# Climate risk and environmental management control systems

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**ABSTRACT**

We investigate whether localized physical climate risk influences firms' to adopot more comprehensive Environmental Management Control Systems (EMCS), and how these systems shape both carbon emissions and climate-related disclosures. The study uses archival data, a novel provincial-level climate index and a hand-collected panel of 1,284 firm-year observations. We also developed a new length-adjusted textual measure to capture climate-related language in MD&A disclosures. Our findings show four key insights. First, firms facing higher localized climate risk are significantly more likely to implement formal EMCS, suggesting that physical exposure drives environmental control practices. Second, contrary to our expectations, the effectiveness of EMCS in managing firms' carbon emissions is limited. Third, in the absence of EMCS, climate-related disclosure increases with emissions intensity; in addition, such disclosure increments significantly when Scope 3 emissions grow. Fourth, and more interestingly, EMCS enhance the positive association between controllable (Scope 1 & 2) emissions and disclosure, but exhibit a *muted* moderating effect for less controllable emissions (Scope 3). Taken together, our results suggest that while EMCS are important tools in firms' responses to climate risk, their effectiveness appears to be uneven and context-dependent. This raises important questions about whether these internal control systems are truly equipped to address the full complexity of corporate carbon accountability.

**KEYWORDS**

Climate risks, Provincial Spanish Actuarial Climate Index, Climate-related disclosure, MD&A report, Environmental Management Control Systems, $CO_2$ emission intensity

## 1. Introduction

We examine the relationship between localized climate risk, the adoption of Environmental Management Control Systems (EMCS), and their effects on carbon emissions and climate-related disclosure. Climate risk has become one of the most pressing strategic considerations for firms, shaping regulatory expectations, investor demands, and reputational concerns (Agarwal, Qin, Sing, & Zhan, 2025; Dietz, Bowen, Dixon, & Gradwell, 2016; Ginglinger & Moreau, 2023; Krueger, Sautner, & Starks, 2020). In response, companies are increasingly investing in internal systems to manage environmental exposure and enhance transparency. EMCS, defined as formalized internal mechanisms that integrate environmental objectives into planning, monitoring, and control (Antonini & Gomez-Conde, 2024) have gained importance as companies seek to embed sustainability into corporate governance and performance evaluation frameworks (Cohen, Kadach, & Ormazabal, 2023; Derchi, Davila, & Oyon, 2023; Journeault, De Rongé, & Henri, 2016; Perego & Hartmann, 2009). Despite their increasing adoption, however, evidence remains scarce on whether EMCS effectively mitigate climate risk or serve primarily as symbolic or compliance-oriented tools (Antonini & Gomez-Conde, 2024; Fiechter, Hitz, & Lehmann, 2022; Grewal, Riedl, & Serafeim, 2019). Responding to calls for a dynamic, evolutionary perspective on control systems continually adapt to changing organizational and environmental conditions (Martin, 2020), we treat EMCS as adaptive mechanisms that firms recalibrate in the face of localized climate risk, and examine how this adoption subsequently influences carbon emissions and disclosure.

We analyze two main questions: the extent to which greater exposure to physical climate risk leads firms to adopt more comprehensive EMCS, and whether these systems influence environmental performance and reporting in ways that differ across emissions categories. These issues are critical given the distinct channels through which climate risk affects firm operations and reporting. While EMCS are designed to support emissions reductions and improve transparency, it remains unclear whether the same systems can be equally effective in achieving both objectives—particularly for Scope 3 emissions, which are difficult to monitor and control (Carrión, Larrinaga, & Rigling Gallagher, 2024; Cohen et al., 2023; Flammer, Toffel, & Viswanathan, 2021). Prior research has examined the determinants of voluntary climate disclosure (Darendeli, Fiechter, Hitz, & Lehmann, 2022; Flammer et al., 2021; Matsumura, Prakash, & Vera-Muñoz, 2014) and the effectiveness of internal control systems in sustainability contexts (Antonini & Gomez-Conde, 2024; Lisi, 2015), but few studies integrate these literatures to assess how climate exposure shapes EMCS adoption and its downstream consequences for emissions and disclosure.

Our argumentation is as follows. Firms located in areas facing higher physical climate risks—such as heatwaves, droughts, or extreme precipitation—are more likely to perceive climate change as a material threat. This perceived threat not only makes managers aware of the risks, but also increases external pressure from regulators, investors, and society to demonstrate active environmental responsibility (Baldini, Maso, Liberatore, Mazzi, & Terzani, 2018; Bansal & Roth, 2000). In response, firms adopt EMCS to formalize environmental oversight, integrate climate concerns into operational planning, and signal credibility through structured environmental reporting. However, the effectiveness of EMCS is likely to differ across environmental outcomes: while these internal systems can directly influence operational emissions (Scope 1 and 2), they may struggle to address value chain emissions (Scope 3) due to limited organizational control and measurement challenges. Moreover, EMCS may enhance the alignment between firms' emissions and their climate-related disclosures by improving data availability and internal accountability mechanisms, particularly where emissions are internally generated and auditable. We therefore expect EMCS to function both as instruments of control and as enablers of transparency.

We exploit the Provincial Spanish Actuarial Climate Index (pSACI), a granular and multi-dimensional measure of climate risk across Spanish provinces (Zhou, Vilar-Zanón, Garrido, & Martínez, 2024). The pSACI captures the frequency and intensity of province-level climate phenomena (e.g., temperature extremes, precipitation anomalies, drought, wind intensity, and sea level changes), allowing us to examine whether firms headquartered in more climate-vulnerable regions are systematically more likely to adopt EMCS. Thus, our empirical setting focuses on publicly listed Spanish firms between 2010 and 2022, yielding a panel of 1,284 firm-year observations across 13 industries and 20 provinces. The adoption of EMCS is assessed through archival data on formal environmental practices. To measure climate-related disclosure, we introduce a novel textual measure—"disinflated climate words," which adjusts the climate-related content of MD&A reports for overall report length inflation to isolate climate-relevant disclosure from broader ESG narrative expansion.

We document four key findings. First, consistent with H1, firms in provinces with higher climate risk are significantly more likely to adopt comprehensive EMCS. Second, in line with H2, EMCS exhibit no effectiveness in reducing carbon emissions (neither Scope 1&2 nor Scope 3)— raising questions about internal control systems' efficacy in addressing carbon accountability. Third, we find that the absolute value of emissions leads to more extensive climate related disclosures (H3a). However, when we look at the relative carbon intensity the disclosure strategy differs. The evidence shows that companies with higher Scope 1 and 2 emission intensity provide less extensive climate disclosure, while Scope 3 emission intensity is a key determinant of the level of climate related disclosures (H3b). Finally, consistent with H4, EMCS amplify the link between Scope 1 and 2 emissions and climate-related disclosure but play a weaker moderating role for Scope 3 emissions. These findings underscore the tension between firms' internal control capacity and external disclosure expectations in the face of climate risk. Additional analyses show that this moderating effect is most evident among firms with strong EMCS (for Scope 1&2) or weak EMCS (for Scope 3) or low profitability.

We contribute to the literature on climate governance, environmental control systems, and environmental disclosure in several ways. First, we advance prior research on the antecedents of environmental management control systems by showing that localized physical climate risk—captured through the provincial Spanish Actuarial Climate Index (pSACI)—is a key driver of EMCS adoption. By incorporating a granular, multidimensional measure of climate exposure, we provide new evidence that firms respond not only to regulatory or reputational pressures but also to localized environmental conditions. This finding advances existing work on institutional and stakeholder determinants of sustainability practices (Antonini & Gomez-Conde, 2024; Arjaliès & Mundy, 2013; Friedman & Ormazabal, 2024; Lisi, 2015). Unlike most research on climate change risk and disclosure, which relies on country-level measures and may obscure significant intra-national variations (Hong, Li, & Xu, 2019; Krueger et al., 2020; Yoon, Tashman, Benischke, Doh, & Kim, 2024), our approach captures spatial heterogeneity in risk exposure and managerial perceptions within a single country. This provides a more granular lens on the link between locally perceived risk and firms' climate-related reporting behaviors.

Second, we examine how EMCS influence carbon emissions across operational (Scopes 1 and 2) and value-chain (Scope 3) boundaries. While prior work has studied the role of control systems in shaping corporate environmental performance (Gomez-Conde, Lunkes, & Rosa, 2019), few studies disentangle their effects across emission types with distinct attribution and accountability challenges. We show that EMCS are not effective in reducing carbon emissions, highlighting the limitations of internal systems and contributing to the growing literature on the boundary conditions of sustainability controls and their interface with supply chain complexity (Carrión et al., 2024; Cohen et al., 2023; Flammer et al., 2021; Henri, Boiral, & Roy, 2014).

Third, we contribute to the literature on environmental disclosure by exploring how emissions intensity—differentiated by scope—influences the extent of climate-related narrative reporting, and whether EMCS moderate these relationships. Our findings suggest that while disclosure is positively associated with Scope 1 and 2 emissions intensity, this link weakens for Scope 3. EMCS increase the positive relationship between controllable emissions and disclosure, but have a reduced effect for less controllable emissions. These results reveal a control-disclosure asymmetry: internal systems reinforce transparency for operational emissions but play a limited role in enabling accountability for supply chain emissions. Importantly, our findings also speak to the growing recognition that climate-related disclosure can expose firms to market penalties, particularly when it reveals unmanaged risks or underperformance (Bonetti, Cho, & Michelon, 2024; Bose, Lim, Minnick, Schorno, & Shams, 2025). In this context, EMCS act a dual-purpose governance tools—supporting environmental performance management while helping firms navigate the reputational and financial trade-offs associated with transparency.

Fourth, we introduce a methodological contribution by developing a "disinflated climate word" metric to capture climate-related content in MD&A disclosures. Unlike traditional bag-of-words approaches, our measure adjusts for report-length inflation and normalizes climate references over time, improving construct validity in disclosure measurement. This innovation addresses recent calls for more sophisticated text-based proxies of environmental communication (De Haas & Popov, 2023), and provides a replicable tool for future research in accounting and sustainability disclosure. Collectively, these contributions increase our understanding of how firms internalize and respond to climate risks through formal control systems and disclosure practices. By integrating granular climate risk data, emissions by scope, and a refined disclosure measure, this study offers a comprehensive framework to assess the effectiveness and limitations of EMCS.

## 2. Literature and Hypotheses Development

Climate change refers to long-term shifts in temperature, precipitation patterns, and extreme weather events caused by anthropogenic activities, particularly greenhouse gas emissions (Dietz et al., 2016; Intergovernmental Panel on Climate Change, 2023; Kunreuther et al., 2013; Schneider, 2001). Related risks are classified into physical risks—such as extreme weather events and chronic environmental stressors—and transition risks associated with regulatory, technological, and market changes (Krueger et al., 2020; Task Force on Climate-Related Financial Disclosures (TCFD), 2017). These risks disrupt economic stability and require adaptive corporate strategies, presenting both financial challenges and strategic opportunities across industries (Bernstein, Gustafson, & Lewis, 2019; Carrión et al., 2024; Dietz et al., 2016; Ginglinger & Moreau, 2023; Krueger et al., 2020; Sautner, van Lent, Vilkov, & Zhang, 2023). A broad literature shows that climate risk shapes firms' financing, regulatory exposure, and strategic adaptation (e.g., green innovation and operational changes) (De Haas & Popov, 2023; Hart & Dowell, 2011; Ilhan, Sautner, & Vilkov, 2021; Javadi & Masum, 2021; Kling, Volz, Murinde, & Ayas, 2021; Stern & Valero, 2021; Weinhofer & Busch, 2013), and that disclosure of exposure to systematic climate risk can reduce firms' cost of capital (Heinle, Smith, & Verrecchia, 2018). In parallel, ESG capabilities support risk mitigation and resilience (Kunreuther et al., 2013; Reinecke & Ansari, 2016). For investors, climate risks represent both threats and opportunities. Institutional investors increasingly recognize the financial implications of climate risk, as evidenced by pricing mechanisms in equity and debt markets (Barnett, Brock, & Hansen, 2020; Hong et al., 2019; Sautner, Van Lent, Vilkov, & Zhang, 2023; Sautner, van Lent, et al., 2023). Both regulatory risks and physical exposure are now factored into valuations and investment decisions (Pástor, Stambaugh, & Taylor, 2022), with ESG-oriented strategies gaining atraction (Avramov, Cheng, Lioui, & Tarelli, 2022; Krueger et al., 2020).

Environmental Management Control Systems (EMCS) are "formalized procedures and systems, such as strategic planning, performance indicators, incentives, and policies, that use financial and non-financial information to maintain or alter patterns of environmental activity" (Journeault et al., 2016, p. 317). EMCS include resource-reduction targets, efficiency goals, sustainable packaging, supply-chain initiatives, training, and ESG-linked pay (Antonini & Gomez-Conde, 2024; Journeault et al., 2016). Their primary role is to embed environmental objectives, monitor performance, and foster innovation, improving sustainability outcomes while reducing ecological footprints (European Commission, 2014; Henri & Journeault, 2010; Lisi, 2015; Passetti, Battaglia, Testa, & Heras-Saizarbitoria, 2020; Perego & Hartmann, 2009). Strategic EMCS choices are typically shaped by the perspectives of top management teams located at corporate headquarters, even when firms operate across multiple regions or countries (Flammer et al., 2021; J. Kim, Wang, & Wu, 2023; Reid & Toffel, 2009). Drawing on institutional theory, these managers form risk perceptions based on their immediate regulatory, social, and cultural environment (Baldini et al., 2018; Bansal & Roth, 2000; Cormier, Magnan, & Van Velthoven, 2005). Therefore, when a firm's head office is situated in a region facing heightened climate vulnerability, local exposure is likely to translate into stronger perceived environmental risks, prompting managers to implement more robust environmental control mechanisms.

