

Climate-Risk Disclosure Capability in Mid-Sized Firms

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Abstract

Climate-related financial disclosure increasingly requires firms to translate environmental uncertainty into governance processes, risk assessments, measurable indicators, and decision-useful corporate reporting. While large corporations generally possess specialized sustainability teams, sophisticated enterprise systems, and greater access to external expertise, mid-sized firms frequently operate with narrower managerial, financial, and analytical resources. Their principal difficulty may therefore lie not simply in willingness to disclose climate information but in developing the organizational capability required to produce reliable, consistent, and strategically meaningful disclosure. This study develops and evaluates a climate-risk disclosure capability framework for mid-sized firms through a transparent simulation-based research design.

The framework integrates governance oversight, climate-risk identification, data infrastructure, metrics and targets, disclosure integration, and scenario-analysis capability. A synthetic dataset representing 240 hypothetical mid-sized firms was constructed to examine how governance maturity, data capability, organizational resources, stakeholder pressure, and scenario-analysis expertise may influence overall disclosure capability. The simulated results indicate that governance oversight and climate-data maturity are the strongest contributors to disclosure capability, while scenario-analysis expertise remains a material but less developed organizational competence.

The capability profile further indicates that firms may develop basic risk recognition substantially earlier than they develop forward-looking scenario analysis or integration of climate considerations into mainstream corporate reporting. These results should not be interpreted as observations of actual firms; rather, they demonstrate theoretically plausible relationships requiring empirical validation..

Keywords: climate-risk disclosure; mid-sized firms; climate governance; sustainability reporting; scenario analysis; environmental accounting; disclosure capability; corporate risk management

1. Introduction

Climate risk has moved progressively from the margins of environmental reporting toward the core of corporate governance, strategic planning, and financial risk assessment. Physical hazards such as flooding, extreme temperatures, water scarcity, and supply-chain disruption can affect productive assets and operating continuity, while transition risks associated with regulation, technology, market expectations, carbon-intensive assets, and changes in consumer behavior may alter costs, revenues,

capital requirements, and competitive positioning. The Task Force on Climate-related Financial Disclosures structured climate-related reporting around governance, strategy, risk management, and metrics and targets, emphasizing information capable of supporting financial decision-making rather than environmental communication alone. This orientation has important consequences for firms because credible climate disclosure presupposes that climate-related risks have first been identified, assigned organizational responsibility, measured, evaluated, and incorporated into decision processes.

The organizational demands associated with such reporting can be particularly significant for mid-sized firms. Compared with large multinational corporations, these firms may have fewer specialized sustainability professionals, less sophisticated environmental information systems, more concentrated managerial responsibilities, and limited resources for scenario analysis or external assurance.

Research examining sustainability management in SMEs has repeatedly emphasized that management tools developed for larger organizations are not automatically transferable to smaller organizations with different resource structures and managerial arrangements. Johnson and Schaltegger's review of sustainability management tools for SMEs identified continuing challenges concerning the accessibility and practical suitability of these instruments, while Bos-Brouwers demonstrated that sustainability activities in smaller firms are closely connected with their particular organizational characteristics and innovation processes. These observations suggest that climate reporting requirements cannot be evaluated solely from the perspective of disclosure standards; organizational capability must also be considered.

A distinction must therefore be made between climate-risk exposure and climate-risk disclosure capability. A company may face substantial physical or transition exposure without possessing the analytical systems necessary to quantify that exposure. Conversely, a company may communicate extensively about climate-related matters while lacking sufficiently developed processes to support the reliability or strategic relevance of its disclosure. Previous evidence has associated stronger governance characteristics with more extensive climate-related disclosure. Ben-Amar and McIlkenny found a positive relationship between board effectiveness and voluntary climate-change disclosure, while Liao, Luo, and Tang reported relationships between governance characteristics and greenhouse-gas disclosure. Rankin, Windsor, and Wahyuni likewise connected voluntary greenhouse-gas reporting with organizational and governance characteristics. The implication is that disclosure quality emerges partly from internal organizational architecture rather than from reporting incentives alone.

The economic relevance of such capability extends beyond environmental accountability. Krueger, Sautner, and Starks showed that institutional investors regarded climate risks as financially consequential and reported that regulatory climate risks had already begun to materialize for portfolio firms. Matsumura, Prakash, and Vera-Muñoz demonstrated that carbon emissions and disclosure can have implications for firm valuation, while Qian and Schaltegger linked changes in carbon disclosure with subsequent changes in carbon performance. These findings reinforce the proposition that climate information becomes economically meaningful when it reflects underlying managerial processes capable of identifying exposure and influencing corporate response.

