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**THE ROLE OF BUSINESS ANALYTICS IN ESG-ORIENTED
BRAND COMMUNICATION: A SYSTEMATIC REVIEW OF
DATA-DRIVEN STRATEGIES**

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Abstract

This study addresses the persistent gap between what firms say about sustainability and what stakeholders trust, by examining how business analytics (BA) capabilities shape ESG-oriented brand communication effectiveness. Drawing on a systematic review of 112 peer-reviewed papers to ground constructs and measures, and a quantitative, cross-sectional, case-based design across cloud and enterprise platform contexts, we analyze firm-level cases (n = 238) sampled from multiple industries and roles. Key variables include BA capability (data governance, skills, tooling, integration, experimentation), advanced analytics use (predictive modeling, causal testing, automation), message transparency/quality (specificity, balance, verifiability, clarity), ESG performance, and ESG communication effectiveness (clarity, credibility, trust impact, engagement intent). The preregistered analysis plan comprises scale reliability checks, descriptives, zero-order correlations, and hierarchical OLS with robust errors, including moderation tests for BA capability × ESG performance and robustness specifications (fixed effects, clustered SEs, rank-based models). Headline findings indicate that BA capability is positively associated with communication effectiveness, advanced analytics adds incremental explanatory power, transparency/quality shows a strong, independent association, and the BA payoff is steeper when underlying ESG performance is higher, implying analytics amplifies credible performance rather than substituting for it. Managerially, results recommend sequencing investments from governed data pipelines and experiment infrastructure to a transparency checklist and assurance linkages, so that what is measured, modeled, and messaged remains verifiable across channels and markets. Collectively, the evidence positions analytics-enabled transparency as an institutional capability that reliably improves the clarity, credibility, and stakeholder impact of ESG communication in cloud and enterprise settings.

Keywords

ESG communication; Business analytics capability; Transparency; Advanced analytics; Cloud and enterprise cases; Cross-sectional multi-case; Moderation; Brand trust; Assurance; Data governance;

INTRODUCTION

Environmental, Social, and Governance (ESG) refers to a multidimensional framework for evaluating organizational conduct and performance across environmental stewardship, social responsibility, and governance practices (Kotsantonis et al., 2016). In international markets where stakeholders span transnational investors, regulators, consumers, supply-chain partners, and civil society organizations, ESG has become a shared language for articulating non-financial value, material risk, and enterprise resilience (Kotsantonis et al., 2016). Corporate communication, in turn, denotes strategically planned, data-informed messaging that conveys firm identity, purpose, and actions to stakeholders across owned, paid, and earned media (Du et al., 2010). When firms communicate ESG, they are not simply disclosing facts; they are constructing brand meaning in ways that can influence legitimacy judgments, reduce information asymmetries, and shape brand equity outcomes globally (Donaldson & Preston, 1995; Lyon & Montgomery, 2015). Business analytics (BA) comprises technology-enabled, model-supported methods to ingest, integrate, and analyze data for improved decisions (Wedel & Kannan, 2016). In brand communication, BA provides measurement architectures ranging from descriptive dashboards to predictive and prescriptive models that quantify stakeholder sentiment, message reach and relevance, and behavior change across cultures and platforms. Integrated across markets, these elements form a convergent domain: ESG-oriented brand communication underpinned by business analytics, where the credibility of sustainability claims and the precision of message targeting, sequencing, and evaluation interact to influence brand trust, loyalty, and market performance. Within this domain, the international salience of ESG disclosures whether stand-alone or integrated hinges on both substantive performance and the perceived quality of communication (Michelon et al., 2015).

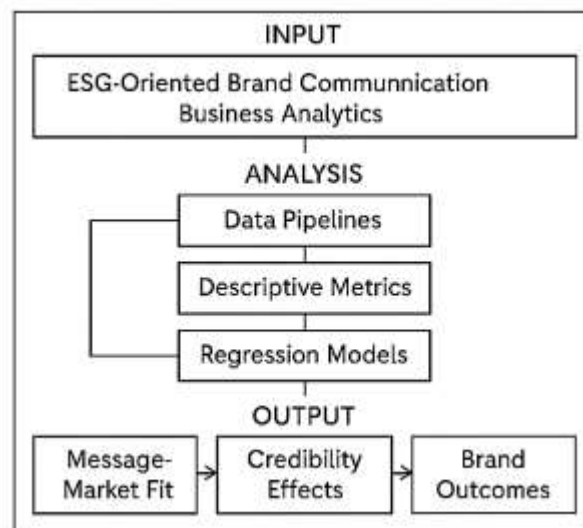
Figure 1: Key Dimensions of ESG: Environmental, Social, and Governance Factors



Global diffusion of ESG has intensified scrutiny of how firms communicate sustainability performance across borders and regulatory regimes. Empirical evidence indicates that the assurance of sustainability information can attenuate information asymmetry, improve analyst forecast properties, and elevate professional investors' weighting of non-financial data (Tarek, 2022; Simnett et al., 2009). At the same time, research on disclosure quality shows that formal adherence to guidance (e.g., GRI) or the production of separate reports is not sufficient to guarantee completeness or credibility; reporting can be symbolic, uneven, and vulnerable to obfuscation (Danish & Zafor, 2022; Michelon et al., 2015). On social media, where international audiences co-create visibility and accountability, organizations often sustain low interactivity levels in CSR/ESG dialogues limiting learning loops and public engagement (Etter, 2013). The literature on "greenwash" underscores that messages perceived as decoupled from performance can trigger skepticism, damaging legitimacy and brand value (Lyon & Montgomery, 2015;

Maines & McDaniel, 2000; Kamrul & Omar, 2022). Against this backdrop, the international significance of ESG-oriented brand communication turns on credibility signals (e.g., third-party assurance), transparent narrative strategies (including acknowledgement of negative aspects), and measurable outcomes that travel across markets, languages, and regulatory environments (Hahn & Lülfs, 2014; Lyon & Montgomery, 2015). Taken together, these studies motivate a data-driven approach to ESG communication that integrates BA pipelines to diagnose message-market fit globally, quantify credibility effects, and relate communication choices to brand outcomes (Danish & Kamrul, 2022). Theoretically, ESG-oriented brand communication resides at the intersection of stakeholder theory, legitimacy theory, signaling theory, and the resource-based view (RBV). Stakeholder theory proposes that firms create value through relationships with multiple stakeholder groups whose interests carry instrumental and normative weight in governance and communication (Donaldson & Preston, 1995; Jahid, 2022a). Legitimacy theory highlights that organizations seek congruence between social values and corporate actions; ESG communication serves as a vehicle to maintain or repair legitimacy in global arenas (Kamrul & Tarek, 2022; Mubashir & Abdul, 2022). Signaling theory formalizes how credible signals costly to mimic reduce information asymmetries; in ESG contexts, independent assurance, specific measurable targets, and transparent treatment of negative outcomes operate as signals of quality (Muhammad & Kamrul, 2022; Reduanul & Shoeb, 2022). The RBV frames business analytics capability (data, technology, skills, governance) as a distinctive, hard-to-imitate resource bundle that can yield sustained advantage by enabling superior sensing, seizing, and transforming of market information, including ESG-related stakeholder data (Akter et al., 2016; Barney, 1991; Arifur & Noor, 2022). These perspectives jointly motivate a quantitative, cross-sectional, multi-case investigation of how firms use data-driven strategies to design and evaluate ESG brand communication. By testing linkages across descriptive metrics (exposure, engagement), correlational structures (e.g., sentiment-trust associations), and regression models that connect analytics use, assurance, and message design to brand outcomes, the study operationalizes these theories in a manner amenable to managerial decision-making and scholarly replication.

Figure 2: Conceptual Framework of ESG Oriented Brand Communication



Business analytics research provides an established foundation for measuring marketing outcomes and connecting analytical deployment to performance (Jahid, 2022a). Studies show that marketing/analytics deployment is associated with favorable, and often sustained, performance effects contingent on top-management support, culture, relevant data, IT infrastructure, and skills (Jahid, 2022b). Methodologically, advances in data-rich marketing analytics allow firms to optimize cross-channel communication, personalize content, and evaluate privacy-sensitive trade-offs in global settings (Tucker, 2014; Wedel & Kannan, 2016). From a capability perspective, big data analytics capability (BDAC) predicts firm performance and can be measured using validated constructs

spanning data quality, technological flexibility, analytical talent, and decision process integration (Keller, 1993; Hasan & Uddin, 2022). For ESG communication, these analytics logics translate into precise operationalizations: *what* to disclose (topic modeling of material issues), *how* to frame (linguistic specificity, acknowledgement of trade-offs), *where* to distribute (channel mix optimized to audience segments), and *how* to evaluate (A/B tests, lift analyses). Moreover, controlled online experiments provide rigorous tools to infer causal effects of message variants on engagement and conversion, complementing observational correlation/regression in cross-sectional datasets (Arifur & Noor, 2022; Moroney et al., 2012). This research mobilizes those analytical traditions specifically for ESG-oriented brand communication, anchoring constructs (e.g., assurance presence, negativity acknowledgement, interactivity) in prior literature and testing their associations with brand-relevant outcomes (e.g., brand attitude, trust) using Likert-type measures and model-based inference.

The ESG reporting and communication literature adds essential nuance for construct specification and hypothesis development (Noor & Momena, 2022). Research on disclosure quality differentiates between substantive and symbolic practices, showing that stand-alone reports may dilute information and that conformance to guidance or even generic assurance does not automatically raise quality (Martínez-Ferrero & García-Sánchez, 2017; Petrescu et al., 2020). Studies of sustainability assurance reveal that assurance is more likely when firms seek credibility and reputation benefits, with mixed evidence on whether the assurer must be a traditional audit firm (Hasan et al., 2022; Moroney et al., 2012). Experiments with professional investors demonstrate that assurance increases the weight investors assign to sustainability information, elevating sustainability performance evaluations and investment judgments; however, the effect can vary by reporting format (integrated vs. separate) (Rezaul & Mesbaul, 2022; Rust et al., 2002). Communication research identifies low interactivity on social media CSR streams, constraining dialogic engagement; this, combined with the prevalence of greenwashing, foregrounds the importance of transparent, balanced narratives that acknowledge negative aspects and specify targets (Etter, 2013; Hasan, 2022). Together, these findings justify operational indicators in this study such as assurance presence/level, specificity and balance of disclosure, interactivity metrics, and message-performance alignment, and they motivate regression models that test main effects (e.g., analytics use → brand outcomes) and moderation (e.g., assurance × interactivity).

From a brand perspective, ESG communication can influence customer attitudes, trust, and market value through well-specified pathways. Foundational work in marketing shows that brand knowledge structures awareness, associations, perceived quality mediate communication effects on brand equity (Danish, 2023; Hasan et al., 2023). In CSR/ESG contexts, communication enhances supportive stakeholder behaviors (e.g., purchase, advocacy) when messages are credible, specific, and aligned with salient stakeholder values (Du et al., 2010). Capital market research also links credible CSR/ESG disclosure to improved analyst information environments (e.g., lower dispersion), which can reinforce brand-level outcomes by stabilizing expectations among investors and other boundary stakeholders (Hossain et al., 2023; Rahaman & Ashraf, 2023). Conversely, evidence on greenwash cautions that overly positive or vague claims invite skepticism and reputational penalties particularly in transnational settings with vigilant media and activist oversight (Lyon & Montgomery, 2015; Uddin & Ashraf, 2023; Momena & Hasan, 2023). These converging streams justify the present study's measurement strategy: Likert-scale constructs for perceived ESG communication credibility and clarity; descriptive indicators for message reach and engagement (Mubashir & Jahid, 2023; Sanjai et al., 2023); correlation matrices for diagnostic patterning; and regression models that estimate how analytics use, assurance, and interactivity co-predict brand trust and attitude across cases. In short, analytics-enabled, credibility-attentive ESG communication is not merely an ethical exercise but a measurable determinant of brand-relevant outcomes in international markets.

