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Accounting and Economicsjournal homepage: www.elsevier.com/locate/jcaeCorporate governance, compensation mechanisms, and
voluntary disclosure of carbon emissions: Evidence from KoreaJiyoung Park^a, Jiyoung Lee^{b,*}, Jewon Shin^c^aYonsei University, School of Business, Building 212, 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, South Korea^bYonsei University, School of Business, Building 212, 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, South Korea^cPennsylvania State University, Smeal College of Business, Business Building, University Park, PA 16802, USA

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ABSTRACT

We investigate the effects of incentive-alignment mechanisms on voluntary disclosure of carbon emissions in Korea, a latecomer in incorporating environmental practices into business operations. We consider in particular the effects of corporate governance and compensation mechanisms. We find that international aspects of governance mechanisms, measured by foreign ownership and foreign subsidiaries, are positively associated with the likelihood that a firm discloses carbon emissions voluntarily as well as with the extent of the details included in such disclosures. Similarly, strong internal governance, measured by board independence and gender diversity, makes voluntary, detailed carbon emissions disclosures more likely. Moreover, firms that employ compensation schemes that explicitly align corporate social responsibility (CSR) with CEO pay and those that set carbon emissions targets, which may be used to define thresholds for CEO bonuses, are more likely to voluntarily disclose carbon emissions information and to do so more extensively. As such, both international influence and internal factors that affect corporate governance and compensation structures, all of which are well-known incentive-alignment mechanisms, play important roles in voluntary carbon emissions disclosure decisions in emerging markets.

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1. Introduction

While South Korea has experienced rapid economic expansion over the past few decades, it has also left an enormous carbon emissions footprint, ranking 17th in cumulative carbon dioxide emissions among 219 countries (Ritchie and Roser, 2020). Following green actions taken in developed markets, Korea recently unveiled its own Green New Deal in 2020 with the goal of transitioning to a low-carbon and green economy. In particular, the Korean government announced step-by-step plans to improve corporate disclosure rules for public firms. The first step encourages firms to publish 'sustainability reports' voluntarily by 2025. The second step requires public firms with total assets valued at over two trillion Korean won (equivalent to approximately two billion US dollars) to disclose environmental, social, and governance (ESG) activities beginning in 2025, and the last step is a mandatory disclosure requirement that applies to all firms listed on the Korea Composite Stock Price Index (KOSPI) beginning in 2030. Although several years remain before the mandatory disclosure require-

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ment takes effect, a number of Korean firms have already adopted voluntary disclosure of carbon emissions. In this paper, we explore the characteristics of Korean firms that voluntarily disclose carbon emissions to understand the factors that promote voluntary disclosure in emerging markets. Moreover, we investigate whether these factors are associated with the extent of the details provided in carbon emissions disclosures.

A number of prior studies analyze voluntary corporate disclosure of carbon emissions in Europe, the US, China, and Australia (Tsang et al., 2019; Liao et al., 2015; He et al., 2021; Ben-Amar et al., 2017; Krishnamurti and Velayutham 2018; Jaggi et al., 2018). Factors that have been identified in prior studies that influence voluntary disclosure of carbon emissions include economic and social pressure (Luo et al., 2012), superior ESG performance (Kim et al., 2021), strong internal governance (Ben-Amar and McIlkenny, 2015), stock-based compensation (Nagar et al., 2003), and ownership structure (Tsang et al., 2019). Despite a large number of studies that explore developed markets and China, voluntary corporate disclosure of carbon emissions in Korea merits investigation in its own right for several reasons. First, as mentioned above, South Korea is considered a latecomer with respect to incorporating ESG into business practices when compared with Western countries (Chapple and Moon, 2005), despite its robust economic growth. Even large Korean firms such as chaebol have begun formulating ESG strategies within the past few years. ESG committees on boards and corporate ESG bonds barely existed until 2020, and a power purchase agreement (PPA) was not even available until October 2021. These phenomena suggest that the integration of climate risk into business planning remains in the earliest stages for Korean firms. Consequently, drivers of voluntary carbon disclosures may differ from those that have emerged in developed markets.

Second, foreign investors own a large portion of Korean firms' shares. Most of these investors are based in Western countries and they tend to pay more attention to ESG issues (Brancato, 1997; Chapple and Moon, 2005; Oh et al., 2011; Shu and Chiang, 2020).¹ According to prior studies, foreign investors have been playing an important role in shaping corporate policies in Korean firms, weighing in on governance structures and CSR compliance (Oh et al., 2011).

We hypothesize that, in the absence of mandatory disclosure requirements, managers in emerging-market firms have little incentive to disclose carbon emissions. This is because in emerging markets the costs of carbon disclosure likely exceed the benefits. For example, compared with other types of voluntary disclosure, carbon emissions disclosures can expose a firm to adverse consequences for their business operations (Coburn et al., 2011; Krishnamurti and Velayutham, 2018). Field et al. (2005) suggest that environmental reporting could leave firms vulnerable to costly lawsuits. Furthermore, Luo et al.'s (2013) finding that the propensity to disclose emissions is positively associated with the resources that are available to a firm, particularly in developing nations, further suggests the costly consequences of voluntary disclosure of carbon emissions. On the other hand, carbon disclosure reduces information asymmetry between insiders and outsiders, which in developed markets could increase corporate value. Because investors in emerging markets typically pay limited attention to environmental issues or regard environmental efforts as costly, this benefit may not be significant in Korea.

We begin our analysis by investigating whether and to what extent incentive-alignment mechanisms influence voluntary disclosure of carbon emissions as well as the extent of such disclosure. We use two variables to measure voluntary disclosure. First, we measure whether a firm voluntarily discloses its carbon emissions information to the public. Second, we exploit information on the scope of carbon emissions to measure the extent of or detail included in carbon emissions disclosure. A firm's carbon emissions are generally classified into three categories based on the scope at which the emissions are monitored: Scope 1 emissions are direct emissions from sources that a company owns or controls directly; Scope 2 emissions are indirect emissions that occur in the process of using electricity, heat, or steam that a company purchases; and Scope 3 emissions are indirect emissions from points along a company's value chain, employee commuting trips, and business trips for which a company is indirectly responsible. We create a variable, $Disclosure^{Scope}$, that equals the number of disclosed items represented by a total emissions dummy, Scope 1 emissions, Scope 2 emissions, and Scope 3 emissions divided by 4 ($Disclosure^{Dummy} + scope1 \text{ disclosure dummy} + scope2 \text{ disclosure dummy} + scope3 \text{ disclosure dummy}$)/4. For incentive-alignment mechanisms, we first focus on international attributes of corporate governance based on the important role that foreign investors, especially those based in Western countries, play in emerging markets. We additionally consider internal corporate governance and CEO compensation schemes.

In a series of empirical analyses, we find that these incentive-alignment mechanisms not only enhance voluntary disclosure of carbon emissions but also result in more finely detailed disclosure. First, we find that international influence on corporate governance, measured by the number of foreign subsidiaries a firm operates and the number of foreign countries in which those subsidiaries operate, is positively associated with the propensity to disclose carbon emissions voluntarily as well as with the extent of the details disclosed. In addition, we find that European investors, among all foreign investors, play an important role in promoting detailed voluntary disclosure.

Second, board independence and gender diversity on boards are positively associated with voluntary disclosure of carbon-emissions information in Korea, which is also the case in developed markets. On the other hand, in our OLS regressions these board characteristics are not significantly associated with $Disclosure^{Scope}$. To address the concern that board independence and gender diversity are endogenous,² we employ an instrumental variable (IV) approach (Ben-Amar et al., 2017;

¹ The Korea Financial Supervisory Service reported, as of December 2021, the following portions of listed stocks held by foreign investors: the US, 40.3%; the UK, 8.4%; Luxembourg, 6.8%; Singapore, 6.8%; and Ireland, 4.3%.

² We thank the referee for suggesting this possibility.

Haque, 2017; Atif et al., 2021). We find that both the likelihood that a firm discloses carbon emissions and $Disclosure^{scope}$ are positively associated with board independence and gender diversity. Third, the likelihood that carbon emissions are disclosed in detail is significantly higher when a manager's compensation package is aligned with ESG performance or when a firm sets emissions-reduction targets, which are likely aligned with bonus pay.

This paper adds to the growing body of literature that analyzes factors that drive voluntary disclosure of carbon emissions. As mentioned above, Luo et al. (2012) show that voluntary disclosure of carbon emissions increases when firms face social and economic pressure. Several studies show that firms that feature strong internal governance are more likely to disclose environmental information voluntarily (e.g. Tsang et al., 2019; Hope et al., 2013; Liao et al., 2015). Peng et al. (2015) find that firms are likely to follow their industry peers' behavior when they decide whether to disclose carbon emissions information. We add to this literature by providing evidence that, in emerging markets, corporate governance involving foreign investors and overseas business operations plays an important role along with compensation schemes. In addition, we show that the origins or home countries of foreign investors matter. In particular, the results of our analysis imply that investors from countries that impose strict environmental standards transfer such practices to emerging markets.