This study consequently examines Climate-Risk Disclosure Capability in Mid-Sized Firms through a capability-based analytical framework. Because no original company dataset has been

supplied, the research does not claim to report observed behavior among actual firms. Instead, a synthetic dataset is used to demonstrate how governance, information infrastructure, resource availability, stakeholder pressure, and scenario-analysis expertise may interact in a theoretically grounded disclosure-capability model.

The study's novelty lies in treating climate reporting as an organizational capability comprising interconnected processes rather than as a simple count of disclosed items. The resulting framework is intended to support future empirical validation, managerial readiness assessment, and research on proportionate climate-reporting systems for firms that occupy the organizational space between small enterprises and large publicly listed corporations.

2. Objectives of the Study

2.1 To Conceptualize Climate-Risk Disclosure as an Organizational Capability

The first objective is to establish a conceptual distinction between the presence of climate-related statements in corporate reports and the organizational capacity necessary to generate decision-useful climate information. Disclosure capability is conceptualized as a multidimensional competence that combines managerial responsibility, risk identification, data collection, analytical processing, target setting, scenario evaluation, and reporting integration. This approach recognizes that a disclosure can be formally present while remaining analytically weak if the underlying information has not been generated through systematic processes.

Such an interpretation is consistent with the architecture of the TCFD recommendations, which links disclosure to governance, strategy, risk management, and metrics and targets rather than treating climate reporting as an independent communications exercise. The objective therefore extends existing disclosure research by examining the organizational infrastructure from which reporting quality is likely to emerge.

2.2 To Identify the Organizational Drivers of Disclosure Readiness

The second objective is to investigate how governance oversight, climate-data maturity, organizational resources, stakeholder pressure, and scenario-analysis expertise may contribute to overall climate-risk disclosure capability. Corporate climate disclosure studies have previously demonstrated that governance arrangements and organizational characteristics can influence whether companies report climate-related information and the quality of such reporting.

For mid-sized firms, however, capability may depend on whether governance expectations can be translated into operational processes despite resource limitations. The study therefore considers whether board-level responsibility by itself is sufficient or whether governance effectiveness depends on complementary investments in information systems, expertise, measurement processes, and management routines.

2.3 To Develop a Practical Capability Profile for Mid-Sized Firms

The third objective is to construct an interpretable capability profile showing where climate-reporting readiness may develop unevenly. Firms may, for example, become competent at identifying climate

hazards before becoming capable of modeling alternative climate scenarios, quantifying financial effects, or embedding climate information within mainstream management reporting.

The resulting capability profile is intended as a diagnostic model rather than a compliance score. It can guide future researchers when designing empirical instruments and assist managers in distinguishing foundational capability gaps from weaknesses that concern presentation alone. The analysis consequently emphasizes organizational development pathways rather than an assumption that all elements of sophisticated climate disclosure can be implemented simultaneously.

3. Review of Literature

3.1 Climate Disclosure, Governance, and Corporate Accountability

Early corporate greenhouse-gas research demonstrated that disclosure behavior is influenced by a combination of organizational and institutional characteristics. Rankin, Windsor, and Wahyuni examined voluntary greenhouse-gas reporting within the Australian governance environment and found that internal organizational systems and corporate governance characteristics were relevant to reporting decisions. Choi, Lee, and Psaros subsequently analyzed Australian corporate carbon disclosure and contributed evidence that firm-specific characteristics influence the extent of carbon-related information communicated by corporations. These studies established an important foundation by showing that environmental disclosure is not independent of internal organizational conditions.

Governance research further strengthened this argument. Ben-Amar and McIlkenny reported a positive association between board effectiveness and both participation in voluntary climate disclosure and disclosure quality. Liao, Luo, and Tang found that gender diversity, board independence, and the presence of environmental committees were associated with greenhouse-gas disclosure among large UK corporations. Liesen, Hoepner, Patten, and Figge additionally demonstrated the relevance of stakeholder pressure to corporate GHG reporting in Europe. Collectively, these findings indicate that credible climate disclosure is shaped by governance responsibility, organizational structures, and external accountability pressures.

