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CEO Managerial Ability and the Strategic Repetition of Climate Disclosures

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ABSTRACT

This study examines whether CEO managerial ability shapes the repetition of firms' climate-related disclosures in mandatory 10-K filings. Climate reporting is highly judgment based and central to firms' broader climate-risk management strategies, yet little is known about why some firms repeatedly use similar climate narratives and others revise them extensively. Using 12,533 US firm-year observations from 2005 to 2023, we measure climate-disclosure repetition through four dictionary-based similarity metrics and an AI-based semantic embedding approach. CEO ability is captured using an efficiency-adjusted managerial ability score. The results show that firms led by higher-ability CEOs provide more repetitive climate narratives over time. These findings remain robust across matching procedures, entropy balancing, within-year disclosure-alignment tests, lagged-ability models, and change-on-change specifications. Overall, the study highlights managerial capability as an important driver of firms' long-term climate-communication strategies and introduces intertemporal repetition as a novel dimension of climate-disclosure practice.

1 | Introduction

Climate-related disclosure has rapidly become one of the most scrutinized components of corporate reporting, driven by regulatory momentum, investor demand, and growing expectations for transparent communication about firms' exposure to environmental threats (Jona and Soderstrom 2022; Griffin and Sun 2024). Frameworks such as the Task Force on Climate-Related Financial Disclosures (TCFD) explicitly emphasize forward-looking, scenario-based assessments of climate-related issues, which require substantial managerial judgment and interpretation (Tumewang et al. 2025). Prior research shows that risk-related disclosures—even in mandatory regimes—remain highly subjective because much of the underlying information is unverifiable, predictive, and inherently uncertain (Dobler 2008). Climate-related issues further heighten economic and policy uncertainty, making disclosure practices contingent on managerial perceptions, value judgments, and internal interpretations of evolving climate science (Li et al. 2019). Empirical evidence confirms that firms vary substantially in how they communicate climate-related issues, with disclosure practices characterized by discretion, heterogeneity, and a lack of standardized guidance (Krause et al. 2017; Borghei et al. 2024).

A central yet understudied feature of climate reporting is the degree of repetition in firms' climate-related narratives across years. Because firms annually update Item 1A risk-factor disclosures, the extent to which they repeat, revise, or meaningfully expand climate-related text is not a mechanical artifact. Instead, repetition reflects managerial judgment regarding prior disclosures, evolving risk assessments, and the strategic purpose of climate communication (Pesci et al. 2015; Brown et al. 2022). Despite the growing attention to climate disclosure quality, very little is known about why firms differ in the extent to which they repeat versus revise climate-related language in their 10-K filings. This gap is striking given

increasing regulatory and investor concerns over boilerplate environmental reporting, perceived passivity in climate-risk communication, and the need for decision-useful climate information.

Management literature suggests that CEO characteristics play a critical role in shaping disclosure outcomes (Lewis et al. 2014). Climate reporting is a high-discretion domain involving uncertainty, ambiguity, and forward-looking assessments—conditions under which CEO cognitive traits, expertise, and strategic tendencies are most influential. Upper echelons theory posits that organizational outcomes—including reporting practices—reflect the cognitive styles and value systems of top executives (Mahran and Elamer 2024; Li et al. 2025). Related research shows that CEO attributes such as education, tenure, analytical sophistication, and environmental experience meaningfully influence environmental reporting choices (Lewis et al. 2014; Shahab et al. 2020; Cahyono et al. 2024). Yet, no prior study examines whether CEO managerial ability—a well-validated measure of CEOs' efficiency in transforming resources into revenue—shapes how firms present climate-related issues across time, particularly in terms of textual repetition.

Theoretically, CEO managerial ability may influence climate-text repetition in competing ways. From an upper echelons perspective, high-ability CEOs may imprint structured, disciplined disclosure architectures that promote continuity in climate communication. Alternatively, more capable executives may update disclosures more frequently in response to evolving climate risks. Because climate reporting is forward-looking and judgment intensive, the direction of this relationship is ambiguous and remains an empirical question (see Section 2). To address this question, we formulate a nondirectional hypothesis that reflects the two competing theoretical perspectives discussed above (see Section 2 for further details). We assemble a comprehensive panel of 12,533 US firm-year observations from 2005 to 2023, combining detailed textual features from Item 1A climate-related risk disclosures, CEO managerial ability scores, and standard financial controls. We construct both dictionary-based and semantic measures of climate-text repetition, including bigram-identified word-level similarity indices (Cosine, Jaccard, Minimum Edit Distance, and Simple Similarity), a PCA-based composite repetition index, and an embedding-based semantic similarity measure.[1] Managerial ability is measured using the established Demerjian et al. (2012) efficiency-adjusted score.

Our results show that CEO managerial ability is positively associated with climate-disclosure repetition across all six similarity measures, with economically meaningful magnitudes. These findings remain robust after an extensive battery of tests, including propensity score matching (PSM), entropy balancing (EB), within-year Risk–MD&A similarity tests, lagged-ability models, and change-on-change specifications. The persistence of the effect across both literal word-based metrics and semantic embedding measures indicates that managerial ability shapes not only linguistic reuse but also deeper semantic repetition in climate narratives.

This study makes several important contributions. First, we advance the climate-disclosure literature by shifting the focus from disclosure quantity or tone to intertemporal narrative structure, introducing climate-text repetition as a theoretically meaningful and previously unexamined dimension of disclosure quality. Prior work examines determinants of climate-risk disclosure levels, scenario analysis, or assurance practices (Li et al. 2019; Tumewang et al. 2025; Borghei et al. 2024), but no study investigates whether firms reuse or revise climate language across years—despite repetition being central to judgments about boilerplate reporting, credibility, and risk communication. Second, we extend the managerial ability literature by demonstrating that CEO capability—widely linked to CSR disclosure, environmental performance, and information environments (Hasan 2020; Hussain et al. 2023; García-Sánchez et al. 2020)—also shapes narrative repetition in a highly discretionary domain. This intersection has not been previously explored, leaving unanswered whether high-ability CEOs favor reinforcement or adaptation in climate-risk communication.

Third, by positioning repetition within competing frameworks—including upper echelons theory, signaling theory, information-asymmetry perspectives, and dynamic managerial capabilities—we clarify the theoretical ambiguity underlying managerial influence on climate reporting and provide the first empirical test to adjudicate these opposing mechanisms. Finally, we contribute to textual-analysis research by offering a comprehensive, dual-method approach to measuring climate-text repetition, combining dictionary-based similarity metrics with an embedding-based semantic similarity measure. This framework provides a scalable, theoretically grounded, and semantically rich way to study firms' strategic reporting behavior in climate disclosures.

The rest of the paper proceeds as follows. Section 2 develops the theoretical framework and presents the competing mechanisms that motivate our non-directional hypothesis. Section 3 describes the research design. Section 4 reports the main regression results. Section 5 presents robustness analyses. Section 6 concludes with implications, limitations, and directions for future research.

2 | Competing Theoretical Perspectives and Hypothesis Development

Climate-related disclosures in 10-K filings are inherently forward-looking, judgment-intensive, and subject to substantial managerial discretion. Prior research shows that risk and climate reporting—even in mandatory settings—remains subjective because much of the underlying information is unverifiable, predictive, and shaped by managerial interpretation (Dobler 2008). Climate-related matters further heighten economic and policy uncertainty, making disclosure outcomes sensitive to managers' perceptions of evolving risks (Li et al. 2019). Contemporary frameworks such as the TCFD add to this complexity by requiring scenario analysis and other forward-looking assessments that are difficult to standardize (Tumewang et al. 2025). Empirical studies indicate that vague regulatory guidance affords firms considerable latitude in the specificity and structure of predictive reporting, especially under heightened uncertainty (Krause et al. 2017). Recent climate-risk evidence likewise documents discretionary

disclosure practices driven by evolving expectations and limited standardization (Borghei et al. 2024). Collectively, this literature underscores that climate disclosure is not mechanically determined by underlying environmental conditions but shaped by managerial judgment.

We anchor our theoretical framework in upper echelons theory, which posits that organizational outcomes reflect the cognitive bases, values, and capabilities of top executives (Mahran and Elamer 2024; Li et al. 2025). In the context of climate reporting, which requires interpretation of uncertain, forward-looking environmental risks, managerial cognition is likely to play a central role in shaping disclosure architecture. CEO managerial ability—capturing the executive's efficiency in processing information and allocating resources (Demerjian et al. 2012)—therefore represents a theoretically meaningful driver of how climate-related disclosures are structured across time. However, although upper echelons theory explains why CEO traits influence disclosure outcomes, it does not, on its own, specify whether repetition should manifest as reinforcement of strategic continuity or as adaptive updating in response to environmental change. To articulate the mechanisms through which managerial cognition may translate into either greater or lower repetition, we draw on complementary perspectives—signaling theory, information-asymmetry reasoning, and dynamic managerial capabilities. Building on this integrated framework, two competing theoretical logics emerge—one predicting more repetition among high-ability CEOs and the other predicting less repetition.

2.1 | Why CEO Managerial Ability May Increase Repetition in Climate Disclosures: Cognitive Imprinting and Strategic Reinforcement

2.1.1 | Structured Reporting Under Upper Echelons Theory

Upper echelons theory posits that CEOs imprint their cognitive styles, strategic orientations, and value systems onto organizational processes, including disclosure practices (Mahran and Elamer 2024; Li et al. 2025). High-ability CEOs, characterized by superior analytical capacity and coordination skills, tend to formulate long-term environmental strategies and manage sustainability issues systematically. This structured strategic orientation can translate into repeated framing of climate-related issues across time (Hussain et al. 2023). Their environmental judgments draw on deeper experience and more developed cognitive schemas, shaping recurring patterns in climate communication (Li et al. 2025). Prior research shows that CEO education, tenure, technical expertise, and strategic orientation influence environmental reporting approaches (Lewis et al. 2014; Cahyono et al. 2024; Shahab et al. 2020). Empirical climate-disclosure evidence further indicates that CEOs with research backgrounds, financial acumen, or generally higher managerial ability are more likely to participate in climate initiatives and provide structured reporting (Hussain et al. 2023; Khalid et al. 2022). Accordingly, high-ability CEOs may produce more repetitive climate disclosures because they rely on established disclosure architectures that reflect disciplined, long-term strategic continuity.

2.1.2 | Repetition as a Credibility Signal Under Signaling Theory

From an upper echelons perspective, executives' cognitive styles influence not only internal strategic decisions but also how firms communicate externally. In uncertain environments characterized by information asymmetry—such as climate-related risk disclosure—signaling theory helps explain how managerial cognition translates into observable communication behavior (Bergh et al. 2014). High-ability managers are known to produce higher-quality environmental disclosures (Chen and Chen 2020) and use disciplined communication, including dividends, to signal sustainable performance (Adams et al. 2024). CEOs with deep firm-specific knowledge issue more accurate forecasts, strengthening investor perceptions of credibility (Brockman et al. 2019; Yang 2012). Disclosure-style research shows that managers imprint personal communication preferences onto reporting, with analytically trained CEOs favoring clarity and disciplined framing (Bamber et al. 2010). Moreover, high-ability managers face stronger reputation concerns and are less inclined toward opportunistic manipulation (Krishnan et al. 2021). CEOs who project predictability through communication are perceived as managing firm risk more effectively (Harrison et al. 2020). Through this lens, repetition becomes a credibility-enhancing signal: High-ability CEOs may repeat climate narratives to reinforce clarity, reduce uncertainty, and legitimize long-term climate strategies.