Our paper also adds to the literature on compensation schemes and CSR. Previous research demonstrates the important role that executive compensation structures play when firms incorporate CSR practices into their strategies. Haque (2017) and Baraibar-Diez et al. (2019) show that CSR-connected compensation improves CSR performance. We add to this line of studies by suggesting that carbon disclosure, which is an essential step towards achieving low-carbon targets, is among the channels through which CSR-connected compensation influences CSR performance.

The rest of the paper proceeds as follows. In section 2, we introduce our hypotheses based on the related literature. In section 3, we describe the details pertaining to the data and the research design. Section 4 presents the empirical results regarding the determinants of voluntary disclosure of carbon emissions and section 5 concludes.

2. Literature review and hypothesis development

2.1. International governance mechanisms

Prior studies show that international aspects of corporate governance play an important role in emerging markets. Tsang et al. (2019) investigate the influence of foreign investors on voluntary disclosure policies in 32 non-US countries and show that foreign institutional investors do more than domestic institutional investors to spur firms to improve their voluntary disclosure practices. This is because foreign investors are unfamiliar with a host country's language, culture, and legal system, thereby facing high information asymmetry. Ezhilarasi and Kabra (2017) and Gerged (2021) also show that foreign institutional investors are positively associated with disclosure of environmental information in India and Jordan, respectively. On the other hand, several papers find that firms with higher foreign ownership shares are not necessarily more likely to disclose information about carbon emissions voluntarily in Canada (Wegener et al., 2013) and China (Shen et al., 2020). In addition, Kiliç and Kuzey (2019a) and Shan et al. (2021) show that foreign ownership is negatively associated with climate change-related disclosures in Turkey and Australia, respectively. Because foreign investors generally play an important role in Korea and Korea is a latecomer to incorporating ESG practices into business operations, we expect firms whose ownership structures include higher foreign ownership shares are likely to be more active in a voluntary disclosure of carbon emissions.

We also use international business operations as another proxy for international influence. In a closely related study, Aragón-Correa et al. (2016) find that top international firms are more transparent than their industry peers in disclosing comprehensive environmental information. This result suggests that international firms seek moral legitimation through voluntary environmental disclosure, a finding that is in line with previous studies (Babiak and Trendafilova, 2011; Bansal and Clelland, 2004). As such, we expect that firms that are highly internationalized are more likely to engage in voluntary disclosure of information, including CSR-related information.

Based on the above discussion, we conjecture that stronger international influence on corporate governance, proxied by foreign ownership, the number of subsidiaries operating in foreign countries, and the number of countries where subsidiaries operate, encourages firms to disclose carbon emissions voluntarily and in greater detail:

H1-a: Strong international influence on corporate governance is positively associated with the likelihood that firms disclose carbon emissions voluntarily and do so in detail.

Next, we examine how foreign investors across various geographical regions affect the likelihood that voluntary disclosure occurs. Dyck et al. (2019) find that European investors drive the greatest improvement in environmental and social performance in foreign countries, whereas investors from other regions show insignificant effects. They suggest that foreign investors from countries featuring strong social norms focus more attention on sustainable performance than on financial returns. Meanwhile, Jo and Park (2020) document that a stronger negative CSR-risk relationship is evident for firms operating in Europe and North America than in the Asia-Pacific region, because European and American investors are likely to give more weight to engagement in CSR. We therefore propose that increases in voluntary disclosure of carbon emissions as well as the fineness in detail with which emissions are disclosed are more pronounced when European or American investors hold large ownership shares.

H1-b: Firms in which foreign investors based in Western countries hold larger ownership shares are more likely to voluntarily disclose carbon-emissions information and to do so in detail.

2.2. Internal governance mechanisms and monitoring

Outside directors and inside directors are subject to quite different incentives and hold quite different values. [Post et al. \(2011\)](#) point out that outside directors are more likely to monitor managerial activities properly, while inside directors are less concerned with managers' opportunistic decisions because of their close ties with those managers. In addition, independent directors pay more attention to long-term goals such as sustainability, whereas internal directors pursue short-term objectives such as superior operating performance ([Johnson and Greening, 1999](#); [Ibrahim and Angelidis, 1995](#)). Several studies find that firms place more value on climate-related challenges and opportunities when their boards include high proportions of outside directors ([Post et al., 2011](#); [Haque, 2017](#)) and report that these firms earn higher CSR scores ([Wang and Coffey, 1992](#)). Recently, [Liao et al. \(2021\)](#) show that, in 34 countries, implementing regulations that mandate changes such as increasing board independence has a positive effect on CSR performance. [Atif et al. \(2021\)](#) find that firms with two or more women on their boards are likely to improve environmental CSR by replacing fossil-derived energy with renewable energy.

With respect to board independence and voluntary disclosure of carbon emissions, [Liao et al. \(2015\)](#) show that, in the UK, the proportion of independent directors on a board is strongly correlated with disclosure propensity. Similar results are reported by prior studies set in several countries: [Ben-Amar and McIlkenny \(2015\)](#) in Canada; [Jaggi et al. \(2018\)](#) in Italy; [Kılıç and Kuzey \(2019b\)](#) in Turkey; and [Elsayih et al. \(2018\)](#) in Australia. These findings highlight the role of the structure of boards of directors in voluntary disclosure of carbon emissions.

Another stream of research investigates board gender diversity and voluntary disclosure of carbon emissions. [Liao et al. \(2015\)](#) analyze the largest companies in the UK and suggest that the presence of female directors plays a significant role in the voluntary disclosure of carbon emissions. [He et al. \(2021\)](#) investigate listed Chinese firms in high-carbon industries and find a positive relationship between the presence of female directors and carbon emissions information disclosure. [Ben-Amar et al. \(2017\)](#) also find that the likelihood that voluntary carbon emissions disclosure occurs increases with the ratio of female board members. In addition, [Elsayih et al. \(2018\)](#) show that both board independence and board diversity positively affect carbon disclosure projects in Australia. Overall, prior studies generally find positive effects of board independence and board gender diversity on voluntary disclosure of carbon emissions.

Based on the above discussion, we conjecture that firms that institute strong internal governance mechanisms, such as high level of board independence and gender diversity, are likely to disclose carbon emissions voluntarily:

H2: Strong internal governance mechanisms, measured by board independence and gender diversity, are positively associated with both the likelihood that voluntary disclosure of carbon emissions occurs and the extent of the details included in disclosures.

2.3. Compensation schemes

As interest in ESG management continues to grow globally, firms are increasingly incorporating ESG factors into executive compensation. This practice has been on the rise in Korea as well. For example, SK Innovation, a firm that engages in petroleum production across the world, announced that it would link carbon emissions and ESG performance to executive compensation metrics.

Several studies focus on the effects of CSR-contingent executive compensation on CSR performance but find mixed results. For example, [Hong et al. \(2016\)](#) show that the existence of compensation contracts tied to CSR in the US improves CSR performance. [Berrone and Gomez-Mejia \(2009\)](#) highlight an insignificant relationship in the US between executive pay linked to environmental management and environmental performance. [Haque \(2017\)](#) finds a positive association between ESG-based compensation and carbon performance, suggesting that sustainable compensation policy motivates managers to address environmental concerns. [Al-Shaer et al. \(2022\)](#) also show that CEOs who receive CSR-related compensation in the UK engage more intensively in improving environmental performance. [Tsang et al. \(2021\)](#) find a positive association between CSR target-connected executive compensation and innovation globally, suggesting that a CSR-linked compensation structure fosters innovation. To the best of our knowledge, the association between CSR-connected compensation and carbon disclosure is explored only by [Luo et al. \(2021\)](#). Using firm-level data from 40 countries, the authors show that, when executive compensation is aligned with stakeholder interests, firms are encouraged to disclose corporate carbon transparency voluntarily. Moreover, the quality and comprehensiveness of carbon emissions disclosure are improved when a compensation scheme is linked to sustainability targets. The 40 countries covered by the study comprise mostly developed markets, and Korea, our country of interest, is not included.