3.2 Climate Information, Performance, and Financial Decision Usefulness

The development of climate disclosure cannot be understood solely as a response to social legitimacy. Carbon-related information can influence assessments of corporate risk, performance, and value. Matsumura, Prakash, and Vera-Muñoz examined firm-value effects associated with carbon emissions and carbon disclosure, providing evidence that capital-market implications can arise from environmental performance and transparency. This reinforces the financial-reporting relevance of measurement capability because unreliable environmental information may weaken the usefulness of disclosure for investors.

Qian and Schaltegger advanced the discussion by examining disclosure and carbon performance from legitimacy and management perspectives. Their longitudinal analysis supported a relationship between changes in disclosure and subsequent changes in carbon performance, suggesting that reporting can become part of organizational management rather than simply an external communication mechanism. Krueger, Sautner, and Starks similarly demonstrated that institutional investors considered climate risk financially material and used management and engagement strategies to address it. These

studies support a capability-based interpretation: the value of climate disclosure increases when reporting systems are connected with genuine risk-management processes.

3.3 Resource Constraints and the Mid-Sized Firm Capability Gap

The sustainability-management literature on smaller organizations provides a different but complementary perspective. Bos-Brouwers found that sustainability and innovation in SMEs develop through organizational practices shaped by the distinctive characteristics of smaller firms. Johnson and Schaltegger's review of two decades of sustainability-management tools concluded that the relevance and implementation of sophisticated management instruments in SMEs remain important concerns. Such findings matter for climate reporting because many contemporary disclosure expectations presuppose advanced data systems, cross-functional coordination, long-term modeling, and specialized expertise.

A significant research gap therefore exists between studies examining sophisticated climate disclosure among large corporations and research addressing sustainability-management capability in smaller organizations. Caby, Ziane, and Lamarque demonstrated that the commitment to and quality of voluntary climate disclosure can be influenced by organizational and contextual determinants, although their empirical setting concerned the banking industry rather than mid-sized nonfinancial firms. The present study bridges these streams by theorizing climate disclosure as a capability that must be developed under resource constraints. Rather than asking merely whether a mid-sized firm reports climate information, the study asks whether the organization possesses the systems necessary to identify, measure, analyze, govern, and communicate climate-related risk.

4. Research Methodology

4.1 Research Design and Simulation Logic

The study employs a simulation-based quantitative research design. This classification is essential because the analysis does not use confidential corporate records, administered questionnaire responses, or observations collected from real firms. A synthetic dataset comprising 240 hypothetical mid-sized firms was constructed solely to evaluate the logical behavior of the proposed disclosure-capability framework. The synthetic sample represents four broad sectors—manufacturing, business services, logistics, and consumer goods—to introduce realistic variation in climate exposure and organizational characteristics without attributing results to identifiable organizations.

Variables were bounded on normalized scales and generated with controlled variation intended to reflect theoretically plausible relationships. Governance oversight, climate-data maturity, organizational resource capacity, stakeholder pressure, and scenario-analysis expertise were treated as explanatory constructs. Overall climate-risk disclosure capability constituted the principal outcome measure. The synthetic design allows the conceptual model to be examined without presenting invented data as empirical evidence. Consequently, all statistical results reported below demonstrate model behavior and should be validated subsequently using primary or verified secondary data.

4.2 Construction of the Climate-Risk Disclosure Capability Index

The capability index was organized around six dimensions: governance oversight, climate-risk identification, data infrastructure, metrics and targets, disclosure integration, and scenario-analysis

capability. The architecture is informed by the TCFD emphasis on governance, strategy, risk management, and metrics and targets. The European Commission's 2019 climate-reporting guidance similarly incorporated climate-related disclosure principles derived substantially from the TCFD architecture.

Each dimension was conceptualized on a 0–100 capability scale. A low score represents fragmented, informal, or largely reactive arrangements, whereas a high score represents documented responsibilities, systematic data processes, repeatable analytical procedures, and integration with management reporting. The purpose of the index is not to certify compliance with any reporting standard. Instead, it measures the organizational readiness required to support credible disclosure.