As firms come under increasing pressure to align with global climate commitments, the local climate context becomes a key influence in how environmental strategies—and EMCS specifically—are designed and deployed. For example, firms operating in provinces with greater climate risk may be more inclined to adopt stricter environmental targets, invest in green technologies, and develop broader performance metrics to address sustainability challenges (Antonini & Gomez-Conde, 2024; Journeault et al., 2016). However, not all firms exposed to climate risk will respond by adopting EMCS. Some may lack the internal capabilities, managerial commitment, or strategic orientation required to implement structured environmental controls. Others may perceive climate risk as a distant or non-material threat, especially if their operations are less directly affected or if they face weak stakeholder pressure. In such cases, firms may either underreact or respond through fragmented, ad hoc initiatives that fall short of formalized control sytems. This heterogeneity in response reflects differences in organizational readiness, resource availability, and the perceived cost-benefit tradeoff of EMCS adoption. Recent evidence suggests that even under regulatory pressure, firms with low environmental maturity or weak governance structures may delay or avoid adopting comprehensive EMCS, relying instead on symbolic compliance or minimal disclosure (Antonini & Gomez-Conde, 2024; Fiechter et al., 2022). Overall, we expect that firms facing greater climate risk are more likely to develop and implement comprehensive EMCS as part of a strategic effort to manage environmental exposure through structured organizational practices. Formally stated, our first hypothesis is as follows:

***H1.*** *Localized climate risk increases the likelihood that firms implement more comprehensive EMCS.*

$CO_2$ emissions constitute the largest share of anthropogenic greenhouse gases contributing to global warming (Charlson et al., 1992), which are typically grouped into three different categories: Scopes 1, 2, and 3 emissions (World Resources Institute & World Business Council for Sustainable Development, 2001, 2011). Scope 1 and 2 emissions, representing direct emissions from a firm's operations and indirect emissions from purchased energy, are easier to measure and control, reflecting operational efficiency and energy management (Luo & Tang, 2014; Matsumura et al., 2014). Scope 3 emissions, which encompass all other indirect emissions throughout the value chain, such as supplier activities and customer use of products (Luo & Tang, 2014; Tuck-Riggs, 2015), represent a holistic view of the full carbon footprint of a firm, but are more challenging and complex to measure, requiring collaboration between stakeholders (Ben-Amar, Chang, & McIlkenny, 2017; Qian & Schaltegger, 2017). From a financial perspective, disclosing Scope 1 and 2 emissions demonstrates immediate operational accountability, which enhances investor confidence and can lead to better capital access (Alsaifi, Elnahass, & Salama, 2020). Scope 3 disclosures, while challenging, are increasingly valued for their comprehensive risk representation, and when managed effectively, have a positive impact on firm valuation and sustainability ratings (Downar, Ernstberger, Reichelstein, Schwenen, & Zaklan, 2021).

EMCS align goals, metrics, and incentives to reduce carbon intensity (Henri & Journeault, 2010; Journeault et al., 2016; Lisi, 2015; Passetti et al., 2020). They are particularly suited to levers affecting Scope 1 and 2 (technology upgrades, resource optimization, internal policies) (Luo & Tang, 2014; Matsumura et al., 2014; Passetti et al., 2020). In contrast, managing Scope 3 emissions may prersent more complex challenges as they encompass indirect emissions throughout the value chain—including upstream suppliers and downstream product use (Qian & Schaltegger, 2017). Because these emissions arise from activities outside the firm's direct control, EMCS may be less effective in managing them, especially when supply chain partners lack environmental capabilities or incentives to cooperate. Moreover, efforts to reduce internal emissions may unintentionally shift carbon intensity to external partners, a phenomenon known as carbon leakage (Aichele & Felbermayr, 2015; Babiker, 2005; Burniaux & Oliveira Martins, 2012). For example, outsourcing production to suppliers with less stringent environmental practices may lower Scope 1 and 2 emissions but increase Scope 3 emissions, thereby undermining the net environmental benefit (Ben-Amar et al., 2017). Similarly, firms seeking to comply with internal targets may restructure operations in ways that reallocate, rather than eliminate, emissions (Fleming & Vanclay, 2010).

Importantly, the presence of EMCS does not guarantee emission reductions.

Firms may adopt EMCS for symbolic or compliance-oriented reasons, without fully integrating them into operational decision-making or resource allocation. In such cases, EMCS may exist on paper but lack the traction needed to drive substantive environmental change. Recent evidence suggests that even under regulatory pressure, internal control systems may fail to produce measurable environmental outcomes if they are not supported by strong managerial commitment, cross-functional coordination, and adequate data infrastructure (Antonini & Gomez-Conde, 2024; Fiechter et al., 2022). Taken together, we expect EMCS to be more effective in reducing carbon emissions that are operationally controllable (Scope 1 and 2), while their influence on value-chain emissions (Scope 3) may be weaker or even offset by strategic reallocation. Formally stated, our second hypothesis is as follows:

***H2.*** *EMCS are associated with lower carbon emission intensity, with a stronger effect on Scope 1 and 2 emissions than on Scope 3 emissions.*

Climate disclosure covers GHG emissions, risks, opportunities, or governance and strategy, often guided by CDP and TCFD frameworks (Ben-Amar et al., 2017; Cohen et al., 2023; Flammer et al., 2021; Friedman & Ormazabal, 2024; Matsumura et al., 2014). Firms disclose due to regulation, stakeholder pressure, competitive positioning, and governance incentives (Clarkson, Li, Pinnuck, & Richardson, 2015; Depoers, Jeanjean, & Jérôme, 2016; He, Luo, Shamsuddin, & Tang, 2022; Ioannou, Li, & Serafeim, 2016). Signaling theory suggests that firms with superior environmental performance disclose more extensively to differentiate themselves from peers (Al-Tuwaijri, Christensen, & Hughes II, 2004; Luo & Tang, 2014); shareholder activism and board structures (e.g., gender diversity) also matter (Ben-Amar et al., 2017; Flammer et al., 2021; Haque, 2017; Lewis, Walls, & Dowell, 2014). Disclosure can reduce information asymmetry and the cost of capital, though its effects vary depending on firms' risk profiles and perceived credibility (Alsaifi et al., 2020; Bonetti et al., 2024; Christensen, Hail, &

Leuz, 2021; Griffin, Lont, & Sun, 2017; Matsumura et al., 2014).

Firms with higher absolute $CO_2$ emissions, particularly in carbon-intensive industries, are more likely to disclose extensive climate-related information in their MD&A reports (Kanodia & Sapra, 2016; J. Kim et al., 2023), consistent with institutional pressures and reputational concerns (Bansal & Roth, 2000; Griffin et al., 2017; Kanodia & Sapra, 2016; J. Kim et al., 2023; Luo & Tang, 2014; Reid & Toffel, 2009). However, disclosure is not solely a function of emission levels—it also reflects the composition and controllability of those emissions. A higher proportion of controllable Scope 1 and 2 emissions may encourage firms to report granular reduction strategies, while heavier reliance on Scope 3—due to their complexity and limited traceability— may lead firms to adopt broader narrative-driven disclosure approaches (Ben-Amar et al., 2017; De Haas & Popov, 2023; Qian & Schaltegger, 2017; Tuck-Riggs, 2015). As a result, firms may avoid detailed disclosure to minimize reputational risk or to prevent drawing attention to areas where they lack control. This asymmetry reflects both strategic disclosure choices and practical constraints in environmental reporting. Formally stated, our third hypothesis is as follows:

***H3.*** *Firms with higher Scope 1 and 2 emissions intensity disclose more climate-related information in their MD&A reports (H3a), whereas firms with higher Scope 3 emissions intensity disclose less (H3b).*

A growing body of research suggests that organizational practices and information systems can substantially shape how managers perceive and respond to environmental risks (Henri & Journeault, 2010; Journeault et al., 2016; Malmi & Brown, 2008). Environmental Management Control Systems (EMCS) help firms integrate environmental objectives into core decision-making by setting clear performance targets, monitoring carbon emissions, and providing structured incentives linked to sustainability performance (Antonini & Gomez-Conde, 2024; Derchi et al., 2023; Lisi, 2015). While these internal mechanisms often target more controllable emissions (Scope 1 and 2), they may also incorporate supply-chain initiatives that address external emission sources (Scope 3) (Huang & Kung, 2010; Merchant & Otley, 2020). EMCS, therefore, create formalized pathways for data gathering and reporting—such as dedicated carbon accounting tools and documented reduction plans—that can be directly translated into more comprehensive climate-related disclosures in the MD&A (Bolton & Kacperczyk, 2021; Passetti et al., 2020).

A key question is whether EMCS influence not only what firms disclose, but how they do so. By embedding carbon tracking and accountability into internal routines, EMCS may promote more concise, data-driven climate disclosures that reduce reliance on unstructured narrative and boilerplate. Such reporting may enhance clarity and verifiability, mitigating the risk of litigation or regulatory sanction for inaccurate environmental communication. Recent findings by Robinson, Skinner, and Wang (2025) support this view, showing that firms adjust their sustainability disclosures in response to heightened litigation threats, particularly in environmental domains. Accordingly, EMCS may serve not only as instruments of operational control, but also as internal safeguards that strengthen the credibility of climate-related disclosures and reduce the potential legal and reputational costs of misreporting.

Moreover, firms with high carbon intensity—whether from Scope 1&2 or Scope 3 sources—are more likely to face scrutiny from regulators, investors, and affected communities (Krueger et al., 2020; Matsumura et al., 2014). This external pressure increases the salience of climate risks within the organization, prompting managers to communicate more openly and defensively. EMCS can reinforce this disclosure behavior by institutionalizing data collection, assigning accountability for emissions performance, and aligning incentives around transparency goals (Henri & Journeault, 2010; Passetti et al., 2020). Recent evidence also points to the role of psychological salience in shaping climate communication. Huynh, Li, and Xia (2025) find that local exposure to pollution influences investment decisions by mutual fund managers—a mechanism related to salience and "local thinking" (Gennaioli & Shleifer, 2010; Kahneman & Tversky, 1972; Tversky & Kahneman, 1974). We argue that the same logic can apply to corporate decision-makers: when environmental risks become more visible or immediate, EMCS can act as a conduit that (1) captures these heightened perceptions in internal systems, and (2) translates them into more credible and responsive disclosures (Andrew & Baker, 2020; Perego & Hartmann, 2009).

Taken together, we argue that EMCS moderate the association between carbon emissions and climate-related disclosure. In firms with high $CO_2$ intensity, EMCS may operate as amplifiers that enhance transparency and encourage structured reporting. However, this moderating effect may vary by emissions scope: EMCS are likely to strengthen the link between Scope 1 and 2 emissions and disclosure, where internal control is feasible, but may have limited influence over Scope 3-related reporting due to external dependencies and measurement challenges. Accordingly, we propose the following hypothesis:

***H4.*** *EMCS moderate the positive association between a firm's $CO_2$ emissions intensity (Scope 1&2 and Scope 3) and the level of climate-related disclosure in its MD&A reports.*

The following figure 1 presents our conceptual framework, which follows a temporal causal sequence. The temporal ordering of variables follows a logical causal sequence that accounts for the inherent lag in corporate decision-making and reporting. Specifically, climate risk exposure in period $t-1$ precedes the adoption of Environmental Management Control Systems (EMCS) in period $t$, capturing the time required for organizational response and implementation (H1). EMCS development then potentilly influences carbon emission intensity in period $t+1$, allowing for the lagged effect of management systems on operational outcomes (H2). A key feature of our specification is the concurrent measurement of emissions and disclosure in period $t+1$, recognizing the that

Management Discussion & Analysis repors refers to activities and outcomes from the same period, even though they are prepared and published with a delay (H3). Meanwhile, $EMCS_t$ moderates the emissions-disclosure in period $t+1$ relationship through interaction effects (H4). This temporal ordering ensures that cause precedes the effect and mitigates reverse causality concerns.

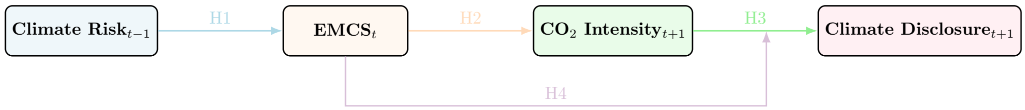


**Figure 1.** Empirical Model and Hypothesis Testing Sequence. The figure depicts the temporal ordering of variables and the four hypotheses tested. Solid arrows represent direct effects (H1-H3), and the dashed arrow represents the moderating effect (H4)

## 3. Data and Methodology

### *3.1. MD&A Report*

We use manually collected annual Management Discussion and Analysis (MD&A) reports (including non-financial statements)[1] from Spanish publicly listed firms from 2010 to 2022 to construct time-varying measures of firm-level climate-related disclosure. The use of MD&A reports from publicly listed companies is a valuable approach for studying climate change risks and $CO_2$ emissions intensity. These sections, mandated by regulators, provide insights into financial performance and forward-looking risks, including environmental challenges (Muslu, Radhakrishnan, Subramanyam, & Lim, 2015). Climate-related disclosures in MD&A reports reflect companies' perceptions and strategies for addressing climate risks, making them a crucial resource for assessing how firms acknowledge and manage such risks (Clarkson, Li, Richardson, & Vasvari, 2008). Unlike voluntary reports, MD&A disclosures are integrated into financial filings, offering greater standardization and credibility (Li et al., 2010; Matsumura et al., 2014).