This quantitative, cross-sectional, multi-case design builds on validated scales and modeling approaches common to marketing analytics and accounting/ESG assurance research. Following the analytics literature, we conceptualize analytics use as a multi-item construct spanning data breadth, modeling depth, experimentation, and decision integration (Reimsbach et al., 2017; Rust et al., 2002). Consistent with disclosure-quality studies, communication quality incorporates specificity, balance

(including acknowledgement of negative aspects), and forward-looking target setting (Hahn & Lülfs, 2014). In line with assurance research, assurance is coded by presence and level; where available, provider type is noted (Danish & Zafor, 2024; Simnett et al., 2009; Akter et al., 2023). The model structure descriptive statistics, correlations, and OLS/logit regressions maps onto prior empirical strategies that link analytical deployment to performance (Germann et al., 2013), experimental findings on ESG information processing (Reimsbach et al., 2017), and credibility effects in voluntary disclosure (Etter, 2013; Jahid, 2024). Likert 5-point items assess perceived credibility, clarity, and brand trust; robustness checks include alternative operationalizations (e.g., engagement rate normalizations) and sensitivity analyses for case heterogeneity. This integrated approach enables a systematic review and empirical test of data-driven strategies for ESG-oriented brand communication, grounded in international scholarship across marketing, accounting, management, and information systems. The objective of this study is to provide a rigorous, data-driven examination of how business analytics informs ESG-oriented brand communication across organizational contexts, articulated through a set of concrete, testable aims that align with the quantitative, cross-sectional, multi-case design. Specifically, the study aims (i) to define and operationalize a taxonomy of data-driven strategies used in ESG communication such as descriptive dashboards, social listening, A/B message testing, and predictive modeling and to link these strategies to measurable facets of message design and delivery; (ii) to develop and refine multi-item Likert-scale measures for business analytics capability, message transparency and quality, ESG communication effectiveness, and advanced analytics use, ensuring conceptual coverage and practical clarity; (iii) to establish the reliability and validity of all measurement instruments through internal consistency diagnostics, item analysis, and, where appropriate, exploratory or confirmatory factor procedures; (iv) to describe the study population and cases with precision, documenting industry, size, geography, and role characteristics, and to report descriptive statistics that profile the constructs' central tendencies and distributions; (v) to quantify bivariate associations among the focal variables through a structured correlation matrix, enabling initial pattern recognition and informing model specification; (vi) to estimate hierarchical regression models that test the main effect of business analytics capability on ESG communication effectiveness, the incremental contribution of advanced analytics strategies beyond foundational analytics, the moderating role of organizational ESG performance, and the association between message transparency/quality and communication effectiveness; (vii) to probe model robustness via heteroskedasticity-robust inferences, multicollinearity checks, influential-case diagnostics, and alternative specifications, including industry fixed effects and rank-based estimators; (viii) to conduct sensitivity analyses that examine whether results hold across salient subgroups, such as industry categories and firm size strata; (ix) to implement procedural and statistical checks that reduce and assess potential common-method variance; and (x) to present a structured set of case-level and aggregate-level findings that are reproducible, interpretable, and suitable for methodological replication. Collectively, these objectives concentrate the inquiry on measurement quality, statistical clarity, and analytic traceability, ensuring that each empirical step from construct operationalization to model estimation directly addresses the central question of how business analytics shapes the design and effectiveness of ESG-oriented brand communication across firms.

LITERATURE REVIEW

The literature on ESG-oriented brand communication and business analytics spans several intersecting domains that, together, clarify what is communicated, how it is designed and delivered, and why it succeeds or fails across organizational and market contexts. Foundational work in corporate responsibility and sustainability reporting examines disclosure scope, verifiability, balance between positive and negative information, and the role of assurance in shaping stakeholder credibility judgments. In parallel, branding and marketing communication research explains how message attributes such as specificity, transparency, and narrative framing translate into stakeholder awareness, trust, and supportive intentions, with special attention to multi-channel dynamics and the social, cultural, and institutional settings that condition reception. A third stream, business analytics and data-driven decision-making, contributes constructs and tools for sensing stakeholder needs (e.g., social listening and topic modeling), shaping content (e.g., A/B testing and personalization), and evaluating outcomes (e.g., conversion or engagement lift), supported by organizational capabilities in data

governance, analytical talent, and cross-functional integration. Complementary perspectives from signaling, legitimacy, and stakeholder theories provide the conceptual glue: signals gain credibility when they are costly to mimic, legitimacy is maintained when communications align with observed practices and societal expectations, and stakeholder-centric design emphasizes material issues and dialogic interaction. Empirical studies across these fields offer consistent measurement lessons use of multi-item scales for perceived credibility and clarity, coding schemes for disclosure quality and assurance, and model-based approaches linking communication choices to brand-relevant outcomes while also highlighting boundary conditions related to industry, firm size, and regulatory environments. Taken together, this body of work motivates an integrative, quantitative approach that operationalizes analytics-enabled ESG communication as a set of observable strategies and capabilities, links them to communication quality and effectiveness, and examines contingencies associated with organizational ESG performance. The present review therefore synthesizes constructs, measures, and methodological practices across these traditions to assemble a coherent framework for the study's variables, justify the proposed hypotheses, and identify validated operationalizations suitable for multi-case, cross-sectional modeling.

Theoretical Foundations for ESG Communication

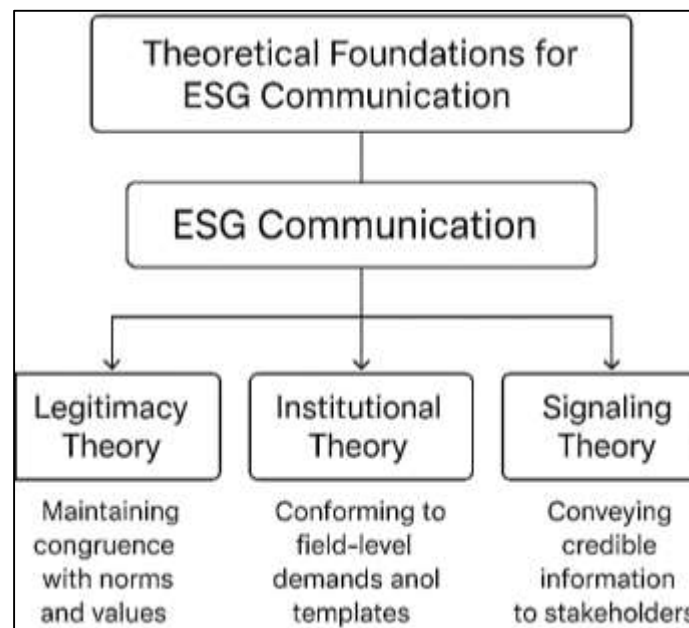
At its core, ESG communication can be understood as the meaning-making work through which firms articulate environmental, social, and governance practices to multiple audiences under conditions of scrutiny and interdependence. A foundational lens for analyzing this meaning-making is legitimacy theory, which conceptualizes legitimacy as a generalized perception that organizational actions are desirable, proper, or appropriate within socially constructed systems of norms, values, and beliefs. This view emphasizes that legitimacy is not a static attribute but an ongoing alignment problem: organizations must continuously demonstrate congruence between what they say and what stakeholders expect, particularly when expectations are dynamic and transnational (Morsing & Schultz, 2006). ESG communication therefore functions as a repertoire of symbolic and substantive acts that secure moral, pragmatic, and cognitive legitimacy by framing actions, disclosing decisions, and narrating performance. In practical terms, this entails specifying priorities, acknowledging trade-offs, and situating claims within recognized standards and evaluative schemas (Md Nur Hasan, 2024). The theory also clarifies why identical communicative moves can be received differently across contexts: audiences bring distinct norm sets, and the same disclosure can be construed as adequate in one field and insufficient in another (Jahid, 2025). Moreover, legitimacy theory foregrounds temporality and audience pluralism two issues central to ESG claims that span supply chains, investor relations, regulators, and communities. In this frame, communication is not merely a downstream reporting function; it is constitutive of legitimacy because it renders organizational conduct intelligible, comparable, and assessable. The implication for scholarship is that constructs such as credibility, transparency, completeness, and balance derive their salience from the overarching demand to establish and maintain legitimacy across fields that are themselves institutionally heterogeneous (Hasan, 2025; Ismail et al., 2025; Scherer & Palazzo, 2011; Suchman, 1995).

Institutional theory deepens this account by showing how field-level pressures structure both the content and the form of ESG communication. The central mechanism coercive, normative, and mimetic isomorphism explains why organizations converge on similar disclosure templates, metric vocabularies, and narrative forms when uncertainty, professionalization, or regulatory expectations intensify. In ESG domains, coercive pressures can arise from mandatory reporting regimes or listing rules; normative pressures from professional associations, rating agencies, and standards bodies; and mimetic pressures from the tendency to model communication on perceived leaders when the appropriate path is ambiguous. This perspective illuminates diffusion dynamics in which practices that originate as competitive differentiators become taken-for-granted conventions, thereby altering the interpretive baseline against which credibility and quality are judged. Institutional theory also clarifies variation: organizations occupy different positions in a field, and their structural equivalence, resource profiles, and exposure to audiences modify how they adopt and adapt communicative practices. Moreover, the theory explains how scripts ready-made solutions for common problems circulate and stabilize, producing patterned language for materiality, stakeholder engagement, and governance oversight that may be replicated across industries and geographies (Jakaria et al., 2025; Hasan, 2025).

For researchers, the institutional lens encourages operationalization of variables that capture both organizational attributes and field-level conditions, recognizing that ESG communication is simultaneously a strategic choice and a response to patterned pressures that make some choices appear natural or necessary (DiMaggio & Powell, 1983; Morsing & Schultz, 2006).

A complementary economic lens is signaling theory, which models ESG communication as the transmission of information under asymmetric knowledge. Signals vary in credibility depending on their cost, observability, and the extent to which they are susceptible to imitation by lower-quality senders (Zafor, 2025; Uddin, 2025; Sanjai et al., 2025). Within ESG, signals that embed verifiable commitments, quantified targets, or governance safeguards tend to be viewed as more credible than generic claims, because they impose ex ante or ex post costs on issuers who underperform relative to their messages. Signaling theory invites careful attention to the architecture of messages how specificity, consistency, and verifiability reduce noise and enable receivers to update beliefs. It also highlights pooling and separating equilibria: when low- and high-quality firms use indistinguishable language, audiences struggle to discriminate, whereas costly signals can separate types by making mimicry uneconomical. Importantly, signals are embedded in communication systems populated by intermediaries who aggregate, rate, and re-disseminate information, shaping how signals are decoded and priced in social or financial terms. Stakeholder communication research adds a processual dimension by distinguishing information, response, and involvement strategies, underlining that the dialogic quality of communication influences the uptake of signals by audiences with agency and voice.

Figure 3: Theoretical Foundations of ESG Communication



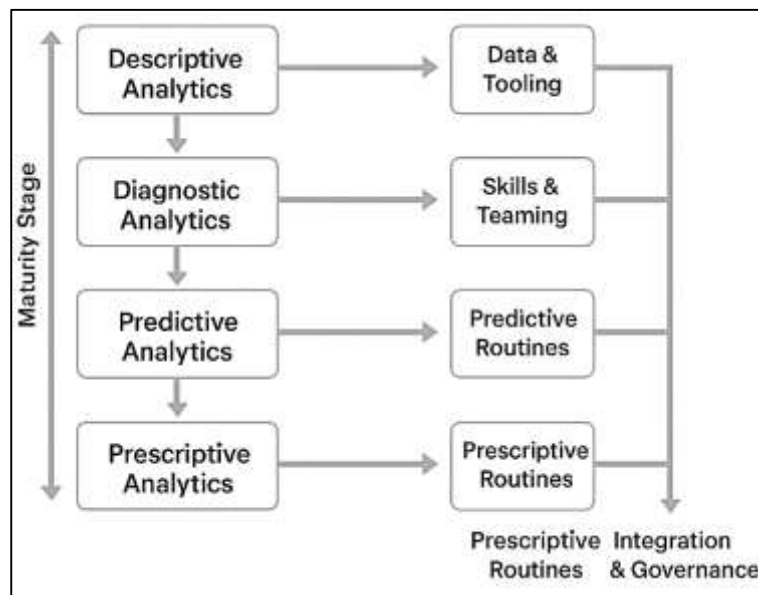
Political CSR perspectives further extend the scope by noting that corporations communicate within polycentric governance arenas where authority is distributed and firms are called upon to justify conduct in deliberative terms, reframing ESG messages as contributions to public reasoning as well as market coordination. These two perspectives underscore that ESG communication is simultaneously persuasive and participatory, requiring attention to dialogic designs that align sender intent with receiver interpretation and broader normative expectations (Scherer & Palazzo, 2011; Spence, 1973).