Table 1: Operationalization of Climate-Risk Disclosure Capability

Construct	Operational Meaning	Illustrative Indicators	Scale
Governance Oversight	Formal responsibility for climate-related risk	Board or senior management responsibility, review frequency, accountability	0–100
Climate-Risk Identification	Ability to recognize material physical and transition exposures	Risk registers, supply-chain exposure, regulatory and market-risk assessment	0–100
Data Infrastructure	Capacity to obtain and control climate-related information	Data ownership, documentation, consistency, internal controls, system integration	0–100
Metrics and Targets	Ability to quantify performance and establish measurable objectives	Emissions metrics, energy indicators, targets, monitoring processes	0–100
Disclosure Integration	Integration of climate information into mainstream reporting	Links with financial planning, risk reporting, management commentary	0–100
Scenario Analysis	Capacity for forward-looking assessment under alternative conditions	Scenario selection, assumptions, financial sensitivity, strategic response	0–100

4.3 Proposed Instrument and Statistical Procedure

A future empirical validation of the framework could use a concise managerial questionnaire supported by documentary verification. For the simulation, descriptive statistics were first used to identify capability strengths and deficiencies. Ordinary least-squares regression was then employed to estimate the relative association of governance oversight, data maturity, resource capacity, stakeholder pressure, and scenario-analysis expertise with the overall capability score. Standardized coefficients are reported

to permit comparison across variables. Since the dataset is synthetic, statistical significance indicates consistency within the simulated data-generating process rather than evidence about a population of real firms.

No human participants, personal information, confidential company information, or experimentally collected observations were used. Consequently, the simulation itself did not require human-subject data collection. Any later empirical application should obtain appropriate institutional or ethical approval where required, secure informed participation, disclose data-management procedures, and distinguish reported observations from modeled estimates.

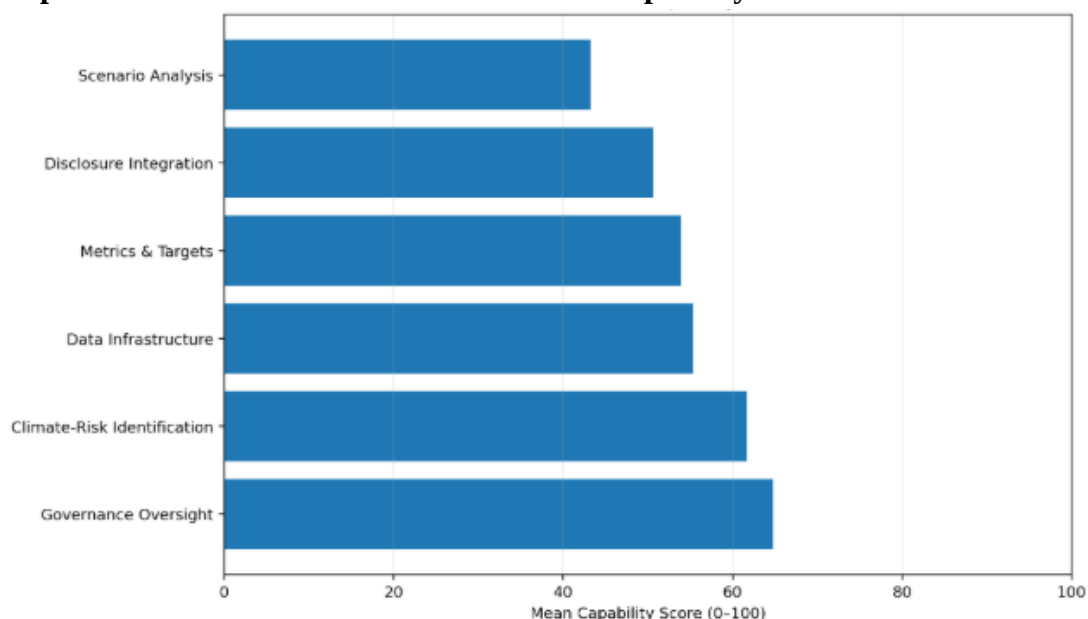
5. Analysis

5.1 Overall Disclosure-Capability Pattern

The simulated climate-risk disclosure capability index produced a mean overall score of approximately 54.5 out of 100, suggesting an intermediate organizational capability profile rather than either complete absence of readiness or fully institutionalized climate reporting. The most developed dimension in the illustrative profile was governance oversight, followed by climate-risk identification. This ordering is theoretically plausible because assigning senior responsibility and introducing risks into management discussions generally requires less analytical infrastructure than developing detailed scenario models or integrated climate-financial datasets.

