine and report the relationship between *Log(Env)* and *GHG_INT*.

emissions and firm value in Korea are associated with each other since the introduction of environmental regulations. We find that firms bound to disclose GHG emissions are valued lower than firms without such obligations. In addition, foreign investors' ownership is lower for mandatory-disclosure firms, suggesting that foreign investors avoid investing in heavy GHG emitters. Within the sample of mandatory-disclosure firms, we find that GHG intensity is negatively associated with firm value. Furthermore, the negative association between GHG intensity and firm value is strengthened after 2015, the year of the Paris Accords. This is consistent with Bolton and Kacperczyk (2021), who find institutional investors' divestment of stocks based on GHG emissions globally, especially for foreign company stocks after the Paris Accords. The results of this paper suggest that GHG emissions affect the investor base and firm value.

Acknowledgements: We thank anonymous reviewers and Simon Shin for useful comments.
Funding: This work was supported by the Sangnam Fellowship Research Fund and the ‘BK21 FOUR (Fostering Outstanding Universities for Research)’ in 2023.
Declarations of conflicts of interest: none

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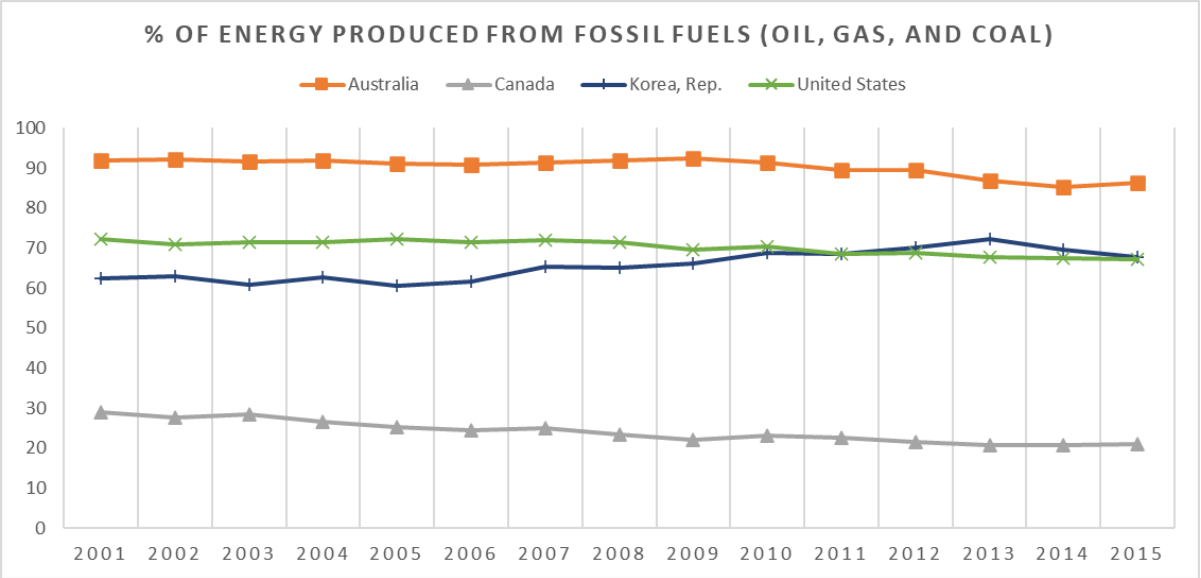

Figure 1. Proportions of energy produced from fossil fuels across countries

The data are available at the World Bank (data.worldbank.org/indicator/).

Table 1. Thresholds for entities of the Target Management System (TMS)

Division	Until 2011.12.31		Beginning 2012.1.1		Beginning 2014.1.1	
	Corporate thresholds	Facility thresholds	Corporate thresholds	Facility thresholds	Corporate thresholds	Facility thresholds
GHG (tCO_2-eq)	125,000	25,000	87,500	20,000	50,000	15,000
Energy (TJ)	500	100	350	90	200	80

This table is available at the National Greenhouse Gas Management System (NGMS) of South Korea.