Leading companies in carbon-intensive sectors such as oil and gas, mining, and steel have adopted executive compensation policies that underlie annual bonus pay ([Ritz, 2022](#)). [Liao et al. \(2015\)](#) show that including short-term bonuses in compensation packages plays a significant role in inducing firms to disclose carbon-related information, whereas long-term bonuses do not. [Ott and Endrikat \(2022\)](#) find that firms that set carbon emissions targets are more likely to achieve superior carbon performance. There is, however, a lack of research on the association between carbon emissions targets and voluntary disclosure of carbon emissions. Because bonuses are commonly set against certain benchmarks, we expect that firms that set carbon emissions targets are likely to offer executives carbon-connected bonuses. Supporting this expectation, [Winschel \(2021\)](#) shows that carbon-related targets are used mainly to determine short-term executive compensation. In addition, [Tang and Demeritt \(2018\)](#) find that some managers in UK-listed firms are rewarded through bonuses if specified emissions-reduction targets are hit.

Based on the above discussion, we hypothesize that firms in which CEO compensation is connected to CSR performance are more likely to engage in voluntary disclosure activities. Similarly, firms that set specific targets for carbon emissions, which are likely used to structure CEO compensation contracts, are more likely to engage in voluntary disclosure of carbon emissions. We also expect these firms to disclose carbon emissions in greater detail:

H3: Firms that employ executive compensation schemes that explicitly align CSR performance with CEO pay and those that set carbon emissions targets are more likely to disclose carbon emissions voluntarily and to do so in greater detail.

3. Data and research design

3.1. Research model

In this section, we provide the results of the tests of the abovementioned hypotheses. We begin by introducing a logit (OLS) regression model that we use to examine the relationship between incentive-alignment mechanisms proposed in the hypotheses and voluntary carbon information disclosure (the extent of detail in carbon emissions disclosures). We control for other firm-level characteristics and industry and year fixed effects. The regression specification is shown below:

$$Disclosure^{Dummy} (Disclosure^{Scope}) = \beta_1 \times IncMech + \sum_{i=2}^n \beta_i \times Control + Industry (and Year) Fixed effects$$

$Disclosure^{Dummy}$ is an indicator variable that equals one if a firm is a voluntary-disclosure firm and zero otherwise. As noted in the introduction, $Disclosure^{Scope}$ is defined as the number of disclosed items among total emissions, Scope 1 emissions, Scope 2 emissions, and Scope 3 emissions divided by 4 ($(Disclosure^{Dummy} + scope1\ disclosure\ dummy + scope2\ disclosure\ dummy + scope3\ disclosure\ dummy)/4$). Based on this definition, we create a unique variable, $Disclosure^{Scope}$, which represents the extent of carbon emissions disclosure.

$IncMech$ represents various incentive-alignment mechanisms, measured by corporate governance and compensation mechanisms. In this model, a positive coefficient on β_1 implies that firms with strong incentive-alignment mechanisms are more likely to disclose carbon emissions information voluntarily and to report carbon emissions in greater detail. In contrast, a negative coefficient suggests that firms with strong incentive-alignment mechanisms are less likely to disclose such information voluntarily or to do so in great detail.

3.2. Data and variables

We collect data on carbon emissions from the Thomson Reuters Eikon Database (hereafter Eikon), which is based on “voluntary” carbon information disclosure.³ We gather primary firm-specific data from the FnGuide database. We obtain demographic data indicating each board member's gender from the Data Analysis, Retrieval and Transfer System (DART) provided by the Korean Financial Supervisory Service, and data indicating their positions from TS-2000. We collect foreign ownership data at the region level from Eikon's shareholder reports and overseas subsidiary data from Korea Trade-Investment Promotion Agency (KOTRA) reports.⁴

Larger firms are more likely to provide data to ESG databases held by the rating agencies (Drempetic et al., 2020), so we confine our attention to firms that are listed on the KOSPI 200 from 2011 through 2019. This enables us to uniformly compare the records of firms that report (and do not report) carbon information. We exclude financial firms because of the specific capital structure they generally share. In addition, we restrict the sample to firms with non-missing variables needed for the analyses. Our final sample includes 245 firms with 1,537 firm-year observations.

As proxies for incentive-alignment mechanisms, we first consider international factors. $ForeignOwn^*$ represents ownership of foreign investors scaled by total ownership. $lnOverseaFirm$ is the natural logarithm of the total number of overseas subsidiaries and $lnOverseaCtry$ is the natural logarithm of the total number of countries in which a firm operates subsidiaries. In addition, we classify foreign ownership by geographical regions. $Region^*$ is defined as foreign investors' shares by the geographic regions in which they are based scaled by total ownership. The regions we consider are the following: Europe ($Europe^*$), the US (US^*), Asia ($Asia^*$), Africa ($Africa^*$), and Oceania ($Oceania^*$). Second mechanism is an internal governance. $OutsideDir^*$ is calculated as the ratio of outsider directors to total directors and $FemaleD$ is an indicator variable that equals one if a firm has at least one female member on its board. We use an indicator variable for board gender diversity because, during our sample period in Korea, firms rarely have more than one female director on their boards and only 11.7% of sample firms have at least one female director. Third, we consider compensation schemes, measured by ESG-linked compensation or target-setting. $ESGPayD$ is an indicator variable that equals one if executive compensation metrics are based on ESG or sustainability factors and zero otherwise. Similarly, $TargetD$ is also an indicator variable that equals one if a firm sets carbon emissions targets and zero otherwise.

³ Eikon gathers CSR information, including carbon emissions data, from the company's corporate social responsibility report, the Carbon Disclosure Project report, and publicly available documents on the company's website. These documents are disclosed voluntarily, not out of a legal obligation.

⁴ Public Data Portal website (<https://www.data.go.kr/data/15085722/fileData.do>).

Control variables are defined as follows. Firm size (*Size*) is the natural logarithm of total assets. Investment (*Investment*) is capital expenditures scaled by lagged total assets. Return volatility (*RETvol*) is the standard deviation of stock returns over the previous 52 weeks. Leverage (*Leverage*) is total liabilities divided by total assets. Tobin's Q (*Q*) is the sum of the market value of equity and total liabilities scaled by total assets. R&D ratio (*R&D*) is the ratio of research and development expenditures to sales. Return on equity (*ROE*) is a firm's net income divided by its total equity. Board size (*BSize*) is the number of directors on a firm's board. *LargOwn*^{*} is a firm's largest shareholder's ownership share scaled by total investor ownership and *lnShrholders* is the natural logarithm of the total number of shareholders. All variables are defined in [Appendix 1](#) and winsorized at 1 percent on both tails of the distribution.

4. Empirical results

4.1. Summary statistics

We report summary statistics for sample firms from 2011 through 2019 in [Table 1](#). In our sample, approximately 31.2% of the firms disclosed their carbon emissions voluntarily (*Disclosure^{Dummy}*). The average value of *Disclosure^{Scope}* in our sample is 0.257. The value of *Disclosure^{Scope}* for a given firm is 0.25 (1.00) if it discloses only one (all four) of the four items (total emissions, scopes 1–3). In addition, approximately 24.5% of sample firms set targets for carbon emissions (*TargetD*) and 11.1% of the sample firms deploy CEO contracts that are explicitly aligned with ESG performance (*ESGPayD*). These findings imply that Korean companies began focusing on environmental and CSR issues during the sample period. The average size of firms in the full sample is 21.93, which is equivalent to about 3,347 billion Korean won in total assets. Our sample firms' leverage ratio is on average 0.473 and the average Tobin's Q is 1.333.

[Table 2](#) displays the Pearson correlation coefficients for the variables in our analysis. We find that *Disclosure^{Dummy}*, our measure of voluntary disclosure of carbon emissions information, is strongly correlated with firm size (*Size*), return volatility (*RETvol*), and leverage (*Leverage*). These findings suggest that a firm with large size, low return volatility, and high leverage has a positive correlation with its disposition to voluntarily disclose carbon emissions. In addition, the correlations between *Disclosure^{Dummy}* and foreign ownership (*ForeignOwn*^{*}), the number of overseas subsidiaries (*lnOverseaFirm*), outside director ratio (*OutsideDir*^{*}), and ESG-linked compensation (*ESGPayD*) are 0.32, 0.49, 0.38, and 0.50, respectively. These findings suggest that these factors are strongly correlated with voluntary disclosure of carbon emissions information. The correlation coefficients between *Disclosure^{Scope}* and these variables are also shown to be similar.

4.2. International aspects of corporate governance

To test Hypothesis H1-a, we examine the association between the international aspects of corporate governance and voluntary disclosure of carbon emissions. Based on the research model presented in [Section 3](#), we report the results of the logit and OLS regressions in [Table 3](#). The dependent variable is *Disclosure^{Dummy}* for Panel A and *Disclosure^{Scope}* for Panel B. The independent variable is *ForeignOwn*^{*} for columns (1) and (2), *lnOverseaFirm* for columns (3) and (4), and *lnOverseaCtry* for columns (5) and (6).⁵ To obtain the results reported in the odd-numbered columns we include industry fixed effects, and for the even-numbered columns we include both year and industry fixed effects. We cluster standard errors at the firm level in all regression specifications.