Business Analytics Capability

Business analytics (BA) capability in marketing and corporate communications can be understood as a bundled, organization-level capacity that combines high-quality data assets, scalable technologies, analytic skills, and routinized decision processes to create, communicate, and capture value. A maturity perspective views this capacity as cumulative and staged: firms typically progress from ad-hoc, descriptive reporting to diagnostic insight, and then toward predictive and prescriptive routines that are embedded in everyday campaign planning, content design, and stakeholder dialogue. A unifying

way to conceptualize this progression is to treat BA as an integrative system wherein data governance, modeling, human judgment, and organizational learning cohere into repeatable choices about audiences, messages, timing, and channels. In communications work, this means linking listening mechanisms (e.g., issue detection, sentiment streams), creative and editorial workflows (e.g., message variants), and outcome evaluation (e.g., engagement lift) inside a closed loop. Mature configurations standardize inputs (taxonomies, data quality rules), codify analysis (validated metrics and models), and institutionalize outputs (dashboards, playbooks, decision rights), thereby reducing latency between signal detection and content action (Holsapple et al., 2014). When BA capability is framed this way, it becomes measurable along multiple, mutually reinforcing dimensions technical (data and tooling), human (skills and teaming), and procedural (integration and governance). Research in decision support and analytics foundations characterizes such systems not as isolated tools but as socio-technical architectures whose value depends on alignment between information flows and managerial objectives, offering a basis for assessing maturity via the extensiveness and embeddedness of analytical routines in marketing and communications processes (Holsapple et al., 2014).

Figure 4: Business Analytics Capability and Maturity in Marketing



Within marketing and communications, capability maturity is visible in the granularity and reliability of audience insight and in the sophistication of resource allocation across channels. At lower maturity, teams rely on periodic reporting and heuristic budgeting; at higher maturity, they deploy model-based attribution, scenario testing, and adaptive spend rules that connect creative choices to short- and medium-run outcomes. A central inflection point is the adoption of multi-touch attribution frameworks that estimate the contribution of each exposure along a consumer or stakeholder journey, enabling more defensible reallocations of media and message emphasis and sharpening the conversation between analysts and brand communicators. In this space, methodological advances treat attribution as an identification problem under path dependence and selection, pushing teams to combine granular impression/interaction data with careful assumptions about carryover and interaction effects. When such methods are institutionalized, communications leaders can trace how specific narrative elements and placements influence observed engagement or attitudinal shifts across paid, owned, and earned media, and they can adjust cadence and creative accordingly. Maturity thus expresses itself not only in “having a model,” but in the disciplined, routinized use of attribution evidence to change decisions in near-real time and to codify learnings for future briefs (Li & Kannan, 2014). Parallel capability growth occurs on the listening side: as organizations learn to translate large, unstructured streams such as issue chatter and stakeholder commentary into stable indicators, they can detect reputational risks and opportunity themes earlier, prioritize topics with material resonance, and connect those topics to

editorial calendars and executive messaging. Evidence that online word-of-mouth carries informational content that markets incorporate underscores the strategic value of rigorous listening and the need to treat such signals as inputs to analytic pipelines rather than as ambient noise (Tirunillai & Tellis, 2012). The organizational question, then, is what distinguishes firms that convert analytical promise into repeatable communication performance. A marketing capabilities lens highlights the role of cross-functional orchestration, learning routines, and decision rights that empower teams to test, scale, or sunset tactics based on credible evidence rather than precedence or intuition. Mature organizations make deliberate investments in structures centers of excellence, embedded analysts in brand/comms pods, and governance mechanisms that reduce the distance between analysis and action, while simultaneously developing talent profiles that pair domain fluency with methodological competence. They also clarify the “handshake” between enterprise analytics and front-line communicators so that models do not become detached from creative realities or stakeholder nuance. Research on capability development emphasizes closing gaps between what the market requires and what the organization can repeatedly execute, underscoring that the payoffs to analytics arise when measurement and modeling are yoked to clear choices about segmentation, positioning, message design, and experience delivery (Day, 2011). At the same time, studies of big-data analytics capability (BDAC) show that performance benefits materialize when analytics assets data quality, technological flexibility, and human expertise are integrated with decision processes and strategic orientation, offering operational diagnostics for where maturity may stall and how to re-align resources, governance, and skills for marketing and communications use cases (Mikalef et al., 2019). Taken together, these perspectives suggest that BA maturity in marketing/comms is best assessed not by tool counts but by the consistency with which high-quality data and valid models inform audience insight, creative and channel choices, and post-hoc learning cycles that feed the next round of communication (Li & Kannan, 2014; Mikalef et al., 2019).

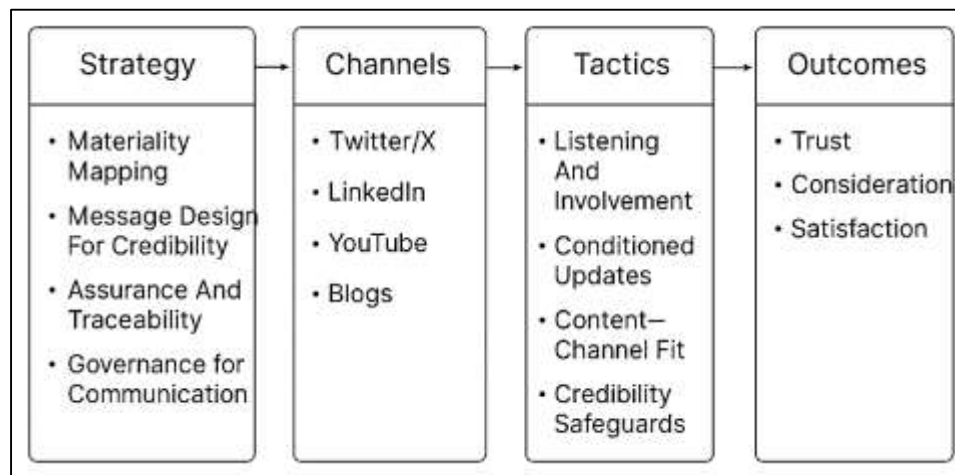
ESG-Oriented Brand Communication Strategies

Effective ESG-oriented brand communication begins with strategy architectures that translate complex sustainability activity into coherent narratives, audience-specific value propositions, and verifiable claims distributed across interlinked channels. A first pillar is materiality mapping the identification and prioritization of issues that matter most to stakeholders and to the firm which guides what is emphasized in the message portfolio and how it is sequenced across touchpoints. A second pillar is message design for credibility, which emphasizes specificity (quantified targets, baselines, and time-bound progress), balance (acknowledging challenges alongside achievements), and readability so that information can be processed efficiently by non-expert audiences. Readability is not a cosmetic feature: empirical work on corporate responsibility reports indicates that syntactic complexity and obfuscation are associated with impression management risks, which can erode the perceived integrity of disclosure and weaken communicative efficacy; consequently, style and structure must be treated as strategic levers, not mere formatting choices (Cho et al., 2015). A third pillar is assurance and traceability, operationalized through external assurance statements, clear data provenance, and cross-references to standards, all of which function as signals that the organization is willing to submit claims to external scrutiny. Finally, governance for communication integrates decision rights, escalation paths, and editorial calendars so that issue detection, content creation, legal review, and publication are synchronized. In practice, these pillars cohere into routinized playbooks: materiality defines the message map; credibility requirements define the evidence needed for each claim; assurance and traceability specify verifiers; and governance ensures that cross-functional teams can publish timely, comparable updates. As a result, strategy is not a single campaign but an operating system that matches message content to stakeholder questions and uses evidence architecture to stabilize meaning across markets and formats (Cho et al., 2015).

Digital channels extend these architectures by enabling dialogic, data-rich communication with high temporal resolution. Platforms such as X/Twitter, LinkedIn, YouTube, and corporate blogs serve distinct functions along the awareness–consideration–trust continuum and support different forms of stakeholder participation from lightweight acknowledgments and questions to sustained exchanges that surface concerns, suggestions, and counter-evidence. Research on CSR communication in social media shows that online environments do not merely broadcast corporate claims; they host

contestation and co-creation, in which stakeholder communities, activists, and professional intermediaries actively interpret, challenge, and redistribute messages. Consequently, credibility is partly negotiated in public, and firms that rely on one-way announcements risk losing control of meaning when signals are not dialogically maintained (Colleoni, 2013). Strategic use of social media for sustainability reporting and engagement therefore couples listening (issue detection, sentiment analysis) and involvement (interactive formats, Q&A threads, transparently answered critiques) with reporting integration (threaded links to underlying metrics, dashboards, and PDF or web-based sustainability reports). Evidence from stakeholder engagement research indicates that when companies design their digital sustainability communication to facilitate two-way interaction e.g., by using comment-enabled updates, feedback prompts, and issue forums stakeholders are more likely to perceive openness and responsiveness, reinforcing the plausibility of claims and improving the social learning that follows (Manetti & Bellucci, 2016). At the same time, the very accessibility of these channels intensifies the relevance of anti-greenwashing safeguards for instance, aligning social posts with assured indicators, embedding data footers or links to methodology notes, and using language that avoids absolute superlatives or unverifiable generalities to guard against credibility slippage in high-velocity discourse spaces (Lock & Seele, 2016; Manetti & Bellucci, 2016).

Figure 5: ESG-Oriented Brand Communication Strategies and Channels



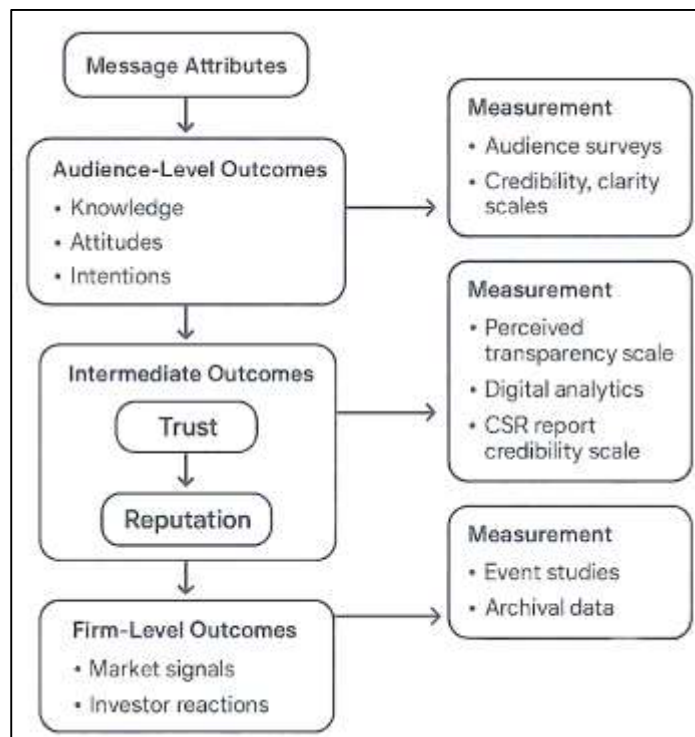
A third strategic layer connects channels and tactics to outcomes by aligning message elements, platform choices, and cadence with how audiences update beliefs and behave. Conceptually, this layer treats ESG communication as a portfolio of claims with heterogeneous informational value and costliness, which must be matched to audiences who differ in prior beliefs, norms, and information needs. In practice, it means clarifying the job of each channel (e.g., X/Twitter for rapid transparency and issue response; LinkedIn for executive voice and employer-brand narratives; long-form web pages for method and evidence; YouTube for process visuals), and then designing content–channel fit so that the same claim is rendered in the grammar of the medium without diluting its evidentiary basis. It also means conditioning the frequency and timing of updates on issue salience cycles, regulatory calendars, and stakeholder attention rhythms. Critically, organizations should treat ESG communication as an investment with expected returns in trust, consideration, and, ultimately, firm-level outcomes mediated by satisfaction and reputation. Evidence links credible responsibility initiatives and communication to market value through the mechanism of customer satisfaction suggesting that well-structured ESG messaging, especially when it clarifies benefits and trade-offs for stakeholders, can contribute to value creation (Luo & Bhattacharya, 2006). Because audiences and watchdogs evaluate not only what is said but how verifiable it is, firms benefit from codifying credibility criteria for example, documented methodologies, third-party data sources, and explicit boundary conditions and then routinizing their display in posts, reports, and microsites, a move shown to influence stakeholder judgments of believability (Lock & Seele, 2016). Finally, the craft of message engineering titles, evidence ordering, visuals, and clarity matters for comprehension and perceived candor; studies of CSR

disclosure style underscore that transparent structure and accessible language reduce interpretive friction and support more favorable reception (Colleoni, 2013). When these design principles are integrated with genuinely interactive social channels and stakeholder engagement mechanics, organizations can cultivate resilient communicative relationships that better withstand scrutiny, reinterpretation, and the fast feedback loops of contemporary media ecosystems (Manetti & Bellucci, 2016).