2.1.3 | Repetition as Information Reinforcement to Reduce Asymmetry

Extending this logic, information-asymmetry and stakeholder-oriented perspectives clarify how the cognitive imprint of high-ability CEOs may manifest in repeated climate disclosures. More able managers reduce agency problems and improve the firm's information environment by providing richer financial and nonfinancial disclosures (Hussain et al. 2023; Baik et al. 2018). Talented CEOs supply comparable and decision-useful CSR information to strengthen stakeholder trust (García-Sánchez et al. 2020). Managerial ability also strengthens the link between strategic orientation and environmental reporting, particularly in stakeholder-focused firms that require sustained communication (Cahyono et al. 2024). In contrast, low-ability managers resort to obfuscation tactics—lower readability, vague tone, and fewer numbers—to hide poor performance (Yan et al. 2021). Even powerful CEOs adopt transparent CSR disclosure under public scrutiny (Jizi et al. 2014). Repeating key climate messages across filings may therefore reinforce material risk themes and facilitate investor interpretation. High-ability CEOs may repeat more to improve transparency and reduce information gaps.

2.1.4 | Disclosure Discipline and Reduced Opportunism Among High-Ability CEOs

A final pathway predicts more repetition through greater disclosure discipline. High-ability CEOs are associated with stronger reporting quality and lower opportunistic manipulation (Habib and Hossain 2013). CEOs with accounting expertise engage less in accrual-based manipulation (Kouaib et al. 2018) and are less

likely to be involved in fraudulent reporting (Sun et al. 2019). The efficient contracting hypothesis argues that reputed or high-ability CEOs avoid low-quality disclosures because poor reporting threatens their human capital and career value (Francis et al. 2008). Hasan (2020) shows that managerial ability increases narrative readability, countering the obfuscation commonly used by weaker managers during poor performance. In contrast to weaker managers who rely on obfuscation tactics—such as complexity, tone inflation, and reduced clarity—to mask negative outcomes (Hassan et al. 2019; Rutherford 2003; Habib and Hasan 2020; Huang et al. 2014; Patelli and Pedrini 2015), high-ability CEOs maintain disciplined disclosure architectures and update only when warranted. In this context, repetition signals structured communication rather than inertia. Thus, higher managerial ability may increase repetition in climate disclosures.

2.2 | Why CEO Managerial Ability May Decrease Repetition in Climate Disclosures: Adaptive Cognitive Updating

2.2.1 | Adaptive Information Processing in Dynamic Climate Environments

An alternative implication of upper echelons theory emphasizes the adaptive dimension of managerial cognition. If CEO managerial ability reflects superior information processing and environmental scanning capacity, high-ability CEOs may be more inclined to update rather than repeat prior climate disclosures. Dynamic managerial capabilities theory provides a mechanism for this adaptive imprint (Adner and Helfat 2003). Managers with strong cognitive skills, ambiguity tolerance, and environmental scanning intensity are better able to handle evolving information (Wang and Chan 1995). Sustainability scholarship highlights that senior executives require advanced competencies—context, complexity, and connectedness—to respond to rapidly changing environmental conditions (Lacy et al. 2009). Empirical evidence shows that high-ability managers proactively mitigate climate exposure following major climate events such as the Stern Review and Paris Accord (Ullah et al. 2024). More able managers integrate climate information into investment decisions more effectively, resulting in adjustments to disclosure content (Almaghrabi 2023). Capable managers also expand climate reporting as part of effective risk-management strategies (Daradkeh et al. 2023). CEOs with research backgrounds or international experience are particularly adept at integrating new sustainability practices, making adaptive revision more likely (Shahab et al. 2020). Under this view, high-ability CEOs revise climate narratives more frequently, reducing repetition.

2.2.2 | Reputational Sensitivity and Stakeholder-Oriented Revision Incentives

High-ability CEOs are often more attuned to reputational consequences and stakeholder perceptions, leading them to avoid excessive repetition that may appear boilerplate. Able CEOs prioritize robust environmental measurement and reporting systems to meet legitimacy expectations (Cahyono et al. 2024). CSR-disclosure evidence shows that talented CEOs provide more decision-useful information to maintain stakeholder trust (García-Sánchez et al. 2020). Hussain et al. (2023) demonstrate that CEO ability increases sustainability disclosure, suggesting more proactive communication. Climate-disclosure research shows that managers treat climate issues as both financial and reputational risks, prompting capable leaders to actively revise information (Daradkeh et al. 2023). Executive-visibility research likewise suggests that visible leaders adjust climate disclosure to manage impressions (Li 2024). High-ability managers voluntarily disclose more carbon emissions (Lee et al. 2023) and provide more readable disclosures (Hasan 2020). These behaviors imply ongoing refinement rather than reliance on prior-year wording. Thus, reputational sensitivity may drive high-ability CEOs to update climate narratives regularly, reducing repetition.

2.2.3 | Transparency Signaling Through Narrative Updating

Another mechanism predicting lower repetition is transparency signaling. In rapidly changing environments, frequent disclosure updates can signal vigilance and responsiveness. Sustainability communication research shows that CEOs adjust framing of climate issues in response to shifting societal norms (Arvidsson and Sabelfeld 2023). Research on dynamic CEO capabilities shows that leaders with strong sensing and adaptation skills adjust ESG communication as regulatory conditions evolve (Heubeck 2024). These tendencies rest on managerial cognitive capabilities that influence executives' ability to detect patterns and revise communication accordingly (Helfat and Peteraf 2015). Leadership-vigilance literature likewise finds that effective CEOs anticipate external shifts and use narratives to signal monitoring (Schoemaker and Day 2021). Therefore, high-ability CEOs may use disclosure updates to signal transparency and oversight, decreasing repetition.

2.2.4 | Tailored, Firm-Specific Disclosure Updating

A final mechanism for lower repetition is the ability of high-ability CEOs to tailor disclosures to firm-specific developments. Low-ability CEOs often rely on static templates, whereas high-ability managers are more capable of adjusting internal systems and responding to evolving climate risks (Ullah et al. 2024). High-ability managers improve narrative readability (Hasan 2020), issue more informative voluntary disclosures (Yan et al. 2021), and provide more granular financial information (Bui et al. 2023). This refined communication inherently reduces year-to-year similarity. Under this perspective, lower repetition reflects skillful adaptation rather than inconsistency.

2.3 | Hypothesis Development

The theoretical landscape presents two competing predictions. On one hand, high managerial ability may increase repetition by promoting structured reporting, credible signaling, information reinforcement, and disciplined communication. On the other hand, high managerial ability may decrease repetition through adaptive information processing, reputational sensitivity, transparency signaling, and tailored disclosure refinement. Taken

together, upper echelons theory provides the foundational premise that CEO managerial ability shapes disclosure architecture. Signaling, information-asymmetry, and dynamic managerial capability perspectives clarify the strategic mechanisms through which this cognitive imprint may result in either reinforcement (greater repetition) or adaptive revision (lower repetition). Because both manifestations are theoretically plausible, the direction of the association remains an empirical question. To reflect this tension, we state a non-directional hypothesis:

Hypothesis 1. *CEO managerial ability is associated with the degree of repetition in firms' climate-related disclosures.*

3 | Research Design

This study examines whether CEO managerial ability influences the degree of strategic repetition in firms' climate-related disclosures contained in mandatory Form 10-K filings. We follow a quantitative archival approach combining large-scale textual analysis of climate expressions in regulatory filings, a validated managerial ability score based on Demerjian et al. (2012), and multivariate regression models linking CEO ability to climate-disclosure repetition while controlling for firm fundamentals and year and firm effects.[2] Importantly, our methodological choices are directly guided by the nature of the research question. Because we examine intertemporal repetition in climate-related disclosures, the empirical design must (i) isolate climate-specific content from standardized regulatory filings, (ii) measure textual similarity in a way that captures both literal and conceptual reuse across years, and (iii) account for persistent firm-level disclosure architectures that may confound managerial effects. The combination of dictionary-based extraction, embedding-based semantic similarity, and panel fixed-effects regressions is therefore aligned with the theoretical objective of identifying whether CEO managerial ability shapes repeated climate disclosure structures over time rather than disclosure quantity or tone alone.

A key feature of our design is that we operationalize climate-related disclosure using two complementary textual pipelines. First, a dictionary-based approach, where climate text is identified using the 100 bigrams of Sautner et al. (2023a, 2023b) and repetition is measured using standard word-level similarity metrics. Second, a semantic approach, where transformer-based sentence embeddings (Sentence-BERT) are used to generate low-dimensional representations of climate-related sentences and quantify year-to-year similarity in meaning. This embedding-based semantic repetition measure captures deeper alignment in climate disclosures even when firms rephrase or restructure their text.

The analysis proceeds in three main steps. First, we identify and extract climate-related textual content from Item 1A of the 10-K (Risk Factors) using the baseline bigram dictionary. Second, we calculate year-to-year repetition using both traditional word-level similarity metrics (Cosine, Jaccard, Minimum Edit Distance, and Simple Similarity) and an embedding-based semantic similarity measure derived from SBERT sentence embeddings. Third, we merge these textual outcomes with CEO managerial ability scores and control variables to estimate whether more capable CEOs provide more or less repetitive climate narratives over time.

3.1 | Sample Selection and Data Sources

We begin by extracting the Item 1A: Risk Factors sections from all Form 10-K filings submitted between 2005 and 2023.[3] The year 2005 marks the implementation of the SEC's mandatory risk-factor disclosure requirement, creating a standardized narrative structure suitable for large-scale textual analysis. Item 1A is particularly relevant for our purposes because it provides a forward-looking, qualitative narrative in which firms commonly discuss environmental, regulatory, operational, and climate-related issues. The extraction process produces 133,017 risk-factor sections.[4]

In the baseline dictionary-based pipeline, we identify climate-related content using a curated climate dictionary derived from prior climate-communication studies and expanded using the 100 climate bigrams developed by Sautner et al. (2023a, 2023b). These bigrams capture general climate expressions including physical climate events, transition issues, emissions terminology, carbon exposure, environmental initiatives, and climate strategy. Appendix A presents the detailed climate-text extraction procedure together with the full list of validated climate bigrams. All sentences containing one or more climate bigrams are extracted from Item 1A. Filings with no climate-related text are removed because repetition cannot be calculated for non-climate content.

After filtering the climate-text corpus and computing repetition across consecutive years, the dataset contains 26,676 firm-year observations with complete climate-related textual measures. This processing ensures that repetition reflects genuine year-to-year persistence in climate language within a standardized regulatory disclosure setting.