Table 2. Number of firms required to report greenhouse gas (GHG) emissions

Year	Total	Firms in ETS	Firms in TMS
2011	153	0 (0%)	153 (100%)
2012	180	0 (0%)	180 (100%)
2013	189	0 (0%)	189 (100%)
2014	237	0 (0%)	237 (100%)
2015	248	188 (75.8%)	60 (24.2%)
2016	258	196 (76.0%)	62 (24.0%)
2017	268	197 (73.5%)	71 (26.5%)
2018	272	198 (72.8%)	74 (27.2%)
2019	284	214 (75.4%)	70 (24.6%)
2020	289	215 (74.4%)	74 (25.6%)
TOTAL	2378	1208	1170

This table provides the number of firms required to report GHG emissions levels from 2011 to 2020. The list is divided into two sectors based on the Korean government's effort in GHG emissions reduction. Firms in the emission trading system (ETS) is a number of firms listed in the ETS, available since 2015. Firms in the target management system (TMS) is a number of firms listed in the TMS, available from 2011. Firms are listed in KOSPI and KOSDAQ.

Table 3. Summary Statistics of firm characteristics, GHG emissions levels and environment performance

Panel A. Firms not required to report GHG emissions levels					
Variable	N obs	Mean	StdDev	Min	Max
Q	14,151	1.51	1.19	0.41	13.36
Size	14,151	18.80	1.15	16.54	23.77
LEV	14,151	0.37	0.20	0.02	0.93
CSH	14,151	0.17	0.15	0.00	0.79
CF	14,151	0.04	0.08	-0.29	0.31
XRD	14,151	0.01	0.03	0.00	0.17
AD	14,151	0.01	0.01	0.00	0.09
FORSHR	14,151	0.06	0.10	0.00	0.56
CPX	14,151	0.04	0.06	0.00	0.41
SG	14,151	1.06	0.37	0.17	4.69
ROA	14,151	-0.00	0.12	-0.76	0.32
Log(Env)	7,017	1.60	1.23	0	4.20
Panel B. Firms required to report GHG emissions levels					
Variable	N obs	Mean	StdDev	Min	Max
Q	2,115	1.08	0.60	0.37	5.66
Size	2,115	20.66	1.65	17.78	25.31
LEV	2,115	0.44	0.21	0.04	0.94
CSH	2,115	0.09	0.09	0.00	0.47
CF	2,115	0.04	0.06	-0.22	0.26
XRD	2,115	0.01	0.01	0	0.09
AD	2,115	0.00	0.01	0	0.06
FORSHR	2,115	0.12	0.14	0	0.73
CPX	2,115	0.05	0.06	0	0.69
SG	2,115	1.02	0.20	0.16	2.68
ROA	2,115	0.02	0.06	-0.30	0.25
GHG_INT	2,115	0.50	1.22	0.00	9.96
Log(Env)	1,380	2.54	0.76	0	4.10

This table presents the summary statistics for our main variables in regression models. The sample period ranges from 2011 to 2020. For environmental performance, the sample period goes up to 2018. Panel A reports the statistics of firms not required to report GHG emissions and Panel B lists the statistics of firms required to report GHG emissions. We have fewer observations for *Log(Env)* because the sample period runs up to 2018 and the database covers environmental performance scores only for large firms. *Q* is firm value. *Size* is the log of book value of assets of a firm. *LEV* is the financial leverage. *CSH* is the cash holdings. *CF* is cashflow. *XRD* is R&D expenditures. *AD* is advertising expenditures. *FORSHR* is the percentage of foreign shares. *CPX* is capex expenditures. *SG* is sales growth. *ROA* is return on assets. *GHG_INT* is GHG intensity. *Log(Env)* is the log of one plus the environmental performance score. The construction of all measures is described in Appendix A. All continuous variables are winsorized at the 1st and 99th percentile annually, to eliminate potential outliers.