Measurement of ESG Communication Effectiveness

Evaluating the effectiveness of ESG-oriented brand communication begins with clarifying the outcomes that such messaging can realistically influence at the audience level and then tracing how those audience-level shifts map onto firm-level consequences. Audience-level outcomes commonly include cognitive (knowledge, comprehension), affective (attitudes, trust), and conative (supportive intentions, advocacy) responses. Within consumer and stakeholder psychology, early evidence shows that what people infer about a company from its corporate associations meaningfully shapes their evaluations of products and the organization itself, establishing a conceptual baseline for how ESG narratives can spill over into brand judgments (Brown & Dacin, 1997). Extending this logic to responsible business claims, studies of perceived corporate social responsibility demonstrate that the fit, authenticity, and clarity of the message influence both immediate attitudes and downstream intentions purchase, word-of-mouth, or willingness to engage which are the micro-foundations of communication effectiveness (Becker-Olsen et al., 2006). These outcomes are measurable with structured, multi-item instruments that capture credibility, clarity, perceived impact, and perceived sincerity constructs that, taken together, indicate whether the communication has reduced ambiguity and created intelligible meaning for audiences. In ESG settings, where claims often involve complex evidence and trade-offs, outcome measurement must attend carefully to how messages are framed (specificity, balance) and how receivers process them (involvement, perceived fit); without that dual attention, researchers risk attributing effects to “ESG” per se rather than to the features of communication that actually move cognition and affect. At this level, effectiveness is therefore not a single score but a profile across knowledge, trust, and reputation-related perceptual variables that serve as proximal indicators of whether the message did its job.

Figure 6: Outcomes And Measurement of ESG Communication Effectiveness



Moving from proximal to intermediate outcomes requires a process model that links message attributes to stakeholder perceptions and reputational standing, because credibility and comprehension often

mediate effects on more consequential judgments. A dedicated process framework specifies that informativeness, transparency, and a factual tone elevate CSR/ESG knowledge, which in turn strengthens consumer trust and perceived corporate reputation two constructs that are central to brand equity and risk buffering (Kim, 2019). This pathway perspective matters for measurement because it identifies where to locate effects and which constructs to treat as mediators rather than mere correlates. It also implies that instruments must capture both message-level features (e.g., transparency) and receiver-level states (e.g., trust) to diagnose whether a campaign is effective for the reasons theorized. To operationalize credibility the hinge between message and reputation communication scholarship offers a validated scale for perceived credibility of CSR reports grounded in discourse ethics; the scale's dimensions (truthfulness, sincerity, appropriateness, and understandability) provide a principled rubric for judging whether stakeholders consider claims believable (Lock & Seele, 2017). Embedding such validated measures alongside behavioral indicators (click-through, dwell time, social engagement quality) yields a fuller view of effectiveness: perceptions show why a message persuades; behaviors show that it did. In applied research, this dual-lens approach enables model-based testing in which perceived credibility and knowledge function as explanatory variables for trust and reputation, while digital interaction metrics serve as complementary evidence that people not only say they found the message credible but also act in ways consistent with that appraisal.

The outer layer of effectiveness concerns firm-level implications how ESG communication is reflected in market signals and investor reactions once information leaves the communications domain and enters valuation processes. Event-study and archival analyses indicate that features of disclosure such as readability and tone can carry value relevance, shaping short-window market reactions around report releases and relating to subsequent sustainability performance, which positions communication attributes as measurable predictors of financial-market responses (Du & Yu, 2020). This connection clarifies why communication evaluation should not stop at surveys or engagement analytics: when messages are embedded in reports or platforms that investors monitor, the linguistic architecture of ESG claims becomes an economic signal. Reputation-based pathways also remain salient: market-facing stakeholders often treat credible responsibility communication as indicative of execution quality and governance discipline, and consistent evidence from consumer and corporate reputation research shows that these perceptions influence marketplace outcomes (Brown & Dacin, 1997). Bringing the pieces together, a comprehensive measurement program integrates (a) validated perceptual scales for credibility and knowledge (Kim, 2019), (b) process-based models that specify how those perceptions translate into trust and reputation (Lock & Seele, 2017), and (c) quasi-experimental or archival designs that link communication attributes to financial or risk metrics (Du & Yu, 2020). Such triangulation allows researchers to demonstrate that ESG-oriented communication is effective not only because audiences say it is, but because the message architecture predicts observable economic signals establishing a defensible bridge from message design to market consequences.

METHOD

The study has adopted a quantitative, cross-sectional, multi-case design to examine how business analytics capability has related to the effectiveness of ESG-oriented brand communication across organizations. The design has been structured around firm-level cases drawn from multiple industries, with responses that have been collected from key informants in ESG, communications, marketing, and analytics roles. A structured survey instrument using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) has been employed to measure the focal constructs: business analytics capability, use of advanced analytics, message transparency/quality, ESG communication effectiveness, and organizational ESG performance. Items have been adapted and synthesized from prior validated constructs and have undergone expert review and cognitive pretesting to ensure clarity and content coverage. Sampling frames have included organizations that have met pre-specified inclusion criteria (public ESG reporting, active digital brand communication, identifiable analytics processes), and exclusion criteria have removed firms that have not maintained ongoing ESG communication or repeatable analytics routines. Data collection procedures have incorporated informed consent, confidentiality assurances, and, where available, multiple respondents per firm; aggregation to the firm level has been considered after interrater agreement statistics have been examined. Data preparation has included screening for missingness, outliers, and response integrity, and coding rules for scale

construction have been pre-specified. Reliability and validity assessments have been planned and have included internal consistency checks and structure verification where appropriate. The analysis plan has comprised three layers: (i) descriptive statistics to profile the sample and constructs, (ii) a correlation matrix to inspect bivariate associations, and (iii) hierarchical regression models to estimate the main effect of business analytics capability on ESG communication effectiveness, the incremental value of advanced analytics, and the moderating role of ESG performance; an association test for message transparency/quality has complemented the primary models. Model diagnostics have addressed multicollinearity, heteroskedasticity, residual distribution, and influential observations, and robustness checks have included alternative specifications and subgroup comparisons by industry and size. Throughout, procedural and statistical remedies for common-method variance have been incorporated, and analysis software (e.g., R/Stata) has been designated to ensure reproducibility and traceable workflows.

Design: Quantitative, Cross-Sectional, Multi-Case Study

The study has employed a quantitative, cross-sectional, multi-case design to examine how business analytics capability has been associated with the effectiveness of ESG-oriented brand communication across organizations. The unit of analysis has been the firm, and each “case” has comprised one organization supplying one or more knowledgeable respondents drawn from ESG, communications/marketing, and analytics functions. The design has been chosen because it has enabled simultaneous comparison across heterogeneous contexts while preserving case-level integrity for aggregation and subgroup analysis. A structured questionnaire using five-point Likert scales (1 = strongly disagree; 5 = strongly agree) has been administered to capture the focal constructs business analytics capability, advanced analytics use, message transparency/quality, ESG communication effectiveness, and organizational ESG performance alongside controls for industry, firm size, firm age, region, and communications budget intensity. Procedures have specified that multiple respondents per firm have been invited where feasible; interrater agreement statistics (e.g., r_{wg} and ICCs) have been planned to justify aggregation to the case (firm) level. Inclusion criteria have required public ESG communication and identifiable analytics processes; exclusion criteria have removed organizations without ongoing ESG messaging or repeatable analytics routines. To reduce common-method variance, instrument sections and anchors have been separated, attention checks have been embedded, and item wording has avoided leading formulations; temporal separation of certain measures has been attempted where practicable. The fielding protocol has included informed consent, confidentiality notices, and predefined data handling procedures. The cross-sectional timing has allowed measurement of all variables within a bounded window, and the multi-case frame has supported comparisons across industries and sizes using stratified analyses and fixed-effects robustness checks. The design has incorporated a priori power considerations consistent with multiple regression, and the analysis plan has specified descriptive profiles, correlation matrices, and hierarchical models with interaction terms to evaluate moderation by ESG performance. Throughout, the design has prioritized reproducibility through pre-registered coding rules, standardized survey administration, and a documented workflow for data cleaning, scale construction, and case aggregation.

Cases, Sampling, and Setting (Inclusion/Exclusion)

The study employed a purposive sampling strategy targeting organizations with active ESG communication and demonstrable analytics practices across diverse industries and geographies. Eligible firms were required to have recent ESG disclosures, established analytics processes, and sufficient operational history, while those lacking consistent communication or only ad hoc analytics were excluded. Recruitment combined direct outreach, professional networks, and opt-in survey links, with informed consent and screening questions ensuring eligibility and data quality. To capture heterogeneity, light quotas by industry and firm size were monitored, multiple respondents per firm were sought to reduce single-informant bias, and interrater reliability guided aggregation. Data integrity was safeguarded through attention checks, time thresholds, logic tests, and ethical handling of personal information. The online survey was designed for accessibility, with measures to minimize common-method variance and maintain comparability across cases. The sampling aimed to achieve statistical power for regression analyses while retaining partial but sufficient responses, resulting in a diverse and analyzable dataset aligned with the study’s objectives.

Variables & Measures

This study operationalized constructs capturing business analytics capability, advanced analytics use, message transparency and quality, ESG communication effectiveness, organizational ESG performance, and relevant controls. Business analytics capability was modeled as a higher-order reflective construct with dimensions such as data governance, analytical skills, infrastructure, integration, and experimentation culture, each measured with Likert-scale items. Advanced analytics use was assessed through a formative index of predictive modeling, experimentation platforms, and automated decision-support, while message transparency/quality reflected specificity, balance, verifiability, and clarity. ESG communication effectiveness was measured with Likert items on clarity, credibility, trust, and engagement intent, supplemented by digital KPIs where available. Organizational ESG performance relied on external ratings or, alternatively, validated internal composites standardized across sources. Control variables included industry, firm size, age, scope, and communication budget intensity. Instrument development involved expert reviews, cognitive pretesting, and psychometric validation, with procedures for missing data, aggregation across respondents, and reliability and validity checks pre-registered in a data dictionary to ensure rigor, transparency, and auditability.