The coefficients on *ForeignOwn*^{*} are positive but only marginally significant, suggesting that foreign investors may weakly encourage Korean firms to disclose carbon emissions. The estimated coefficients reported in column (2) of Panel A suggest that a one-standard-deviation increase in foreign ownership is associated with 0.47 higher log odds that voluntary disclosure occurs. The coefficient reported in column (2) of Panel B, on the other hand, is not statistically significant at conventional levels ($p = 0.148$). The coefficient on *lnOverseaFirm* (*lnOverseaCtry*) is positive and statistically significant in both columns, suggesting that firms that operate large numbers of overseas subsidiaries (firms that operate subsidiaries in multiple countries) are more likely to engage in voluntary disclosure of carbon emissions and to report emissions in greater detail.

Regarding control variables, *Size* has a positive and significant coefficient in all columns. This result is consistent with prior studies that analyze the propensity to engage in carbon-related disclosure to carbon disclosure projects ([Cui and Hwang, 2018](#); [Kim et al., 2021](#); [Choi and Noh, 2016](#)). In addition, capital expenditures (*Investment*) and R&D expenditures (*R&D*) are positively associated with the probability that carbon emissions are disclosed voluntarily, a finding that is consistent with [Cui and Hwang \(2018\)](#). The results imply overall that international aspects of governance induce firms to participate more actively in voluntary disclosure of carbon emissions, supporting Hypothesis 1-a.

Next, we test Hypothesis 1-b, which proposes that ownership by investors from European countries and the US is positively associated with voluntary disclosure of carbon emissions. The results reported in [Table 4](#) illustrate how foreign investors across various geographical regions affect the likelihood that carbon information is disclosed voluntarily. We include industry fixed effects and year fixed effects in all the regression analyses and standard errors are clustered at the firm level.

⁵ For this analysis, we exclude firms with missing values and restrict the sample to 852 firm-year observations. Given that the overseas subsidiary dataset is constructed based on firms that agree voluntarily to provide their information to KOTRA, we cannot arbitrarily regard missing values as cases in which firms do not operate subsidiaries in foreign countries.

Table 1

Summary Statistics. This table displays summary statistics for sample firms. The sample consists of firms with observations for the period spanning 2011–2019. We restrict the sample to KOSPI200. In addition, we exclude financial firms and firms with missing values needed for the analyses. All variables are defined in Appendix I and winsorized at 1 percent on both tails of the distribution.

	N	Mean	SD	Min	p25	p50	p75	Max
<i>Disclosure^{Dummy}</i>	1537	0.312	0.463	0.000	0.000	0.000	1.000	1.000
<i>Disclosure^{Scope}</i>	1537	0.257	0.397	0.000	0.000	0.000	0.750	1.000
<i>ForeignOwn[%]</i>	1537	0.203	0.155	0.006	0.084	0.168	0.275	0.776
<i>InOverseaFirm</i>	852	1.730	1.158	0.000	0.693	1.946	2.485	4.762
<i>InOverseaCtry</i>	852	1.447	1.016	0.000	0.693	1.386	2.079	4.234
<i>Europe[%]</i>	1537	0.060	0.102	0.000	0.012	0.031	0.071	0.878
<i>US[%]</i>	1537	0.083	0.079	0.000	0.034	0.062	0.110	0.863
<i>Asia[%]</i>	1537	0.040	0.110	0.000	0.000	0.006	0.028	0.998
<i>Africa[%]</i>	1537	0.000	0.003	0.000	0.000	0.000	0.000	0.074
<i>Oceania[%]</i>	1537	0.000	0.001	0.000	0.000	0.000	0.000	0.021
<i>OutsideDir[%]</i>	1537	0.535	0.163	0.000	0.429	0.571	0.667	1.000
<i>FemaleD</i>	1537	0.117	0.322	0.000	0.000	0.000	0.000	1.000
<i>ESGPayD</i>	1537	0.111	0.314	0.000	0.000	0.000	0.000	1.000
<i>TargetD</i>	1537	0.245	0.430	0.000	0.000	0.000	0.000	1.000
<i>Size</i>	1537	21.93	1.48	18.41	20.78	21.78	22.92	26.01
<i>RETvol</i>	1537	0.023	0.007	0.008	0.018	0.022	0.026	0.053
<i>Investment</i>	1537	0.041	0.053	0.000	0.007	0.024	0.055	0.528
<i>Leverage</i>	1537	0.473	0.189	0.075	0.319	0.488	0.614	0.967
<i>Q</i>	1537	1.333	0.949	0.435	0.841	1.006	1.418	8.297
<i>R&D</i>	1537	0.016	0.031	0.000	0.000	0.002	0.014	0.205
<i>ROE</i>	1537	0.070	0.146	-1.090	0.025	0.070	0.124	0.996
<i>BSize</i>	1537	6.302	2.263	2.000	5.000	6.000	7.000	15.000
<i>LargOwn[%]</i>	1537	0.420	0.157	0.068	0.309	0.408	0.529	0.808
<i>InShrholders</i>	1537	9.636	1.595	1.609	8.956	9.747	10.516	12.978

The dependent variable is *Disclosure^{Dummy}* for Panel A and *Disclosure^{Scope}* for Panel B. The primary variable of interest is *Region[%]*. We first decompose foreign investors' nationality into five regions: Europe, the US, Asia, Africa, and Oceania. We then calculate the total share of foreign investors in each firm by reference to geographical region. The shares of European, American, Asian, African, and Oceanian investors are used in the analysis reported in columns (1), (2), (3), (4), and (5), respectively. In both Panel A and Panel B, only the coefficient on *Europe[%]* reported in column (1) is positive and statistically significant at the 1% level, whereas the coefficients reported in all the other columns are statistically insignificant. In particular, the estimate in column (1) of Panel A implies that a one-standard-deviation increase in European ownership results in a 0.55 increase in the log odds that voluntary disclosure occurs. We include all geographical-region variables to estimate the results reported in column (6). We find that the coefficient on *Europe[%]* is positive and statistically significant in both panels. These results indicate overall that firms whose ownership structures include substantial portions of shares owned by European investors, but not those representing the US or other regions, are likely to disclose environmental practices voluntarily and to disclose carbon emissions in greater detail, supporting the proposition that European investors drive the positive movement of carbon emissions disclosure activities among foreign investors.

4.3. Internal corporate governance and monitoring

Next, we turn our attention to internal governance mechanisms and monitoring, which are measured by outside and female directors on boards. As proposed in Hypothesis 2, we expect to find that the propensity to disclose carbon emissions voluntarily will be more pronounced in firms that feature high board independence and gender diversity (Ben-Amar et al., 2017; Liao et al., 2015).

Table 5 displays the results. The dependent variable is *Disclosure^{Dummy}* for Panel A and *Disclosure^{Scope}* for Panel B. The independent variables are the share of outside directors (*OutsideDir[%]*) for columns (1) and (2) and the presence of female directors (*FemaleD*) for columns (3) and (4). We include industry fixed effects in the analysis associated with columns (1) and (3), whereas we include both industry fixed effects and year fixed effects for columns (2) and (4). The coefficients on *OutsideDir[%]* and *FemaleD* reported in Panel A are statistically significant and positive in all columns, suggesting that firms featuring larger shares of outside directors or the presence of female directors are more likely to voluntarily disclose carbon-related information. Regarding the magnitudes of the coefficients reported in column (2) ((4)), a one-standard-deviation increase in the percentage of outside directors (the presence of female directors) produces, on average, a 0.48 (0.34) increase in the log odds that carbon emissions are disclosed voluntarily. In contrast, the coefficients of interest reported in Panel B are insignificant in all columns.