[1] We also consider sustainability reports, corporate social responsibility reports, and integrated annual reports before 2018, since the term *non-financial statements* was formalized after the implementation in 2018 of EU Directive 2014/95 in Spain.

Additionally, the textual nature of MD&A reports allows for the application of advanced textual analysis to systematically examine climate-related content, covering how companies articulate climate-related risks and strategies and whether these narratives align with their actual emissions performance (Li et al., 2010; Reid & Toffel, 2009), providing insights into the relationship between climate risks and corporate environmental accountability (E. Kim & Lyon, 2011). Our final sample includes 1284 firm-year observations from 121 Spanish listed firms headquartered in 20 spanish provinces. Spain is an appropriate setting to study the relationship among climate risk, EMCS, environmental performance, and disclosure. The Spanish context offers several advantages for this analysis. First, the country exhibits substantial regional heterogeneity in physical climate risk, including variations in temperature extremes, drought frequency, and coastal vulnerability—captured through the Provincial Spanish Actuarial Climate Index (pSACI). Second, Spain has undergone a gradual but structured implementation of environmental reporting and control practices, influenced by EU-level directives and national transpositions, which allows for variation in EMCS adoption across firms and time. Third, the availability of detailed firm-level data on emissions, governance, and MD&A disclosures facilitates a robust empirical design with temporal ordering. This setting enables us to examine how localized environmental threats translate into internal control responses and reporting behaviors, while mitigating concerns about simultaneity and reverse causality.

### *3.2. Carbon Emissions Intensity*

We measure firms' climate actions using $CO_2$ emissions intensity. $CO_2$ emissions are widely recognized as a critical indicator of exposure to climate risks (Bolton & Kacperczyk, 2021, 2023). Analyzing emissions is also the most frequently used climate risk management tool (Krueger et al., 2020), and it remains a primary target of policy and investor initiatives to achieve net-zero emissions (Sautner, van Lent, et al., 2023). Using carbon emissions as a metric offers several advantages: they are straightforward to understand and calculate, readily accessible through environmental, social, and governance (ESG) databases, and intrinsically linked to global climate change dynamics. Moreover, firms have faced considerable opposition when reporting emission intensities, highlighting their sensitivity and importance in both corporate disclosures and investor decision-making.

Rather than relying on absolute $CO_2$ emissions, we employ Refinitiv's $CO_2$ emission intensity metric (i.e., emissions relative to revenues) to mitigate size-related biases. We collect Scope 1 and 2, as well as Scope 3 data, standardizing emissions by revenues to ensure comparability across firms and over time (Bolton & Kacperczyk, 2021, 2023; Sautner, van Lent, et al., 2023). Hereafter, the terms $CO_2$ emissions refer to $CO_2$ emissions intensity ($CO_2$ emissions standardized by revenues).

To link emissions data with our sample, we use firms' ticker symbols and ISIN numbers. Due to the limited volume of the Spanish market, we ultimately match 514 firm-year observations with Scope 1 and 2 emissions data, and 399 firm-year observations with Scope 3 emissions data, covering 13 industries between 2010 and 2022. This matching approach follows common empirical methods (Bolton & Kacperczyk, 2021; Sautner, van Lent, et al., 2023) and ensures consistency in the construction of our panel.

### *3.3. The Provincial Spanish Actuarial Climate Index*

We use the Provincial Spanish Actuarial Climate Index (pSACI) (Zhou et al., 2024) as a metric of climate change in the headquarter province of the firm. Zhou and Vilar-Zanón (2024, 2025) demonstrate that the Spanish Actuarial Climate Index (SACI) and its subregional index (pSACI) are effective tools to assess the risk of climate change, particularly in hail insurance claims.

Figure 2 illustrares the 5-year moving average of the Provincial Spanish

Actuarial Climate Index (pSACI), highlighting the unique climate change characteristics of each province in Spain where firms' headquarters are located. The trends reveal significant regional variations in the progression of climate risks, emphasizing the localized nature of climate change impacts.

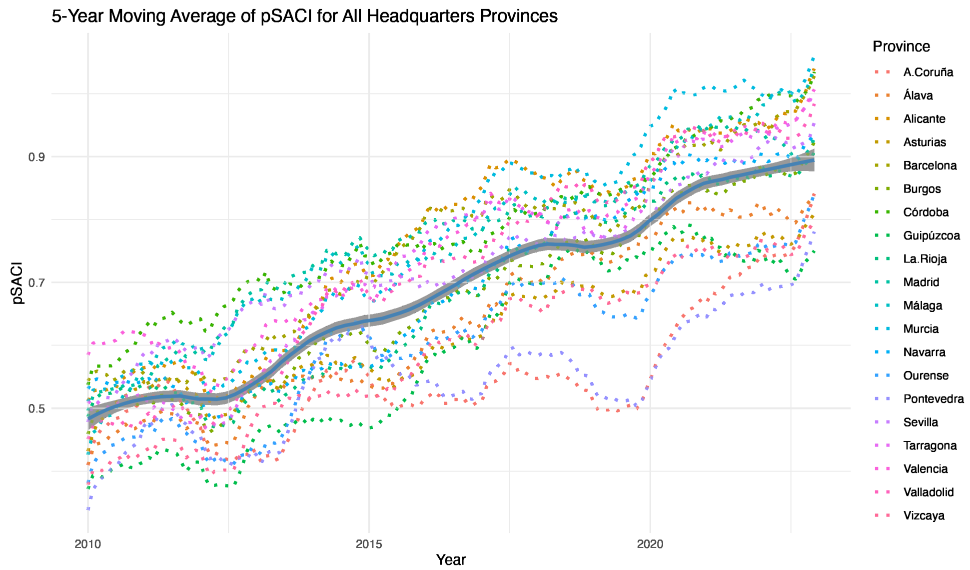


**Figure 2.** 5-Year Moving Average of the Provincial Spanish Actuarial Climate Index (pSACI) for All Firms' Headquarters Provinces, 2010-2022. Each colored diamond represents a province's MA value; the steel-blue LOESS curve (with shaded 95 % CI) highlights the overall upward trend, indicating a growing impact of climate change on the regions where firms' headquarters are located.

### *3.4. Measurement of Climate Disclosure: A disinflated measure of Climate Change Words*

Over time, the number of climate change-related words in MD&A reports can be influenced by factors unrelated to climate issues, such as the overall expansion of the report and the increased inclusion of ESG (Environmental, Social, and Governance) content. Existing studies often measure a company's focus on information disclosure, by using a measure that calculates the relevance of ESG words with respect to the total number of words (Li et al., 2010; Loughran & McDonald, 2016; Sautner, van Lent, et al., 2023). However, this relative measure poses two challenges: it cannot fully eliminate the impact of the overall report length expansion, nor can it accurately capture the absolute increase in word usage.

To more accurately assess the true extent of climate change information disclosure, we draw on the concept of "disinflation[2]" from economics by introducing a "Disinflation Factor". This factor is used to standardie the number of climate change-related words, thereby yielding a standardised absolute metric after removing the confounding effects of overall report length and ESG content growth. Specifically, the Disinflation Factor is determined by the rate of change in ESG-related words relative to a base year (e.g., 2010), as well as the rate of change in total words relative to the same base year, which allows for a more precise reflection of a firm's genuine progress in climate-related disclosures. Compared to traditional percentage-based methods, this approach not only facilitates better cross-year comparisons but also more effectively highlights the actual trends in corporate climate-related information disclosure. Hereafter, the Disinflated Numbers of Climate Change Words are denoted as *"Climate Disclosure"*.

$$\text{Climate Disclosure}_{i,t} = \frac{\text{N\_CCW}_{i,t}}{\text{Disinflation Factor}_t}$$

$$\text{Disinflation Factor}_t = \left(\frac{\overline{\text{N\_ESGW}_t}}{\overline{\text{N\_ESGW}_{2010}}}\right) \times \left(\frac{\overline{\text{N\_TotalW}_{2010}}}{\overline{\text{N\_TotalW}_t}}\right)$$

Where:

- $\text{N\_CCW}_{i,t}$: Number of Total Climate Change Words in MD&A Report for firm $i$ in year $t$.
- $\overline{\text{N\_ESGW}_t}$: Mean of Number of ESG Words in MD&A Report for all sample firms in year $t$.
- $\overline{\text{N\_TotalW}_t}$: Mean of Number of Total MD&A Report Words for all sample firms in year $t$.

[2] In economics, "inflation" typically refers to the rise in the general price level over time. To compare the real changes in data across different periods, it is necessary to convert nominal values into real values in order to remove the confounding effects of inflation. In other words, when we focus on the "actual" growth or change over a certain period, we must "disinflate" (through disinflation or deflation) the variable in question.

We initially adopt deep learning techniques (specifically a recurrent neural network model, RNN) to create an ESG words' list, comprising 2,385 terms. We specifically run the RNN models to annual reports published by publicly listed companies from 2014 to 2022[3], adhered to the guidelines outlined in the more recently issued Corporate Sustainability Reporting Directive (CSRD) [4] and utilized the glossary provided by the European Sustainability Reporting Standards (ESRS) (Brown, Hinson, & Tucker, 2024; Lai, Xu, Liu, & Zhao, 2015). Subsequently, to ensure high accuracy, we conducted a manual review of reports from 2020 to 2022, removing misclassified and duplicate terms, standardizing formats, and retraining the RNN model. This process produced our final, comprehensive set of ESG word list, tailored for Spanish ESG disclosure texts (Bochkay, Brown, Leone, & Tucker, 2023; García, Hu, & Rohrer, 2023; Henry & Leone, 2016; Jain, 2025).

Drawing on this ESG dictionary, we then identified climate-related terms by referring to the Task Force on Climate-related Financial Disclosures (TCFD) framework and the climate-related seed words proposed by (Lin, Shen, Wang, & Julia Yu, 2024). Our final climate-related dictionary ultimately contains 265 terms. Detailed climate-related dictionaries are available in the Appendix B.

### *3.5. Empirical Models*

To test our hypotheses, we employ a fixed effects (FE) panel regression framework that controls for both year and industry fixed effects. This approach ef-

[3]We restrict the analysis to the period 2014–2022 to align with the introduction and progressive implementation of the EU Non-Financial Reporting Directive (NFRD), which was adopted in 2014 and came into effect in 2017. The post-2014 period marks a regulatory turning point that not only expanded ESG disclosure requirements but also introduced more standardized and policy-aligned terminology.

[4]The selection of the Corporate Sustainability Reporting Directive (CSRD) over the Non-Financial Reporting Directive (NFRD) is grounded in its temporal relevance and regulatory evolution. While the NFRD as an early EU framework imposed limited ESG disclosure requirements, the CSRD—through its European Sustainability Reporting Standards (ESRS)—provides a structured, context-sensitive terminology framework essential for disambiguating ESG terms in Spanish texts (e.g., differentiating "emisiones" by environmental or financial contexts). This choice accounts for the anticipatory adoption of CSRD guidelines by Spanish firms during 2018–2022, reflecting regulatory trends and emerging ESG concepts (e.g., biodiversity, just transition) absent in the NFRD. Furthermore, the CSRD's emphasis on dual materiality and standardized lexicons aligns methodologically with the hybrid NLP approach, ensuring consistency in capturing both predefined and contextually derived ESG terminology while addressing syntactic and lexical nuances specific to Spanish ESG narratives.

fectively accounts for time-invariant unobserved heterogeneity across industries and common temporal shocks that may affect all firms simultaneously. The use of fixed effects helps mitigate omitted variable bias and provides more robust causal inference (Wooldridge, 2010).

For H1, where the dependent variable (EMCS) is an ordinal measure with seven categories representing increasing levels of environmental management system comprehensiveness, we utilize an ordered logit model with fixed effects. The ordered logit model is appropriate for categorical dependent variables that have a natural ordering but unknown spacing between categories (Long, 1997). This model estimates the probability of a firm being in a higher category of EMCS based on the explanatory variables, while maintaining the ordinal nature of the outcome variable. The inclusion of year and industry fixed effects through dummy variables ensures that we control for both temporal trends and industry-specific characteristics. Model fit is assessed using Nagelkerke $R^2$, a pseudo R-squared measure that provides an approximation of the variance explained for categorical dependent variables, along with AIC and BIC statistics.

For H2-H4, where the dependent variables are continuous measures of carbon emissions and disclosure levels, we employ linear fixed effects models. All models include clustered standard errors at the firm level (ISIN) to account for potential heteroskedasticity and within-firm correlation of errors.