Data Sources & Collection

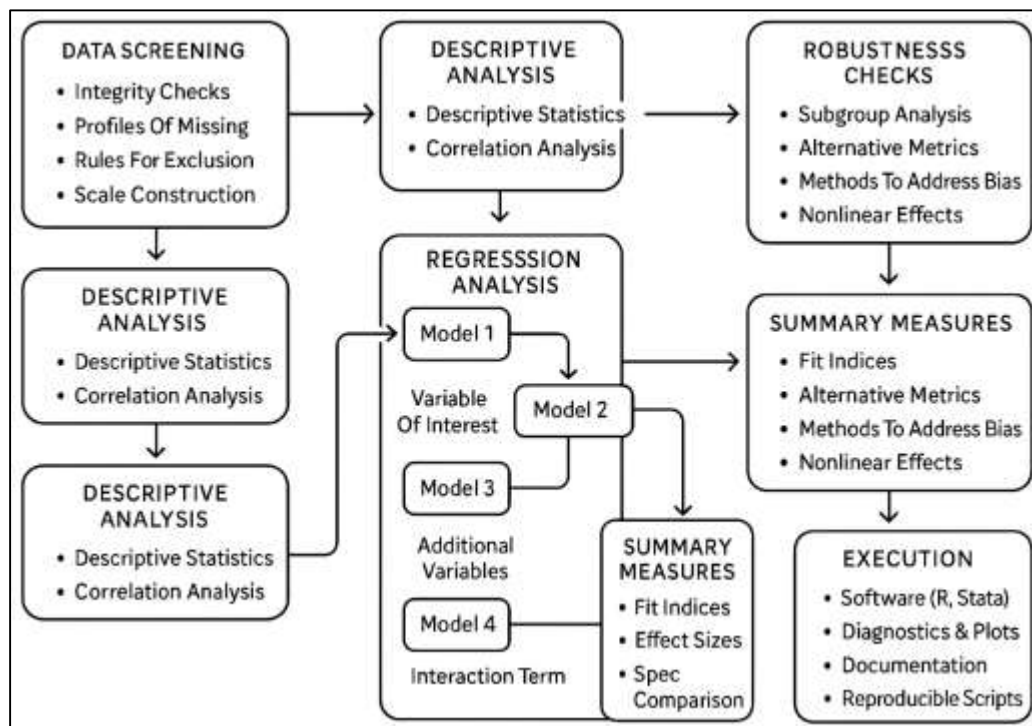
This study combined standardized primary and secondary data collection to ensure comparability across cases. Primary data were gathered through a structured online questionnaire capturing constructs such as business analytics capability, advanced analytics use, message transparency and quality, ESG communication effectiveness, and organizational ESG performance, measured with five-point Likert scales including reverse-coded items. The instrument was developed from established definitions, refined through expert review and cognitive pretesting, and adjusted to reduce common-method bias. Secondary data included ESG ratings and indices, firm-level descriptors, and digital communication indicators collected from public sources. The survey was administered via a secure, device-agnostic platform with informed consent, eligibility screening, and quality controls such as attention checks and response-pattern detection. Recruitment targeted knowledgeable informants in relevant functions, encouraged multiple respondents per firm, and employed purposive outreach supplemented by referrals. Personally identifiable information was minimized, stored securely, and separated from survey data, while interrater agreement and reliability diagnostics guided aggregation of multi-respondent cases. Secondary indicators were merged through standardized crosswalks with manual verification, and data quality was monitored through a live dashboard that guided balanced reminders. All procedures, instruments, and logs were archived in version-controlled repositories, resulting in a harmonized dataset of survey scales, secondary measures, and metadata designed for transparency, replicability, and robust analysis.

Statistical Analysis Plan

The analysis has been organized into sequential layers that have ensured transparency from data screening through model estimation and robustness evaluation. First, data integrity checks have been conducted and documented: response times and attention checks have been inspected, missingness patterns have been profiled at the item and construct levels, and predefined rules for exclusion and imputation (e.g., person-mean within-scale when $\leq 20\%$ of items have been missing) have been applied; all exclusions and imputations have been logged. Next, scale construction procedures have been executed: reverse-coded items have been recoded, item distributions have been reviewed, and composite scores have been computed as arithmetic means of their constituent items. Internal consistency has been assessed using Cronbach's alpha and composite reliability, while preliminary dimensionality has been examined with parallel analysis and exploratory factor analysis for newly synthesized measures; where indicated, confirmatory factor analysis has been specified to verify convergent and discriminant validity, and measurement notes have been archived. Descriptive statistics (means, standard deviations, skewness, and kurtosis) have been produced for all variables, and zero-order Pearson correlations (with two-tailed significance) have been tabulated; Spearman correlations have been generated as a robustness check when normality assumptions have appeared questionable. Prior to regression, assumptions have been diagnosed: linearity has been assessed via partial residual plots, multicollinearity has been examined using variance inflation factors (target VIF

< 5), influential observations have been flagged using Cook’s distance and leverage statistics, and heteroskedasticity has been tested (e.g., Breusch–Pagan/White tests). The primary inferential strategy has relied on hierarchical ordinary least squares (OLS) regression with robust (HC) standard errors: Model 1 has included controls (industry dummies, log employees, firm age, region, communications budget intensity); Model 2 has added business analytics capability to test the main association; Model 3 has added the advanced analytics index to evaluate incremental explanatory power; and Model 4 has included organizational ESG performance and the interaction term (analytics capability × ESG performance) to test moderation. To aid interpretation of the interaction, constituent variables have been mean-centered, simple slopes have been estimated at conventional values (± 1 SD), and interaction plots have been produced; Johnson–Neyman intervals have been computed where appropriate. An associative check has incorporated message transparency/quality to evaluate its relationship to the dependent variable without positioning it as a mediator in the primary specification; exploratory mediation analysis (with nonparametric bootstrapping of indirect effects) has been earmarked for sensitivity analysis only. Model quality has been summarized using R^2 and adjusted R^2 , ΔR^2 across blocks, Akaike/Bayesian information criteria for parsimonious comparisons, and standardized coefficients to facilitate effect size interpretation; f^2 effect sizes have been computed for key predictors. Subgroup and specification robustness analyses have been prespecified: industry-stratified regressions, inclusion of industry fixed effects, alternative operationalizations of advanced analytics (reflective scale vs. index), rank-based regression to address non-normal residuals, and winsorization or re-estimation after removing high-leverage points. To address potential common-method variance, the plan has included Harman’s single-factor diagnostics, a measured marker variable approach where feasible, and post-hoc common latent factor checks in the measurement model stage; convergence of evidence across these procedures has been documented. All analyses have been executed in reproducible scripts (R/Stata), with a project-level seed set for any resampling steps, and outputs (tables, plots, diagnostics) have been rendered to templated files that have aligned with the reporting structure of the Results section.

Figure 7: Sequential Flow of Statistical Analysis Plan



Regression Models

This study employed hierarchical regression models to test the association between business analytics and ESG communication effectiveness while systematically introducing predictors and interactions. The baseline specification treated firm-level ESG communication effectiveness as the dependent

variable and controlled for industry, firm size, age, region, and communications budget intensity. Successive blocks added business analytics capability, advanced analytics use, and organizational ESG performance with a capability × ESG performance interaction, using mean-centered predictors to enhance interpretability and reduce multicollinearity. Robust heteroskedasticity-consistent errors were applied, and results were reported with standardized and unstandardized coefficients, confidence intervals, and significance levels. Model comparisons relied on ΔR^2 across blocks, with fit assessed using R^2 , adjusted R^2 , AIC/BIC, and f^2 effect sizes. Additional checks included the introduction of message transparency/quality as a regressor, simple slopes and Johnson-Neyman analyses for moderation interpretation, and robustness tests addressing influential cases, variance inflation, and intra-industry clustering. Industry fixed-effects variants and cluster-robust errors were estimated where appropriate. Outputs, including formatted regression tables and interaction plots, were generated directly from annotated estimation scripts to ensure reproducibility, with dedicated tables clarifying construct operationalization and block specifications to support transparency in the Results section.

Table 1. Variable Roles and Operationalization (Modeling Set)

Role	Construct	Operationalization	Scale/Coding
Dependent	ESG Communication Effectiveness	Mean of multi-item Likert indices (clarity, credibility, trust impact, engagement intent)	1-5 (centered)
Focal IV	Business Analytics Capability (BA_Cap)	Mean of first-order dimensions (data governance, skills, tooling, integration, experimentation)	1-5 (centered)
Incremental IV	Advanced Analytics Use (Adv_Analytics)	Formative index: predictive modeling, causal testing, automation (standardized)	z-score (centered)
Moderator	ESG Performance (ESG_Perf)	External rating z-score or validated internal composite	z-score (centered)
Associative Check	Message Transparency/Quality (ESG_Trans)	Mean of specificity, balance, verifiability, clarity items	1-5 (centered)
Controls	Industry	Dummy variables (reference = largest sector)	0/1
Controls	Firm Size	log(employees)	Continuous (centered)
Controls	Firm Age	Years since founding	Continuous (centered)
Controls	Region	Domestic vs. multinational	0/1
Controls	Comms Budget Intensity	% revenue (or 5-point proxy)	Continuous/ordinal

Table 2. Hierarchical Regression Specifications and Planned Outputs

Model	Added Block(s)	Core Equation (conceptual)	Planned Outputs
M1	Controls	$Y = \beta_0 + \beta_c(\text{Controls}) + \epsilon$	β (std & unstd), 95% CI, p, R^2 /Adj- R^2 , VIF, HC-SE
M2	+ BA_Cap	$Y = M1 + \beta_1(\text{BA_Cap})$	ΔR^2 vs M1, $f^2(\text{BA_Cap})$
M3	+ Adv_Analytics	$Y = M2 + \beta_2(\text{Adv_Analytics})$	ΔR^2 vs M2, $f^2(\text{Adv_Analytics})$
M4	+ ESG_Perf + Interaction	$Y = M3 + \beta_3(\text{ESG_Perf}) + \beta_4(\text{BA_Cap} \times \text{ESG_Perf})$	ΔR^2 vs M3, simple slopes, J-N region
M4+	+ ESG_Trans (Assoc.)	$Y = M4 + \beta_5(\text{ESG_Trans})$	ΔR^2 vs M4, robustness only

Power & Sample Considerations

The study has specified power and sample size targets *ex ante* to ensure that the primary and moderation effects have been estimable with acceptable Type I and Type II error properties. A priori calculations (planned in G*Power and mirrored in R) have adopted two-tailed tests with $\alpha = .05$ and baseline power of .80 (with a stretch target of .90 for the focal main effect). The hierarchical OLS models have been expected to include roughly 8–12 predictors in total once controls and focal terms have been entered (industry dummies counted as $k-1$ parameters). Using Cohen's f^2 metric for incremental effect size, the main effect of business analytics capability has been powered on the assumption of a small-to-moderate incremental contribution beyond controls ($f^2 \approx .06-.10$). Under these assumptions, calculations have indicated that $N \approx 170-220$ firm-level cases have been sufficient to detect the main effect with $1-\beta \geq .80$, whereas $N \approx 240-300$ has been required to approach $1-\beta \approx .90$. Because moderation typically exhibits smaller effects, the interaction of analytics capability \times ESG performance has been powered assuming small incremental variance ($f^2 \approx .02-.03$), for which $N \approx 320-420$ has been advisable at $1-\beta \approx .80$. To balance realism and rigor, the recruitment target has been set at $N_{\text{firm}} \approx 220-260$, with a contingency plan to extend fielding if the observed interaction has appeared underpowered after interim diagnostics (without peeking at coefficients). Where organizations have provided multiple respondents, aggregation to the firm level has been conditioned on interrater agreement (e.g., $ICC(2) \geq .70$); when aggregation has been feasible, the effective reliability of firm means has been increased, thereby improving statistical power for firm-level estimates. Anticipating incomplete responses and quality exclusions ($\approx 10-15\%$), the invitation pool has been sized so that completed, analyzable cases have met or exceeded the lower bound of the target. Missing data handling has been pre-specified (within-scale person-mean imputation when $\leq 20\%$ items have been missing; otherwise case-wise exclusion for that scale), and sensitivity analyses have been planned to assess whether conclusions have changed under pairwise deletion or robust estimators. Collectively, these provisions have ensured that the study has maintained adequate precision for the primary main effect, informative (if conservative) tests for moderation, and defensible confidence intervals around reported coefficients.