The weaker dimensions were disclosure integration and scenario analysis. This distinction is important. A firm may acknowledge climate change, assign responsibility, and maintain selected environmental indicators while still being unable to translate climate variables into assumptions about revenue, operating cost, capital expenditure, supply disruption, asset impairment, insurance availability, or long-term strategic resilience. The simulation therefore illustrates a potential progression from recognition, through measurement, toward financial and strategic integration.

Graph 1: Simulated Climate-Risk Disclosure Capability Profile of Mid-Sized Firms



Interpretation: Governance structures appear comparatively more mature than forward-looking analytical capability. The 21.6-point difference between governance oversight and scenario analysis illustrates how formal responsibility can develop more quickly than the technical ability to model uncertain climate outcomes.

Key Finding: Climate-reporting readiness should not be inferred from board responsibility alone. Governance needs complementary analytical and data capabilities before it can generate sophisticated forward-looking disclosure.

5.2 Drivers of Climate-Risk Disclosure Capability

Regression analysis indicates that governance oversight and climate-data maturity are the two strongest simulated predictors of disclosure capability. Governance produced a standardized coefficient of $\beta = 0.324$, while data maturity produced $\beta = 0.319$. Both relationships were statistically strong within the synthetic dataset. This pattern suggests that disclosure capability requires both managerial authority and information availability. Strong governance without reliable data may produce policy statements with limited analytical content, whereas sophisticated datasets without clear accountability may remain disconnected from strategic decision-making.

Scenario-analysis expertise also displayed a meaningful association with capability, followed by organizational resources and stakeholder pressure. Stakeholder pressure produced the smallest standardized coefficient among the variables included in the model. The implication is not that external pressure is unimportant; earlier research demonstrates its relevance to corporate greenhouse-gas reporting. Rather, the simulation suggests that external demand is likely to generate higher-quality reporting only when firms possess sufficient internal capability to respond.

Table 2: Simulated Regression Results for Overall Climate-Risk Disclosure Capability

Explanatory Variable	Standardized β	p-value	Simulated Interpretation
Governance Oversight	0.324	<0.001	Strong positive capability driver
Climate-Data Maturity	0.319	<0.001	Strong positive capability driver
Scenario-Analysis Expertise	0.164	0.003	Meaningful analytical capability effect
Organizational Resource Capacity	0.127	0.015	Moderate enabling effect
Stakeholder Pressure	0.105	0.046	Positive but comparatively weaker direct effect
Model R^2	0.379	—	Model explains 37.9% of simulated variation
Adjusted R^2	0.366	—	Moderate explanatory performance

Sample: 240 synthetic mid-sized firms. Source: Authors' simulation. Important Note: Coefficients and significance values are generated from synthetic observations and must not be interpreted as estimates for an actual corporate population.

The model's R^2 of 0.379 also implies that a substantial proportion of simulated capability variation remains unexplained. In real organizational environments, additional determinants could include executive sustainability competence, industry carbon intensity, ownership structure, lender requirements, customer concentration, supply-chain exposure, regulatory expectations, assurance arrangements, information-technology sophistication, and previous experience with sustainability reporting. Future empirical analysis should therefore extend rather than mechanically reproduce the present model.

5.3 Capability Maturity and the Disclosure Implementation Gap

The results support the concept of a disclosure implementation gap. This gap occurs when stakeholder expectations or corporate commitments develop more rapidly than the organizational mechanisms needed to generate robust evidence. A company can publicly recognize climate change but still lack documented risk taxonomies, controlled datasets, quantitative targets, financial sensitivity analysis, or procedures for reconciling sustainability information with mainstream corporate reporting.

The literature provides reasons to take such a gap seriously. Ben-Amar and McIlkenny connected effective governance with better voluntary climate disclosure, while Caby, Ziane, and Lamarque showed that the quality of climate disclosure is influenced by identifiable organizational determinants. Johnson and Schaltegger's SME research also demonstrates why sophisticated sustainability-management tools cannot simply be assumed to function identically across organizations of different sizes. The simulated evidence consequently suggests that mid-sized firms require staged capability development rather than immediate replication of complex systems designed for multinational corporations.

6. Discussion

6.1 Governance Must Be Converted Into Operational Capability

The first major implication is that governance responsibility represents a necessary but incomplete condition for credible climate disclosure. Formal oversight can improve organizational attention, allocate responsibility, and establish expectations for risk monitoring. This interpretation corresponds with Ben-Amar and McIlkenny's empirical evidence connecting board effectiveness with climate disclosure and with Liao, Luo, and Tang's findings regarding governance structures and greenhouse-gas transparency. Nevertheless, a board cannot disclose information that the underlying organization cannot reliably generate.