Prior studies have raised concerns that board characteristics might be determined endogenously, potentially confounding analyses of the effects of such characteristics on corporate policies (Greene, 2003; Ben-Amar et al., 2017). To address this endogeneity concern, we conduct a two-stage least squares analysis that incorporates instrumental variables. We present the results in Panel C and Panel D. We employ firm size, firm value, sales growth, and board size as instrumental variables

Table 2

Correlation Matrix. This table displays the Pearson correlation coefficients for the variables used in the analysis. All variables are defined in Appendix I and winsorized at 1 percent on both tails of the distribution. Statistical tests of relationships between variables are conducted for both measurements of correlations. ^a, ^b, and ^c indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	
(1) <i>Disclosure^{Dummy}</i>	1.0 ^a																			
(2) <i>Disclosure^{Scope}</i>	0.96 ^a	1.0 ^a																		
(3) <i>ForeignOwn[*]</i>	0.32 ^a	0.35 ^a	1.0 ^a																	
(4) <i>InOverseaFirm</i>	0.49 ^a	0.50 ^a	0.19 ^a	1.0 ^a																
(5) <i>InOverseaCtry</i>	0.48 ^a	0.49 ^a	0.17 ^a	0.97 ^a	1.0 ^a															
(6) <i>OutsideDir[*]</i>	0.38 ^a	0.37 ^a	0.16 ^a	0.37 ^a	0.36 ^a	1.0 ^a														
(7) <i>FemaleD</i>	0.07 ^b	0.05 ^c	0.09 ^a	-0.04	-0.05	0.00	1.0 ^a													
(8) <i>ESGPayD</i>	0.50 ^a	0.51 ^a	0.19 ^a	0.35 ^a	0.35 ^a	0.22 ^a	0.05 ^c	1.0 ^a												
(9) <i>TargetD</i>	0.77 ^a	0.78 ^a	0.35 ^a	0.48 ^a	0.47 ^a	0.31 ^a	0.02	0.43 ^a	1.0 ^a											
(10) <i>Size</i>	0.64 ^a	0.63 ^a	0.34 ^a	0.64 ^a	0.62 ^a	0.48 ^a	0.00	0.42 ^a	0.59 ^a	1.0 ^a										
(11) <i>RETvol</i>	-0.09 ^a	-0.09 ^a	-0.25 ^a	-0.11 ^a	-0.09 ^b	-0.07 ^a	0.02	-0.10 ^a	-0.08 ^a	-0.21 ^a	1.0 ^a									
(12) <i>Investment</i>	0.08 ^a	0.10 ^a	0.14 ^a	-0.03	-0.06	-0.06 ^b	0.02	0.06 ^b	0.09 ^a	-0.04 ^c	0.04 ^c	1.0 ^a								
(13) <i>Leverage</i>	0.18 ^a	0.18 ^a	-0.14 ^a	0.33 ^a	0.36 ^a	0.21 ^a	-0.05 ^b	0.11 ^a	0.18 ^a	0.37 ^a	0.22 ^a	-0.04	1.0 ^a							
(14) <i>Q</i>	-0.02	-0.01	0.15 ^a	-0.24 ^a	-0.23 ^a	-0.04	0.13 ^a	-0.09 ^a	-0.05 ^c	-0.31 ^a	0.20 ^a	0.15 ^a	-0.18 ^a	1.0 ^a						
(15) <i>R&D</i>	0.05 ^b	0.06 ^b	0.03	-0.16 ^a	-0.15 ^a	0.05 ^b	0.07 ^a	0.04	0.07 ^a	-0.08 ^a	0.11 ^a	0.09 ^a	-0.11 ^a	0.27 ^a	1.0 ^a					
(16) <i>ROE</i>	0.03	0.04 ^c	0.24 ^a	-0.09 ^a	-0.11 ^a	-0.07 ^b	-0.01	-0.01	0.02	-0.09 ^a	-0.09 ^a	0.21 ^a	-0.32 ^a	0.28 ^a	0.04	1.0 ^a				
(17) <i>BSize</i>	0.30 ^a	0.30 ^a	0.29 ^a	0.37 ^a	0.32 ^a	0.14 ^a	0.17 ^a	0.24 ^a	0.25 ^a	0.41 ^a	-0.14 ^a	-0.02	0.11 ^a	-0.04	-0.10 ^a	-0.03	1.0 ^a			
(18) <i>LargOwn[*]</i>	-0.24 ^a	-0.27 ^a	-0.32 ^a	-0.15 ^a	-0.17 ^a	-0.20 ^a	-0.02	-0.16 ^a	-0.24 ^a	-0.22 ^a	-0.01	-0.06 ^b	-0.08 ^a	-0.05 ^c	-0.18 ^a	-0.01	-0.13 ^a	1.0 ^a		
(19) <i>InShrholders</i>	0.43 ^a	0.43 ^a	0.17 ^a	0.40 ^a	0.41 ^a	0.32 ^a	0.02	0.32 ^a	0.41 ^a	0.50 ^a	0.03	0.07 ^a	0.23 ^a	0.01	0.08 ^a	-0.12 ^a	0.25 ^a	-0.29 ^a	1.0 ^a	

Table 3

International Aspects of Corporate Governance. This table displays the results of analyses in which we examine whether international aspects of corporate governance are associated with voluntary disclosure of carbon emissions. The dependent variable for Panel A is $Disclosure^{Dummy}$, an indicator variable that equals one if a firm is a voluntary-disclosure firm and zero otherwise, and the dependent variable for Panel B is $Disclosure^{Scope}$, the number of disclosed items ($Disclosure^{Dummy}$, Scope 1 emissions, Scope 2 emissions, and Scope 3 emissions) divided by 4. $ForeignOwn^{\%}$ is ownership of foreign investors scaled by the total ownership of investors. $lnOverseaFirm$ is the natural log of the number of oversea subsidiaries and $lnOverseaCtry$ is the natural log of the number of countries in which subsidiaries operate. Control variables include $Size$, $Investment$, $RETvol$, $Leverage$, Q , $R\&D$, ROE , $BSize$, $LargOwn^{\%}$, and $lnShrholders$. All variables are defined in Appendix 1 and winsorized at 1 percent on both tails of the distribution. Numbers in parentheses are t-values and standard errors are clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Dep. variable – $Disclosure^{Dummy}$						
$ForeignOwn^{\%}$	2.751*	3.001*				
	(1.705)	(1.823)				
$lnOverseaFirm$			1.711***	1.758***		
			(3.734)	(3.777)		
$lnOverseaCtry$					1.178***	1.214***
					(2.820)	(2.833)
$Size$	1.915***	1.957***	1.202**	1.237**	1.439**	1.482**
	(4.724)	(4.657)	(2.147)	(2.080)	(2.568)	(2.493)
$RETvol$	11.926	10.944	–0.072	4.748	–5.304	–3.423
	(0.767)	(0.500)	(0.002)	(0.118)	(0.189)	(0.092)
$Investment$	1.588	1.509	9.191**	10.022***	8.091**	8.838**
	(0.638)	(0.593)	(2.550)	(2.708)	(2.477)	(2.637)
$Leverage$	–0.957	–0.982	–2.045	–1.995	–1.274	–1.189
	(0.549)	(0.536)	(0.561)	(0.500)	(0.349)	(0.300)
Q	0.665***	0.640***	0.928***	0.966***	0.883***	0.917***
	(2.893)	(2.743)	(3.058)	(2.803)	(2.930)	(2.751)
$R\&D$	13.993**	14.360**	38.766***	40.604***	30.248**	31.806**
	(2.426)	(2.415)	(3.401)	(3.319)	(2.548)	(2.481)
ROE	1.110	1.311	1.898	2.007	2.252	2.374
	(1.262)	(1.434)	(1.249)	(1.221)	(1.429)	(1.404)
$BSize$	–0.020	–0.021	–0.120	–0.113	–0.075	–0.071
	(0.212)	(0.231)	(0.988)	(0.859)	(0.608)	(0.562)
$LargOwn^{\%}$	0.232	0.376	1.433	1.686	1.833	2.077
	(0.185)	(0.295)	(0.814)	(0.966)	(1.091)	(1.235)
$lnShrholders$	0.194	0.237*	0.183	0.228	0.182	0.225
	(1.606)	(1.891)	(1.166)	(1.368)	(1.067)	(1.268)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	No	Yes
N	1537	1537	852	852	852	852
R^2	0.604	0.615	0.671	0.682	0.656	0.667
Panel B: Dep. variable – $Disclosure^{Scope}$						
$ForeignOwn^{\%}$	0.167	0.166				
	(1.474)	(1.450)				
$lnOverseaFirm$			0.083***	0.082***		
			(3.187)	(3.171)		
$lnOverseaCountry$					0.077***	0.077**
					(2.631)	(2.607)
$Size$	0.165***	0.166***	0.115***	0.116***	0.126***	0.127***
	(9.615)	(9.654)	(4.153)	(4.112)	(4.627)	(4.581)
$RETvol$	1.061	0.354	0.078	–0.229	0.105	–0.245
	(0.777)	(0.204)	(0.043)	(0.104)	(0.057)	(0.109)
$Investment$	0.096	0.101	0.449*	0.468*	0.439*	0.457*
	(0.572)	(0.583)	(1.789)	(1.766)	(1.715)	(1.695)
$Leverage$	–0.085	–0.084	–0.210	–0.212	–0.213	–0.215
	(0.783)	(0.763)	(1.299)	(1.271)	(1.282)	(1.257)
Q	0.053***	0.054***	0.068**	0.070**	0.070**	0.072**
	(2.896)	(2.850)	(2.172)	(2.155)	(2.121)	(2.104)
$R\&D$	0.365	0.408	1.423*	1.478*	1.248	1.309
	(0.714)	(0.789)	(1.870)	(1.896)	(1.587)	(1.627)
ROE	0.136**	0.127*	0.176*	0.159	0.175*	0.157
	(2.020)	(1.863)	(1.779)	(1.639)	(1.747)	(1.603)
$BSize$	–0.004	–0.004	–0.010	–0.011	–0.007	–0.008
	(0.579)	(0.618)	(1.139)	(1.173)	(0.847)	(0.898)
$LargOwn^{\%}$	–0.107	–0.098	0.038	0.041	0.047	0.051
	(1.265)	(1.151)	(0.323)	(0.348)	(0.418)	(0.442)
$lnShrholders$	0.019**	0.020**	0.024**	0.024***	0.024**	0.024**
	(2.325)	(2.394)	(2.608)	(2.643)	(2.556)	(2.591)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	No	Yes
N	1537	1537	852	852	852	852
R^2	0.605	0.609	0.662	0.666	0.659	0.663