The general form of our fixed effects models can be expressed as:

$$Y_{it} = \alpha + \beta X_{it} + \gamma Controls_{it} + \delta_i + \theta_t + \epsilon_{it} \tag{1}$$

Where:

- $Y_{it}$: Outcome variable for firm $i$ in year $t$
- $X_{it}$: Key independent variable(s) of interest
- $Controls_{it}$: Vector of firm-level control variables

- $\delta_i$: Industry fixed effects
- $\theta_t$: Year fixed effects
- $\epsilon_{it}$: Error term, clustered at the firm level

*Model Specifications by Hypothesis*

**Hypothesis 1 (H1):** Tests the relationship between prior climate risk and Environmental Management Control Systems (EMCS).

$$\text{EMCS}_{i,t} = \alpha + \beta_1 \text{Climate Risk}_{i,t-1} + \Gamma \text{Controls}_{i,t-1} + \delta_i + \theta_t + \epsilon_{i,t} \tag{H1}$$

**Hypothesis 2 (H2):** Examines the impact of EMCS on subsequent carbon emission intensity, analyzed separately for Scope 1&2 and Scope 3 emissions.

$$\text{CO2 Intensity}_{i,t} = \alpha + \beta_1 \text{EMCS}_{i,t-1} + \Gamma \text{Controls}_{i,t-1} + \delta_i + \theta_t + \epsilon_{i,t} \tag{H2}$$

**Hypothesis 3 (H3):** Investigates how carbon emissions influence climate-related disclosures, testing both absolute emissions (H3a) and relative emissions compared to industry peers (H3b).

$$\begin{aligned}
\text{Disclosure}_{i,t} &= \alpha + \beta_1 \text{CO2 Emissions}_{i,t} + \beta_2 \text{Climate Risk}_{i,t} \\
&\quad + \beta_3 \text{Climate Risk}_{i,t-1} + \Gamma \text{Controls}_{i,t} + \delta_i + \theta_t + \epsilon_{i,t} \qquad \text{(H3a)} \\
\text{Disclosure}_{i,t} &= \alpha + \beta_1 \text{CO2 Percentage}_{i,t} + \beta_2 \text{Total CO2}_{i,t} \\
&\quad + \beta_3 \text{Climate Risk}_{i,t} + \beta_4 \text{Climate Risk}_{i,t-1} + \Gamma \text{Controls}_{i,t} \\
&\quad + \delta_i + \theta_t + \epsilon_{i,t} \qquad \text{(H3b)}
\end{aligned}$$

**Hypothesis 4 (H4):** Tests whether EMCS moderates the relationship between carbon emissions and climate disclosures.

$$\begin{aligned}\text{Disclosure}_{i,t} = \alpha &+ \beta_1 \text{EMCS}_{i,t-1} + \beta_2 \text{CO2 Emissions}_{i,t} \\ &+ \beta_3 (\text{EMCS}_{i,t-1} \times \text{CO2 Emissions}_{i,t}) + \Gamma \text{Controls}_{i,t} \\ &+ \delta_i + \theta_t + \epsilon_{i,t} \qquad \text{(H4)}\end{aligned}$$

All models include year and industry fixed effects to control for temporal trends and industry-specific characteristics. Standard errors are clustered at the firm level (ISIN) to account for potential heteroskedasticity and within-firm correlation. The following control variables are included in all specifications: firm size, leverage, return on assets (ROA), and book-to-market ratio, measured with appropriate time lags as specified in each hypothesis. Model fit is assessed using R-squared, within R-squared, AIC, BIC, and log-likelihood statistics as appropriate for each model type.

## 4. Results

### *4.1. Sample Distribution and Descriptive Statistics*

| Variable | Min | 1st Qu. | Median | Mean | 3rd Qu. | Max | Sd. |
|---|---|---|---|---|---|---|---|
| **EMCS** | 0.00 | 3.00 | 4.00 | 4.20 | 6.00 | 7.00 | 1.67 |
| **Climate Risk** | 0.16 | 0.72 | 0.80 | 0.83 | 0.95 | 1.33 | 0.18 |
| **Climate disclosure** | 0.00 | 3.80 | 33.91 | 125.87 | 162.20 | 2044.25 | 228.21 |
| **log(Climate disclosure)** | -0.57 | 1.33 | 3.52 | 3.19 | 5.09 | 7.62 | 2.16 |
| **Scope 1&2** | -2.38 | 2.11 | 3.53 | 3.60 | 5.39 | 7.37 | 2.12 |
| **Scope 3** | -3.85 | 0.51 | 3.65 | 3.42 | 5.76 | 13.40 | 3.04 |
| **Leverage** | 0.00 | 17.40 | 31.21 | 36.36 | 47.62 | 193.94 | 26.16 |
| **ROA** | -93.95 | 0.16 | 2.10 | 1.72 | 5.33 | 91.20 | 11.41 |
| **Size** | 14.73 | 19.45 | 21.23 | 21.32 | 23.11 | 27.34 | 2.42 |
| **BM ratio** | -13.37 | 0.29 | 0.58 | 0.73 | 1.02 | 25.38 | 1.65 |

**Table 1.** Summary statistics for the main metrics. The variable Climate Risk represents the Provincial Spanish Actuarial Climate Index, which measures climate change risk at the company's headquarters location. The dataset spans the years 2010 to 2022, comprising a total of 1,284 observations from 121 firms across 13 industries.

In Table 1, we provide descriptive statistics of key variables. The main variables include *Climate Risk* (CR), *Climate Disclosure*, its logarithmic transformation (log(Climate Disclosure)), and carbon dioxide emissions (*Scope 1&2* and *Scope 3*). The control variables are *Leverage*, *ROA*, *Size* and *Book-to-Market ratio*. *Climate Risk* ranges from 0.16 to 1.33, with a mean of 0.83, a median of 0.80, and a standard deviation of 0.18; *Climate Disclosure* ranges from 0.00 to 2044.25, with a mean of 125.87, a median of 33.91, and a standard deviation of 228.21; the log-transformed *Climate Disclosure* (log(Climate Disclosure)) ranges from -0.57 to 7.62, with a mean of 3.19 and a standard deviation of 2.16. In terms of carbon dioxide emissions, *Scope 1&2* emissions range from -2.38 to 7.37, with a mean of 3.60 and a standard deviation of 2.12, while *Scope 3* emissions range from -3.85 to 13.40, with a mean of 3.42 and a standard deviation of 3.04. These variables exhibit varying degrees of missing data. To maximize sample size, this study did not exclude missing data at this stage but performed data cleaning in subsequent analyses based on the variables required by the models. In terms of industry distribution (non-tabulated), a total of 121 companies are spread across 13 industries.[5]. Table 2 presents the proportion and the cumulative distribution of observations by EMCS level, as shown that the majority of firms score between 3 and 6 on the EMCS scale.

| **EMCS** | **Proportion (%)** | **Cumulative (%)** |
|---|---|---|
| 0 | 3.10 | 3.10 |
| 1 | 3.26 | 6.36 |
| 2 | 8.99 | 15.35 |
| 3 | 17.05 | 32.40 |
| 4 | 23.10 | 55.50 |
| 5 | 15.81 | 71.32 |
| 6 | 24.96 | 96.28 |
| 7 | 3.72 | 100.00 |

**Table 2.** Proportion and Cumulative Distribution of Observations by EMCS Level.

Table 3 presents the correlation matrix between the main variables

[5]We obtain 391 observations in the C (Manufacturing), and 181, 165, 122, 103, and 82 observations in the F (Construction), K (Financial and insurance activities), J (Information and communication), D (Electricity, gas, steam and air conditioning supply), and L (Real estate activities) industries, respectively, and the remaining 7 industry categories totaling 240 observations

and control variables. *Climate Risk* is significantly positively correlated with log(Climate Disclosure) (correlation coefficient of 0.25, significance level $p < 0.01$) and with *Leverage* (0.13, $p < 0.01$). log(Climate Disclosure) is significantly positively correlated with *Scope 1&2* emissions (0.19, $p < 0.01$) and *Scope 3* emissions (0.46, $p < 0.01$). *EMCS* is significantly positively correlated with log(Climate Disclosure) (0.32, $p < 0.01$). Overall, these correlations are consistent with extant prior work (Downar et al., 2021; Matsumura, Prakash, & Vera-Muñoz, 2024).

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| (1) EMCS | 1 | 0.02 | 0.32*** | 0.12*** | 0.16*** | 0.18*** | 0 | 0.40*** | -0.05 |
| (2) C.R. | | 1 | 0.25*** | -0.04 | 0.13*** | 0.03 | -0.01 | 0 | 0.02 |
| (3) log(C.D.) | | | 1 | 0.19*** | 0.46*** | 0.07** | 0.03 | 0.59*** | 0.01 |
| (4) Scope 1&2 | | | | 1 | 0.60*** | -0.37*** | 0.03 | -0.06 | -0.16*** |
| (5) Scope 3 | | | | | 1 | -0.44*** | 0.01 | -0.11** | -0.10** |
| (6) Leverage | | | | | | 1 | -0.32*** | 0.44*** | 0.01 |
| (7) ROA | | | | | | | 1 | 0.04 | 0.11*** |
| (8) Size | | | | | | | | 1 | 0.08*** |
| (9) BM ratio | | | | | | | | | 1 |

**Table 3.** Correlation Matrix. Climate Risk; log(C.D.): log(Climate Disclosure); Scope 1&2: Scope 1&2 Emissions to revenues; Scope 3: Scope 3 Emissions to revenues; Leverage: Debt Ratio; ROA: Retrun on Assets; Size: Log(Total Assets); EMCS: Environmental Management Control Systems;BM ratio: Book to Market ratio. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

### *4.2. Main Results*

#### *4.2.1. Results for H1*

Table 4 presents the results from our ordered logit model, which examines how a firm's previous climate risk influences the comprehensiveness of Environmental Management Control Systems (EMCS). Overall, our findings reveal that climate risk positively impacts the adoption of EMCS. The coefficient for the variable of interest, that is, the level of climate risk is 1.594 and statistically significant at the 10% level. This indicates that firms experiencing higher climate risk in the previous period tend to implement more comprehensive EMCS measures. Essentially, heightened climate risk appears to prompt companies to enhance their internal environmental management practices.

| Dependent Variables: | $EMCS_t$ |
|---|---|
| Climate $Risk_{t-1}$ | 1.594* |
| | (0.820) |
| $Size_{t-1}$ | 0.763*** |
| | (0.071) |
| $Leverage_{t-1}$ | 0.017*** |
| | (0.005) |
| $ROA_{t-1}$ | 0.018 |
| | (0.012) |
| BM $ratio_{t-1}$ | -0.204 |
| | (0.134) |
| *Fixed-effects* | |
| Year | Yes |
| Industry | Yes |
| AIC | 1851.906 |
| BIC | 1999.419 |
| Log Likelihood | -891.953 |
| Observations | 566 |
| Nagelkerke's $R^2$ | 0.349 |

*Clustered (ISIN) standard-errors in parentheses*
*Signif. Codes:* ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

**Table 4.** H1: The Impact of Climate Risk on Environmental Management Control Systems. This table presents the results of an ordered logit regression examining the effect of prior period climate risk (Climate $Risk_{t-1}$) on the current level of Environmental Management Control Systems ($EMCS_t$).

Related to control variables, as expected, firm size also has a strong positive effect, with a coefficient of 0.763 ($p < 0.01$). Larger firms, often endowed with greater resources and subject to more rigorous regulatory oversight, are more likely to invest in and maintain a higher level of EMCS. Interestingly, even though the leverage coefficient is relatively small at 0.017, it is highly significant ($p < 0.01$). This suggests that firms with higher debt levels strengthen their internal environmental management systems to mitigate external financing risks or satisfy regulatory pressures. The overall model fit is also quite revealing. A Nagelkerke $R^2$ of 0.349 indicates that the model accounts for a substantial portion of the variation in EMCS comprehensiveness. The AIC and Log Likelihood values further support the robustness of the model. The model controls for both year and industry fixed effects.

### 4.2.2. Results for H2

Hypothesis H2 posits that *EMCS reduces carbon emission intensity, with a stronger effect on Scope 1&2 than on Scope 3*. However, the findings presented in Table 5 do not support this hypothesis.

| Dependent Variables: Model: | Scope $1\&2_t$ (1) | Scope $3_t$ (2) |
|---|---|---|
| *Variables* | | |
| $\text{EMCS}_{t-1}$ | 0.0372 | 0.1681 |
| | (0.0859) | (0.1284) |
| $\text{Size}_{t-1}$ | 0.3552*** | 0.4601** |
| | (0.1160) | (0.1983) |
| $\text{Leverage}_{t-1}$ | -0.0113 | -0.0117 |
| | (0.0118) | (0.0117) |
| $\text{ROA}_{t-1}$ | -0.0182 | -0.0104 |
| | (0.0148) | (0.0247) |
| BM $\text{ratio}_{t-1}$ | 0.1097 | 0.3029 |
| | (0.1723) | (0.4469) |
| *Fixed-effects* | | |
| Year | Yes | Yes |
| Industry | Yes | Yes |
| *Fit statistics* | | |
| Observations | 444 | 345 |
| $R^2$ | 0.65770 | 0.62549 |
| Within $R^2$ | 0.11354 | 0.11822 |

*Clustered (ISIN) standard-errors in parentheses*
*Signif. Codes:* $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

**Table 5.** H2: The Impact of EMCS on Carbon Emission Intensity. This table presents the results of fixed effects regressions examining the effect of prior period EMCS ($\text{EMCS}_{t-1}$) on the current period carbon emission intensity for Scope 1&2 (Model 1) and Scope 3 (Model 2).

In both the Scope 1&2 and Scope 3 models, the coefficients for the lagged EMCS variable are statistically insignificant (0.037 for Scope 1&2 and 0.168 for Scope 3). These results suggest that, after controlling for firm characteristics and including year and industry fixed effects, EMCS does not have a discernible effect on reducing carbon emission intensity in either scope. Contrary to our expectations, the positive direction of both coefficients, while not significant, does not provide evidence that EMCS leads to emission reductions.

Regarding the control variables, firm size exhibits a positive and significant effect in both models (0.355 for Scope 1&2, $p < 0.01$ and 0.460 for Scope 3, $p < 0.05$). This suggests that larger firms tend to have higher carbon emission intensity, possibly due to more extensive production activities. Leverage shows a negative but statistically insignificant relationship with emission intensity in both models. Similarly, ROA and book-to-market ratio do not demonstrate statistically significant effects on carbon emissions.