To measure CEO managerial ability, we merge the climate-text dataset with the managerial ability (MA) scores developed by Demerjian et al. (2012).[5] The merge is conducted using the SEC CIK identifier. A total of 12,621 observations lack matching MA information and are dropped, leaving 14,055 firm-year observations with both climate repetition and managerial ability data.

Next, we extract additional textual attributes from the climate-filtered corpus, including readability (Fog Index), tone (positive and negative climate wordlists), and forward-looking orientation (future-oriented expressions). These features are constructed from the same climate-specific text to ensure coherence across measures. Missing or insufficient textual content results in the removal of 1445 observations, producing a textual-feature-complete sample of 12,610 firm-years.

We then merge this dataset with firm-level financial fundamentals retrieved from Refinitiv and Bloomberg, using ticker symbols and standardized firm-name crosswalks to ensure accurate alignment across data sources. Observations lacking financial information after the merge (77 firm-years) are removed, resulting in a final sample of 12,533 firm-year observations with complete textual features, managerial ability scores, and financial

controls. These observations form the basis for the empirical analyses examining the association between CEO managerial ability and repetition in climate disclosures. The complete sampling pipeline is summarized in Table 1.

3.2 | Climate-Text Identification and Repetition Measures (*CLMTREP*)

Strategic repetition captures the extent to which firms reuse climate-related language across consecutive 10-K filings. We operationalize climate-disclosure repetition using two complementary approaches. First, a dictionary-based, word-level approach that focuses on literal reuse of climate-related wording identified through the 100 climate bigrams of Sautner et al. (2023a). Second, a semantic, embedding-based approach that leverages transformer-generated sentence embeddings to capture similarity in meaning even when wording changes. Repetition is interpreted as a managerial communication decision—reflecting whether CEOs choose to update, refine, or recycle previously disclosed climate information over time.

3.2.1 | Dictionary-Based Climate Text and Word-Level Repetition

Because meaningful repetition requires a relatively stable disclosure format, our analysis focuses exclusively on Item 1A (Risk Factors), where firms routinely present environmental, regulatory, operational, and climate-related issues. Risk Factors combine mandatory structure with considerable managerial discretion in narrative framing, making them appropriate for year-to-year textual comparison.

In the baseline pipeline, climate-related sentences are extracted annually using the validated set of 100 climate bigrams from Sautner et al. (2023a, 2023b). For each firm-year, we concatenate all climate-related sentences into a single document and compute word-level similarity between year t and year $t-1$. To quantify repetition, we compute four widely used similarity metrics (*CLMTREP_COS*, *CLMTREP_JAC*, *CLMTREP_MINEDT*, and *CLMTREP_SIMP*), each capturing a distinct linguistic dimension. The final composite index (*CLMTREP_INDX*) is generated using PCA. These word-level repetition measures are standard in the textual-similarity and repetition literature (Cohen et al. 2020; Brown and Tucker 2011; Wang et al. 2023; Rajabalizadeh et al. 2025) and are well suited for capturing literal reuse of climate-related wording across years.

3.2.1.1 | Cosine Similarity (*CLMTREP_COS*). Cosine similarity measures the semantic closeness of climate-related text in consecutive filings. Let D_1 and D_2 represent the climate-text documents for years $t-1$ and t. Let T be the union of all terms across both documents ($T = D_{s1} \cup D_{s2}$). The term-frequency vectors are as follows:

$$D_1^{TF} = \left[n_{D_1}(t_1), n_{D_1}(t_2), \ \ldots, n_{D_1}(t_N)\right]$$

$$D_2^{TF} = \left[n_{D_2}(t_1), n_{D_2}(t_2), \ \ldots, n_{D_2}(t_N)\right]$$

Cosine similarity is calculated as follows:

$$\text{Sim\_Cosine} = \frac{D_1^{TF} \cdot D_2^{TF}}{\| D_1^{TF} \| \ \| D_2^{TF} \|}$$

Higher values indicate stronger semantic alignment across years.

3.2.1.2 | Jaccard Similarity (*CLMTREP_JAC*). Jaccard similarity captures the proportion of shared climate bigrams across years, focusing on vocabulary overlap rather than frequency:

$$\text{Sim\_Jaccard} = \frac{| D_1^{TF} \cap D_2^{TF} |}{| D_1^{TF} \cup D_2^{TF} |}$$

TABLE 1 | Sample construction steps.

Step	Description	Observations remaining	Obs. dropped
1	Raw extraction of Item 1A Risk-Factor sections from 10-K filings (2005–2023)	133,017	—
2	Climate-text filtering using 100 climate bigrams (Sautner et al. 2023a, 2023b); removal of filings with no climate text	26,676	(106,341)
3	Merge with managerial ability (MA) dataset using CIK	14,055	(12,621)
4	Extraction of additional climate textual variables (readability, tone, forward-looking); removal of missing-text cases	12,610	(1445)
5	Merge with firm-level financial fundamentals retrieved from Refinitiv and Bloomberg using ticker symbols and firm-name crosswalks. Observations lacking financial data after the merge are removed	12,533	77
6	Complete dataset with climate repetition, textual features, managerial ability, and firm fundamental controls	12,533	—

Note: This table reports the sequential steps used to construct the final sample of climate-related disclosures from Item 1A of Form 10-K filings between 2005 and 2023. At each stage, filings are filtered based on the presence of climate text, availability of CEO managerial ability scores, completeness of extracted textual features, and the availability of financial data. The process results in a final dataset of 12,533 firm-year observations containing climate-disclosure repetition measures, additional textual attributes, managerial ability, and firm fundamentals from Refinitiv and Bloomberg.

A value of 1 indicates identical sets of climate expressions across years.

3.2.1.3 | Minimum Edit Distance (*CLMTREP_MINEDT*). Minimum Edit Distance quantifies the number of insertions, deletions, or substitutions needed to transform last year's climate text into the current year's text. We use a normalized version so that lower values indicate more changes (i.e., less repetition) and higher values indicate fewer changes (i.e., more repetition). This metric captures structural similarity beyond vocabulary overlap.

3.2.1.4 | Simple Similarity (*CLMTREP_SIMP*). Simple Similarity evaluates the proportion of textual alterations between documents, normalized by document size:

$$\text{Sim\_Simple} = \frac{c_{\max} - c}{c_{\max}}$$

where

$$c = \frac{\text{additions} + \text{deletions} + \text{changes}}{\left(\text{Size}\left(D_1\right) + \text{Size}\left(D_2\right)\right)/2}$$

Higher values indicate more repetition across years.

3.2.1.5 | Composite Strategic Repetition Index (*CLMTREP_INDX*). To create a unified measure of overall climate-disclosure repetition, we apply PCA to the four individual similarity metrics. The first principal component (PC1)—which captures the largest share of shared variance—is used as the composite index *CLMTREP_INDX*.[6]

The use of multiple similarity metrics is deliberate and methodologically motivated. Different textual similarity measures capture distinct dimensions of repetition—lexical overlap (Jaccard), vector-based proximity in term space (Cosine), structural edit operations (Minimum Edit Distance), and normalized document-level textual change (Simple Similarity). Relying on a single metric could bias inference toward one dimension of similarity. Employing this battery of metrics reduces measurement error and strengthens construct validity by ensuring that results are not driven by the properties of any single algorithm. The PCA-based composite index further mitigates noise by extracting the shared variance across the four similarity measures, providing a theoretically grounded aggregate indicator of strategic repetition in climate disclosures.

3.2.2 | Semantic Repetition Based on Sentence Embeddings

The preceding measures—both dictionary-based and AI-assisted—are primarily bag-of-words metrics that focus on explicit overlap in terms or local edit operations. Although these metrics are standard and powerful, they may understate repetition when firms rephrase climate disclosures but retain similar meaning. To address this limitation, we construct a semantic repetition measure using transformer-based sentence embeddings.

For each firm-year, we take the climate-related Item 1A text identified by our baseline bigram dictionary and split it into sentences. We then use a pretrained Sentence-BERT model (Reimers and Gurevych 2019), such as all-MiniLM-L6-v2, to compute an embedding vector for each sentence. The firm-year climate embedding is defined as the simple average of all sentence embeddings in that year, providing a low-dimensional representation of the overall semantic content of the climate discussion.

Let $\mathbf{e}_{i,t}$ denote the embedding vector for the climate-related risk-factor text of firm i in year t, and $\mathbf{e}_{i,t-1}$ the corresponding vector for year $t-1$. We define the semantic repetition measure as the cosine similarity between the two embeddings:

$$\text{CLMTREP\_EMB}_{i,t} = \frac{\mathbf{e}_{i,t} \cdot \mathbf{e}_{i,t-1}}{\| \mathbf{e}_{i,t} \| \, \| \mathbf{e}_{i,t-1} \|}$$

Higher values indicate greater semantic alignment of climate narratives across consecutive filings. This measure captures similarity in meaning rather than exact word overlap and is therefore less sensitive to purely stylistic rephrasing.

In our main empirical tests, we estimate the baseline specification using both the composite word-based index (*CLMTREP_INDX*) and the embedding-based semantic repetition measure (*CLMTREP_EMB*) as alternative dependent variables, allowing us to assess whether the association between CEO managerial ability and climate-disclosure repetition holds when repetition is measured in semantic space rather than purely at the word level.

The embedding-based approach is particularly relevant in the climate-reporting context, where firms may rephrase disclosures while preserving substantive meaning. Traditional bag-of-words similarity measures can understate repetition when wording changes but conceptual framing remains stable. Transformer-based sentence embeddings allow us to capture deeper semantic alignment and reduce sensitivity to superficial linguistic variation. Using SBERT therefore enhances measurement validity by distinguishing genuine disclosure updates from stylistic rewriting and ensures that repetition reflects persistence in climate-related content rather than mechanical word reuse.

3.3 | Independent Variables: CEO Managerial Ability (*CEOMA*)

In this study, we use the managerial ability scores constructed by Demerjian et al. (2012), obtained directly from the publicly available repository maintained by Peter Demerjian. These scores provide a widely accepted, theory-based measure of managerial skill (Demerjian et al. 2013; Demerjian et al. 2020; Anggraini and Sholihin 2023).

The overall approach behind the measure is as follows. Demerjian et al. (2012) first calculate how efficiently each firm converts its operating inputs into revenues using data envelopment analysis (DEA). This efficiency reflects the firm's ability to generate output relative to comparable firms within the same industry. However, because firm efficiency can be influenced

by structural factors unrelated to the CEO—such as firm size, market share, or organizational scale—they remove these firm-driven effects using a regression model. The remaining unexplained portion (the residual) represents the component of efficiency that cannot be attributed to firm characteristics and is therefore interpreted as managerial ability.

Conceptually, the Demerjian measure captures how effectively a CEO utilizes available firm resources relative to industry peers, after purging structural advantages. It isolates the portion of performance attributable to managerial discretion rather than inherited firm attributes. This distinction is critical in our setting, as we seek to understand whether disclosure architecture reflects managerial capability rather than firm-level environmental exposure or reporting infrastructure. Importantly, the measure does not rely on subjective assessments, survey data, or market-based proxies. Instead, it is constructed using observable operating inputs (e.g., cost of goods sold, SG&A, PPE, and R&D) and output (sales), ensuring that ability is grounded in operational efficiency rather than reputational perceptions. This objective construction reduces concerns that the ability score merely captures firm size, profitability, or industry characteristics.