Table 4

Regions of Foreign Investors. This table displays the results of analyses in which we examine whether foreign investors across various geographical regions are associated with voluntary disclosure of carbon emissions. The dependent variable for Panel A is $Disclosure^{Dummy}$, an indicator variable that equals one if a firm is a voluntary-disclosure firm and zero otherwise, and the dependent variable for Panel B is $Disclosure^{Scope}$, the number of disclosed items ($Disclosure^{Dummy}$, Scope 1 emissions, Scope 2 emissions, and Scope 3 emissions) divided by 4. $Europe^*$, US^* , $Asia^*$, $Africa^*$, and $Oceania^*$ are foreign investors' shares by reference to geographical region in which they are based scaled by total ownership. Control variables include $Size$, $Investment$, $RETvol$, $Leverage$, Q , $R\&D$, ROE , $BSize$, $LargOwn^*$, and $lnShrholders$. All variables are defined in Appendix 1 and winsorized at 1 percent on both tails of the distribution. Numbers in parentheses are t-values and standard errors are clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Dep. variable – $Disclosure^{Dummy}$						
$Europe^*$	5.373*** (3.581)					5.298*** (3.548)
US^*		0.876 (0.350)				0.937 (0.367)
$Asia^*$			-2.432 (0.943)			-1.980 (0.757)
$Africa^*$				-10.115 (0.510)		-15.910 (0.769)
$Oceania^*$					-59.994 (0.472)	-54.933 (0.389)
$Size$	2.152*** (4.871)	2.025*** (4.868)	2.037*** (4.865)	2.037*** (4.879)	2.048*** (4.806)	2.149*** (4.771)
$RETvol$	6.478 (0.288)	5.349 (0.239)	5.047 (0.220)	4.782 (0.212)	4.448 (0.195)	6.959 (0.305)
$Investment$	1.930 (0.804)	1.910 (0.806)	1.966 (0.851)	1.935 (0.833)	1.988 (0.863)	1.941 (0.802)
$Leverage$	-1.499 (0.876)	-1.555 (0.897)	-1.751 (1.063)	-1.613 (0.951)	-1.642 (0.971)	-1.582 (0.934)
Q	0.691*** (2.866)	0.711*** (3.077)	0.725*** (3.153)	0.722*** (3.149)	0.732*** (3.069)	0.692*** (2.798)
$R\&D$	15.579*** (2.672)	13.131** (2.097)	12.611** (1.997)	13.038** (2.080)	13.005** (2.086)	15.445*** (2.675)
ROE	1.601* (1.801)	1.477 (1.619)	1.516* (1.653)	1.495 (1.625)	1.501 (1.632)	1.604* (1.823)
$BSize$	-0.064 (0.695)	0.003 (0.032)	0.009 (0.103)	0.002 (0.018)	0.003 (0.029)	-0.057 (0.630)
$LargOwn^*$	-0.074 (0.057)	-0.459 (0.370)	-0.764 (0.636)	-0.600 (0.475)	-0.644 (0.509)	-0.137 (0.117)
$lnShrholders$	0.182 (1.455)	0.189 (1.525)	0.173 (1.547)	0.180 (1.595)	0.181 (1.609)	0.187 (1.382)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	1537	1537	1537	1537	1537	1537
R^2	0.620	0.610	0.611	0.610	0.610	0.620
Panel B: Dep. variable – $Disclosure^{Scope}$						
$Europe^*$	0.386** (2.573)					0.380** (2.524)
US^*		0.054 (0.231)				0.011 (0.050)
$Asia^*$			-0.069 (0.989)			-0.060 (0.889)
$Africa^*$				-0.137 (0.172)		-0.663 (0.800)
$Oceania^*$					8.507 (0.916)	7.658 (0.884)
$Size$	0.174*** (10.428)	0.171*** (9.848)	0.172*** (10.297)	0.172*** (10.318)	0.171*** (10.191)	0.172*** (9.928)
$RETvol$	0.196 (0.113)	-0.035 (0.020)	-0.167 (0.095)	-0.085 (0.049)	-0.150 (0.087)	0.092 (0.053)
$Investment$	0.129 (0.782)	0.126 (0.714)	0.136 (0.783)	0.128 (0.739)	0.134 (0.773)	0.140 (0.830)
$Leverage$	-0.100 (0.914)	-0.108 (0.939)	-0.109 (0.976)	-0.112 (1.017)	-0.106 (0.958)	-0.092 (0.795)
Q	0.053*** (2.768)	0.058*** (2.864)	0.059*** (2.979)	0.059*** (2.951)	0.058*** (2.935)	0.052*** (2.701)
$R\&D$	0.415 (0.818)	0.392 (0.752)	0.376 (0.720)	0.383 (0.732)	0.353 (0.675)	0.382 (0.758)
ROE	0.133** (1.974)	0.136** (1.992)	0.137** (2.002)	0.138** (2.014)	0.132* (1.905)	0.128* (1.865)

Table 4 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)
<i>BSize</i>	-0.005 (0.808)	-0.002 (0.402)	-0.002 (0.349)	-0.002 (0.412)	-0.003 (0.438)	-0.004 (0.778)
<i>LargOwn</i> [*]	-0.097 (1.152)	-0.127 (1.402)	-0.132 (1.477)	-0.137 (1.555)	-0.128 (1.485)	-0.086 (0.976)
<i>InShrholders</i>	0.019 ^{**} (2.196)	0.019 ^{**} (2.163)	0.019 ^{**} (2.273)	0.019 ^{**} (2.259)	0.019 ^{**} (2.204)	0.019 ^{**} (2.031)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	1537	1537	1537	1537	1537	1537
<i>R</i> ²	0.612	0.607	0.607	0.607	0.607	0.613

Table 5

Internal Corporate Governance. This table displays the results of analyses in which we examine whether internal corporate governance is associated with voluntary disclosure of carbon emissions. We report the coefficients of the logistic regression in Panel A, those of the OLS regression in Panel B, and those of the 2SLS regression in Panels C and D. The dependent variables for Panel A and C are *Disclosure*^{Dummy}, an indicator variable that equals one if a firm is a voluntary-disclosure firm and zero otherwise, and the dependent variables for Panel B and D are *Disclosure*^{Scope}, the number of disclosed items (*Disclosure*^{Dummy}, Scope 1 emissions, Scope 2 emissions, and Scope 3 emissions) divided by 4. *OutsideDir*^{*} is the ratio of outside directors to total directors. *FemaleD* is an indicator variable that has equals one if a firm has a female board director and zero otherwise. Control variables include *Size*, *Investment*, *RETvol*, *Leverage*, *Q*, *R&D*, *ROE*, *BSize*, *LargOwn*^{*}, and *InShrholders*. All variables are defined in Appendix I and winsorized at 1 percent on both tails of the distribution. Numbers in parentheses are *t*-values and standard errors are clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Panel A: Dep. variable – <i>Disclosure</i> ^{Dummy} (Logistic)				
<i>OutsideDir</i> [*]	2.723* (1.919)	2.961** (2.087)		
<i>FemaleD</i>			0.996** (2.261)	1.059** (2.378)
<i>Size</i>	1.875*** (4.444)	1.919*** (4.436)	2.012*** (4.966)	2.059*** (4.913)
<i>RETvol</i>	6.819 (0.411)	3.468 (0.150)	3.997 (0.245)	-0.260 (0.011)
<i>Investment</i>	2.019 (0.773)	1.783 (0.686)	2.199 (0.941)	2.008 (0.850)
<i>Leverage</i>	-1.751 (1.090)	-1.865 (1.076)	-1.654 (1.060)	-1.740 (1.046)
<i>Q</i>	0.746*** (3.331)	0.730*** (3.162)	0.737*** (3.320)	0.719*** (3.174)
<i>R&D</i>	11.951* (1.892)	12.237* (1.875)	12.554** (2.049)	12.642** (1.990)
<i>ROE</i>	1.258 (1.377)	1.420 (1.502)	1.482* (1.691)	1.652* (1.833)
<i>Bsize</i>	0.029 (0.291)	0.026 (0.262)	-0.018 (0.207)	-0.021 (0.238)
<i>LargOwn</i> [*]	-0.353 (0.291)	-0.252 (0.203)	-0.841 (0.698)	-0.801 (0.647)
<i>InShrholders</i>	0.148 (1.373)	0.180* (1.648)	0.161 (1.355)	0.196 (1.597)
Industry FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
<i>N</i>	1537	1537	1537	1537
<i>R</i> ²	0.605	0.615	0.604	0.614
Panel B: Dep. variable – <i>Disclosure</i> ^{Scope} (OLS)				
	(1)	(2)	(3)	(4)
<i>OutsideDir</i> [*]	0.107 (1.398)	0.115 (1.507)		
<i>FemaleD</i>			0.034 (1.026)	0.037 (1.103)
<i>Size</i>	0.166*** (8.991)	0.166*** (9.028)	0.171*** (10.266)	0.172*** (10.290)
<i>RETvol</i>	0.738 (0.539)	-0.075 (0.043)	0.616 (0.452)	-0.216 (0.125)
<i>Investment</i>	0.143 (0.842)	0.145 (0.826)	0.127 (0.760)	0.129 (0.747)