In summary, the evidence does not support Hypothesis H2. Instead of reducing carbon emission intensity, EMCS appears to have no statistically significant relationship with emissions in either scope. These findings challenge the assumption that environmental management control systems directly lead to emission reductions and suggest that other factors may play a more important role in determining firms' carbon performance.

*4.2.3. Results for H3*

The results presented in Table 6 provide insights into how carbon emission intensity—both absolute and relative—affects the extent of climate-related disclosure in MD&A reports, based on fixed effects regression analysis.

For H3a, which examines absolute emissions, the results show significant positive relationships between emissions and climate disclosure. In Model (1), Scope 1&2 emissions have a coefficient of 0.147 ($p < 0.05$), indicating that firms with higher controllable emissions tend to provide more climate-related disclosures. Model (2) reveals an even stronger relationship for Scope 3 emissions, with a coefficient of 0.198 ($p < 0.01$), suggesting that firms with higher uncontrollable emissions are particularly motivated to enhance their disclosure practices.

Moving to H3b, which focuses on relative emission composition, the patterns

| | H3a | | H3b | |
|---|---|---|---|---|
| Dependent Variable: | Disclosure$_t$ | | | |
| Model: | (1) | (2) | (3) | (4) |
| *Variables* | | | | |
| Scope 1&2$_t$ | 0.1468$^{**}$ | | | |
| | (0.0646) | | | |
| Scope 3$_t$ | | 0.1980$^{***}$ | | |
| | | (0.0533) | | |
| Scope 1&2 Percentage$_t$ | | | -0.1222 | |
| | | | (0.2451) | |
| Scope 3 Percentage$_t$ | | | | 0.8886$^{***}$ |
| | | | | (0.2824) |
| Scope 1&2&3$_t$ | | | 0.1925$^{***}$ | 0.1763$^{**}$ |
| | | | (0.0659) | (0.0722) |
| Climate Risk$_{t-1}$ | -0.1258 | 0.0403 | -0.1002 | 0.1217 |
| | (0.6127) | (0.6181) | (0.5551) | (0.5723) |
| Climate Risk$_t$ | 0.4284 | 0.3266 | 0.4107 | 0.2987 |
| | (0.6598) | (0.7899) | (0.6137) | (0.7416) |
| Size$_{t-1}$ | 0.4619$^{***}$ | 0.3926$^{***}$ | 0.4153$^{***}$ | 0.3961$^{***}$ |
| | (0.1076) | (0.1080) | (0.0941) | (0.1107) |
| Leverage$_{t-1}$ | -0.0054 | -0.0095 | -0.0062 | -0.0105 |
| | (0.0073) | (0.0096) | (0.0071) | (0.0092) |
| ROA$_{t-1}$ | -0.0033 | -0.0014 | -0.0047 | -0.0004 |
| | (0.0101) | (0.0109) | (0.0100) | (0.0109) |
| BM ratio$_{t-1}$ | 0.0268 | 0.0715 | -0.0069 | 0.0641 |
| | (0.0971) | (0.1219) | (0.1005) | (0.1239) |
| *Fixed-effects* | | | | |
| Year | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | Yes | Yes |
| *Fit statistics* | | | | |
| Observations | 460 | 353 | 460 | 353 |
| $R^2$ | 0.47424 | 0.54925 | 0.49509 | 0.55383 |
| Within $R^2$ | 0.25598 | 0.31103 | 0.28549 | 0.31804 |

*Clustered (ISIN) standard-errors in parentheses*
*Signif. Codes:* $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

**Table 6.** H3: The Impact of Carbon Emissions on Climate Disclosure. This table presents the results of fixed effects regressions examining how absolute emissions (Models 1-2) and relative emission composition (Models 3-4) affect climate-related disclosure.

are more nuanced. Model (3) shows that the proportion of Scope 1&2 emissions has a negative but statistically insignificant coefficient (-0.122), suggesting that the relative share of controllable emissions does not significantly influence disclosure levels. In contrast, Model (4) demonstrates a strong positive relationship for Scope 3 emission proportion, with a coefficient of 0.889 ($p < 0.01$). This indicates that firms with a higher percentage of Scope 3 emissions relative to their total emissions are substantially more likely to provide detailed climate disclosures.

The total emissions variable (Scope 1&2&3) shows consistent positive and significant coefficients across Models (3) and (4) (0.193, $p < 0.01$ and 0.176, $p < 0.05$ respectively), reinforcing that overall emission levels remain an important driver of disclosure transparency.

Regarding climate risk variables, neither current nor lagged climate risk shows statistically significant effects on disclosure across any of the models, suggesting that climate risk perceptions may not directly drive disclosure behaviors when controlling for emission levels and other firm characteristics.

Among control variables, firm size consistently exhibits positive and highly significant coefficients across all models, confirming that larger firms are more likely to engage in comprehensive climate disclosure. Leverage shows negative but generally insignificant coefficients, while ROA and book-to-market ratio do not demonstrate statistically significant relationships with disclosure. The model fit statistics indicate good explanatory power, with overall $R^2$ values ranging from 0.474 to 0.554. The within $R^2$ values (0.256 to 0.318) suggest that the explanatory variables account for a substantial portion of the within-firm variation in disclosure practices over time.

In summary, the evidence supports H3, revealing that both absolute emission levels and the relative composition of emissions, particularly the proportion of Scope 3 emissions, significantly influence firms' climate disclosure practices. These findings highlight the increasing importance of uncontrollable emissions in corporate transparency and stakeholder accountability.

*4.2.4. Results for H4*

Table 7 presents the results examining how EMCS moderates the relationship between carbon emissions and climate-related disclosures, based on fixed effects regression analysis.

The results reveal important insights about the moderating role of EMCS in the relationship between emissions and disclosure. In Model (1) for Scope 1&2 emissions, the direct effect of emissions is negative but statistically insignificant (-0.123). However, the interaction term between Scope 1&2 emissions and EMCS is positive and significant (0.064, $p < 0.05$), indicating that EMCS strengthens the relationship between controllable emissions and climate disclosure. This suggests that firms with robust environmental management systems are more likely to translate their controllable emission levels into comprehensive disclosures.

For Scope 3 emissions in Model (2), the pattern differs. The direct effect of Scope 3 emissions is positive but statistically insignificant (0.118), and the interaction term with EMCS, while positive (0.018), does not reach statistical significance. This indicates that EMCS does not significantly moderate the relationship between uncontrollable emissions and disclosure practices.

The direct effect of EMCS on disclosure is negative and significant in model 1 (-0.336, $p < 0.01$) but not in model 2, suggesting that environmental management systems alone may not directly lead to increased disclosure and may even be associated with reduced disclosure in some contexts. This could reflect that firms with established EMCS may feel less pressure to provide extensive qualitative disclosures, as their systematic environmental management practices already demonstrate commitment to environmental stewardship.

Regarding climate risk variables, neither current nor lagged climate risk shows statistically significant effects on disclosure in either model, consistent with previous findings that climate risk perceptions may not be primary drivers of disclosure behavior when controlling for other factors.

| Dependent Variable: | Disclosure$_t$ | |
|---|---|---|
| Model: | (1) | (2) |
| *Variables* | | |
| Scope 1&2$_t$ | -0.1229 | |
| | (0.1124) | |
| Scope 1&2$_t$ × EMCS$_{t-1}$ | 0.0642$^{**}$ | |
| | (0.0275) | |
| Scope 3$_t$ | | 0.1183 |
| | | (0.1188) |
| Scope 3$_t$ × EMCS$_{t-1}$ | | 0.0184 |
| | | (0.0208) |
| EMCS$_{t-1}$ | -0.3357$^{***}$ | -0.1675 |
| | (0.1199) | (0.1108) |
| Climate Risk$_{t-1}$ | -0.1802 | 0.1327 |
| | (0.7247) | (0.6962) |
| Climate Risk$_t$ | 0.4101 | 0.2380 |
| | (0.7339) | (0.8292) |
| Size$_{t-1}$ | 0.5582$^{***}$ | 0.4664$^{***}$ |
| | (0.1166) | (0.1155) |
| Leverage$_{t-1}$ | -0.0060 | -0.0107 |
| | (0.0076) | (0.0094) |
| ROA$_{t-1}$ | -0.0017 | -0.0022 |
| | (0.0104) | (0.0117) |
| BM ratio$_{t-1}$ | -0.0462 | 0.0415 |
| | (0.0986) | (0.1146) |
| *Fixed-effects* | | |
| Year | Yes | Yes |
| Industry | Yes | Yes |
| *Fit statistics* | | |
| Observations | 444 | 345 |
| $R^2$ | 0.48468 | 0.56239 |
| Within $R^2$ | 0.27797 | 0.33478 |

*Clustered (ISIN) standard-errors in parentheses*
*Signif. Codes:* $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

**Table 7.** H4: The Moderating Effect of EMCS on Emissions-Disclosure Relationship. This table presents the results of fixed effects regressions examining how EMCS moderates the relationship between carbon emissions and climate disclosure for Scope 1&2 (Model 1) and Scope 3 (Model 2).

Among control variables, firm size consistently exhibits strong positive and significant relationships with disclosure (0.558, $p < 0.01$ in Model 1; 0.466, $p < 0.01$ in Model 2), reinforcing that larger firms are more transparent about their environmental impacts. Leverage shows negative but statistically insignificant coefficients, while ROA and book-to-market ratio do not demonstrate significant relationships with disclosure.

The model fit statistics indicate good explanatory power, with overall $R^2$ values of 0.485 for Scope 1&2 and 0.562 for Scope 3. The within $R^2$ values (0.278 and 0.335 respectively) suggest that the explanatory variables account for a substantial portion of the within-firm variation in disclosure practices. In conclusion, the evidence partially supports H4, demonstrating that EMCS moderates the relationship between emissions and disclosure for Scope 1&2 emissions but not for Scope 3 emissions. This differential effect highlights the importance of distinguishing between controllable and uncontrollable emissions when examining the role of environmental management systems in corporate transparency.

### *4.3. Additional Results*

To further explore the conditional effects observed in the main models, we perform additional analyses by splitting the sample based on the strength of EMCS and firm profitability (ROA). These analyses help uncover how internal control capacity and financial performance shape firms' environmental disclosure practices in response to emissions.

The subsample analysis reveals important conditional patterns in how EMCS moderates the relationship between emissions and disclosure. When dividing the sample by EMCS strength (Table 8), we observe distinct patterns for Scope 1&2 and Scope 3 emissions.

For Scope 1&2 emissions, the interaction with EMCS is positive and significant only among firms with high EMCS (coefficient = 0.058, $p < 0.05$ in Model 3). This suggests that well-developed environmental management sys-

| | Low EMCS | | High EMCS | |
|---|---|---|---|---|
| Dependent Variable: | Disclosure$_t$ | | | |
| Model: | (1) | (2) | (3) | (4) |
| *Variables* | | | | |
| Scope 1&2$_t$ | -0.0444 | | -0.1321 | |
| | (0.1931) | | (0.1354) | |
| Scope 1&2$_t$ × EMCS$_{t-1}$ | -0.0130 | | 0.0580** | |
| | (0.0711) | | (0.0278) | |
| Scope 3$_t$ | | -0.3201* | | 0.0662 |
| | | (0.1677) | | (0.1607) |
| Scope 3$_t$ × EMCS$_{t-1}$ | | 0.1406** | | 0.0182 |
| | | (0.0613) | | (0.0268) |
| EMCS$_{t-1}$ | -0.2547 | -0.6387*** | -0.3045** | -0.0211 |
| | (0.2884) | (0.1789) | (0.1235) | (0.1291) |
| Climate Risk$_{t-1}$ | -0.0981 | 0.9286 | -0.0690 | 0.0745 |
| | (2.085) | (2.538) | (0.7082) | (0.5648) |
| Climate Risk$_t$ | -1.256 | -4.654** | 0.3702 | 0.0844 |
| | (1.538) | (1.812) | (0.7938) | (0.7999) |
| Size$_{t-1}$ | 0.8027*** | 0.9184*** | 0.4237*** | 0.3833*** |
| | (0.1146) | (0.1258) | (0.1182) | (0.1336) |
| Leverage$_{t-1}$ | -0.0062 | -0.0119* | -0.0089 | -0.0157 |
| | (0.0048) | (0.0069) | (0.0128) | (0.0142) |
| ROA$_{t-1}$ | -0.0121 | -0.0221 | 0.0036 | -0.0094 |
| | (0.0083) | (0.0131) | (0.0168) | (0.0144) |
| BM ratio$_{t-1}$ | -0.2171* | -0.0475 | 0.1028 | 0.2131 |
| | (0.1191) | (0.1573) | (0.1831) | (0.1713) |
| *Fixed-effects* | | | | |
| Industry | Yes | Yes | Yes | Yes |
| Year | Yes | Yes | Yes | Yes |
| *Fit statistics* | | | | |
| Observations | 110 | 74 | 334 | 271 |
| $R^2$ | 0.77270 | 0.85383 | 0.55315 | 0.62214 |
| Within $R^2$ | 0.50560 | 0.70688 | 0.19457 | 0.25229 |

*Clustered (ISIN) standard-errors in parentheses*
*Signif. Codes:* $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

**Table 8.** Subsample Analysis by EMCS Level. This table presents fixed effects regression results split by EMCS strength, examining how the moderating effect of EMCS varies between firms with weak (Models 1-2) and strong (Models 3-4) environmental management systems.