Table 4. Regressions of firm value on GHG mandatory reporting firms

Dependent variable: Tobin's Q (*Q*)				
	(1)	(2)	(3)	(4)
GHG_Dummy	-0.150***	-0.146***	-0.127***	-0.081
	(0.042)	(0.041)	(0.041)	(0.053)
Size		-0.342***	-0.353***	-0.318***
		(0.050)	(0.050)	(0.078)
LEV		0.370***	0.375***	0.583***
		(0.113)	(0.112)	(0.160)
CSH		0.630***	0.608***	0.437**
		(0.115)	(0.114)	(0.198)
CF		1.235***	1.235***	1.313***
		(0.228)	(0.230)	(0.432)
CPX		0.295**	0.320***	-0.155
		(0.122)	(0.123)	(0.239)
SG		0.015	0.018	-0.026
		(0.022)	(0.023)	(0.045)
XRD		4.814***	4.633***	4.111*
		(1.496)	(1.485)	(2.300)
AD		4.4636**	4.485***	-1.895
		(1.788)	(1.732)	(2.717)
ROA		-0.192	-0.161	0.188
		(0.168)	(0.166)	(0.267)
Log(Env)				-0.064***
				(0.015)
Year FE	YES	YES	NO	NO
Firm FE	YES	YES	YES	YES
Industry-Year FE	NO	NO	YES	YES
N	15492	15492	15492	5747
R^2	0.645	0.660	0.666	0.789

This table shows the regression results of firm value on firms mandated to report GHG emissions. The sample period ranges from 2011 to 2020. The dependent variable *Q* is the Tobin's Q defined as a ratio of firm's market value of assets plus book value of debt to its book value of assets. *GHG_Dummy* is equal to one if the firm is obliged to report GHG emissions and zero otherwise. Size is the log of book value of assets of a firm. *LEV* is the financial leverage. *CSH* is the cash holdings. *CF* is cashflow. *XRD* is R&D expenditures. *AD* is advertising expenditures. *CPX* is capex expenditures. *SG* is sales growth. *ROA* is return on assets. *Log(Env)* is the log of one plus the environmental performance score. See Appendix A for variable definitions. We include firm and year fixed effects for the first two columns, and firm and industry-year fixed effects for the last two columns. All continuous variables are winsorized at the 1st and 99th percentile annually, to eliminate potential outliers. In the parentheses are standard errors reported for each coefficient. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5. Regressions of foreign shares outstanding on GHG mandatory reporting firms

Dependent variable: Foreign Shares (*FORSHR*)				
	(1)	(2)	(3)	(4)
GHG_Dummy	-0.008*	-0.007*	-0.010**	-0.012**
	(0.004)	(0.004)	(0.004)	(0.005)
Q		0.007***	0.007***	0.026***
		(0.001)	(0.001)	(0.005)
Size		0.023***	0.022***	0.004***
		(0.003)	(0.003)	(0.002)
LEV		-0.009	-0.011	-0.029**
		(0.007)	(0.007)	(0.013)
CSH		0.012*	0.014**	0.026**
		(0.006)	(0.006)	(0.013)
CF		0.076***	0.076***	0.130***
		(0.013)	(0.013)	(0.027)
CPX		-0.021***	-0.020***	-0.061***
		(0.006)	(0.006)	(0.015)
SG		-0.05***	-0.05***	-0.008**
		(0.001)	(0.001)	(0.003)
XRD		0.079	0.060	0.087
		(0.069)	(0.070)	(0.171)
AD		0.159*	0.124	0.257
		(0.094)	(0.093)	(0.182)
ROA		-0.008	-0.008	0.001
		(0.009)	(0.008)	(0.014)
Log(Env)				-0.001
				(0.001)
Year FE	YES	YES	NO	NO
Firm FE	YES	YES	YES	YES
Industry-Year FE	NO	NO	YES	YES
N	15477	15477	15477	5747
R^2	0.862	0.868	0.873	0.915

This table shows the regression results of foreign shares outstanding on firms mandated to report GHG emissions. The sample period ranges from 2011 to 2020. The dependent variable *FORSHR* is the ratio of a firms' foreign shares outstanding to sum of common and preferred shares outstanding. *GHG_Dummy* is equal to one if the firm is obliged to report GHG emissions and zero otherwise. *Q* is the Tobin's Q defined as a ratio of firm's market value of assets plus book value of debt to its book value of assets. Size is the log of book value of assets of a firm. *LEV* is the financial leverage. *CSH* is the cash holdings. *CF* is cashflow. *XRD* is R&D expenditures. *AD* is advertising expenditures. *CPX* is capex expenditures. *SG* is sales growth. *ROA* is return on assets. *Log(Env)* is the log of one plus the environmental performance score. See Appendix A for variable definitions. We include firm and year fixed effects for the first two columns, and firm and industry-year fixed effects for the last two columns. All continuous variables are winsorized at the 1st and 99th percentile annually, to eliminate potential outliers. In the parentheses are standard errors reported for each coefficient. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6. Regressions of firm value on GHG intensity