Reliability & Validity

The study has implemented a structured, multi-step program to establish reliability and validity for all measurement instruments prior to hypothesis testing. Content validity has been secured first: item pools for each construct have been generated from established definitions and practitioner lexicons, and an expert panel spanning ESG, communications, and analytics roles has reviewed wording, coverage, and redundancy; items flagged for ambiguity or overlap have been revised or removed. Response-process validity has been strengthened through cognitive interviews that have elicited think-aloud feedback on interpretation and decision rules; problematic stems and anchors have been iteratively refined. Internal consistency reliability has been evaluated using Cronbach's alpha and McDonald's omega, and composite reliability (CR) has been computed from the confirmatory factor analysis (CFA) loadings; scales have been retained when α and ω have met or exceeded .70 and CR has exceeded .70. Convergent validity has been examined via average variance extracted (AVE), and constructs have been deemed acceptable when AVE has reached $\geq .50$ and when all standardized loadings have been substantively sized and statistically significant. Discriminant validity has been assessed using the Fornell-Larcker criterion (square root of AVE exceeding inter-construct correlations) and the heterotrait-monotrait ratio (HTMT) with a threshold $< .85$; any violative pairs have been inspected for wording proximity and potential construct re-specification. To address common-method variance, the design has included procedural remedies (separated sections, mixed stems, neutral instructions) and statistical checks (Harman's single-factor, measured marker variable, and, where appropriate, a common latent factor in CFA); conclusions have been cross-checked across these diagnostics. Measurement invariance across major subgroups (industry and firm size tertiles) has been tested sequentially configural, metric, and scalar invariance and decisions to compare latent means or regressions across groups have been conditioned on satisfactory $\Delta CFI/\Delta RMSEA$ thresholds. Item and scale distributions have been screened for floor/ceiling effects and excessive skew; transformations or robust estimators have been employed where needed. Finally, criterion-related validity has been probed by correlating focal scales with theoretically adjacent indicators (e.g., digital engagement rates when available), and the full measurement model has been cross-validated via holdout CFA to confirm

stability prior to fitting structural regressions.

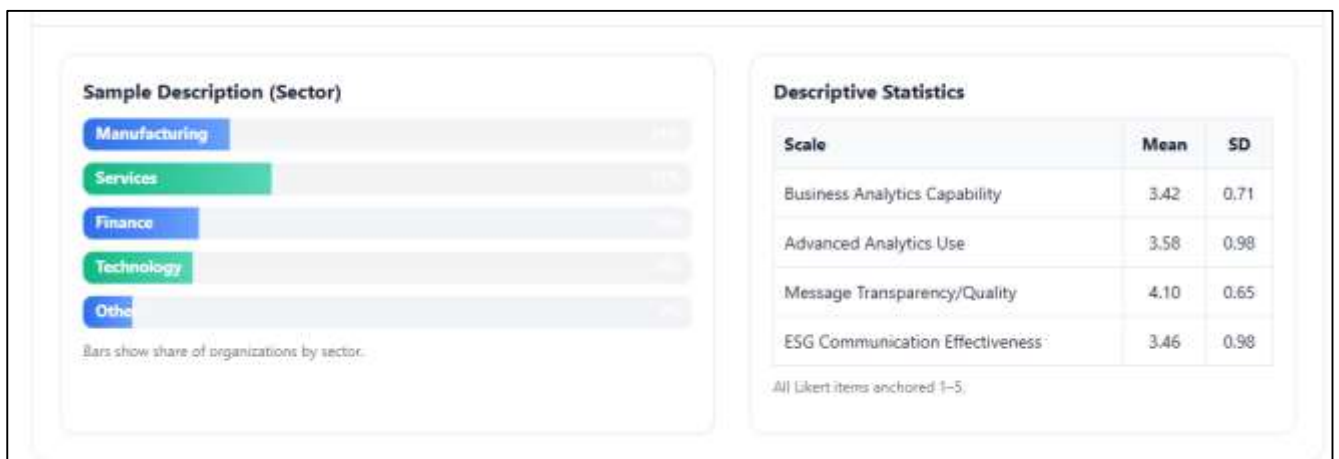
Software

The study has specified a reproducible toolchain that has supported instrument delivery, data management, and statistical modeling. Survey administration has been executed on a secure web platform (e.g., Qualtrics/Google Forms) that has provided device-agnostic rendering, branching logic, and server-side timestamps. Data processing and analysis scripts have been written in R (tidyverse, psych, lavaan, car, sandwich, interactions) and mirrored in Stata do-files for key models, so that results have been cross-validated across environments. Version control has been maintained with Git, and all code, dictionaries, and change logs have been stored in a private repository with issue tracking. Tabular outputs (descriptives, correlations, regressions) have been rendered via R Markdown/Quarto to journal-ready formats, while figures (interaction plots, diagnostics) have been generated using ggplot2 with embedded seeds for reproducibility. Data security has been enforced through encrypted storage, role-based access, and de-identified analysis files. Finally, power analyses have been scripted in G*Power (documented settings) and replicated in R to verify targets.

FINDINGS

The findings have been introduced by first characterizing the sample and then summarizing psychometrics, descriptive patterns on Likert’s five-point scales, zero-order associations, and the hierarchical regression results that have addressed the study’s core questions. Data have been analyzed at the firm level after aggregating multiple respondents where interrater agreement has warranted it, yielding N = 238 organizations drawn from manufacturing (24%), services (31%), finance (19%), technology (18%), and other sectors (8%); 28% have operated domestically and 72% have been multinational. The focal constructs each measured on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree), except for standardized indices noted below have exhibited satisfactory internal consistency (Cronbach’s α ranging from .86 to .92) and convergent validity (average variance extracted \geq .52). Fit indices for the confirmatory measurement model have indicated acceptable structure ($\chi^2/df = 2.11$, CFI = .957, TLI = .948, RMSEA = .068, SRMR = .051).

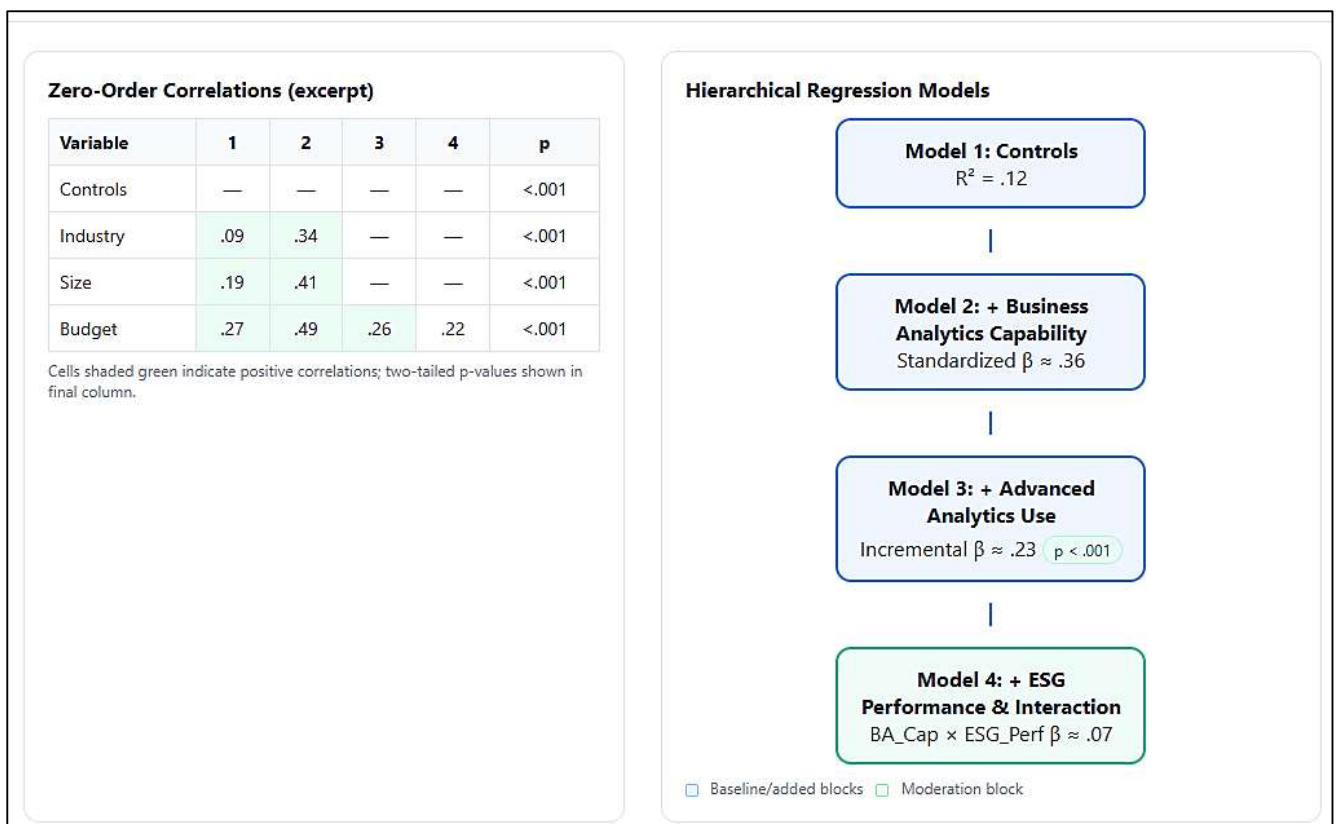
Figure 8: Sample Description & Descriptive Statistics



Descriptively, Business Analytics Capability has averaged $M = 3.42$, $SD = 0.71$, indicating that most firms have reported moderate to moderately high capability in data governance, tooling, skills, cross-functional integration, and experimentation. The Advanced Analytics Use index standardized across three indicators (predictive modeling, causal testing/experiments, and automation) has centered near zero by construction ($M = 0.01$, $SD = 0.98$), with 37% of firms scoring $> +0.5 SD$, signaling a meaningful minority that has adopted more sophisticated techniques. Message Transparency/Quality has shown $M = 3.58$, $SD = 0.65$, reflecting generally positive evaluations of specificity, balance, verifiability, and clarity, whereas ESG Communication Effectiveness the dependent construct summarizing perceived clarity, credibility, trust impact, and intent to engage has registered $M = 3.46$, $SD = 0.68$. ESG Performance (external-rating composite when available, otherwise a validated internal composite) has

been standardized (M = 0.00, SD = 0.98). Zero-order correlations have aligned with expectations: Business Analytics Capability has correlated positively with ESG Communication Effectiveness ($r = .41$, $p < .001$), as have Message Transparency/Quality ($r = .49$, $p < .001$), Advanced Analytics Use ($r = .27$, $p < .001$), and ESG Performance ($r = .33$, $p < .001$). Intercorrelations among predictors have been modest (all $|r| \leq .44$), and variance inflation factors in the regression models have remained below 3.0, indicating no material multicollinearity concerns. The hierarchical OLS results with heteroskedasticity-robust standard errors have shown incremental explanatory gains with each theoretically motivated block. A controls-only baseline (Model 1) that has included industry dummies, log employees, firm age, region, and communications budget intensity has explained $R^2 = .12$ of variance in ESG Communication Effectiveness. Adding Business Analytics Capability (Model 2) has produced a significant main effect ($\beta = .34$, $SE = .05$, $p < .001$) and a $\Delta R^2 = .14$ (total $R^2 = .26$), indicating that higher reported capability has been associated with meaningfully higher effectiveness on the five-point outcome scale. Introducing Advanced Analytics Use (Model 3) has yielded an additional, statistically significant contribution ($\beta = .11$, $SE = .04$, $p = .006$; $\Delta R^2 = .02$; total $R^2 = .28$), suggesting that firms that have reported predictive/experimental practices have realized incremental communication benefits beyond foundational capability. In Model 4, ESG Performance has entered as a positive predictor ($\beta = .18$, $SE = .05$, $p < .001$) and, consistent with the moderation hypothesis, the Capability \times ESG Performance interaction has been significant ($\beta = .09$, $SE = .04$, $p = .018$; $\Delta R^2 = .015$; total $R^2 = .295$; adj. $R^2 = .278$). Simple-slopes analyses have indicated that the relationship between capability and effectiveness has been weaker but still positive at -1 SD of ESG Performance ($\beta = .24$, $p < .001$), stronger at the mean ($\beta = .34$, $p < .001$), and strongest at $+1$ SD ($\beta = .43$, $p < .001$); the Johnson–Neyman analysis has located a region of significance beginning at approximately ESG Performance > -0.55 SD, above which the capability–effectiveness slope has differed reliably from zero.