| | Low ROA | | High ROA | |
|---|---|---|---|---|
| Dependent Variable: | Disclosure$_t$ | | | |
| Model: | (1) | (2) | (3) | (4) |
| *Variables* | | | | |
| Scope 1&2$_t$ | -0.1351 | | -0.2784 | |
| | (0.1132) | | (0.3643) | |
| Scope 1&2$_t$ × EMCS$_{t-1}$ | 0.0542** | | 0.1118 | |
| | (0.0242) | | (0.0844) | |
| Scope 3$_t$ | | -0.0767 | | 0.3174 |
| | | (0.0824) | | (0.2013) |
| Scope 3$_t$ × EMCS$_{t-1}$ | | 0.0502*** | | -0.0074 |
| | | (0.0183) | | (0.0419) |
| EMCS$_{t-1}$ | -0.3467*** | -0.3006*** | -0.3963 | -0.0860 |
| | (0.1290) | (0.0993) | (0.2868) | (0.2435) |
| Climate Risk$_{t-1}$ | 0.7121 | 0.7631** | -1.338 | 1.363 |
| | (0.4732) | (0.3531) | (1.373) | (0.8380) |
| Climate Risk$_t$ | 0.0168 | -0.5397 | 0.5541 | 2.519*** |
| | (0.5912) | (0.4662) | (1.176) | (0.7973) |
| Size$_{t-1}$ | 0.3718*** | 0.3378*** | 0.8883*** | 0.6671*** |
| | (0.0940) | (0.1086) | (0.1862) | (0.2211) |
| Leverage$_{t-1}$ | 0.0040 | -0.0025 | -0.0167 | -0.0251 |
| | (0.0063) | (0.0068) | (0.0120) | (0.0203) |
| ROA$_{t-1}$ | 0.0052 | -0.0022 | -0.0035 | 0.0407 |
| | (0.0103) | (0.0112) | (0.0152) | (0.0312) |
| BM ratio$_{t-1}$ | -0.0136 | 0.0574 | -0.6444 | 1.638** |
| | (0.1188) | (0.1266) | (0.4476) | (0.7338) |
| *Fixed-effects* | | | | |
| Industry | Yes | Yes | Yes | Yes |
| Year | Yes | Yes | Yes | Yes |
| *Fit statistics* | | | | |
| Observations | 313 | 251 | 110 | 76 |
| $R^2$ | 0.52191 | 0.60064 | 0.72905 | 0.66815 |
| Within $R^2$ | 0.15476 | 0.18991 | 0.58784 | 0.60492 |

*Clustered (ISIN) standard-errors in parentheses*
*Signif. Codes:* $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

**Table 9.** Subsample Analysis by Profitability Level. This table presents fixed effects regression results split by ROA, examining how the moderating effect of EMCS varies between firms with low (Models 1-2) and high (Models 3-4) profitability.

tems enhance the relationship between controllable emissions and disclosure, possibly because firms with robust EMCS have better measurement capabilities and greater confidence in reporting their controllable emissions.

For Scope 3 emissions, the interaction with EMCS shows the opposite pattern. The moderating effect is positive and significant among firms with low EMCS (coefficient = 0.141, $p < 0.05$ in Model 2) but insignificant among high-EMCS firms. This indicates that firms with weaker control systems may compensate for higher Scope 3 emissions with increased disclosure, possibly to maintain legitimacy, while firms with strong EMCS may rely more on their established systems rather than additional disclosures.

The analysis by profitability level (Table 9) further illuminates these conditional effects. Among low-ROA firms, both Scope 1&2 and Scope 3 interactions with EMCS are positive and significant (coefficients = 0.054, $p < 0.05$ and 0.050, $p < 0.01$ respectively). This suggests that financially constrained firms are more responsive to emissions through disclosure when they have EMCS in place, possibly due to greater stakeholder pressure or legitimacy concerns.

In contrast, high-ROA firms show no significant moderating effects of EMCS for either emission scope. The interaction term for Scope 3 emissions is actually negative though insignificant (coefficient = -0.007 in Model 4), indicating that profitable firms may feel less compelled to adjust their disclosure practices in response to emissions, regardless of their environmental management systems.

The direct effect of EMCS on disclosure remains consistently negative across most subsamples, reinforcing the main finding that environmental management systems alone may not directly drive increased disclosure. Firm size maintains its strong positive relationship with disclosure across all subsamples, while climate risk variables show mixed and generally insignificant effects.

Overall, these additional results demonstrate that the moderating role of EMCS is highly conditional on both the strength of environmental management systems and firm profitability. The findings suggest that disclosure responses to emissions are shaped by the interplay between internal organizational capacities and external financial constraints.

## 5. Conclusions

In this study, we analyze how firm-level climate disclosures, carbon emissions intensity,localized climate risk and Environmental Management Control Systems (EMCS) are intertwined. Our findings offer four key insights.

First, firms headquartered in provinces with higher climate risk are significantly more likely to develop robust EMCS, highlighting that variations in climate vulnerability drive internal control mechanisms aimed at monitoring and mitigating environmental impact. Second, our study does not offer evidence that EMCS influence firms' carbon emission intensity. Third, we find that the volume of $CO_2$ emissions affects climate-related disclosures. Particularly, Scope 3 emissions are key determinants of the level of climate-related disclosures, signalling a response to potential reputational regulatory and stakeholder pressures. Finally, when studying the interplay between the effect of emissions and EMCS on the amount of climate related disclosure our interaction variable shows that EMCS significantly strengthens the link between Scope 1&2 emissions and disclosures. Conversely, EMCS does not affect the level of climate-related disclosures en the MD&D report across companies with higher levels of Scope 3 emissions. This divergence may stem from the lower controllability or more complex measurement of external supply-chain emissions relative to internal operations. Taken together, these findings provide nuanced evidence on how localized climate risk and organizational practices converge to shape better firms' climate-related reporting.

From a policy and managerial perspective, our study has several implications. Policymakers may consider refining disclosure requirements that highlight localized climate vulnerabilities, encouraging firms to internalize region-specific risks in their strategic decision-making. Managers, can take advantage of EMCS as a critical tool for aligning operational performance with climate rhetoric, thereby enhancing both transparency and stakeholder trust. Such further exploration will enrich the discourse on climate disclosures and pave the way toward more targeted and effective environmental reporting policies.

Despite these contributions, our research has also potential limitations. First, the sample is restricted to Spanish listed firms between 2010 and 2022, potentially limiting the external validity of the findings. Moreover, while focusing on MD&A reports provides consistent data on climate disclosures, these reports may not capture certain forms of voluntary or informal climate communication. Future research could address these shortcomings by examining larger samples across multiple countries and employing more diverse disclosure measures, thereby expanding our comprehension of firm-level climate communication patterns. Including further dimensions of EMCS implementation (e.g., budgeting, environmental audits, or training practices) could also enrich the analysis of how internal mechanisms support sustainability goals.

## References


Agarwal, S., Qin, Y., Sing, T. F., & Zhan, C. (2025). Sea level rise risks, adaptation strategies, and real estate prices in Singapore. *Journal of Public Economics*, *241*, 105290.

Aichele, R., & Felbermayr, G. (2015). Kyoto and carbon leakage: An empirical analysis of the carbon content of bilateral trade. *Review of Economics and Statistics*, *97*(1), 104–115.

Alsaifi, K., Elnahass, M., & Salama, A. (2020). Carbon disclosure and financial performance: UK environmental policy. *Business Strategy and the Environment*, *29*(2), 711-726.

Al-Tuwaijri, S., Christensen, T., & Hughes II, K. (2004). The relations among environmental disclosure, environmental performance, and economic performance: A simultaneous equations approach. *Accounting, Organizations and Society*, *29*(5-6), 447-471.

Andrew, J., & Baker, M. (2020). Corporate social responsibility reporting: The last 40 years and a path to sharing future insights. *Abacus*, *56*(1), 35-65.

Antonini, C., & Gomez-Conde, J. (2024). Environmental management control systems and environmental innovation: Unintended consequences of the EU non-financial reporting Directive. *Management Accounting Research*, *65*.

Arjaliès, D.-L., & Mundy, J. (2013). The use of management control systems to manage CSR strategy: A levers of control perspective. *Management Accounting Research*, *24*(4), 284–300.

Avramov, D., Cheng, S., Lioui, A., & Tarelli, A. (2022). Sustainable investing with ESG rating uncertainty. *Journal of Financial Economics*, *145*(2), 642-664.

Babiker, M. H. (2005). Climate change policy, market structure, and carbon leakage. *Journal of International Economics*, *65*(2), 421–445.

Baldini, M., Maso, L., Liberatore, G., Mazzi, F., & Terzani, S. (2018). Role of country- and firm-level determinants in environmental, social, and governance disclosure. *Journal of Business Ethics*, *150*(1), 79-98.

Bansal, P., & Roth, K. (2000). Why companies go green: A model of ecological responsiveness. *Academy of Management Journal*, *43*(4), 717-736.

Barnett, M., Brock, W., & Hansen, L. (2020). Pricing uncertainty induced by climate change. *Review of Financial Studies*, *33*(3), 1024-1066.

Ben-Amar, W., Chang, M., & McIlkenny, P. (2017). Board gender diversity and corporate response to sustainability initiatives: Evidence from the carbon disclosure project. *Journal of Business Ethics*, *142*(2), 369-383.

Bernstein, A., Gustafson, M. T., & Lewis, R. (2019). Disaster on the horizon: The price effect of sea level rise. *Journal of Financial Economics*, *134*(2), 253–272.

Bochkay, K., Brown, S., Leone, A., & Tucker, J. (2023). Textual analysis in accounting: What's next?*. *Contemporary Accounting Research*, *40*(2), 765-805.

Bolton, P., & Kacperczyk, M. (2021). Do investors care about carbon risk? *Journal of Financial Economics*, *142*(2), 517-549.

Bolton, P., & Kacperczyk, M. (2023). Global pricing of carbon-transition risk. *The Journal of Finance*, *78*(6), 3677–3754.

Bonetti, P., Cho, C. H., & Michelon, G. (2024). Environmental disclosure and the cost of capital: Evidence from the fukushima nuclear disaster. *European Accounting Review*, *33*(5), 1693–1721.

Bose, S., Lim, E. K., Minnick, K., Schorno, P. J., & Shams, S. (2025). Does carbon risk influence stock price crash risk? International evidence. *Journal of Business Finance & Accounting*.

Brown, S., Hinson, L., & Tucker, J. (2024). Financial statement adequacy and firms' MD&A disclosures. *Contemporary Accounting Research*, *41*(1), 126-162.

Burniaux, J.-M., & Oliveira Martins, J. (2012). Carbon leakages: a general equilibrium view. *Economic Theory*, *49*, 473–495.

Carrión, E., Larrinaga, C., & Rigling Gallagher, D. (2024). Carbon accounting for the translation of net-zero targets into business operations. *British Accounting Review*, 101456.

Charlson, R., Schwartz, S., Hales, J., Cess, R., Coakley Jr., J., Hansen, J., & Hofmann, D.

(1992). Climate forcing by anthropogenic aerosols. *Science*, *255*(5043), 423-430.
Christensen, H. B., Hail, L., & Leuz, C. (2021). Mandatory CSR and sustainability reporting: Economic analysis and literature review. *Review of Accounting Studies*, *26*(3), 1176–1248.
Clarkson, P., Li, Y., Pinnuck, M., & Richardson, G. (2015). The valuation relevance of greenhouse gas emissions under the European Union carbon emissions trading scheme. *European Accounting Review*, *24*(3), 551-580.
Clarkson, P., Li, Y., Richardson, G., & Vasvari, F. (2008). Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis. *Accounting, Organizations and Society*, *33*(4-5), 303-327.
Cohen, S., Kadach, I., & Ormazabal, G. (2023). Institutional investors, climate disclosure, and carbon emissions. *Journal of Accounting and Economics*, *76*(2-3).
Cormier, D., Magnan, M., & Van Velthoven, B. (2005). Environmental disclosure quality in large german companies: Economic incentives, public pressures or institutional conditions? *European Accounting Review*, *14*(1), 3-39.
Darendeli, A., Fiechter, P., Hitz, J.-M., & Lehmann, N. (2022). The role of corporate social responsibility (CSR) information in supply-chain contracting: Evidence from the expansion of CSR rating coverage. *Journal of Accounting and Economics*, *74*(2-3), 101525.
De Haas, R., & Popov, A. (2023). Finance and green growth. *Economic Journal*, *133*(650), 637-668.
Depoers, F., Jeanjean, T., & Jérôme, T. (2016). Voluntary disclosure of greenhouse gas emissions: Contrasting the carbon disclosure project and corporate reports. *Journal of Business Ethics*, *134*(3), 445-461.
Derchi, G.-B., Davila, A., & Oyon, D. (2023). Green incentives for environmental goals. *Management Accounting Research*, *59*, 100830.
Dietz, S., Bowen, A., Dixon, C., & Gradwell, P. (2016). Climate value at risk' of global financial assets. *Nature Climate Change*, *6*(7), 676-679.
Downar, B., Ernstberger, J., Reichelstein, S., Schwenen, S., & Zaklan, A. (2021). The impact of carbon disclosure mandates on emissions and financial operating performance. *Review of Accounting Studies*, *26*(3), 1137-1175.
European Commission. (2014). Directive 2014/95/EU of the European Parliament and of the Council of 22 october 2014 amending Directive 2013/34/EU as regards disclosure of non-financial and diversity information by certain large undertakings and groups. *Official Journal of the European Union*, *L330*, 1–9.
Fiechter, P., Hitz, J.-M., & Lehmann, N. (2022). Real effects of a widespread CSR reporting mandate: Evidence from the European Union's CSR Directive. *Journal of Accounting Research*, *60*(4), 1499–1549.
Flammer, C., Toffel, M., & Viswanathan, K. (2021). Shareholder activism and firms' voluntary disclosure of climate change risks. *Strategic Management Journal*, *42*(10), 1850-1879.
Fleming, A., & Vanclay, F. (2010). Farmer responses to climate change and sustainable agriculture. a review. *Agronomy for Sustainable Development*, *30*, 11–19.
Friedman, H. L., & Ormazabal, G. (2024). The role of information in building a more sustainable economy: A supply and demand perspective. *Journal of Accounting Research*, *62*(5), 1575-1609.
García, D., Hu, X., & Rohrer, M. (2023). The colour of finance words. *Journal of Financial Economics*, *147*(3), 525-549.
Gennaioli, N., & Shleifer, A. (2010). What comes to mind. *The Quarterly Journal of Economics*, *125*(4), 1399–1433.
Ginglinger, E., & Moreau, Q. (2023). Climate risk and capital structure. *Management Science*, *69*(12), 7492–7516.
Gomez-Conde, J., Lunkes, R. J., & Rosa, F. S. (2019). Environmental innovation practices and operational performance: The joint effects of management accounting and control systems and environmental training. *Accounting, Auditing & Accountability Journal*, *32*(5), 1325–1357.
Grewal, J., Riedl, E. J., & Serafeim, G. (2019). Market reaction to mandatory nonfinancial

disclosure. *Management Science*, *65*(7), 3061–3084.