(continued on next page)

Table 5 (continued)

	(1)	(2)	(3)	(4)
<i>Leverage</i>	-0.120 (1.116)	-0.121 (1.087)	-0.112 (1.049)	-0.111 (1.015)
<i>Q</i>	0.056*** (2.865)	0.057*** (2.834)	0.057*** (2.987)	0.058*** (2.957)
<i>R&D</i>	0.306 (0.599)	0.352 (0.682)	0.314 (0.607)	0.359 (0.687)
<i>ROE</i>	0.149** (2.184)	0.139** (2.019)	0.152** (2.246)	0.142** (2.082)
<i>Bsize</i>	-0.001 (0.229)	-0.002 (0.277)	-0.003 (0.448)	-0.003 (0.509)
<i>LargOwn</i> *	-0.140 (1.619)	-0.130 (1.497)	-0.147* (1.677)	-0.138 (1.561)
<i>InShrholders</i>	0.018** (2.146)	0.019** (2.223)	0.019** (2.200)	0.019** (2.284)
Industry FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
<i>N</i>	1537	1537	1537	1537
<i>R</i> ²	0.605	0.608	0.604	0.607
Panel C: Dep. variable – <i>Disclosure</i> ^{Dummy} (2SLS)				
	(1)	(2)	(3)	(4)
<i>OutsideDir</i> %	3.960*** (13.495)	4.093*** (13.261)		
<i>FemaleD</i>			0.660*** (4.230)	1.419*** (4.489)
<i>RETvol</i>	2.469 (0.954)	-0.363 (0.121)	-11.775*** (5.624)	-12.858*** (4.577)
<i>Investment</i>	0.628* (1.910)	0.580* (1.727)	0.257 (1.153)	-0.078 (0.264)
<i>Leverage</i>	-0.412*** (3.765)	-0.447*** (3.928)	0.425** (6.262)	0.216** (2.365)
<i>Q</i>			-0.034** (2.254)	-0.022 (1.178)
<i>R&D</i>	-0.693 (1.032)	-0.507 (0.744)	0.367 (0.945)	0.538 (0.846)
<i>ROE</i>	0.197* (1.709)	0.177 (1.494)	0.407*** (4.590)	0.479*** (4.212)
<i>LargOwn</i> *	0.008 (0.656)	0.012 (0.950)	0.111*** (14.495)	0.100*** (10.280)
<i>InShrholders</i>	0.101 (0.889)	0.155 (1.327)	-0.291*** (3.817)	-0.182* (1.785)
Industry FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
<i>N</i>	1537	1537	1537	1537
<i>F</i> -statistic	56.309***	52.868***	20.605***	8.106***
Panel D: Dep. variable – <i>Disclosure</i> ^{Scope} (2SLS)				
	(1)	(2)	(3)	(4)
<i>OutsideDir</i> %	3.282*** (13.407)	3.385*** (13.151)		
<i>FemaleD</i>			0.538*** (4.054)	1.195*** (4.461)
<i>RETvol</i>	1.792 (0.830)	-0.679 (0.272)	-10.215*** (5.736)	-11.187*** (4.699)
<i>Investment</i>	0.607** (2.214)	0.559** (1.998)	0.373** (1.970)	0.013 (0.052)
<i>Leverage</i>	-0.317*** (3.470)	-0.342*** (3.603)	0.379** (6.571)	0.207** (2.680)
<i>Q</i>			-0.027** (2.115)	-0.016 (0.979)
<i>R&D</i>	-0.648 (1.158)	-0.492 (0.866)	0.369 (1.114)	0.349 (0.648)
<i>ROE</i>	0.185* (1.923)	0.167* (1.699)	0.361*** (4.790)	0.416*** (4.317)
<i>LargOwn</i> *	0.006 (0.627)	0.009 (0.876)	0.092*** (14.094)	0.082*** (9.951)
<i>InShrholders</i>	-0.013 (0.134)	0.029 (0.299)	-0.328*** (5.060)	-0.251*** (2.900)
Industry FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
<i>N</i>	1537	1537	1537	1537
<i>F</i> -statistic	56.309***	52.868***	20.605***	8.106***

Table 6

CSR-connected Compensation and Carbon Emission Targets. This table displays the results of analyses in which we examine whether compensation schemes and carbon emissions targets are associated with voluntary disclosure of carbon emissions. The dependent variable for Panel A is $Disclosure^{Dummy}$, an indicator variable that equals one if a firm is a voluntary-disclosure firm and zero otherwise, and the dependent variable for Panel B is $Disclosure^{Scope}$, the number of disclosed items ($Disclosure^{Dummy}$, Scope 1 emissions, Scope 2 emissions, and Scope 3 emissions) divided by 4. $ESGPayD$ is an indicator variable that equals one if executive compensation metrics are based on ESG factors and zero otherwise. $TargetD$ is an indicator variable that equals one if a firm sets carbon emissions targets and zero otherwise. Control variables include $Size$, $Investment$, $RETvol$, $Leverage$, Q , $R\&D$, ROE , $BSize$, $LargOwn^{\%}$, and $InShrholders$. All variables are defined in Appendix 1 and winsorized at 1 percent on both tails of the distribution. Numbers in parentheses are t-values and standard errors are clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Panel A: Dep. variable – $Disclosure^{Dummy}$				
$ESGPayD$	3.876*** (2.877)	3.987*** (3.277)		
$TargetD$			3.546*** (5.856)	3.706*** (5.954)
$Size$	1.801*** (4.431)	1.852*** (4.352)	1.403*** (3.947)	1.426*** (3.821)
$RETvol$	1.680 (0.090)	-6.671 (0.266)	21.911 (1.021)	38.101 (1.396)
$Investment$	2.510 (1.012)	2.241 (0.894)	1.555 (0.610)	2.421 (0.984)
$Leverage$	-0.893 (0.538)	-0.926 (0.523)	-1.958 (1.221)	-1.943 (1.141)
Q	0.757*** (3.385)	0.756*** (3.301)	0.461** (2.045)	0.417* (1.841)
$R\&D$	15.739*** (2.628)	16.347*** (2.695)	7.780 (1.033)	7.518 (0.985)
ROE	1.513 (1.559)	1.542 (1.583)	1.462 (1.162)	1.805 (1.401)
$Bsize$	-0.009 (0.100)	-0.013 (0.147)	0.074 (0.781)	0.104 (1.077)
$LargOwn^{\%}$	-0.063 (0.049)	0.074 (0.056)	-0.676 (0.487)	-0.524 (0.372)
$InShrholders$	0.098 (0.890)	0.138 (1.220)	0.198* (1.922)	0.236** (2.287)
Industry FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
N	1537	1537	1537	1537
R^2	0.633	0.644	0.684	0.695
Panel B: Dep. variable – $Disclosure^{Scope}$				
	(1)	(2)	(3)	(4)
$ESGPayD$	0.256*** (5.081)	0.259*** (5.159)		
$TargetD$			0.464*** (8.712)	0.464*** (8.615)
$Size$	0.152*** (8.785)	0.152*** (8.839)	0.089*** (5.099)	0.089*** (4.966)
$RETvol$	0.587 (0.469)	-0.325 (0.204)	0.456 (0.389)	0.525 (0.360)
$Investment$	0.164 (0.971)	0.165 (0.943)	0.151 (1.071)	0.172 (1.199)
$Leverage$	-0.081 (0.818)	-0.080 (0.788)	-0.031 (0.421)	-0.028 (0.373)
Q	0.059*** (3.014)	0.060*** (3.005)	0.037*** (2.790)	0.036*** (2.609)
$R\&D$	0.324 (0.716)	0.375 (0.822)	-0.078 (0.193)	-0.080 (0.197)
ROE	0.132** (2.037)	0.119* (1.827)	0.090 (1.299)	0.087 (1.260)
$BSize$	-0.003 (0.466)	-0.003 (0.533)	0.002 (0.547)	0.003 (0.599)
$LargOwn^{\%}$	-0.125 (1.572)	-0.114 (1.443)	-0.078 (1.228)	-0.078 (1.226)
$InShrholders$	0.012 (1.525)	0.013 (1.613)	0.010** (2.049)	0.010** (2.075)
Industry FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
N	1537	1537	1537	1537
R^2	0.630	0.634	0.714	0.716