Panel A. Before considering environmental performance evaluations as a control

Dependent variable: Tobin's Q (*Q*)						
	Full Sample Period 2011 ~ 2020		Before Paris Accords 2011 ~ 2014		After Paris Accords 2015 ~ 2020	
	(1)	(2)	(3)	(4)	(5)	(6)
GHG_INT	-0.097**	-0.078*	-0.037*	-0.033	-0.151***	-0.146***
	(0.040)	(0.040)	(0.021)	(0.021)	(0.049)	(0.044)
Size		-0.195**		-0.165		-0.151
		(0.092)		(0.146)		(0.131)
LEV		0.413**		0.828*		0.124
		(0.194)		(0.495)		(0.217)
CSH		0.478*		-0.662		0.386
		(0.259)		(0.508)		(0.319)
CF		1.021***		0.933*		0.803
		(0.389)		(0.487)		(0.634)
CPX		0.127		-0.026		0.075
		(0.250)		(0.133)		(0.517)
SG		0.083		-0.098		0.077
		(0.081)		(0.094)		(0.096)
XRD		5.294		-12.942**		8.155
		(3.721)		(5.591)		(5.091)
AD		3.021		-3.160		7.846
		(2.548)		(3.195)		(4.877)
ROA		-0.443		0.138		-0.768
		(0.558)		(0.380)		(0.770)
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
N	2058	2058	628	628	1430	1430
R^2	0.755	0.767	0.824	0.840	0.821	0.829

Panel B. After considering environmental performance evaluations as a control

Dependent Variable: Tobin's Q (*Q*)						
	Full Sample Period 2011-2019		Before Paris Accords 2011-2014		After Paris Accords 2015-2019	
	(1)	(2)	(3)	(4)	(5)	(6)
*GHG*_INT	-0.092***	-0.100***	-0.069	-0.091	-0.105***	-0.088**
	(0.029)	(0.027)	(0.082)	(0.100)	(0.040)	(0.038)
SIZE		-0.426***		-0.345		-0.430***
		(0.077)		(0.210)		(0.126)
LEV		0.432*		0.648		0.080
		(0.247)		(0.392)		(0.324)
CSH		0.236		-0.355		-0.059
		(0.292)		(0.390)		(0.277)
CF		0.996**		1.026		0.815
		(0.461)		(0.633)		(0.573)
CPX		-0.072		-0.200		-0.262
		(0.258)		(0.467)		(0.317)
SG		0.048		-0.081		0.082
		(0.065)		(0.206)		(0.063)
XRD		0.421		-11.078*		1.637
		(5.777)		(6.690)		(7.972)
AD		-1.901		-7.185		-0.288
		(2.915)		(7.501)		(3.527)
ROA		0.041		-0.089		-0.232
		(0.376)		(0.391)		(0.543)
Log(Env)		0.001		0.064		0.006
		(0.016)		(0.038)		(0.016)
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
N	1339	1339	402	402	937	937
R2	0.795	0.813	0.875	0.889	0.865	0.875

This table shows the regression results of firm value on GHG intensity. The full sample period ranges from 2011 to 2020. The dependent variable *Q* is the Tobin's Q defined as a ratio of firm's market value of assets plus book value of debt to its book value of assets. *GHG_INT* is the GHG intensity, defined as GHG emissions scaled by sales. *Size* is the log of book value of assets of a firm. *LEV* is the financial leverage. *CSH* is the cash holdings. *CF* is cashflow. *XRD* is R&D expenditures. *AD* is advertising expenditures. *CPX* is capex expenditures. *SG* is sales growth. *ROA* is return on assets. *Log(Env)* is the log of one plus the environmental performance score. See Appendix A for variable definitions. Panel A presents the regression results where we do not account for *Log(Env)* as a control, while Panel B presents the regression results where we include *Log(Env)* as a control. The first two columns cover full sample periods, whereas columns 3 and 4 cover the period before the Paris Accords, 2011 – 2014, and columns 5 and 6 cover the period after the Paris Accords, 2015 – 2020. We include firm and year fixed effects throughout all columns. All continuous variables are winsorized at the 1st and 99th percentile annually, to eliminate potential outliers. In the parentheses are standard errors reported for each coefficient. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Appendix A. Variable Definitions