Griffin, P., Lont, D., & Sun, E. (2017). The relevance to investors of greenhouse gas emission disclosures. *Contemporary Accounting Research*, *34*(2), 1265-1297.

Haque, F. (2017). The effects of board characteristics and sustainable compensation policy on carbon performance of UK firms. *British Accounting Review*, *49*(3), 347-364.

Hart, S., & Dowell, G. (2011). A natural-resource-based view of the firm: Fifteen years after. *Journal of Management*, *37*(5), 1464-1479.

He, R., Luo, L., Shamsuddin, A., & Tang, Q. (2022). Corporate carbon accounting: A literature review of carbon accounting research from the Kyoto Protocol to the Paris Agreement. *Accounting and Finance*, *62*(1), 261-298.

Heinle, M. S., Smith, K. C., & Verrecchia, R. E. (2018). Risk-factor disclosure and asset prices. *The Accounting Review*, *93*(2), 191–208.

Henri, J.-F., Boiral, O., & Roy, M.-J. (2014). The tracking of environmental costs: motivations and impacts. *European Accounting Review*, *23*(4), 647–669.

Henri, J.-F., & Journeault, M. (2010). Eco-control: The influence of management control systems on environmental and economic performance. *Accounting, Organizations and Society*, *35*(1), 63-80.

Henry, E., & Leone, J. (2016). Measuring qualitative information in capital markets research: Comparison of alternative methodologies to measure disclosure tone. *The Accounting Review*, *91*(1), 153-178.

Hong, H., Li, F., & Xu, J. (2019). Climate risks and market efficiency. *Journal of Econometrics*, *208*(1), 265-281.

Huang, C.-L., & Kung, F.-H. (2010). Drivers of environmental disclosure and stakeholder expectation: Evidence from taiwan. *Journal of Business Ethics*, *96*(3), 435-451.

Huynh, T. D., Li, F. W., & Xia, Y. (2025). Something in the air: Does air pollution affect fund managers' carbon divestment? *Review of Accounting Studies*, 1–28.

Ilhan, E., Sautner, Z., & Vilkov, G. (2021). Carbon tail risk. *Review of Financial Studies*, *34*(3), 1540-1571.

Intergovernmental Panel on Climate Change. (2023). *Climate change 2023: Synthesis report*. Geneva, Switzerland: IPCC. (Available at `https://www.ipcc.ch/report/ar6/syr/`)

Ioannou, I., Li, S., & Serafeim, G. (2016). The effect of target difficulty on target completion: The case of reducing carbon emissions. *The Accounting Review*, *91*(5), 1467-1492.

Jain, A. (2025). Disclosure tone and short-selling pressure: Evidence from regulation-sho. *European Accounting Review*, *34*(2), 695–720.

Javadi, S., & Masum, A. (2021). The impact of climate change on the cost of bank loans. *Journal of Corporate Finance*, *69*.

Journeault, M., De Rongé, Y., & Henri, J.-F. (2016). Levers of eco-control and competitive environmental strategy. *British Accounting Review*, *48*(3), 316-340.

Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive psychology*, *3*(3), 430–454.

Kanodia, C., & Sapra, H. (2016). A real effects perspective to accounting measurement and disclosure: Implications and insights for future research. *Journal of Accounting Research*, *54*(2), 623-676.

Kim, E., & Lyon, T. (2011). When does institutional investor activism increase shareholder value? The carbon disclosure project. *B.E. Journal of Economic Analysis and Policy*, *11*(1).

Kim, J., Wang, C., & Wu, F. (2023). The real effects of risk disclosures: evidence from climate change reporting in 10-ks. *Review of Accounting Studies*, *28*(4), 2271-2318.

Kling, G., Volz, U., Murinde, V., & Ayas, S. (2021). The impact of climate vulnerability on firms' cost of capital and access to finance. *World Development*, *137*.

Krueger, P., Sautner, Z., & Starks, L. (2020). The importance of climate risks for institutional investors. *Review of Financial Studies*, *33*(3), 1067-1111.

Kunreuther, H., Heal, G., Allen, M., Edenhofer, O., Field, C., & Yohe, G. (2013). Risk management and climate change. *Nature Climate Change*, *3*(5), 447-450.

Lai, S., Xu, L., Liu, K., & Zhao, J. (2015). Recurrent convolutional neural networks for text classification. In *29th aaai conference on artificial intelligence, aaai 2015 and the 27th innovative applications of artificial intelligence conference, iaai 2015* (Vol. 3, p. 2267-2273).

Lewis, B., Walls, J., & Dowell, G. (2014). Difference in degrees: CEO characteristics and firm environmental disclosure. *Strategic Management Journal*, *35*(5), 712-722.

Li, F., et al. (2010). Textual analysis of corporate disclosures: A survey of the literature. *Journal of Accounting Literature*, *29*(1), 143–165.

Lin, Y., Shen, R., Wang, J., & Julia Yu, Y. (2024). Global evolution of environmental and social disclosure in annual reports. *Journal of Accounting Research*, *62*(5), 1941-1988.

Lisi, I. (2015). Translating environmental motivations into performance: The role of environmental performance measurement systems. *Management Accounting Research*, *29*, 27-44.

Long, J. S. (1997). *Regression models for categorical and limited dependent variables.* Sage Publications.

Loughran, T., & McDonald, B. (2016). Textual analysis in accounting and finance: A survey. *Journal of Accounting Research*, *54*(4), 1187–1230.

Luo, L., & Tang, Q. (2014). Does voluntary carbon disclosure reflect underlying carbon performance? *Journal of Contemporary Accounting and Economics*, *10*(3), 191-205.

Malmi, T., & Brown, D. A. (2008). Management control systems as a package—opportunities, challenges and research directions. *Management Accounting Research*, *19*(4), 287–300.

Martin, M. A. (2020). An evolutionary approach to management control systems research: A prescription for future research. *Accounting, Organizations and Society*, *86*, 101186.

Matsumura, E., Prakash, R., & Vera-Muñoz, S. (2014). Firm-value effects of carbon emissions and carbon disclosures. *The Accounting Review*, *89*(2), 695-724.

Matsumura, E., Prakash, R., & Vera-Muñoz, S. C. (2024). Climate-risk materiality and firm risk. *Review of Accounting Studies*, *29*(1), 33–74.

Merchant, K. A., & Otley, D. (2020). Beyond the systems versus package debate. *Accounting, Organizations and Society*, *86*, 101185.

Muslu, V., Radhakrishnan, S., Subramanyam, K., & Lim, D. (2015). Forward-looking MD&A disclosures and the information environment. *Management Science*, *61*(5), 931-948.

Passetti, E., Battaglia, M., Testa, F., & Heras-Saizarbitoria, I. (2020). Multiple control mechanisms for employee health and safety integration: Effects and complementarity. *Accounting, Auditing and Accountability Journal*, *33*(7), 1595-1626.

Perego, P., & Hartmann, F. (2009). Aligning performance measurement systems with strategy: The case of environmental strategy. *Abacus*, *45*(4), 397-428.

Pástor, Stambaugh, R., & Taylor, L. (2022). Dissecting green returns. *Journal of Financial Economics*, *146*(2), 403-424.

Qian, W., & Schaltegger, S. (2017). Revisiting carbon disclosure and performance: Legitimacy and management views. *British Accounting Review*, *49*(4), 365-379.

Reid, E., & Toffel, M. (2009). Responding to public and private politics: Corporate disclosure of climate change strategies. *Strategic Management Journal*, *30*(11), 1157-1178.

Reinecke, J., & Ansari, S. (2016). Taming wicked problems: The role of framing in the construction of corporate social responsibility. *Journal of Management Studies*, *53*(3), 299-329.

Robinson, S. A., Skinner, A. N., & Wang, J. (2025). Does litigation risk shape environmental disclosure decisions? Evidence from peers' environmental disclosure lawsuits. *The Accounting Review*, 1–31.

Sautner, Z., Van Lent, L., Vilkov, G., & Zhang, R. (2023). Firm-level climate change exposure. *Journal of Finance*, *78*(3), 1449-1498.

Sautner, Z., van Lent, L., Vilkov, G., & Zhang, R. (2023). Pricing climate change exposure. *Management Science*, *69*(12), 7540-7561.

Schneider, S. (2001). What is 'dangerous' climate change? *Nature*, *411*(6833), 17-19.

Stern, N., & Valero, A. (2021). Research policy, chris freeman special issue innovation, growth and the transition to net-zero emissions. *Research Policy*, *50*(9).

Task Force on Climate-Related Financial Disclosures (TCFD). (2017). Final report: Recommendations of the task force on climate-related financial disclosures. *Financial Stability Board Publications*.

Tuck-Riggs, C. A. (2015). *Financial statement disclosure of carbon footprint costs in the airline industry* (Unpublished doctoral dissertation). Walden University.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases: Biases in judgments reveal some heuristics of thinking under uncertainty. *Science*, *185*(4157), 1124–1131.

Weinhofer, G., & Busch, T. (2013). Corporate strategies for managing climate risks. *Business Strategy and the Environment*, *22*(2), 121-144.

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data* (2nd ed.). Cambridge: The MIT Press.

World Resources Institute, & World Business Council for Sustainable Development. (2001). *The greenhouse gas protocol: A corporate accounting and reporting standard.*

World Resources Institute, & World Business Council for Sustainable Development. (2011). *The greenhouse gas protocol: Corporate value chain (scope 3) accounting and reporting standard.*

Yoon, H., Tashman, P., Benischke, M., Doh, J., & Kim, N. (2024). Climate impact, institutional context, and national climate change adaptation ip protection rates. *Journal of Business Venturing*, *39*(1).

Zhou, N., & Vilar-Zanón, J. L. (2024). Impact assessment of climate change on hailstorm risk in spanish wine grape crop insurance: Insights from linear and quantile regressions. *Risks*, *12*(2).

Zhou, N., & Vilar-Zanón, J. L. (2025). Climate Change and Crop Insurance: Geographical Heterogeneity in Hailstorm Risk for Wine Grapes in Spain. *European Actuarial Journal*.

Zhou, N., Vilar-Zanón, J. L., Garrido, J., & Martínez, A.-J. H. (2024). *Iberian actuarial climate index (iaci) and its variant the provincial spanish actuarial climate index (psaci)*. (Available at: https://docta.ucm.es/entities/publication/380c9656-b097-4cd0-b88d-24101d482fc0)

## Appendix A. Variables, Definitions, and Sources

**Table A.** Variable Description

| Variable Name | Description | Source |
|---|---|---|
| Size | Firm size, measured by the logarithm of total assets | Bloomberg & Orbis |
| Leverage | Financial leverage, the ratio of total debt to total assets | Bloomberg & Orbis |
| ROA | Return on Assets, measured by net income to average total assets | Bloomberg & Orbis |
| Climate Disclosure | The disinflated count of climate change–related words in the firm's MD&A report, detailed calculation see Section 3.4 | MD&A Reports |
| Climate Risk | Provincial Spanish Actuarial Climate Index (pSACI), based on the location of firms' headquarters | Public on Docta Complutense (Zhou et al., 2024) |
| $CO_2$ Intensity (Scope 1&2) | The ratio of $CO_2$ emissions (Scope 1&2) to revenues | Refinitiv |
| $CO_2$ Intensity (Scope 3) | The ratio of $CO_2$ emissions (Scope 3) to revenues | Refinitiv |
| Scope $1\&2_t$ | Natural logarithm of $CO_2$ Intensity (Scope 1&2) | Refinitiv |
| Scope $3_t$ | Natural logarithm of $CO_2$ Intensity (Scope 3) | Refinitiv |
| EMCS | Environmental Management Control System, consists of seven binary items | Refinitiv |
| BM ratio | Book to market ratio, measured by the Book Equity to Market Equity | Refinitiv |

**Note**: EMCS includes seven binary items: resource reduction targets, water and energy efficiency goals, sustainable packaging policies, environmental supply chain initiatives, environmental management training, and executive compensation policies tied to ESG performance.

## Appendix B. Climate-related Words Dictionary

The following is a comprehensive list of climate-related terms in Spanish, followed by their English translations in parenthesis and italics. Terms are arranged in multiple columns for better readability.