The Demerjian managerial ability score has been extensively validated in the literature. Prior research links it to earnings quality, disclosure transparency, innovation efficiency, CSR reporting quality, and reduced fraud likelihood (e.g., Chen et al. 2015; Gan 2019; Hasan 2020). These validations support its interpretation as a stable managerial trait rather than a transient firm-level outcome. In the context of climate disclosures, managerial ability is theoretically relevant because climate reporting involves judgment-intensive, forward-looking assessments and structured communication decisions. If the Demerjian score captures a CEO's capacity to allocate resources efficiently and process complex information, it should also reflect the ability to structure and maintain coherent disclosure architectures over time. Thus, the operationalization of *CEOMA* is directly aligned with the cognitive and strategic dimensions emphasized in upper echelons theory.

A detailed description of the full analytical procedure and how Demerjian et al.'s measure is constructed is provided in Appendix B.

3.4 | Control Variables

Our empirical specifications incorporate a series of text-level and firm-level control variables to isolate the association between CEO managerial ability and strategic repetition of climate disclosures. These controls account for linguistic features, disclosure incentives, and underlying firm economics that may independently influence year-to-year repetition in climate-related narratives.

Textual controls (i.e., climate-specific characteristics) capture stylistic and linguistic attributes of climate-related sentences that may mechanically affect similarity scores. Readability is measured using the Fog Index of climate text (*CLMTFOG*), computed as follows:

$$CLMTFOG = 0.4 \times \left(\frac{\text{words}}{\text{sentences}} + 100 \times \frac{\text{complex words}}{\text{words}} \right)$$

where complex words contain three or more syllables. Higher Fog scores reflect more complex or boilerplate climate language (Efretuei and Hussainey 2023; Bifulco et al. 2025), which may mechanically yield higher repetition if firms reuse dense narrative templates. Controlling for readability helps ensure that similarity does not primarily reflect linguistic opacity.

Climate tone is captured using counts of negative and positive climate-related expressions. The negative climate tone measure (*CLMTNEG*) reflects the number of climate-specific negative words, whereas the positive tone measure (*CLMTPOS*) captures the number of climate-related positive words (Hassan 2019; Hamza and Jarboui 2022). Firms experiencing adverse climate exposure may repeatedly emphasize risks, whereas firms highlighting progress or sustainability achievements may reuse optimistic phrasing. These variables ensure that repetition is not conflated with the sentiment embedded in climate discussions.

Forward-looking climate content (*CLMTFW*) captures future-oriented climate statements. Following Li (2010) and Thomas et al. (2024), we use natural language processing techniques to identify sentences containing verbs and expressions indicative of future plans, projections, or strategic intentions (e.g., "will," "expect," "plan," "anticipate," and "strategy"). To reduce linguistic variation (e.g., expect, expected, and expecting), we apply the Porter stemming algorithm. CEOs may repeat forward-looking claims due to regulatory expectations or internal communication templates; controlling for *CLMTFW* helps disentangle strategic repetition from routine forward-looking disclosure patterns. We also control for the prior year's disclosure length (*CLMTLENGTH*), measured as the natural logarithm of the number of climate-related words disclosed in Item 1A in year $t-1$. Longer disclosures mechanically increase the likelihood of overlap; thus, including lagged length helps ensure that similarity captures content persistence rather than scale effects.

Beyond textual determinants, firm-level controls capture economic fundamentals correlated with climate reporting. Firm size (*SIZE*), measured as the natural logarithm of total assets, accounts for the greater regulatory scrutiny and more standardized reporting practices of larger firms (Goodwin and Ahmed 2006). Research and development intensity (*RD*), defined as R&D scaled by total assets, reflects firms' exposure to innovation-driven transition risks that may influence climate narrative patterns (Zhang et al. 2025). Lagged profitability (*ROALAG*), measured as the prior-year return on assets, captures economic performance that may shape disclosure emphasis and narrative updating (Aly et al. 2018). Firm age (*AGE*), the natural logarithm of years since the firm's first appearance in our dataset, controls for the maturity of reporting systems and disclosure routines that can affect narrative persistence. Finally, we include an indicator of internal control problems (*ICPRBLM*), coded as 1 if the auditor reports any internal control issue—including material weaknesses, absence of an auditor's report, disclaimers, or delayed filings—and 0 otherwise. This control captures reporting-quality constraints that may affect the reliability of climate-related disclosures (Aziz and Cek 2025).

The fixed-effects specification is appropriate for this setting because disclosure architecture and reporting culture are highly persistent within firms. Firm fixed effects absorb all time-invariant characteristics—including industry exposure, baseline environmental risk, governance structure, and long-standing disclosure templates—thereby isolating within-firm variation in repetition associated with CEO managerial ability. Year fixed effects control for evolving regulatory expectations, macroeconomic shocks, and time-specific shifts in climate-reporting norms. Together, these controls ensure that estimated relationships reflect within-firm variation in climate-disclosure repetition rather than structural differences across firms or periods. Operational definitions of all variables are provided in Appendix B.

3.5 | Model Specifications

To assess whether CEO managerial ability influences the strategic repetition of climate-related disclosures, we estimate a series of panel regressions in which multiple repetition measures serve as dependent variables. Specifically, we examine six alternative measures of climate-text repetition: five dictionary-based word-level similarity metrics—Cosine Similarity (*CLMTREP_COS*), Jaccard Similarity (*CLMTREP_JAC*), Minimum Edit Distance Similarity (*CLMTREP_MINEDT*), Simple Similarity (*CLMTREP_SIMP*), and a PCA-based composite repetition index (*CLMTREP_INDX*)—and one semantic similarity metric based on Sentence-BERT embeddings (*CLMTREP_EMB*):

$$\begin{aligned}\mathrm{CLMTREP}_{i,t} = {} & \beta_0 + \beta_1 CEOMA_{i,t} + \beta_2 CLMTFOG_{i,t} + \beta_3 CLMTNEG_{i,t} \\ & + \beta_4 CLMTPOS_{i,t} + \beta_5 CLMTFW_{i,t} + \beta_6 CLMTLENGTH_{i,t} \\ & + \beta_7 SIZE_{i,t} + \beta_8 RD_{i,t} + \beta_9 ROALAG_{i,t} + \beta_{10} AGE_{i,t} \\ & + \mathrm{FirmFE}_i + \mathrm{YearFE}_t + \varepsilon_{i,t}\end{aligned}$$

The coefficient of interest is β_1, which captures the relationship between CEO managerial ability and the degree of repetition in climate-related disclosures. A positive β_1 indicates that firms led by more capable CEOs exhibit higher repetition in climate narratives across years, after controlling for textual structure (readability, sentiment, forward-looking tone, and length) and firm fundamentals. A negative β_1 suggests that higher-ability CEOs update, refine, or adapt climate disclosures more frequently, resulting in lower year-to-year similarity.

4 | Results

4.1 | Descriptive Statistics and Correlations

Table 2 presents descriptive statistics for the 12,533 firm-year observations in the final sample. The climate-disclosure repetition measures show substantial variation across firms and years. The cosine similarity measure (*CLMTREP_COS*) has a mean of 0.883, indicating a generally high degree of year-to-year repetition in climate-related language. Jaccard similarity (mean = 0.695) and Simple Similarity (mean = 0.728) also suggest considerable vocabulary overlap and modest textual changes across years. Minimum Edit

TABLE 2 | Descriptive statistics ($n = 12{,}533$).

Variables	Mean	SD	1%	Q1	Median	Q3	99%
CLMTREP_COS	0.883	0.167	0.260	0.839	0.958	0.997	1
CLMTREP_JAC	0.695	0.281	0.067	0.471	0.750	0.977	1
CLMTREP_MINEDT	0.567	0.370	0.005	0.202	0.602	0.979	1
CLMTREP_SIMP	0.728	0.270	0.074	0.535	0.803	0.987	1
CLMTREP_INDX	0.000	1.000	−2.497	−0.722	0.194	1.000	1.074
CLMTREP_EMB	0.897	0.144	0.383	0.853	0.962	0.999	1
CEOMA	−0.012	0.149	−0.253	−0.101	−0.043	0.036	0.536
CLMTFOG	14.016	1.210	10.783	13.320	14.030	14.760	16.91
CLMTNEG	5.654	8.411	0	1	3	7	43
CLMTPOS	1.043	3.078	0	0	0	1	13
CLMTFW	4.451	6.969	0	1	2	6	33
CLMTLENGTH	5.016	1.377	1.946	4.111	5.142	5.979	7.905
SIZE	7.353	2.025	1.943	6.134	7.459	8.687	11.929
RD	0.026	0.074	0	0	0	0.018	0.358
ROALAG	−0.062	1.086	−1.475	−0.020	0.034	0.074	0.286
AGE	2.796	0.591	1.386	2.398	2.996	3.258	3.497
ICPRBLM	0.202	0.402	0	0	0	0	1

Note: This table reports descriptive statistics for all variables used in the empirical analyses. All variables are defined in Appendix C.

Distance (*CLMTREP_MINEDT*) displays wider dispersion (mean = 0.567), reflecting heterogeneity in firms' structural updates to climate narratives. The PCA-based repetition index (*CLMTREP_INDX*) is standardized with mean 0 and standard deviation 1. The semantic repetition measure (*CLMTREP_EMB*) exhibits a mean of 0.897, showing that even when firms rephrase climate disclosures, the underlying semantic content remains closely aligned across filings.

CEO managerial ability (*CEOMA*) has a mean of −0.012 with moderate variation (SD = 0.149), consistent with prior studies using Demerjian et al.'s (2012) measure. Text-level characteristics also vary meaningfully: Climate readability (*CLMTFOG*) averages 14.0, with negative tone (*CLMTNEG*) and forward-looking orientation (*CLMTFW*) displaying right-skewed distributions typical of qualitative climate discussions. Positive climate words (*CLMTPOS*) are infrequent, with a median of zero, indicating that firms rarely express optimistic climate sentiments. Lagged climate-text length (*CLMTLENGTH*) averages 5.016 (log words), suggesting moderate disclosure volume in the climate sub-corpus.

Firm-level controls reflect a diverse set of companies in terms of size, innovation intensity, profitability, and age. *SIZE* averages 7.353 (log total assets), whereas R&D intensity (*RD*) remains low for most firms (median = 0). Lagged profitability (*ROALAG*) centers around zero, with substantial dispersion (SD = 1.086), and firm age (*AGE*) averages 2.796. Internal-control problems (*ICPRBLM*) occur in approximately 20% of firm-years, consistent with prior studies documenting recurring control weaknesses among US public companies.[7]

Table 3 reports the correlation matrix. The four dictionary-based climate-repetition measures—Cosine, Jaccard, Minimum

TABLE 3 | Correlations ($n = 12{,}533$).