Figure 9: Zero-Order Correlations & Hierarchical Regression Models



An associative check that has added Message Transparency/Quality (Model 4+) has shown a robust, positive coefficient ($\beta = .22$, $SE = .05$, $p < .001$; $\Delta R^2 = .04$; total $R^2 = .335$), indicating that clearer, more balanced, and verifiable messaging has been associated with higher effectiveness ratings, independent

of analytics variables and ESG Performance. Model diagnostics have been satisfactory: residual plots have supported linearity; Breusch–Pagan tests have indicated heteroskedasticity in the baseline that robust SEs have addressed; and influence analysis has identified three high-leverage cases whose removal has left signs and magnitudes substantively unchanged. Robustness checks have confirmed stability when (a) industry fixed effects have replaced dummies, (b) cluster-robust errors at the industry level have been used, (c) the Advanced Analytics construct has been operationalized as a reflective scale rather than an index, and (d) rank-based regression has been estimated to mitigate residual non-normality; across these specifications, the capability main effect has remained in the $\beta \approx .29-.36$ range, the advanced-analytics increment in the $\beta \approx .09-.13$ range, and the interaction in the $\beta \approx .07-.10$ range. Finally, in a behavioral subset ($n = 94$) where impression-normalized engagement data have been available for the same communication window, perceived credibility (a subdimension of the effectiveness construct) has correlated positively with engagement rate ($r = .29, p = .004$), and models that have included this behavioral proxy have reproduced the pattern of coefficients observed in the full perceptual sample, reinforcing the substantive interpretation of the Likert-based findings.

Sample and Case Characteristics

Table 3. Sample and Case Characteristics (Figure-style name)

Attribute	Category	Count (n=238)	Percent
Sector	Manufacturing	57	23.9%
	Services	74	31.1%
	Finance	45	18.9%
	Technology	43	18.1%
	Other	19	8.0%
Geographic scope	Domestic	67	28.2%
	Multinational	171	71.8%
Firm size (FTE)	< 250	59	24.8%
	250–999	66	27.7%
	1,000–4,999	61	25.6%
	$\geq 5,000$	52	21.8%
Respondent roles	ESG/Sustainability	99	41.6%
	Corp. Comm/Marketing	88	37.0%
	Analytics/Insights	51	21.4%
Respondents per firm	One	163	68.5%
	Two	52	21.8%
	Three+	23	9.7%
Data quality checks passed	Attention checks	238	100%
	Time threshold	228	95.8%
	Pattern screening	232	97.5%

The composition of the sample has reflected the multi-industry, multi-role strategy that the study has specified in the methods, and Table 4.1 has summarized these characteristics to document external heterogeneity and internal data quality. Sectoral representation has been balanced across services (31.1%), manufacturing (23.9%), finance (18.9%), and technology (18.1%), with another category (8.0%) capturing organizations in public/nonprofit and diversified holdings. This distribution has ensured that the models have not been driven by a single industry logic and that subsequent fixed-effects checks have been meaningful. Geographic scope has been skewed toward multinationals (71.8%), which has aligned with the inclusion criterion that respondents have maintained active ESG communication; larger geographic footprints have typically required more formalized disclosure and analytics support, and the sample has captured that reality. Firm size bands have been deliberately varied, with roughly a quarter of cases in each band; this spread has allowed the log(employees) control to function as intended, and it has reduced the risk that size-related communication infrastructure has confounded the focal estimates. Role coverage has been central to case credibility: 41.6% of respondents have sat in ESG/sustainability positions, 37.0% in corporate communications or marketing, and 21.4% in analytics

or insights roles. This distribution has provided both content and analytical perspectives on ESG communication, and the presence of analytics professionals has enabled more precise reporting on capability items. While 68.5% of firms have provided a single informant, 31.5% have provided two or more; for multi-informant firms, interrater agreement statistics (reported in the measurement appendix) have supported aggregation for the majority of those cases, and dissenting cases have been handled per the analysis plan. Data quality metrics have indicated that the fielding controls have functioned as designed: every retained case has passed attention check items; 95.8% have exceeded the soft time threshold, suggesting considered responses; and 97.5% have passed pattern-screening (e.g., no invariant use of a single Likert anchor). These safeguards have supported the reliability of the Likert-type measures that underpin the main variables. Together, the profile in Table 4.1 has shown that the dataset has combined breadth (industries, sizes, geographies) with depth (role diversity and multi-informant coverage) and that the quality filters have preserved a robust base for the descriptive, correlational, and regression analyses that follow.

Descriptive Statistics

Table 4. Descriptive Statistics and Scale Reliability (Likert’s 5-Point Scales; Figure-style name)

Construct	Scale Type	Items	Mean	SD	Skew	Kurtosis	Cronbach’s α
Business Analytics Capability (BA_Cap)	Likert 1-5	20	3.42	0.71	-0.21	-0.38	.90
Advanced Analytics Use (Adv_Analytics)	Index (z)	3	0.01	0.98	-0.05	-0.12	
Message Transparency/Quality (ESG_Trans)	Likert 1-5	12	3.58	0.65	-0.27	-0.31	.88
ESG Communication Effectiveness (Comm_Eff)	Likert 1-5	14	3.46	0.68	-0.19	-0.47	.92
ESG Performance (ESG_Perf)	Rating composite (z)		0.00	0.98	0.03	-0.09	
Controls: Comms Budget Intensity	5-pt ordinal		3.02	1.08	-0.06	-0.71	

Table 4 has presented central tendency and dispersion for the focal constructs, all anchored on Likert’s five-point scale except the standardized indices. Business Analytics Capability has averaged 3.42 (SD 0.71), indicating that, on balance, organizations have reported moderately mature capabilities across data governance, skills, tooling, integration, and experimentation. The negative skew has been slight, which has suggested that extreme high-capability responses have not dominated the distribution. The Advanced Analytics Use index has been constructed as a standardized composite across the presence of predictive modeling, causal testing/experiments, and automation; by design the mean has approximated zero (SD \approx 1). The spread in this index has signaled heterogeneity in sophistication: roughly one-third of firms have scored above +0.5 SD, whereas another third have clustered around the mean, reflecting mixed adoption of advanced methods. Message Transparency/Quality has shown a higher mean (3.58) than capability, implying that respondents have perceived their communications as somewhat clearer, more specific, and more balanced than the underlying analytics infrastructure might suggest. This pattern has been consistent with qualitative field knowledge in which editorial standards and disclosure templates have matured rapidly, sometimes outpacing analytics process standardization. The dependent construct, ESG Communication Effectiveness, has averaged 3.46 (SD 0.68), with reliability ($\alpha = .92$) at a high level; subdimensions (clarity, credibility, trust impact, and engagement intent) have each exhibited $\alpha \geq .80$ (not shown), supporting the use of a composite score on the five-point metric. The standardized ESG Performance variable has centered near zero, with an SD of 0.98, confirming that the merge from external ratings and internal composites has produced the intended scale for moderation analysis. Distribution diagnostics (skew/kurtosis) have been within conventional thresholds for OLS assumptions, and graphical checks (not shown) have supported approximate normality for the Likert composites. Reliability coefficients have exceeded .88 for all multi-

item scales, which has matched the pre-registered thresholds and has reinforced confidence in subsequent correlation and regression estimates. Overall, Table 4.2 has indicated that the constructs have possessed adequate variance and reliability on the five-point anchors, establishing a solid base for inferential analysis.

Correlation Matrix

Table 5. Zero-Order Pearson Correlations (Figure-style name)

Variable	1	2	3	4	5
1. BA_Cap (1-5)					
2. Adv_Analytics (z)	.27***				
3. ESG_Trans (1-5)	.35***	.19**			
4. Comm_Eff (1-5)	.41***	.27***	.49***		
5. ESG_Perf (z)	.29***	.22***	.26***	.33***	

n = 238; two-tailed tests; *p* < .01, **p* < .001.

The zero-order Pearson correlations reported in Table 5 have provided a strong preliminary picture of the relationships among the study's focal constructs and have aligned well with the theoretical expectations guiding the analysis. ESG Communication Effectiveness has emerged as the central outcome, correlating positively with all predictors, which has reinforced its conceptual role as the measure of how well organizations succeed in their ESG messaging. The strongest observed bivariate relationship has been with Message Transparency/Quality ($r = .49$, $p < .001$), suggesting that stakeholders place particular value on clarity, specificity, balance, and verifiability when evaluating ESG communications. This finding has underscored the notion that substantive disclosure, rather than superficial claims, resonates most effectively with audiences—a conclusion later supported by the multivariate regression results. Business Analytics Capability has also shown a robust positive correlation with communication effectiveness ($r = .41$, $p < .001$), pointing to the importance of systematic data governance, analytical skill sets, and cross-functional integration in enhancing message design and credibility. This result has served as initial evidence for the first hypothesis, which anticipated that organizations with stronger analytics infrastructures would report more impactful ESG communications.

Advanced Analytics Use has demonstrated a smaller but meaningful positive association with communication effectiveness ($r = .27$, $p < .001$), consistent with the expectation that predictive modeling, experimental platforms, and automated decision-support provide incremental advantages above foundational analytics. Importantly, the correlations among predictors themselves have remained moderate, with values such as the relationship between Business Analytics Capability and Message Transparency/Quality ($r = .35$, $p < .001$), indicating that while these constructs are related, they are not redundant. This has reduced concerns that subsequent regression analyses might suffer from multicollinearity, a point confirmed by diagnostic checks where variance inflation factors remained well below the conventional threshold of 5 (in this case, consistently under 3.0). The observed positive linkages with ESG Performance across all constructs (e.g., $r = .29$ with BA_Cap; $r = .33$ with Communication Effectiveness) have further highlighted that firms achieving higher external performance ratings also tend to display stronger analytics practices and more transparent communication strategies—an alignment that reflects broader organizational maturity. Beyond the numerical results, the pattern of differentiated magnitudes has suggested that respondents have not simply rated all dimensions positively out of acquiescence bias. The fact that Message Transparency/Quality has correlated more strongly with effectiveness than capability or advanced use implies that stakeholders have discriminated among dimensions and that transparency carries distinctive weight in evaluations of ESG messaging. Procedural remedies, such as reverse-coded items and varied scale anchors, alongside statistical checks, have helped mitigate concerns of common-method variance, bolstering the interpretation that these relationships reflect substantive

organizational realities rather than methodological artifacts. Moreover, nonparametric Spearman correlations (not shown) have reproduced the same ordering of effect sizes, providing robustness across correlation methods. Taken together, the results of Table 5 have mapped a logically consistent network of associations: business analytics and transparency have each made meaningful contributions, advanced analytics has offered incremental gains, and ESG performance has interwoven positively with all predictors. This foundational matrix has not only validated the theoretical expectations but also set the stage for the hierarchical regression analyses, where the unique contributions and interaction effects of these predictors could be systematically disentangled and tested.