- Iniciativas empresariales globales de acción climática
  *(Global corporate climate action initiatives)*
- Task Force on Climate-related Financial Disclosures
- Derechos de emisión de gases de efecto invernadero
  *(Greenhouse gas emission rights)*
- Sistema europeo de comercio de derechos de emisión
  *(European Union Emissions Trading System)*
- Prevención de la contaminación y cambio climático
  *(Pollution prevention and climate change)*
- Sistema de gestión de gases de efecto invernadero
  *(Greenhouse gas management system)*
- Carbon Disclosure Project sobre cambio climático
  *(Carbon Disclosure Project on climate change)*
- Emisiones asociadas al consumo de electricidad
  *(Emissions associated with electricity consumption)*
- Emisiones indirectas de gas efecto invernadero
  *(Indirect greenhouse gas emissions)*
- Partnership for Carbon Accounting Financials
- Agenda 2030 sobre el desarrollo sostenible
  *(2030 Agenda for Sustainable Development)*
- Intergovernmental Panel on Climate Change
- Sistema energético renovable y sostenible
  *(Renewable and sustainable energy system)*
- Comisario europeo de acción por el clima
  *(European Commissioner for Climate Action)*
- Emisiones de gases de efecto invernadero
  *(Greenhouse gas emissions)*
- Emisión de gases con efecto invernadero
  *(Greenhouse gas emissions)*
- Reducción de nuestras propias emisiones
  *(Reduction of our own emissions)*
- Emisión de gases de efecto invernadero
  *(Greenhouse gas emissions)*
- Emisión de partículas no contaminantes
  *(Emission of non-polluting particles)*

- Modelo de gestión del cambio climático
  *(Climate change management model)*
- Registro nacional de huella de carbono
  *(National carbon footprint registry)*
- Emisiones totales de $CO_2$ consolidadas
  *(Total consolidated $CO_2$ emissions)*
- Nueva agenda de desarrollo sostenible
  *(New sustainable development agenda)*
- Climate Performance Leadership Index
- Combustibles sostenibles de aviación
  *(Sustainable aviation fuels)*
- Inventario de emisiones corporativas
  *(Corporate emissions inventory)*
- Oficina Española de Cambio Climático
  *(Spanish Office for Climate Change)*
- Sistema energético de cero emisiones
  *(Zero-emission energy system)*
- Directiva de emisiones industriales
  *(Industrial Emissions Directive)*
- Objetivos de desarrollo sostenibles
  *(Sustainable development goals)*
- Objetivos del desarrollo sostenible
  *(Sustainable development goals)*
- Carbon Disclosure Leadership Index

- Combustible sostenible de aviación
*(Sustainable aviation fuel)*
- Objetivos de desarrollo sostenible
*(Sustainable development goals)*
- Combustibles líquidos sostenibles
*(Sustainable liquid fuels)*
- Objetivo de desarrollo sostenible
*(Sustainable development goal)*
- Política de desarrollo sostenible
*(Sustainable development policy)*
- Derechos de emisión transferidos
*(Transferred emission rights)*
- Huella de carbono organizacional
*(Organizational carbon footprint)*
- Lucha contra el cambio climático
*(Fight against climate change)*
- Riesgos climáticos y ambientales
*(Climate and environmental risks)*
- Índice Carbon Disclosure Project
*(Carbon Disclosure Project Index)*
- Agenda de desarrollo sostenible
*(Sustainable development agenda)*
- Cadena de suministro sostenible
*(Sustainable supply chain)*
- Cumbre de desarrollo sostenible
*(Sustainable development summit)*
- Emisiones de dióxido de carbono
*(Carbon dioxide emissions)*
- Emisiones de efecto invernadero
*(Greenhouse gas emissions)*
- Gestión de la huella de carbono
*(Carbon footprint management)*
- Planes de transición energética
*(Energy transition plans)*
- Desafíos sociales y climáticos
*(Social and climate challenges)*
- Emisión de dióxido de carbono
*(Carbon dioxide emission)*
- Net Zero Asset Owner Alliance
- Objetivos de cambio climático
*(Climate change goals)*
- Plan de transición energética
*(Energy transition plan)*
- Reducción de emisiones de GEI
*(Reduction of GHG emissions)*
- Emisiones neutras de carbono
*(Carbon-neutral emissions)*
- Gestión de huella de carbono
*(Carbon footprint management)*
- Gestión del cambio climático
*(Climate change management)*
- Global Climate Change Report
- Huella ambiental corporativa
*(Corporate environmental footprint)*
- Modelo energético sostenible
*(Sustainable energy model)*
- Net-Zero Insurance Alliance
- Programa de cambio climático
*(Climate change program)*
- Biocombustibles sostenibles
*(Sustainable biofuels)*
- Emisiones al medio ambiente
*(Emissions to the environment)*
- Emisiones indirectas de GEI
*(Indirect GHG emissions)*
- Estrategia climática global
*(Global climate strategy)*
- Estrategia de carbonización
*(Carbonization strategy)*
- Gases de efecto invernadero
*(Greenhouse gases)*
- Gestión de descarbonización
*(Decarbonization management)*
- Net-Zero Insurance Alliance
- Plan de actuación climática
*(Climate action plan)*
- Acuerdo climático de París
*(Paris Climate Agreement)*
- Reducción de las emisiones
*(Reduction of emissions)*
- Carbon Disclosure Project
- CDP Disclosure Leadership
- Central térmica de carbón
*(Coal-fired power plant)*
- Ciudades sostenibles 2030
*(Sustainable Cities 2030)*
- Compensación de emisiones
*(Emission offsetting)*
- Descenso de las emisiones
*(Decline in emissions)*
- Fotovoltaicos sostenibles
*(Sustainable photovoltaics)*
- Net Zero Banking Alliance
- Combustibles sostenibles
*(Sustainable fuels)*
- Gases efecto invernadero
*(Greenhouse gases)*
- Huella de carbono propia
*(Own carbon footprint)*
- Neutralidad de emisiones
*(Emission neutrality)*
- Plan de acción climática
*(Climate action plan)*
- Plan de descarbonización
*(Decarbonization plan)*
- Reporte de emisiones GEI
*(GHG emissions report)*

- Compensación de carbono
  *(Carbon offsetting)*
- Economía descarbonizada
  *(Decarbonized economy)*
- Emisión de bonos verdes
  *(Green bond issuance)*
- Generación de emisiones
  *(Emission generation)*
- Huella de carbono total
  *(Total carbon footprint)*
- Inventario de emisiones
  *(Emissions inventory)*
- Objetivos de desarrollo
  *(Development goals)*
- Aeroespaciales ligeros
  *(Lightweight aerospace)*
- Combustible sostenible
  *(Sustainable fuel)*
- Compromisos climáticos
  *(Climate commitments)*
- Eliminación de carbono
  *(Carbon removal)*
- Emisiones industriales
  *(Industrial emissions)*
- Energía descarbonizada
  *(Decarbonized energy)*
- Neutralidad de carbono
  *(Carbon neutrality)*
- Neutralidad en carbono
  *(Carbon neutrality)*
- Reducción de emisiones
  *(Emission reduction)*

- Análisis de emisiones
  *(Emissions analysis)*
- Climáticamente neutro
  *(Climate neutral)*
- European Climate Pact
- Huella medioambiental
  *(Environmental footprint)*
- Neutralidad climática
  *(Climate neutrality)*
- Transición energética
  *(Energy transition)*
- Aeronaves eléctricas
  *(Electric aircraft)*
- Calentamiento global
  *(Global warming)*
- Cero emisiones netas
  *(Net zero emissions)*
- Ciudades sostenibles
  *(Sustainable cities)*
- Control de emisiones
  *(Emission control)*
- Emergencia climática
  *(Climate emergency)*
- Emisiones de carbono
  *(Carbon emissions)*
- Emisiones indirectas
  *(Indirect emissions)*
- Emisiones netas cero
  *(Net zero emissions)*
- Emisiones operativas
  *(Operational emissions)*
- Emisiones residuales
  *(Residual emissions)*
- Energías sostenibles
  *(Sustainable energies)*
- Estrategia climática
  *(Climate strategy)*
- Gestión de emisiones
  *(Emission management)*
- Packaging sostenible
  *(Sustainable packaging)*
- Reporte de emisiones
  *(Emissions report)*
- Ahorro de emisiones
  *(Emission savings)*
- Aviación sostenible
  *(Sustainable aviation)*
- Carbono operacional
  *(Operational carbon)*
- CEO Climate Leaders
- Créditos de carbono
  *(Carbon credits)*
- Derechos de emisión
  *(Emission rights)*
- Emisiones asociadas
  *(Associated emissions)*
- Emisiones de metano
  *(Methane emissions)*
- Emisiones derivadas
  *(Derived emissions)*
- Emisiones fugitivas
  *(Fugitive emissions)*
- Gases contaminantes
  *(Pollutant gases)*
- Gases refrigerantes
  *(Refrigerant gases)*
- Mercados de carbono
  *(Carbon markets)*
- Neutra en emisiones
  *(Emission neutral)*
- Ratios de emisiones
  *(Emission ratios)*
- Dióxido de carbono
  *(Carbon dioxide)*
- Emisiones directas
  *(Direct emissions)*
- Emisiones evitadas
  *(Avoided emissions)*
- Emisión de carbono
  *(Carbon emission)*
- Emission Reduction
- Energía sostenible
  *(Sustainable energy)*
- Gestión de carbono
  *(Carbon management)*
- Huella de plástico
  *(Plastic footprint)*
- Neutros en carbono
  *(Carbon neutral)*
- Precio del carbono
  *(Carbon price)*
- Riesgos climáticos
  *(Climate risks)*
- The Climate Pledge
- Acuerdos de París
  *(Paris Agreements)*
- Carbon Disclosure
- Carbono absorbido
  *(Absorbed carbon)*
- Ciencia climática
  *(Climate science)*
- Emisiones limpias
  *(Clean emissions)*
- Emisiones propias
  *(Own emissions)*
- Energy Transition
- Envase sostenible
  *(Sustainable packaging)*
- Factor de emisión
  *(Emission factor)*

- Fondos de carbono *(Carbon funds)*
- Huella de carbono *(Carbon footprint)*
- Líderes del clima *(Climate leaders)*
- Net-Zero Standard
- Neutra en carbono *(Carbon neutral)*
- Precio al carbono *(Carbon price)*
- Precio de carbono *(Carbon price)*
- Acción climática *(Climate action)*
- Acuerdo de París *(Paris Agreement)*
- Cambio climático *(Climate change)*
- Carbon Footprint
- Crisis climática *(Climate crisis)*
- Cumbre del clima *(Climate summit)*
- Descarbonización *(Decarbonization)*
- Emisiones de $CO_2$ *($CO_2$ emissions)*
- Emisiones de GEI *(GHG emissions)*
- Emisión de gases *(Gas emissions)*
- Emisión residual *(Residual emission)*
- Estrés climático *(Climate stress)*
- Fondo de carbono *(Carbon fund)*
- Gases renovables *(Renewable gases)*
- Huella ambiental *(Environmental footprint)*
- Riesgo climático *(Climate risk)*
- Ámbito climático *(Climate scope)*
- Bajas emisiones *(Low emissions)*
- Carbon emission
- Decarbonización *(Decarbonization)*
- Descarbonizarse *(To decarbonize)*
- Ecocombustibles *(Ecofuels)*
- Emisiones netas *(Net emissions)*
- Emisión directa *(Direct emission)*
- Emission factor
- Gases de escape *(Exhaust gases)*
- Acuerdo global *(Global agreement)*
- Carbon dioxide
- Cero emisiones *(Zero emissions)*
- Climate change
- Climáticamente *(Climatically)*
- Consumo de gas *(Gas consumption)*
- Descarbonizada *(Decarbonized)*
- Descarbonizado *(Decarbonized)*
- Gas sostenible *(Sustainable gas)*
- Global warming
- Greenhouse gas
- Huella hídrica *(Water footprint)*
- Pacto de París *(Paris Pact)*
- Reto del clima *(Climate challenge)*
- Acuerdo verde *(Green agreement)*
- Calentamiento *(Warming)*
- Cero residuos *(Zero waste)*
- Descarbonizar *(To decarbonize)*
- Emisiones GEI *(GHG emissions)*
- Gas renovable *(Renewable gas)*
- GHG emissions
- Huella global *(Global footprint)*
- Meteorológica *(Meteorological)*
- Pacto mundial *(Global pact)*
- Protocolo GHG *(GHG Protocol)*
- Cero residuo *(Zero waste)*
- Clima global *(Global climate)*

- $CO_2$ emission
- GHG emission
- GHG Protocol
- Race to Zero
- Agenda 2030
- Copernicus
- One Planet
- Transición *(Transition)*
- Zero Waste
- Cero neto *(Net zero)*
- Climática *(Climate)*
- $CO_2$eq/ $m^2$
- Copernico *(Copernicus)*
- Emisiones *(Emissions)*
- Neto cero *(Net zero)*
- Taxonomía *(Taxonomy)*
- $CO_2$eq/$m^2$
- Emission
- Net zero
- Carbono *(Carbon)*
- Climate
- Emisión *(Emission)*
- Scope 1
- Scope 2
- Scope 3
- Warming
- Carbon
- Carbón *(Coal)*
- COP 26
- AEMET
- Clima *(Climate)*
- COP26
- ECMWF
- IPCC
- CDP
- CDS
- $CO_2$
- Gas
- GEI
- GHG
- ODS
- SDG