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) *CLMTREP_COS*	1								
(2) *CLMTREP_JAC*	0.85***	1							
(3) *CLMTREP_MINEDT*	0.56***	0.80***	1						
(4) *CLMTREP_SIMP*	0.80***	0.96***	0.81***	1					
(5) *CLMTREP_INDX*	0.87***	0.98***	0.86***	0.97***	1				
(6) *CLMTREP_EMB*	0.89***	0.81***	0.54***	0.76***	0.82***	1			
(7) *CEOMA*	0.011*	0.012**	0.013***	0.011**	0.013**	0.014*	1		
(8) *CLMTFOG*	0.09***	0.10***	0.04***	0.09***	0.09***	0.11***	0.03***	1	
(9) *CLMTNEG*	0.13***	−0.04***	−0.20***	−0.09***	−0.05***	0.12***	0.01	0.10***	1
(10) *CLMTPOS*	0.07***	−0.05***	−0.16***	−0.08***	−0.06***	0.06***	−0.03***	−0.01	0.61***
(11) *CLMTFW*	0.12***	−0.05***	−0.21***	−0.09***	−0.06***	0.12***	−0.02***	0.04***	0.82***
(12) *CLMTLENGTH*	0.43***	0.16***	−0.10***	0.09***	0.15***	0.39***	0.01	0.06***	0.47***
(13) *SIZE*	0.05***	−0.02**	−0.10***	−0.03***	−0.03***	0.06***	0.17***	0.14***	0.10***
(14) *RD*	−0.03***	0.01	0.03***	0.01	0.01	−0.03***	0.04***	0.02*	−0.07***
(15) *ROALAG*	0.03***	0.02***	0.02*	0.02**	0.02***	0.02*	0.01	0.03***	0.01
(16) *AGE*	0.08***	0.08***	0.04***	0.07***	0.07***	0.08***	0.08***	0.02*	−0.08***
(17) *ICPRBLM*	−0.02**	0.01*	0.05***	0.02**	0.02*	−0.02**	−0.05***	−0.03***	0.01

Variables	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(10) *CLMTPOS*	1							
(11) *CLMTFW*	0.75***	1						
(12) *CLMTLENGTH*	0.31***	0.48***	1					
(13) *SIZE*	−0.04***	0.05***	0.20***	1				
(14) *RD*	0.02*	−0.07***	−0.10***	−0.26***	1			
(15) *ROALAG*	−0.05***	−0.01	0.02***	0.19***	−0.20***	1		
(16) *AGE*	−0.09***	−0.09***	0.04***	0.35***	−0.14***	0.10***	1	
(17) *ICPRBLM*	0.07***	0.02**	−0.07***	−0.52***	0.15***	−0.15***	−0.30***	1

Note: Coefficients are shown on two-tailed tests: ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$. All variable definitions are provided in Appendix C.

Edit Distance, and Simple Similarity—are strongly and positively correlated with one another ($\rho = 0.56–0.98$; all $p < 0.01$). This pattern is expected, as each metric captures a different linguistic dimension of year-to-year repetition in climate-related language (semantic overlap, vocabulary reuse, structural similarity, and normalized edits). The PCA-based composite measure (*CLMTREP_INDX*) is similarly and strongly correlated with all four underlying components ($\rho = 0.86–0.98$), confirming that it effectively summarizes the common variation in dictionary-based repetition.

Importantly, the embedding-based semantic repetition measure (*CLMTREP_EMB*) is positively and significantly associated with all dictionary-based measures ($\rho = 0.54–0.89$; all $p < 0.01$). This confirms that the AI-based semantic metric aligns with traditional word-level repetition but captures additional semantic depth—consistent with the idea that firms may retain meaning even when modifying wording. The convergence of dictionary-based and embedding-based approaches strengthens the validity of our repetition construct.

CEO managerial ability (*CEOMA*) is positively correlated with all repetition measures, although at small magnitudes ($\rho = 0.011–0.014$; significant at conventional levels). Despite their small size—typical in large archival datasets—these positive associations are theoretically meaningful. They align with upper echelons theory, signaling theory, and information-asymmetry reasoning, which suggest that high-ability CEOs tend to produce more structured and repetitive disclosures. As discussed in Section 2.1, high-ability CEOs develop long-term climate strategies, rely on disciplined disclosure architectures, and reinforce credible climate narratives to reduce uncertainty (Hussain et al. 2023; Li et al. 2025; Adams et al. 2024). The positive correlation between *CEOMA* and climate-disclosure repetition therefore provides preliminary evidence consistent with our regression results.

Regarding textual controls, climate readability (*CLMTFOG*) shows modest positive correlations with repetition measures ($\rho = 0.04–0.11$; $p < 0.01$), suggesting that more complex climate narratives tend to exhibit higher repetition over time, consistent with boilerplate reuse. Negative climate tone (*CLMTNEG*) and forward-looking content (*CLMTFW*) exhibit mixed correlations—negative with structural similarity but strongly positive with each other ($\rho = 0.82$), reflecting that more substantive climate disclosure often integrates both risk emphasis and forward-looking orientation. Positive climate tone (*CLMTPOS*) has weaker correlations, consistent with the infrequency of positive climate expressions.

Lagged textual length (*CLMTLENGTH*) correlates positively with several repetition measures ($\rho = 0.09–0.43$; $p < 0.01$), indicating that longer prior disclosures mechanically increase opportunities for overlap—justifying its inclusion as a control. Firm-level characteristics (*SIZE*, *RD*, *ROALAG*, and *AGE*) behave as expected. Larger, older firms exhibit slightly higher repetition ($\rho = 0.05–0.08$), consistent with more standardized reporting systems. R&D intensity (*RD*) shows small negative or near-zero correlations with repetition, reflecting heterogeneous innovation exposure. Internal control problems (*ICPRBLM*) correlate negatively with most repetition measures, consistent with weaker reporting quality and less structured disclosure processes (Aziz and Cek 2025; Habib and Hossain 2013).[8]

4.2 | Regression Results and Insights

Table 4 presents the main regression results linking CEO managerial ability (*CEOMA*) to year-to-year repetition in climate-related disclosures. Across all six specifications, *CEOMA* is positively associated with repetition, with statistical significance ranging from the 1% to the 10% levels. The effect is highly significant for *CLMTREP_COS* (0.033***), *CLMTREP_MINEDT* (0.078***), and significant at the 5% level for *CLMTREP_JAC* (0.042**) and *CLMTREP_SIMP* (0.042**). The PCA-based composite index (*CLMTREP_INDX*) is also significant at the 5% level (0.160**), whereas the embedding-based semantic measure (*CLMTREP_EMB*) is significant at the 10% level (0.017*). This consistent positive pattern supports the view that more capable CEOs produce more repetitive and disciplined climate narratives over time.[9] The positive association between CEO managerial ability and climate-disclosure repetition is consistent with the reinforcement logic developed in Section 2. High-ability CEOs appear to imprint disciplined and structured disclosure architectures that persist across years. This pattern aligns with upper echelons theory, which posits that executive cognitive capabilities shape organizational communication structures. The results further suggest that repetition functions as reinforcement rather than inertia, reflecting strategic continuity in climate reporting.

Turning to control variables, textual features behave as expected. Readability (*CLMTFOG*) is positively associated with repetition across all models, consistent with the tendency of more complex or boilerplate climate language to be reused. Negative climate tone (*CLMTNEG*) reduces repetition, reflecting that firms revise or update risk-emphasizing segments more frequently. Forward-looking climate content (*CLMTFW*) is negatively associated with repetition, consistent with forward-looking statements being more sensitive to changes in expected climate exposures. Prior climate-disclosure length (*CLMTLENGTH*) shows a strong positive effect, indicating that firms with larger baseline disclosures tend to repeat more language year-to-year.

Among firm-level controls, R&D intensity (*RD*), profitability (*ROALAG*), and firm age (*AGE*) are generally positively associated with repetition, suggesting that more innovative, profitable, and mature firms exhibit more repetitive climate narratives. Internal control problems (*ICPRBLM*) also exhibit a small positive effect, consistent with the idea that firms with weaker reporting systems may rely more on standardized language templates. Overall, the results provide robust evidence that CEO managerial ability is positively associated with repetition in climate disclosures. This empirical pattern is primarily consistent with upper echelons theory, which suggests that managerial cognitive capabilities imprint structured disclosure architectures. The findings also align with complementary signaling and information-asymmetry mechanisms discussed in Section 2.

TABLE 4 | CEO managerial ability and year-to-year repetition in climate disclosures.

Variables	(1) *CLMTREP_COS*	(2) *CLMTREP_JAC*	(3) *CLMTREP_MINEDT*	(4) *CLMTREP_SIMP*	(5) *CLMTREP_INDX*	(6) *CLMTREP_EMB*
CEOMA	0.033***	0.042**	0.078***	0.042**	0.160**	0.017*
	(0.012)	(0.021)	(0.028)	(0.021)	(0.075)	(0.010)
CLMTFOG	0.009***	0.023***	0.021***	0.023***	0.076***	0.010***
	(0.002)	(0.003)	(0.005)	(0.003)	(0.012)	(0.002)
CLMTNEG	−0.000	−0.002***	−0.004***	−0.003***	−0.008***	−0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.003)	(0.000)
CLMTPOS	0.001	−0.001	−0.002	−0.002	−0.002	−0.000
	(0.001)	(0.002)	(0.003)	(0.002)	(0.007)	(0.001)
CLMTFW	−0.002***	−0.003**	−0.005***	−0.003***	−0.012***	−0.001
	(0.001)	(0.001)	(0.002)	(0.001)	(0.004)	(0.001)
CLMTLENGTH	0.071***	0.079***	0.040***	0.069***	0.289***	0.054***
	(0.002)	(0.003)	(0.005)	(0.003)	(0.012)	(0.002)
SIZE	0.004	0.003	−0.014*	0.003	0.003	0.004
	(0.004)	(0.006)	(0.009)	(0.006)	(0.023)	(0.003)
RD	0.136***	0.161*	0.168	0.140*	0.637**	0.083**
	(0.048)	(0.086)	(0.115)	(0.084)	(0.305)	(0.042)
ROALAG	0.008***	0.012***	0.013**	0.012***	0.045***	0.005**
	(0.002)	(0.004)	(0.006)	(0.004)	(0.015)	(0.002)
AGE	0.027**	0.082***	0.160***	0.094***	0.335***	0.021**
	(0.012)	(0.022)	(0.030)	(0.022)	(0.079)	(0.011)
ICPRBLM	0.006	0.018*	0.022	0.020*	0.063*	0.010**
	(0.006)	(0.010)	(0.014)	(0.010)	(0.037)	(0.005)
C	0.303***	−0.219*	−0.121	−0.125	−3.197***	0.303***
	(0.070)	(0.125)	(0.167)	(0.123)	(0.445)	(0.062)
FirmFE and YearFE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,533	12,533	12,533	12,533	12,533	12,533
R-squared	0.471	0.414	0.391	0.385	0.410	0.457
Adj R-squared	0.355	0.285	0.257	0.250	0.280	0.338
F value	129.5***	73.82***	37.86***	59.24***	74.08***	100.7***

Note: This table reports the results of panel regressions estimating the association between CEO managerial ability (*CEOMA*) and multiple measures of year-to-year repetition in climate-related risk disclosures. Columns 1–4 present dictionary-based similarity metrics (Cosine, Jaccard, Minimum Edit Distance, and Simple Similarity), Column 5 reports the PCA-based composite index (*CLMTREP_INDX*), and Column 6 presents the embedding-based semantic similarity measure (*CLMTREP_EMB*). All models include firm and year fixed effects. Standard errors are clustered at the firm level. ***, *, and * denote significance at the 1%, 5%, and 10% levels, respectively. All variable definitions are provided in Appendix C.