to analyze the effects of including outside directors on a board (Haque, 2017; Lim et al., 2007), while we use firm size, sales growth, the female–male worker ratio, and board size as instrumental variables to analyze the effects of including female directors (Atif et al., 2021; Ben-Amar et al., 2017; Haque, 2017). We first conduct an instrument validation test. For the outside directors' ratio (the presence of female directors), we find F-statistics of 56.31 (52.87) as reported in column (1) ((2)) and of 20.61 (8.11) as reported in column (3) ((4)).⁶ The p-value of the weak-instrument test is 0.000 in all columns, rejecting the null hypothesis that the instrument is weak for the ratio of outside directors and the presence of female directors, respectively (Cragg and Donald, 1993; Stock and Yogo, 2005). As can be seen in Panel C, the results remain qualitatively the same when we use these instrumented variables compared with when we use raw variables in the regressions of $Disclosure^{Dummy}$ (Panel A). On the other hand, for Panel D, the dependent variable is $Disclosure^{Scope}$ and the coefficient reported in each column turns positive and significant, implying that firms that deploy effective internal corporate governance mechanisms are more likely to disclose their carbon emissions and to do so in detail.

As such, we conclude that strong internal governance through monitoring has a significant and positive effect on voluntary disclosure of carbon emissions as well as on the fineness of the details included, which is consistent with Hypothesis 2. We interpret these results to imply that board independence and diversity, which seem to enhance decision-making from a variety of perspectives, are positively associated with environmental disclosure practices (Bear et al., 2010).

4.4. Compensation schemes

In this section, we present the results of a logistic regression analysis that considers the effects of executive compensation schemes that are linked to CSR performance on voluntary disclosure of carbon emissions (Hypothesis 3). Table 6. shows the results. As in the previous analyses, here the dependent variables are $Disclosure^{Dummy}$ and $Disclosure^{Scope}$ for panels A and B, respectively. The main independent variables are $ESGPayD$ and $TargetD$ for columns (1)–(2) and (3)–(4), respectively. The estimated coefficient on $ESGPayD$ reported in both columns is positive and significant at the 1% level, suggesting that ESG-oriented compensation policies encourage managers to disclose carbon information voluntarily and to do so in greater detail. Furthermore, the estimated coefficient on $TargetD$ in both columns is positive and significant. This finding implies that if a firm sets carbon emissions targets, which likely is linked to bonus compensation schemes, it is more likely to disclose carbon emissions voluntarily. In sum, firms that employ compensation policies to enhance sustainability performance are more likely to disclose carbon emissions voluntarily and to do so in greater detail.

5. Conclusion

This paper examines the effects of incentive-alignment mechanisms on voluntary disclosure of carbon emissions in Korea. We focus on Korea first because this country is a latecomer to incorporating ESG practices into business operations. Lagging behind Western countries, Korea has highlighted the importance of ESG only recently and most Korean firms have begun to incorporate the associated practices into their business processes relatively recently. Moreover, foreign investors play a significant role in Korean firms. Because most foreign investors in Korean firms are based in Western countries where sensitivity to environmental issues has been higher than it has been in Korea for many years, they are more likely require firms to engage in ESG-related disclosure practices.

Using data from the Thomson Reuters Eikon Database for a period running from 2011 through 2019, we show that incentive-alignment mechanisms encourage firms to disclose their carbon-related information voluntarily and to do so in greater detail. We introduce three categories of incentive-alignment mechanisms: international corporate governance, internal corporate governance, and executive compensation schemes. Our main findings are as follows. First, international influence on corporate governance positively affects whether and to what extent carbon emissions are disclosed voluntarily. Among foreign investors, this effect is driven mostly by the influence of European investors. Second, echoing findings from studies set in developed countries, we find that strong internal corporate governance, proxied by board independence and board gender diversity, positively affects the likelihood that firms disclose carbon emissions voluntarily as well as the extent of such reporting. Third, a CEO compensation contract that is aligned with CSR performance or the existence of carbon emissions targets appears to encourage voluntary disclosure of carbon emissions as well as to do so in greater detail.

This paper makes an important contribution to our understanding of environmental policies in emerging markets. Our results suggest that the influence of developed markets plays an important role in encouraging firms to adopt proactive environmental policies such as voluntary disclosure of carbon emissions. In addition, CSR-linked compensation schemes and carbon emissions target-setting appear to incentivize managers to make environmentally transparent decisions. Without mandatory disclosure requirements or such incentive-alignment mechanisms, it could be difficult to motivate firms in emerging markets to engage in environmentally transparent actions voluntarily.

This reluctance may be partly due to the characteristics of disclosure of carbon emissions. Perhaps to a greater extent than is the case with other types of voluntary disclosure, disclosing carbon emissions can expose firms to adverse consequences for their business operations (Coburn et al., 2011; Krishnamurti and Velayutham, 2018). For example, environmental report-

⁶ In general, an F-statistic below 10 is often taken to indicate a weak instrument. We, however, use the same instrumental variables as Atif et al. (2021), where the F-statistic was 10.24.

Appendix I

Variable Definitions.

Variable	Definition
<i>Disclosure^{Dummy}</i>	An indicator variable that equals one if a firm is a voluntary-disclosure firm and zero otherwise.
<i>Disclosure^{Scope}</i>	The number of disclosed items among <i>Disclosure^{Dummy}</i> , Scope 1 emissions, Scope 2 emissions, and Scope 3 emissions divided by 4.
<i>ForeignOwn[*]</i>	Ownership of foreign investors scaled by total ownership of investors.
<i>lnOverseaFirm</i>	The natural log of the number of oversea subsidiaries.
<i>lnOverseaCtry</i>	The natural log of the number of countries in which subsidiaries operate.
<i>Region[*]</i>	Foreign investors' shares by the geographic regions (Europe, US, Asia, Africa, or Oceania) in which they are based scaled by total ownership.
<i>OutsideDir[*]</i>	The ratio of outside directors to total directors.
<i>FemaleD</i>	An indicator variable that equals one if a firm includes a female member on its board.
<i>ESGPayD</i>	An indicator variable that equals one if a firm adopts a non-financial performance-oriented compensation policy for executives based on ESG or sustainability factors and zero otherwise.
<i>TargetD</i>	An indicator variable that equals one if a firm sets carbon emissions targets and zero otherwise.
<i>Size</i>	The natural log of a firm's total assets.
<i>RETvol</i>	The standard deviation of stock returns over the previous 52 weeks.
<i>Investment</i>	Capital expenditures scaled by lagged total assets.
<i>Leverage</i>	Total liabilities divided by total assets.
<i>Q</i>	The sum of the market value of equity and total liabilities scaled by total assets.
<i>R&D</i>	The ratio of research and development (R&D) expenditures to sales.
<i>ROE</i>	Return on equity, calculated by dividing a firm's net income by its total equity.
<i>BSize</i>	The number of directors on a board.
<i>LargOwn[*]</i>	Ownership of the largest shareholders scaled by total ownership of investors.
<i>lnShrholders</i>	The natural log of the number of shareholders of a firm.

ing can result in costly lawsuits (Field et al., 2005). On the other hand, when a firm discloses carbon information voluntarily, investors may take such disclosure as a signal that the firm is committed to carbon-emissions management. In addition, disclosure of emissions may reduce information asymmetry between insiders and stakeholders. In emerging markets, such benefits may not be significant, though, as investors in such markets may not pay as much attention to environmental issues as they do in developed markets, and thus pressure from investors from developed markets and executive compensation mechanisms may play an important role in encouraging firms to disclose carbon information. As such, the results of our analyses emphasize overall the importance of the roles that international governance as well as internal governance and executive compensation mechanisms can play in improving environmental transparency in firms that operate in emerging markets.

CRedit authorship contribution statement

Jiyoung Park: Writing – original draft, Visualization. **Jiyoon Lee:** Conceptualization, Writing – review & editing. **Jewon Shin:** Methodology, Software.

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Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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