Variables	Name	Definition
SIZE	Size	Log of total asset.
Q	Tobin's Q	(Market value of equity+ book value of debt) / total asset.
LEV	Financial Leverage	Total debt / total asset.
CSH	Cash holdings	(Cash + short-term investments) / total asset.
CF	Cashflow	Operating income before depreciation / total asset in prior year.
XRD	R&D Expenses	R&D expenses / total asset in prior year.
AD	Advertising Expenses	Advertising expenses / total asset in prior year.
FORSHR	Foreign Shares	Foreign Shares / (common shares + preferred shares).
CPX	Capital Expenditures	[Δ(tangibles + intangibles) + depreciations of (tangibles and intangibles)] / total asset in prior year, CPX = 0 if negative.
SG	Sales Growth	Sales / sales in the prior year.
ROA	Return on Asset	Net income / total asset.
GHG_Dummy	GHG Dummy	If the firm is required to report GHG emissions, it is equal to one, otherwise zero.
ETS	ETS Firm Dummy	ETS = 1 if the firm is listed in the emission trading system, otherwise ETS = 0.
TMS	TMS Firm Dummy	TMS = 1 if the firm is listed in the target management system, otherwise TMS = 0.
GHG_INT	Intensity of Greenhouse Gas Emissions	Greenhouse gas emissions / sales.
Log(GHG)	Log of Greenhouse Gas Emissions	Log of greenhouse gas emissions.
Log(Env)	Log of environmental score	Log of (1 + the score of the subsector in E(SG) classified as an environmental performance).

Appendix B. Summary Statistics and Correlations

Table B1 reports the summary statistics for our main variables in regression models: firm characteristics, GHG intensity, GHG emissions, and environmental performance for firms assigned to the emission trading system (ETS) and the target management system (TMS). The sample period for firms assigned to the ETS ranges from 2015 to 2020. The sample period for firms assigned to the TMS ranges from 2011 to 2020. For environmental performance, the sample period goes up to 2018. Thus, we have a fewer number of observations for *Log(GHG)* and *Log(Env)*. Table B2 reports the average correlations of the main variables used in the regression analyses for four sample groups: (1) firms that are not required to report GHG emissions levels, (2) firms that are required to report GHG emissions levels, (3) firms that are included in the ETS, and (4) firms that are included in the TMS. See Appendix A for variable definitions.

Table B1. Summary statistics of firms assigned to the ETS and the TMS

Panel A. Firms assigned to the ETS, Sample period: 2015 – 2020

Variable	N obs	Mean	StdDev	Min	Max
Size	1,102	20.82	1.64	17.98	25.09
Q	1,102	1.10	0.66	0.37	5.66
LEV	1,102	0.44	0.21	0.04	0.94
CSH	1,102	0.09	0.10	0.00	0.47
CF	1,102	0.04	0.06	-0.22	0.22
XRD	1,102	0.01	0.01	0	0.09
AD	1,102	0.00	0.01	0	0.06
FORSHR	1,102	0.12	0.14	0.00	0.70
CPX	1,102	0.05	0.06	0	0.69
SG	1,102	1.01	0.21	0.16	2.68
ROA	1,102	0.02	0.07	-0.30	0.25
GHG_INT	1,102	0.62	1.44	0.00	9.96
Log(GHG)	618	19.09	1.55	16.40	23.70
Log(Env)	618	2.51	0.72	0	4.10