5 | Robustness Checks

To ensure that the positive association between CEO managerial ability and climate-disclosure repetition is not driven by model specification, selection bias, or endogeneity concerns, we conduct a comprehensive set of robustness tests. Because CEO assignment is not random and higher-ability managers may systematically match with firms exhibiting stronger disclosure infrastructures or more stable reporting environments, we employ multiple causal-inference strategies—including PSM and EB—to address observable selection bias and strengthen identification credibility. These procedures complement the fixed-effects

framework by ensuring covariate comparability between treatment and control firms while preserving the economic interpretation of the baseline results. Additionally, we implement alternative definitions of repetition (within-year Risk–MD&A similarity), timing-based identification (lagged-ability measures), and differenced specifications (change-on-change models). Across all tests, the core evidence remains unchanged: Higher-ability CEOs consistently produce more repetitive and structured climate narratives.

5.1 | Robustness Checks for CEO–Firm Selection Bias

A potential concern in our empirical setting is that CEO managerial ability may not be randomly assigned across firms. High-ability CEOs may self-select into firms with more repetitive disclosure templates, stronger reporting environments, or better-established climate strategies. To address these concerns, we employ two complementary approaches used widely in accounting and finance research—PSM and EB. PSM reduces selection bias by matching high-ability and low-ability CEO firms with comparable observable characteristics, whereas EB provides a more flexible reweighting framework that ensures exact covariate balance in the first, second, and third moments without discarding observations.

5.1.1 | PSM

To further mitigate concerns that the baseline results may be influenced by nonrandom sorting of higher-ability CEOs into firms with inherently more repetitive disclosure structures, we conduct PSM. PSM balances observable firm characteristics between firms led by high-ability and low-ability CEOs, thereby improving causal interpretation (Shipman et al. 2017). We define the treatment as firms whose CEO managerial ability falls in the top quartile within each fiscal year (*HIGHCEOMA* = 1), whereas all remaining firms constitute the control group.[10] Propensity scores are estimated using a logistic model that includes all major textual and financial determinants of disclosure style. We apply one-to-one nearest-neighbor matching without replacement to construct a matched sample of comparable treatment and control firms.

Panel A of Table 5 reports the covariate balance results. After matching, all covariates exhibit percent bias well below the 10% threshold; the *t*-tests show no meaningful differences between the treatment and control groups, and the variance ratios for nearly all variables are close to one. These diagnostics indicate strong balance, confirming that matched firms are statistically comparable on observed characteristics.

Panel B of Table 5 presents the post-matching regression results. Re-estimating the baseline fixed-effects specification on the matched sample shows that CEO managerial ability (*CEOMA*) remains positive and statistically significant across all six measures of climate-disclosure repetition, with significance levels at the 5% and 10% thresholds. The magnitudes are consistent with the baseline effects, and the PCA-based composite index reinforces the overall pattern.

5.1.2 | EB

To further address concerns that the relation between CEO managerial ability and climate-disclosure repetition may be influenced by nonrandom CEO–firm matching, we employ entropy balancing as an advanced reweighting procedure. Unlike PSM, which relies on matched subsamples and balances covariates approximately, EB reweights the control group to achieve exact balance in the first moment (mean) of all covariates while retaining the full sample. This approach reduces distributional differences across groups without discarding observations, thereby preserving statistical efficiency and improving comparability between high- and low-ability CEO firms.

Consistent with the PSM specification, we define the treatment as firms led by high-ability CEOs, operationalized as those in the top quartile of managerial ability within each year. The control group includes all remaining firms. EB (Hainmueller 2012) is applied to reweight the control observations such that their covariate distribution matches the treated firms in terms of mean, variance, and skewness across all major textual and financial determinants of disclosure behavior.

Panel A of Table 6 reports the pre-balancing differences. As expected, several covariates—including climate-fog, length, and firm size—show noticeable differences in moments between high-ability and low-ability CEO firms. Panel B shows the post-balancing results: the entire set of covariates exactly matches across moments, confirming successful balancing. The procedure achieves this without discarding any observations, ensuring full statistical efficiency.

Re-estimating the baseline fixed-effects regressions using entropy-balanced weights (Panel C) yields results that closely mirror the original findings. CEO managerial ability remains positively associated with all six measures of climate-disclosure repetition, with significance at conventional levels. The magnitudes for the PCA index and the semantic embedding measure remain particularly strong, reinforcing the idea that high-ability CEOs produce more repetitive and semantically aligned climate narratives.

5.2 | Within-Year Climate Repetition: Risk Factors vs. MD&A

As an additional robustness test, we examine whether CEO managerial ability is associated with climate-disclosure repetition within the same filing, between Item 1A (Risk Factors) and Item 7 (MD&A). This within-year perspective allows us to assess whether high-ability CEOs generate internal alignment in climate narratives across sections that serve different regulatory purposes. Re-estimating the baseline model using the set of Risk–MD&A similarity measures (*CLMTREP_RM*) shows that the coefficient on *CEOMA* remains positive and statistically significant across all specifications (untabulated). Effect sizes are very similar to those in the main analyses. These results indicate that the link between CEO ability and climate-disclosure repetition is not solely a year-to-year phenomenon but also reflects cross-sectional alignment within the same 10-K, reinforcing the

TABLE 5 | Propensity score matching analysis of CEO managerial ability and climate-disclosure repetition.

Panel A. Covariate balance between high-ability and low-ability CEOs after matching

	Mean			Statistics		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Treatment**	**Control**	**%bias**	***t*-test**	***p***	**V(T)/V(C)**
CLMTFOG	14.078	14.041	3	1.17	0.243	1.15*
CLMTNEG	5.713	5.649	0.8	0.32	0.752	0.86*
CLMTPOS	0.878	1.007	−4.7	−1.97	0.049	0.45*
CLMTFW	4.241	4.252	−0.2	−0.07	0.941	0.64*
CLMTLENGTH	5.041	5.000	3	1.19	0.234	0.95
SIZE	7.966	7.952	0.7	0.27	0.791	1.16*
RD	0.028	0.027	1.3	0.51	0.612	0.98
ROALAG	−0.038	−0.052	1.1	0.66	0.512	1.69*
AGE	2.866	2.856	1.6	0.64	0.520	1.02
ICPRBLM	0.165	0.184	−4.7	−1.93	0.053	

Panel B. Post-matching fixed-effects regressions: CEO managerial ability and climate-disclosure repetition

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	***CLMTREP_COS***	***CLMTREP_JAC***	***CLMTREP_MINEDT***	***CLMTREP_SIMP***	***CLMTREP_INDX***	***CLMTREP_EMB***
CEOMA	0.025*	0.062**	0.080*	0.063**	0.221**	0.027*
	(0.013)	(0.030)	(0.042)	(0.030)	(0.107)	(0.014)
C and controls	Yes	Yes	Yes	Yes	Yes	Yes
FirmFE and YearFE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5493	5493	5493	5493	5493	5493
R-squared	0.583	0.525	0.491	0.504	0.525	0.578
Adj R-squared	0.398	0.315	0.266	0.283	0.314	0.390
F value	25.47***	22.44***	14.94***	21.55***	23.22***	24.79***

Note: This table reports the results of the propensity score matching (PSM) analysis. Panel A presents covariate balance statistics after 1:1 nearest-neighbor matching without replacement. Panel B reports the regression of climate-disclosure repetition measures on *CEOMA* using the matched sample. All models include firm and year fixed effects, and standard errors are clustered at the firm level. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. All variable definitions are provided in Appendix C.

interpretation that high-ability CEOs maintain disciplined climate communication.

5.3 | Lagged CEO Ability Tests

To mitigate simultaneity concerns, we repeat the regressions using CEO managerial ability measured at $t-1$, $t-2$, and $t-3$. This timing separation helps ensure the ability score precedes climate-disclosure production. The results (untabulated) show a clear pattern. $CEOMA_{t-1}$ remains positive across all six measures; the cosine metric is significant at the 10% level. $CEOMA_{t-2}$ yields stronger results, with four of the six repetition metrics—including the PCA index and the semantic embedding metric—positive and statistically significant. $CEOMA_{t-3}$ effects weaken and become statistically insignificant, consistent with the expected decay of managerial influence over longer horizons. Taken together, these results confirm that the main findings are not driven by simultaneity. Managerial ability predicts climate-disclosure repetition most strongly within the most recent one to two years, consistent with a persistent (but not permanent) CEO imprint on disclosure style.

5.4 | Change-on-Change Specification

To test whether the main results are driven by persistent firm-level differences, we estimate a change-on-change (Δ–Δ) model relating year-to-year changes in climate-disclosure repetition to changes in CEO ability. This specification removes all time-invariant firm effects. The coefficients on *ΔCEOMA* are small and statistically insignificant across all repetition measures

TABLE 6 | Entropy balancing analysis of CEO managerial ability and climate-disclosure repetition.