Mid-sized firms should therefore connect governance mandates with identifiable data owners, reporting schedules, internal-control procedures, risk registers, escalation mechanisms, and management decision points. Climate governance becomes substantively meaningful when questions raised by boards can be answered through repeatable evidence rather than occasional qualitative narratives. From this perspective, the relevant managerial question is not whether the firm has a climate policy, but whether responsibility, information, analysis, and action are linked through an operational system.

6.2 Data Infrastructure Is the Bridge Between Risk Awareness and Reporting Quality

The simulation positions climate-data maturity almost equal to governance oversight in explanatory importance. This finding reflects the practical reality that quantitative disclosure depends on identifiable data sources, consistent boundaries, measurement methodologies, documented assumptions, and internal review. When information is dispersed across utility invoices, production systems, supplier communications, spreadsheets, procurement records, and facility-management platforms, the reporting process can become labor intensive and difficult to reproduce.

For mid-sized firms, data capability does not necessarily require immediate investment in complex enterprise sustainability platforms. A proportionate architecture can begin with defined data ownership, controlled calculation files, reconciliations with operational or financial records, documented estimation methods, and a consistent reporting calendar. The objective should be progressive reliability. The TCFD framework emphasizes decision-useful disclosure across governance, strategy, risk management, and metrics and targets; therefore, data systems should evolve toward supporting management decisions rather than producing isolated environmental statistics.

6.3 Scenario Analysis Represents the Next Capability Frontier

Scenario analysis received the lowest average capability score in the simulated profile. This is significant because forward-looking assessment is among the areas where traditional historical reporting processes are least sufficient. Scenario analysis requires firms to consider uncertain pathways involving regulation, technology, physical hazards, demand patterns, energy prices, supply-chain changes, and strategic adaptation. The TCFD provided dedicated technical guidance because scenario analysis involves different analytical challenges from conventional retrospective reporting.

Mid-sized organizations may therefore benefit from proportionate scenario methods rather than attempting to reproduce the modeling complexity of major financial institutions or multinational corporations. Initial exercises might use a limited number of internally coherent scenarios, identify the most material business assumptions, evaluate directional financial sensitivity, document management responses, and progressively improve quantitative sophistication. The objective should not be false precision. It should be to demonstrate that management has considered how materially different climate-related conditions could affect strategy, cash flows, operations, assets, financing, and organizational resilience.

7. Conclusion

This study develops a capability-oriented interpretation of climate-risk disclosure for mid-sized firms. The central proposition is that meaningful disclosure is an output of organizational processes rather than an isolated reporting activity. Governance oversight, risk identification, data infrastructure, metrics and targets, scenario analysis, and integration into mainstream reporting together determine whether a company can produce climate information that is consistent, explainable, and useful for managerial and stakeholder decision-making.

The simulation suggests that governance and climate-data maturity may be especially influential in shaping disclosure capability. It also demonstrates a plausible maturity imbalance in which firms become capable of recognizing climate risks and assigning responsibility before they acquire

sophisticated forward-looking analytical capability. Scenario analysis consequently emerges as a likely development frontier for mid-sized organizations. The results are intentionally illustrative and cannot be generalized to real firms because the dataset is synthetic.

From a managerial perspective, climate-disclosure development should therefore be treated as a staged capability-building process. Firms can begin by establishing governance responsibility and identifying material exposures, then improve data ownership and internal controls, introduce measurable indicators and targets, develop proportionate scenario analysis, and finally strengthen integration between climate information, strategic planning, enterprise risk management, and financial reporting. Such sequencing can help avoid a situation in which disclosure commitments advance substantially faster than the systems available to support them.

The principal limitation of the study is also its methodological safeguard: it does not claim empirical validation from actual corporate observations. Future research should administer the proposed five-item instrument alongside detailed capability measures to real mid-sized firms across sectors and jurisdictions. Subsequent studies could test industry differences, ownership effects, regulatory exposure, external assurance, financing relationships, and the influence of digital reporting systems. Longitudinal research would be especially valuable for determining whether improved disclosure capability leads not only to better reporting but also to stronger climate-risk management, more resilient strategic planning, and measurable improvement in environmental and financial performance.

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