Panel B. Firms assigned to the TMS, Sample period: 2011 – 2020

Variable	N obs	Mean	StdDev	Min	Max
Size	1,013	20.49	1.64	17.78	25.31
Q	1,013	1.06	0.52	0.41	5.05
LEV	1,013	0.45	0.20	0.05	0.94
CSH	1,013	0.09	0.08	0.00	0.45
CF	1,013	0.05	0.05	-0.13	0.26
XRD	1,013	0.01	0.01	0	0.09
AD	1,013	0.00	0.01	0	0.06
FORSHR	1,013	0.12	0.14	0	0.73
CPX	1,013	0.05	0.07	0	0.69
SG	1,013	1.03	0.19	0.31	2.14
ROA	1,013	0.02	0.06	-0.30	0.24
GHG_INT	1,013	0.36	0.90	0.00	9.54
Log(GHG)	762	18.67	1.57	16.40	23.66
Log(Env)	762	2.57	0.79	0	4.05

Table B2. Correlation table

Panel A. Firms not required to report GHG emissions levels

	Size	*Q*	*LEV*	*CSH*	*CF*	*XRD*	*AD*	*FORSHR*	*CPX*	*SG*	ROA
Size	1.00										
Q	-0.18***	1.00									
LEV	0.14***	-0.07***	1.00								
CSH	-0.29***	0.26***	-0.32***	1.00							
CF	0.22***	-0.00	-0.19***	0.03***	1.00						
XRD	-0.16***	0.29***	-0.08***	0.20***	-0.04***	1.00					
AD	0.05***	0.15***	-0.06***	0.04***	0.13***	0.05***	1.00				
FORSHR	0.40***	0.10***	-0.13***	0.07***	0.24***	0.01	0.13***	1.00			
CPX	-0.02***	0.11***	0.10***	-0.08***	0.14***	0.09***	0.06***	-0.01*	1.00		
SG	0.03***	0.12***	0.01	0.02*	0.32***	0.08***	0.05***	0.03***	0.14***	1.00	
ROA	0.26***	-0.12***	-0.28***	-0.02***	0.73***	-0.03***	0.05***	0.18***	0.10***	0.21***	1.00

Panel B. Firms required to report GHG emissions levels

	Size	*Q*	*LEV*	*CSH*	*CF*	*XRD*	*AD*	*FORSHR*	*CPX*	*SG*	*ROA*	*GHG_INT*
Size	1.00											
Q	0.03	1.00										
LEV	0.12***	0.05**	1.00									
CSH	-0.09***	0.12***	-0.38***	1.00								
CF	0.12***	0.28***	-0.30***	0.21***	1.00							
XRD	0.19***	0.30***	-0.04*	0.02	0.13***	1.00						
AD	0.19***	0.09***	0.01	0.02	0.12***	0.04*	1.00					
FORSHR	0.63***	0.11***	-0.16***	0.14***	0.26***	0.25***	0.22***	1.00				
CPX	0.09***	0.17***	0.15***	-0.10***	0.17***	0.18***	0.10***	0.09***	1.00			
SG	0.03	0.18***	0.03	-0.06***	0.3***	0.06***	0.06***	0.05**	0.19***	1.00		
ROA	0.07***	0.16***	-0.47***	0.21***	0.75***	0.11***	0.06***	0.20***	0.09***	0.22***	1.00	
GHG_INT	-0.11***	-0.04*	-0.07***	0.00	0.00	-0.10***	-0.11***	-0.10***	-0.01	-0.01	0.04*	1.00

Panel C. Firms included in the ETS

	Size	*Q*	*LEV*	*CSH*	*CF*	*XRD*	*AD*	*FORSHR*	*CPX*	*SG*	*ROA*	*GHG_INT*
Size	1.00											
Q	0.01	1.00										
LEV	0.06*	0.03	1.00									
CSH	-0.10***	0.14***	-0.37***	1.00								
CF	0.16***	0.25***	-0.33***	0.20***	1.00							
XRD	0.27***	0.23***	-0.05*	0.00	0.11***	1.00						
AD	0.20***	0.05	0.04	-0.02	0.11***	0.02	1.00					
FORSHR	0.69***	0.08***	-0.14***	0.07**	0.28***	0.32***	0.24***	1.00				
CPX	0.12***	0.17***	0.15***	-0.08***	0.15***	0.19***	0.10***	0.12***	1.00			
SG	0.02	0.20***	0.00	-0.05	0.30***	0.07**	0.04	0.04	0.12***	1.00		
ROA	0.10***	0.13***	-0.46***	0.20***	0.75***	0.10***	0.04	0.19***	0.08***	0.22***	1.00	
GHG_INT	-0.13***	-0.04	-0.06*	0.02	0.02	-0.11***	-0.13***	-0.13***	0.00	-0.04	0.07**	1.00