Panel A. Pre-balancing distributional differences (first, second, and third moments)

	Treatment (high-ability CEOs)			Control (low-ability CEOs)		
Variables	**Mean**	**Variance**	**Skewness**	**Mean**	**Variance**	**Skewness**
CLMTFOG	14.080	1.733	0.251	14.000	1.373	−0.113
CLMTNEG	5.713	58.140	3.294	5.634	74.930	4.536
CLMTPOS	0.881	4.171	5.732	1.097	11.220	10.300
CLMTFW	4.242	27.530	3.218	4.520	55.540	5.952
CLMTLENGTH	5.041	1.855	−0.309	5.008	1.911	−0.221
SIZE	7.969	5.153	−0.455	7.149	3.586	−0.327
RD	0.028	0.007	5.667	0.025	0.005	6.078
ROALAG	−0.071	2.908	−27.500	−0.058	0.605	−27.070
AGE	2.866	0.327	−1.037	2.773	0.354	−0.830
ICPRBLM	0.167	0.139	1.789	0.214	0.168	1.397

Panel B. Post-balancing distributional equality achieved via entropy balancing

	Treatment (high-ability CEOs)			Control (low-ability CEOs)		
	Mean	**Variance**	**Skewness**	**Mean**	**Variance**	**Skewness**
CLMTFOG	14.080	1.733	0.251	14.080	1.510	0.120
CLMTNEG	5.713	58.140	3.294	5.715	65.180	4.000
CLMTPOS	0.881	4.171	5.732	0.882	5.425	7.442
CLMTFW	4.242	27.530	3.218	4.244	35.520	5.477
CLMTLENGTH	5.041	1.855	−0.309	5.041	1.796	−0.321
SIZE	7.969	5.153	−0.455	7.969	3.543	−0.403
RD	0.028	0.007	5.667	0.028	0.007	6.192
ROALAG	−0.071	2.908	−27.500	−0.072	1.564	−21.870
AGE	2.866	0.327	−1.037	2.866	0.318	−1.030
ICPRBLM	0.167	0.139	1.789	0.167	0.139	1.788

Panel C. Fixed-effects regression results weighted by entropy balancing weights

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variables	***CLMTREP_COS***	***CLMTREP_JAC***	***CLMTREP_MINEDT***	***CLMTREP_SIMP***	***CLMTREP_INDX***	***CLMTREP_EMB***
CEOMA	0.017*	0.047**	0.080***	0.048**	0.179**	0.023**
	(0.010)	(0.021)	(0.029)	(0.021)	(0.075)	(0.010)
C and controls	Yes	Yes	Yes	Yes	Yes	Yes
FirmFE and YearFE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,533	12,533	12,533	12,533	12,533	12,533
R-squared	0.500	0.437	0.406	0.406	0.434	0.489
Adj R-squared	0.390	0.314	0.275	0.275	0.310	0.376
F value	150.5***	49.35***	29.91***	39.84***	47.82***	47.25***

Note: This table reports the entropy balancing robustness analysis used to adjust for nonrandom sorting of high-ability CEOs into firms with systematically different disclosure environments. Entropy balancing constructs weights for the control group (low-ability CEOs) so that the first three moments (mean, variance, and skewness) of the covariate distribution match those of the treatment group (high-ability CEOs). Panel A presents the pre-balancing moment differences, and Panel B shows the post-balancing equality of moments. Panel C reports weighted fixed-effects regressions of climate-disclosure repetition on CEO managerial ability (*CEOMA*). All models include firm and year fixed effects; standard errors are clustered at the firm level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Variable definitions appear in Appendix C.

(untabulated), but importantly, four out of six measures—including the PCA composite index—retain the same positive sign as in the main models. These results are expected: CEO ability is highly persistent, and short-term changes carry little economic meaning. The overall pattern suggests that the main effects reflect a stable managerial imprint on disclosure architecture rather than transient annual fluctuations, consistent with upper echelons and signaling theory predictions.[11]

6 | Conclusion and Remarks

In this paper, we examine whether CEO managerial ability influences the degree of repetition in firms' climate disclosures. This question is important because climate reporting remains highly judgment-intensive, forward-looking, and uncertain (Dobler 2008; Li et al. 2019; Tumewang et al. 2025). Although regulators and investors increasingly scrutinize climate disclosures, the intertemporal structure of these disclosures—and the role of managerial traits in shaping that structure—has been largely overlooked. By focusing on year-to-year repetition, we address an essential but understudied aspect of climate reporting and extend the literature by linking managerial ability to repeated climate disclosures using both traditional textual measures and semantic embedding techniques.

Our empirical analysis shows that CEO managerial ability is positively associated with climate-disclosure repetition across all six similarity measures. High-ability CEOs lead firms that exhibit more repetitive climate disclosures from year to year, and this pattern persists when similarity is measured at both the word level and deeper semantic level using SBERT embeddings. The magnitude of the effects is economically meaningful and robust to the inclusion of detailed textual and financial controls. These results suggest that CEO quality is an important determinant of how firms construct and maintain climate disclosures over time.

Our findings are consistent with upper echelons theory, which posits that executive cognitive capabilities shape organizational outcomes, including disclosure architecture. The evidence suggests that high-ability CEOs imprint disciplined and structured communication frameworks onto climate reporting. Rather than reflecting mechanical boilerplate, repetition appears to represent strategic continuity in climate-risk communication under capable leadership. In this sense, intertemporal repetition can be interpreted as a manifestation of managerial discipline and coherence rather than disclosure inertia.

We also demonstrate that these findings are highly robust. PSM (Shipman et al. 2017) and EB (Hainmueller 2012) confirm that the positive association persists after accounting for CEO–firm sorting on observable characteristics. Within-year Risk–MD&A similarity tests show that the effect is not confined to year-to-year repetition but also appears within the same filing. Lagged-ability specifications mitigate simultaneity concerns, whereas Δ–Δ models confirm that the pattern reflects a stable managerial imprint rather than short-term shocks. Across all tests, the positive relation remains, reinforcing the credibility of our conclusions.

Our findings have several implications for regulators, boards, and investors. As climate disclosures become increasingly central to financial reporting, recognizing the influence of managerial traits on intertemporal disclosure structure may help regulators refine guidance around boilerplate identification and repeated climate language. Boards may also value managerial ability not only for operational efficiency but for the disciplined climate communication it enables. Investors, similarly, can interpret repetition by high-ability CEOs as a signal of structured climate oversight rather than inattention or obfuscation.

Despite its contributions, this study has limitations. Managerial ability is measured using the Demerjian et al. (2012) residual-based score, which—though widely adopted—captures efficiency rather than the full range of cognitive or behavioral attributes. Our climate-text identification relies on lexicon-based extraction and transformer embeddings applied to climate disclosures, both of which entail modeling assumptions. Additionally, our evidence is drawn from US mandatory filings and may not generalize to other reporting environments with different climate-disclosure regimes.

These limitations open avenues for future research. Scholars may examine how other CEO traits—such as risk tolerance, integrity, or environmental expertise—shape the evolution of climate disclosures over time. Future work could also explore how investors react to more repetitive versus more dynamically updated climate disclosures or how cross-country regulatory differences influence managerial imprinting on climate reporting. Further, qualitative analyses or manual coding could complement automated similarity measures to deepen understanding of why certain climate disclosures exhibit persistent repetition.

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Endnotes

[1] Throughout the paper, we examine the degree of climate-related repetition in corporate disclosures. Because repetition is quantified using standard textual-similarity metrics, the terms "repetition" and "similarity" are used interchangeably. In all cases, higher similarity scores indicate greater year-to-year (or within-year in robustness tests) repetition of climate disclosure content.

[2] Although BoardEx and ExecuComp provide detailed information on board structure, audit committee composition, and CEO demographic characteristics, we do not include these variables in the main regression models. Integrating these databases leads to a substantial reduction in sample size, cutting the number of observations by more than half (from 12,573 to 5748 firm-year observations). Such a sharp decline introduces meaningful selection concerns and materially weakens the representativeness of the final sample. Additionally, many governance variables exhibit limited within-firm variation over time or are sparsely populated for smaller firms, reducing their

usefulness as consistent controls in a longitudinal textual-analysis setting. Because our primary objective is to isolate the association between CEO managerial ability and repetition in climate disclosures, we retain only the managerial ability measure, which is thoroughly documented, validated, and consistently available across firms. The CEO ability measure used in this study is explained in detail in Appendix B, following the methodology proposed by Demerjian et al. (2012).

[3] Thanks to the Loughran-McDonald Repository (https://sraf.nd.edu/sec-edgar-data/cleaned-10x-files/) which provide the cleaned and raw 10-X files. The Notre Dame Software Repository for Accounting and Finance (SRAF) is a website designed to provide a central repository for programs and data used in accounting and finance research.

[4] Item 1A is well suited for studying repetition in climate disclosures. Unlike MD&A, which varies substantially in narrative structure, or Notes to the financial statements, which are quantitative and compliance driven, Item 1A provides a relatively stable format across firms and years. This comparability is essential for computing textual similarity across consecutive filings.

[5] The Demerjian dataset (Managerial ability - Peter Demerjian) includes full MA scores. We use the most recent version of the dataset—the 2024 update released on September 2, 2025—which provides MA scores from 1980 to 2024. After filtering, 24,321 observations are removed due to missing MA scores, leaving 223,199 CIK-matched observations available for merging.

[6] PCA results indicate that the first principal component (PC1) has an eigenvalue of 3.402, explaining 85.05% of the total variance across the four measures. All four indicators exhibit high factor loadings on PC1 (0.857–0.981) and low uniqueness values, confirming that they capture a strong common repetition construct. Following standard practice, we retain only PC1 under both the Kaiser criterion (eigenvalue >1) and the scree-plot inflection. Rotating the factor (orthogonal Varimax) yields identical loadings because only one factor is extracted. The composite index *CLMTREP_INDX* is computed using regression scoring coefficients generated in Stata (sim_cosine: 0.256, sim_jaccard: 0.288, sim_minedit: 0.252, sim_simple: 0.286). Higher values of *CLMTREP_INDX* indicate greater overall strategic repetition of climate-related text across years.

[7] Several variables in Table 2 (e.g., *CLMTNEG*, *CLMTFW*, *CLMTFOG*, *SIZE*, and *ROALAG*) exhibit standard deviations above 1 because they are measured either as raw counts (e.g., tone and forward-looking word frequencies), financial ratios, or logarithmic transformations (e.g., total assets). These variables are not bounded between 0 and 1, and therefore, dispersion exceeding 1 reflects natural economic heterogeneity rather than scaling irregularities. In contrast, the climate-disclosure repetition measures (*CLMTREP_**) are similarity indices bounded between 0 and 1 (except for the standardized PCA index), and their standard deviations remain within expected ranges. The variation observed is consistent with large-sample archival datasets and does not affect coefficient interpretation in the regression analyses.

[8] Given the large sample size ($n=12{,}533$), even economically small correlations may achieve statistical significance. Accordingly, statistical significance in Table 3 should not be interpreted as evidence of economic magnitude. The correlation matrix is primarily presented for diagnostic purposes (e.g., multicollinearity assessment). Variance inflation factors (VIFs) in the regression models are well below conventional thresholds, indicating no multicollinearity concerns.

[9] To assess the economic significance of the *CEOMA* effect, we follow the interquartile-standardized effect size approach proposed by Mitton (2024). This method evaluates how much the dependent variable changes (in standard deviation units) when the independent variable increases from its 25th percentile to its 75th percentile. Formally, $E_S^{IQR} = \frac{|b(p_{75} - p_{25})|}{s_y}$, where b is the *CEOMA* coefficient, $p_{75} - p_{25}$ is the IQR of *CEOMA* ($0.036-(-0.101)=0.137$), and s_y is the standard deviation of each repetition measure (reported in Table 2). The standardized effects are approximately: 0.011 SD for *CLMTREP_COS*, 0.020 SD for *CLMTREP_JAC*, 0.029 SD for *CLMTREP_MINEDT*, 0.021 SD for *CLMTREP_SIMP*, 0.022 SD for *CLMTREP_INDX*, and 0.022 SD for *CLMTREP_EMB*. These values indicate that although the effects are modest—as expected in large-sample disclosure studies—they are directionally consistent across all measures and statistically robust. The results therefore reinforce our theoretical prediction that higher managerial ability is associated with more repetitive and disciplined climate disclosures over time.

[10] We also verified the robustness of our treatment definition by (i) classifying *HIGHCEOMA* using an above-median split rather than a top-quartile indicator and (ii) restricting the sample to the extreme groups only, excluding firms with *CEOMA* between the 25th and 75th percentiles. Across all alternative classifications, the results remained qualitatively unchanged, with CEO managerial ability continuing to exhibit a positive and statistically significant association with climate-disclosure repetition.

[11] We also estimated an IV specification using the industry–year average managerial ability (two-digit SIC, excluding the focal firm) as an instrument for *CEOMA*. The IV coefficients remain positive across all six repetition measures, consistent with the baseline results, but are statistically insignificant due to a weak first stage under firm and year fixed effects. These directional results suggest that the main findings are unlikely to be driven by endogenous sorting.

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Appendix A

Climate-Text Extraction Procedure

This study follows the methodological logic of Sautner et al. (2023a) to identify climate-related content within firms' 10-K filings. Although our extraction approach is lexicon-based rather than machine learning driven, it directly incorporates the validated climate bigrams generated through their keyword-discovery procedure. These bigrams allow us to capture nuanced, evolving, and domain-specific climate terminology more effectively than traditional keyword lists.

As highlighted by Sautner et al. (2023a), extracting climate-related language from corporate reports is challenging because climate vocabulary is highly specialized and constantly changing; firms frequently discuss climate topics alongside regulation, technology, and strategy; and many climate terms are ambiguous unless expressed as bigrams, such as "clean energy," "carbon price," or "extreme weather." To overcome these challenges, Sautner et al. (2023a) expand a small set of manually verified initial bigrams into a richer, domain-specific set that reliably distinguishes climate-related sentences from other text. Although we do not replicate their machine-learning procedure, our climate-text extraction directly relies on the final validated set of bigrams they provide. This approach ensures broader coverage of technical climate terminology, more precise identification of climate-related disclosures in regulatory filings, and improved capture of transition, regulatory, and physical climate-related issues.

In this study, we apply the 100 validated climate bigrams as the core of our climate dictionary to extract climate-related sentences exclusively from Item 1A (Risk Factors). Each risk-factor section is programmatically scanned, and any sentence containing at least one bigram is classified as climate-related. These extracted climate sentences form the basis for constructing all textual measures, including climate-disclosure repetition—computed by comparing climate-related content across consecutive years for the same firm. Accordingly, climate disclosure is operationally defined as any sentence in Item 1A that contains one or more of the Sautner et al. bigrams.

Top 100 climate change exposure bigrams (Sautner et al. 2023a) include "renewable energy," "electric vehicle," "clean energy," "new energy," "climate change," "wind power," "wind energy," "energy efficient," "greenhouse gas," "solar energy," "air quality," "clean air," "carbon emission," "gas emission," "extreme weather," "carbon dioxide," "water resource," "autonomous vehicle," "energy environment," "wind resource," "government india," "battery power," "air pollution," "battery electric," "integrate resource," "clean power," "carbon price," "world population," "solar farm," "energy regulatory," "obama administration," "heat power," "carbon tax," "unite nation," "onshore wind," "electric motor," "provide energy," "efficient solution," "global warm," "power generator," "solar pv," "scale solar," "need clean," "coastal area," "energy star," "environmental footprint," "design use," "area energy," "charge station," "clean water," "major design," "vehicle manufacturer," "future energy," "motor control," "combine heat," "electric bus," "distribute power," "environmental benefit," "eco friendly," "electrical vehicle," "carbon neutral," "fast charge," "cell power," "energy team," "cycle gas," "coal gasification," "environmental concern," "carbon intensity," "energy application," "produce electricity," "help state," "environmental standard," "power agreement," "supply energy," "electric hybrid," "source power," "sustainability goal," "energy reform," "plant power," "compare conventional," "gas vehicle," "effort energy," "pass house," "carbon free," "driver assistance," "electrical energy," "solar installation," "snow ice," "renewable natural," "promote use," "farm project," "laser diode," "deliver energy," "protect environment," "sustainable energy," "manage energy," "invest energy," "electric energy," "forest land," and "capacity energy."

Appendix B

Detailed Methodology of CEO Managerial Ability as Proposed by Demerjian et al. (2012)

Demerjian et al. (2012) developed an approach to quantify managerial ability, focusing on a CEO's talent in optimizing resource efficiency to enhance firm profitability. This methodology involves a two-step process:

1. DEA: The first step involves employing DEA to assess corporate efficiency. This analysis uses seven key inputs, differentiated by industry and year, to calculate a firm's output efficiency. The DEA model treats each firm as a unique decision-making unit, formulated as follows:

$$MAX_y \lambda = \frac{SALES}{V1\,COGS + V2\,SG\&A + V3\,PPE + V4\,OPLEASE + V5\,R\&D + V6\,GOODWILL + V7\,OTHERINTAN}$$

Here, λ represents the firm's efficiency score, ranging between 0 and 1, where 1 indicates high efficiency and 0 indicates inefficiency in converting inputs into sales. The inputs include cost of goods sold (*COGS*); selling, general and administrative expenses (SG&A); property, plant, and equipment (*PPE*); operating lease expenses (*OPLEASE*); research and development expenditures (*R&D*); *GOODWILL*; and other intangible assets (*OTHERINTAN*).

2. Tobit regression model: The second step involves regressing the firm efficiency scores obtained from DEA on six firm-specific variables within each industry. The model, incorporating both industry-fixed and year-fixed effects, is as follows:

$$\begin{aligned}\text{Firm Efficiency} = {} & \beta_0 + \beta_1 \ln(\text{Total Assets}) + \beta_2\,\text{Market Share} \\ & + \beta_3\,\text{Positive FCF} + \beta_4 \ln(\text{Age}) \\ & + \beta_5\,\text{Business Segment Concentration} \\ & + \beta_6\,\text{Foreign Currency} + \text{YEAR FE}\end{aligned}$$

In this model, Firm Efficiency is the efficiency score for a fiscal year. The explanatory variables include the natural logarithm of total assets (*ln (Total Assets)*), the firm's market share in its industry (*Market Share*), an indicator for positive free cash flow (*Positive FCF*), the natural logarithm of company age (*ln (Age)*), business segment concentration (measured as the sum of squares of the sales ratio per division to total firm sales), and a binary variable for foreign currency adjustments (*Foreign Currency*).

The residuals from this regression provide a continuous score of managerial ability at the firm level. Consistent with prior CEO-focused research, we attribute this managerial ability score to the CEO in office and refer to it as CEO managerial ability (*CEOMA*) in our empirical analyses.

Appendix C

Variable Definitions

Variable	Definition/operationalization
Dependent variables (*CLMTREP*)	
CLMTREP_COS	Cosine similarity between climate-related text in Item 1A for year t and year $t-1$. Computed using TF–IDF term-frequency vectors: $\text{Sim\_Cosine} = \frac{D_1^{TF} \cdot D_2^{TF}}{\| D_1^{TF} \| \, \| D_2^{TF} \|}$. Higher values indicate greater semantic similarity
CLMTREP_JAC	Jaccard similarity between climate-related bigram sets for years t and $t-1$: $\text{Sim\_Jaccard} = \frac{\| D_1 \cap D_2 \|}{\| D_1 \cup D_2 \|}$
CLMTREP_MINEDT	Normalized Minimum Edit Distance between year t and $t-1$ climate text. Lower values reflect more textual changes; higher values reflect greater repetition
CLMTREP_SIMP	Simple Similarity score: $\text{Sim\_Simple} = \frac{c_{\max} - c}{c_{\max}}$, where $c = \frac{\text{additions} + \text{deletions} + \text{changes}}{(Size(D_1) + Size(D_2))/2}$. Captures document-level textual changes
CLMTREP_INDX	Composite repetition index based on the first principal component (PC1) from PCA using *CLMTREP_COS*, *CLMTREP_JAC*, *CLMTREP_MINEDT*, and *CLMTREP_SIMP*
CLMTREP_EMB	Embedding-based semantic repetition measure, defined as the cosine similarity between the average Sentence-BERT embedding of climate-related Item 1A text in year t and year $t-1$. Captures the *semantic* similarity of climate disclosures over time, allowing for conceptual alignment even when firms rephrase or restyle climate-related narratives
Independent variable	
CEOMA	CEO managerial ability based on Demerjian et al. (2012). Firm efficiency is estimated using data envelopment analysis (DEA), then regressed on firm characteristics; the residual represents managerial ability attributed to the CEO in office. Detailed construction described in Appendix B
Control variables	
CLMTFOG	Fog Index of climate-related sentences: $CLMTFOG = 0.4 \times \left(\frac{\text{words}}{\text{sentences}} + 100 \times \frac{\text{complex words}}{\text{words}} \right)$. Controls for readability and boilerplate complexity
CLMTNEG	Count of negative climate-related words appearing in Item 1A. Captures pessimistic climate sentiment
CLMTPOS	Count of positive climate-related words appearing in Item 1A. Captures optimistic climate sentiment
CLMTFW	Count of forward-looking climate expressions (e.g., *will*, *expect*, *plan*, *strategy*, and *anticipate*). Identified using Python NLP methods based on Li (2010) and Thomas et al. (2024), with Porter stemming applied to unify variants (e.g., *expect*, *expected*, and *expecting*)
CLMTLENGTH	Natural logarithm of the number of climate-related words disclosed in Item 1A in year $t-1$. This variable controls for prior disclosure volume
SIZE	Natural logarithm of total assets. Controls for firm size and reporting capacity
RD	Research and development expenditures scaled by total assets (missing values set to zero). Captures innovation intensity and transition-related exposure
ROALAG	Lagged return on assets. Controls for prior-year profitability and performance-driven disclosure behavior
AGE	Natural logarithm of firm age, measured as years since first appearance in the dataset. Captures maturity and reporting-system stability
ICPRBLM	Indicator variable equal to 1 if the auditor reports any internal control issue—including material weakness, lack of an auditor's report, disclaimer, or delayed filing—and 0 if the internal control report is effective with no material weaknesses
YEARFE	Controls for macroeconomic factors, regulatory changes, and period-specific disclosure trends
FIRMFE	Controls for all time-invariant firm characteristics (industry, reporting culture, environmental exposure, and business model)
Additional variables	
HIGHCEOMA	Indicator variable equal to 1 if the CEO's managerial ability score (*CEOMA*) falls in the top quartile within the same fiscal year and 0 otherwise
CLMTREP_RM	A set of five within-year climate disclosure repetition measures capturing similarity between climate-related text in Item 1A (Risk Factors) and Item 7 (MD&A) of the same 10-K filing. Components (five measures): • *CLMTREP_RM_COS*: Cosine similarity of climate text between Risk Factors and MD&A • *CLMTREP_RM_JAC*: Jaccard similarity based on shared climate-related term • *CLMTREP_RM_MINEDT*: Normalized minimum edit-distance similarity between the two sections. • *CLMTREP_RM_SIMP*: Simple similarity based on normalized additions, deletions, and replacements • *CLMTREP_RM_INDX*: PCA-based composite index of the four word-level within-year similarities