Panel D. Firms included in the TMS

	Size	*Q*	*LEV*	*CSH*	*CF*	*XRD*	*AD*	*FORSHR*	*CPX*	*SG*	*ROA*	*GHG_INT*
Size	1.00											
Q	0.06*	1.00										
LEV	0.20***	0.09***	1.00									
CSH	-0.08***	0.07**	-0.41***	1.00								
CF	0.09***	0.35***	-0.26***	0.23***	1.00							
XRD	0.12***	0.40***	-0.03	0.05	0.15***	1.00						
AD	0.19***	0.14***	-0.02	0.06*	0.13***	0.05*	1.00					
FORSHR	0.56***	0.15***	-0.18***	0.23***	0.24***	0.18***	0.21***	1.00				
CPX	0.06*	0.18***	0.14***	-0.12***	0.18***	0.16***	0.09***	0.07**	1.00			
SG	0.06*	0.15***	0.06**	-0.07**	0.30***	0.06*	0.08**	0.06*	0.27***	1.00		
ROA	0.04	0.21***	-0.48***	0.23***	0.75***	0.13***	0.07**	0.22***	0.10***	0.22***	1.00	
GHG_INT	-0.12***	-0.05	-0.08**	-0.05	-0.01	-0.09***	-0.09***	-0.08***	0.00	0.06*	0.01	1.00

Appendix C. Time-varying Peer Effects

In Appendix C we control directly for time-varying peer effects across our three hypotheses. For H1 and H2, we construct an industry-adjusted *GHG dummy*, which is a firm's *GHG dummy* minus the portion of firms that are required to disclose GHG emissions in the same industry and year. In addition, for H3, we construct industry-adjusted *GHG_INT*, which is a firm's *GHG_INT* minus the median of other firms' *GHG_INT* in the same industry and year. In Table C1 Panels A and B, we include firm and year fixed effects for the first two columns and firm and industry-year fixed effects in the last column. In Table C1 Panel C, we include firm and year fixed effects for every column. See Appendix A for variable definitions. All continuous variables are winsorized at the 1st and 99th percentile annually, to eliminate potential outliers. In the parentheses are standard errors reported for each coefficient. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table C1. Controlling for time-varying peer effects

Panel A. Tobin's Q vs. GHG_Dummy

	Dependent variable: Tobin's Q (*Q*)		
	(1)	(2)	(3)
GHG_Dummy (adjusted)	-0.132***	-0.122***	-0.127***
	(0.041)	(0.041)	(0.041)
Size		-0.341***	-0.353***
		(0.050)	(0.050)
LEV		0.372***	0.375***
		(0.113)	(0.112)
CSH		0.630***	0.608***
		(0.115)	(0.114)
CF		1.252***	1.235***
		(0.228)	(0.230)
CPX		0.295**	0.320***
		(0.122)	(0.123)
SG		0.015	0.018
		(0.022)	(0.023)
XRD		4.814***	4.633***
		(1.496)	(1.485)
AD		4.456**	4.485***
		(1.788)	(1.732)
ROA		-0.195	-0.160
		(0.168)	(0.166)
Year FE	YES	YES	NO
Firm FE	YES	YES	YES
Industry-Year FE	NO	NO	YES
N	15492	15492	15492
R2	0.645	0.660	0.666

Panel B. Foreign shares vs. GHG_Dummy

Dependent variable: Foreign Shares (*Forshares*)			
	(1)	(2)	(3)
GHG_Dummy (adjusted)	-0.010**	-0.010**	-0.010**
	(0.004)	(0.004)	(0.004)
Q		0.007***	0.007***
		(0.001)	(0.001)
Size		0.023***	0.022***
		(0.003)	(0.003)
LEV		-0.009	-0.011
		(0.007)	(0.007)
CSH		0.012*	0.014**
		(0.006)	(0.006)
CF		0.076***	0.076***
		(0.013)	(0.013)
CPX		-0.021***	-0.020***
		(0.006)	(0.006)
SG		-0.005***	-0.005***
		(0.001)	(0.001)
XRD		0.079	0.060
		(0.069)	(0.070)
AD		0.159*	0.124
		(0.094)	(0.093)
ROA		-0.008	-0.008
		(0.009)	(0.008)
Year FE	YES	YES	NO
Firm FE	YES	YES	YES
Industry-Year FE	NO	NO	YES
N	15477	15477	15477
R2	0.862	0.868	0.873

Panel C. Tobin's Q vs. GHG_INT

Dependent variable: Tobin's Q (*Q*)						
	Full Sample Period		2011-2014		2015-2020	
	(1)	(2)	(3)	(4)	(5)	(6)
GHG_INT (adjusted)	-0.070***	-0.046**	-0.032**	-0.026	-0.092**	-0.070**
	(0.020)	(0.020)	(0.013)	(0.018)	(0.038)	(0.033)
Size		-0.176**		-0.162		-0.153
		(0.070)		(0.100)		(0.117)
LEV		0.444***		0.872***		0.108
		(0.141)		(0.324)		(0.199)
CSH		0.556***		-0.479		0.458**
		(0.196)		(0.324)		(0.229)
CF		1.025**		1.030**		0.745
		(0.401)		(0.407)		(0.547)
CPX		0.119		-0.014		0.087
		(0.171)		(0.123)		(0.320)
SG		0.103*		-0.087		0.102
		(0.060)		(0.072)		(0.081)
XRD		5.162*		-13.046**		7.832**
		(2.625)		(5.567)		(3.440)
AD		3.015		-2.92		7.908*
		(2.644)		(3.405)		(4.419)
ROA		-0.433		0.192		-0.773
		(0.516)		(0.354)		(0.616)
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
N	2027	2027	613	613	1414	1414
R2	0.753	0.765	0.818	0.835	0.821	0.828

Appendix D. GHG Intensity and Environmental Performance Evaluations

In appendix D, we examine the association between GHG intensity and a firm's environmental performance evaluations among firms mandated to report GHG emissions. The sample period ranges from 2011 to 2018. The dependent variable *Log(Env)* is the log of one plus environmental score, which specifically measures the environmental performance subsector in the environment category. In addition to *GHG INT*, we analyze the association between *Log(Env*) and unscaled greenhouse gas emissions, *Log(GHG)*. We expect outsiders to rate firms that exhibit high GHG intensity or high GHG emissions levels poorly. For example, as they incorporate information on GHG emissions, ESG rating agencies will evaluate such firms poorly, ceteris paribus, along the relevant environmental dimensions.

For Table D1 columns 1 and 3, the variable of interest is *GHG_INT*. For columns 2 and 4, the variable of interest is *Log(GHG)*. We include firm and year fixed effects for every column. The coefficient of interest is negative and statistically significant in all columns. The coefficient in column 3, -0.126, implies that a one-standard-deviation increase in *GHG_INT* decreases *Log(Env)* by 0.154. As such, our results remain consistent with our expectations.

See Appendix A for variable definitions. All continuous variables are winsorized at the 1st and 99th percentile annually, to eliminate potential outliers. In the parentheses are standard errors reported for each coefficient. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table D1. Regressions of environment performance on GHG intensity and GHG emissions amount

	Dependent variable*: Log(Env)*			
	(1)	(2)	(3)	(4)
GHG_INT	-0.129***		-0.126***	
	(0.035)		(0.039)	
Log(GHG)		-0.223*		-0.209*
		(0.114)		(0.111)
Q			0.061	0.060
			(0.097)	(0.097)
Size			-0.152	-0.084
			(0.108)	(0.111)
LEV			-0.190	-0.113
			(0.301)	(0.299)
CSH			-0.352	-0.307
			(0.465)	(0.459)
CF			-0.462	-0.419
			(0.680)	(0.690)
CPX			-0.623*	-0.613*
			(0.336)	(0.337)
SG			0.443***	0.500***
			(0.131)	(0.132)
XRD			-11.905	-11.556
			(7.802)	(8.000)
AD			0.064	0.534
			(2.794)	(2.882)
ROA			-0.590	-0.509
			(0.475)	(0.469)
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
N	1311	1311	1311	1311
R^2	0.557	0.569	0.557	0.568