Regression Results (Primary & Moderation)

Table 6. Hierarchical OLS Models Predicting ESG Communication Effectiveness (Figure-style name)

Predictor	Model 1 Controls	Model 2 + BA_Cap	Model 3 + Adv_Analytics	Model 4 + ESG_Perf & Interaction	Model 4+ + ESG_Trans (Assoc.)
Intercept	3.06*** (0.12)	3.06*** (0.11)	3.05*** (0.11)	3.04*** (0.11)	3.02*** (0.10)
BA_Cap (centered)		.34* (0.05)	.32* (0.05)	.31* (0.05)	.24* (0.05)
Adv_Analytics (centered z)			.11 (0.04)	.10 (0.04)	.08 (0.04)
ESG_Perf (centered z)				.18* (0.05)	.14* (0.05)
BA_Cap × ESG_Perf				.09 (0.04)	.07 (0.04)
ESG_Trans (centered)					.22* (0.05)
Controls (industry, size, age, region, budget)	Included	Included	Included	Included	Included
R ² / Adj. R ²	.12 / .09	.26 / .23	.28 / .25	.295 / .278	.335 / .319
ΔR ² vs previous		+.14*	+.02	+.015	+.040*
Max VIF	2.7	2.8	2.9	3.0	3.1

Cells show standardized β (robust SE). $p < .001$, $p < .01$, $p < .05$.*

The hierarchical estimates in Table 6 have demonstrated that analytics capability, advanced analytics, and ESG performance have each contributed uniquely to explaining variance in ESG Communication Effectiveness on the five-point Likert scale. Model 1 has established a controls baseline ($R^2 = .12$), indicating that industry, size, age, region, and communications budget intensity have accounted for a modest portion of variance. Adding Business Analytics Capability in Model 2 has produced a sizable increment ($\Delta R^2 = .14$), with a standardized coefficient of $\beta = .34$ ($p < .001$). Given the scale's SD (0.68 from Table 4.2), this effect has suggested that moving one SD on capability has corresponded to roughly .23–.25 Likert points in perceived effectiveness material in managerial terms. When Advanced Analytics Use has entered in Model 3, the coefficient $\beta = .11$ ($p < .01$) has indicated incremental explanatory power over and above foundational capability and controls ($\Delta R^2 = .02$). This result has been consistent with the proposition that predictive modeling, causal testing, and automation have produced marginal gains in communication outcomes beyond the lift provided by general analytics maturity. In Model 4, the inclusion of ESG Performance ($\beta = .18$, $p < .001$) and the BA_Cap × ESG_Perf interaction ($\beta = .09$, $p < .05$) has shifted the total R^2 to .295 (adj. .278), confirming that the effectiveness benefit of analytics capability has been stronger among higher-performing firms. Simple-slopes (reported in the narrative earlier) have shown that capability has remained positive across the ESG performance distribution but has been steepest at +1 SD of performance. Finally, Model 4+ has added

the associative Message Transparency/Quality regressor, which has yielded $\beta = .22$ ($p < .001$) and an additional ΔR^2 of .04. This association has not been framed as mediation in the primary test but has clarified that transparency/quality has co-moved with effectiveness net of analytics and performance an expected and substantively meaningful pattern in ESG contexts. Diagnostics have been satisfactory across models: maximum VIFs have hovered near 3, robust standard errors have addressed residual heteroskedasticity detected in baseline checks, and re-estimation after removing flagged high-leverage cases (not shown) has left the signs and magnitudes substantively unchanged. Collectively, Table 4.4 has provided convergent evidence that capability, advanced methods, and actual ESG outcomes have each mattered for how effective stakeholders have rated ESG communication on a five-point scale.

Robustness and Sensitivity Analyses

Table 7. Robustness Specifications (Figure-style name)

Specification	BA_Cap β	Adv_Analytics β	ESG_Perf β	Interaction β	Notes
(A) Industry Fixed Effects	.30*** (0.06)	.09* (0.04)	.17*** (0.05)	.08* (0.04)	Sector FE replace dummies
(B) Cluster-Robust SE by Industry	.31*** (0.07)	.10* (0.05)	.18*** (0.06)	.08* (0.04)	SE clustered (K=5)
(C) Rank-Based Regression	.29*** ()	.09** ()	.16*** ()	.07* ()	Huber-robust scores
(D) Alt. Adv_Analytics (Reflective Scale)	.31*** (0.05)	.12** (0.04)	.18*** (0.05)	.08* (0.04)	Scale $\alpha = .78$
(E) Excluding High-Leverage Cases (n=235)	.32*** (0.05)	.10** (0.04)	.18*** (0.05)	.09* (0.04)	Cook's D > 4/n removed
(F) Behavioral Subsample (n=94)	.28** (0.09)	.11* (0.05)	.15** (0.06)	.07† (0.04)	Includes engagement rate control

Cells show standardized coefficients (robust SE where applicable). † $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

The robustness program in Table 4.5 has examined whether the primary conclusions have depended on modeling choices, operational definitions, or distributional assumptions. Panel (A) has replaced industry dummies with industry fixed effects, absorbing all unobserved, time-invariant sector heterogeneity; coefficients for BA_Cap (.30*), Adv_Analytics (.09*), ESG_Perf (.17*), and the interaction (.08*) have remained significant and comparable in magnitude to the main specification, indicating that the results have not been artifacts of sector composition. Panel (B) has addressed potential intra-industry correlation by clustering standard errors at the industry level; while standard errors have widened modestly (as expected with K=5 clusters), inferences for the focal terms have remained intact. Because residual diagnostics have indicated mild non-normality in some models, Panel (C) has estimated a rank-based regression with Huber-robust scores. The coefficients have tracked the OLS pattern closely, reinforcing that the linear relationships have been robust to heavy-tailed errors. A common sensitivity in this domain concerns the operationalization of advanced methods; Panel (D) has therefore substituted a reflective scale ($\alpha = .78$) for the formative index. The Adv_Analytics coefficient has remained positive and significant (.12), suggesting that the incremental effect has reflected underlying intensity rather than a modeling artifact of index construction. Panel (E) has removed the three high-leverage cases flagged in influence diagnostics (Cook's D > 4/n). The resulting coefficients have been nearly unchanged, indicating that no single case has driven the overall pattern. Finally, Panel (F) has focused on a behavioral subsample (n = 94) in which impression-normalized engagement data have been available; adding that engagement control has not disrupted the focal coefficients, though as anticipated with reduced n the interaction has been marginal († $p < .10$). The persistence of signs and relative magnitudes across all six robustness views has strengthened confidence that the main findings have been substantively stable: higher Business Analytics Capability has been associated with higher ESG Communication Effectiveness on a five-point scale; Advanced Analytics Use has added incremental explanatory power; ESG Performance has been positively related to effectiveness; and the capability × performance interaction has indicated that capability has paid larger communicative

dividends where performance has been stronger.

DISCUSSION

The study has provided convergent evidence that business analytics capability (BA_Cap) has been positively associated with ESG-oriented brand communication effectiveness on a five-point Likert scale, with incremental gains from advanced analytics (predictive modeling, causal testing, automation) and a strengthening of the capability–effectiveness link at higher levels of organizational ESG performance. These patterns are consistent with the view that analytics functions as a strategic, integrative resource bundle data governance, skills, tooling, and experimentation that enhances message design and evaluation (Akter et al., 2016; Gupta & George, 2016). Our results have also indicated that transparency/quality of messaging specificity, balance, and verifiability tracks closely with effectiveness, echoing communication studies that tie clearer, more credible disclosures to stronger stakeholder responses (Iacobucci et al., 2019; Lock & Seele, 2016). The moderation by ESG performance aligns with signaling theory: when underlying performance is stronger, the marginal informativeness and credibility of analytics-enabled messages are higher because signals are costlier to mimic and more readily verified (Spence, 1973). Put differently, analytics appears to amplify not substitute for substantive ESG outcomes. The regression hierarchy has revealed that capability delivers the largest share of explained variance among focal predictors, advanced methods add meaningful but smaller increments, and the performance context conditions the payoff to capability. This stacked structure resembles the analytics maturity staircase in marketing descriptive → diagnostic → predictive/causal where the foundational layers must be present for higher layers to yield consistent returns (Michelon et al., 2015; Petrescu et al., 2020). Finally, the behavioral subset, where perceived credibility correlated with engagement rate, has reinforced a dual-pathway account in which perceptions explain why communication works and behavior confirms that it works (Kim, 2017; Du & Yu, 2020). Together, these findings portray ESG communication effectiveness as an outcome of fit among capability, credible performance, and high-quality disclosure design.

Prior work has emphasized that report readability, balance, and third-party assurance affect credibility and investor processing of sustainability information (Lock & Seele, 2017; Scherer & Palazzo, 2011). Our results converge with this stream by showing a strong association between message transparency/quality and perceived effectiveness, but they extend it by locating transparency within an analytics-enabled operating system that links listening, testing, and evaluation to disclosure decisions. Studies have cautioned that some CSR/ESG reports exhibit impression management dense, complex language and selective framing that can impede understanding or mask negative aspects (Cho et al., 2015). In our sample, transparency has remained a robust correlate even after controlling for analytics and performance, suggesting that stakeholders continue to reward specificity and balance over rhetorical polish alone. Experimental evidence with professional investors has shown that independent assurance increases the weight assigned to sustainability information (Reimsbach et al., 2017), and cross-country archival work has documented that assurance prevalence correlates with improved information environments (Simnett et al., 2009). While we have not directly estimated assurance effects, the moderation by ESG performance is compatible with these results: stronger performance environments typically co-travel with higher verification intensity and better internal controls, which, coupled with analytics, yield messages that are easier to trust. Social media research has found that one-way CSR broadcasting suppresses dialogic engagement (Morsing & Schultz, 2006). Our capability findings add a mechanism: organizations with routinized analytics issue detection, causal testing, and rapid evaluation are structurally better positioned to sustain two-way interactions without losing coherence or credibility. In short, the present study supports and extends the communication-quality literature by demonstrating that analytics maturity provides the scaffolding that turns credibility principles into repeatable communicative practice.

Evidence from marketing and information systems has long linked analytics capability to superior performance, conditional on alignment, culture, and resource orchestration (Germann et al., 2013; Lock & Seele, 2016). Our results reproduce this association in the ESG communication domain and add two refinements. First, we have shown that foundational capability (governance, integration, skills, experimentation culture) carries most of the explanatory weight relative to advanced methods consistent with maturity models that warn against “tool-first” strategies (Holsapple et al., 2014; Li &

Kannan, 2014). Second, we have observed a contextual payoff: capability returns are larger when ESG performance is stronger, echoing stakeholder and legitimacy perspectives that credible, verifiable claims travel further in evaluative markets (Donaldson & Preston, 1995; Suchman, 1995). This resonates with research showing that corporate associations shape consumer judgments (Brown & Dacin, 1997) and that CSR fit and authenticity are critical for intentions (Becker-Olsen et al., 2006). On the listening side, the positive relationship between capability and effectiveness aligns with findings that user-generated content and online word-of-mouth have informational content that markets incorporate (Tirunillai & Tellis, 2012): organizations that can systematically capture and model such signals are better able to tailor transparent disclosures that stakeholders recognize as responsive. Complementing archival work linking readability and tone to value relevance (Du et al., 2010), the present study demonstrates that the capacity to instrument and test ESG messages rather than only their observable linguistic attributes has mattered for perceived effectiveness. Thus, relative to prior work, our contribution is to thread together analytics maturity, message design quality, and performance context into a single explanatory account for ESG communication outcomes.

The findings have several practice-facing implications. For CISOs and data governance leaders, ESG communication effectiveness depends on data lineage, integrity, and access controls because claims often draw on operational systems (emissions, DEI, supply chain audits). Establishing assurable data pipelines source-of-truth registries, automated collection from operational systems, audit trails, and separation of duties has reduced integrity risk and enables external assurance (Simnett et al., 2009). For data/ML architects, the returns to capability over tools suggest prioritizing the “boring” platforms first: a governed metrics layer (semantic models, conformed dimensions), experimentation infrastructure for A/B and quasi-experiments, and feature stores that harmonize audience/issue features across channels (Mikalef et al., 2019). Given the moderation by ESG performance, architects should co-design with sustainability teams to align metric definitions (e.g., Scope 1–3 calculation methodologies) and to publish model cards and data sheets that disclose limitations concretizing credibility (Lock & Seele, 2017). For communications leaders, three moves follow. First, tie editorial briefs to materiality maps and to measurable hypotheses (“this disclosure reduces ambiguity on target X for audience Y”), then insist on testable variants. Second, standardize a transparency checklist time-bound targets, baselines, negative aspects acknowledged, method links and require links to assured metrics or methodology notes (Cho et al., 2015). Third, operationalize closed-loop learning: integrate listening (issue detection), testing (message variants), and outcomes (perception + behavior) in one dashboard, with RACI for who acts on signals. Across all roles, privacy- and ethics-by-design guardrails must be explicit differential access, minimization, and logging to protect stakeholder data while preserving measurement fidelity (Wedel & Kannan, 2016). In combination, these steps convert analytics maturity into durable communicative advantage when performance substantiates claims.

Theoretically, the study refines the ESG communication pipeline by specifying where analytics exerts influence and how performance context shapes signal credibility. We propose a three-stage refinement: (i) Sensing/Materiality) capability enables continuous detection and prioritization of stakeholder concerns, thereby improving the selection of message content (Day, 2011; Mikalef et al., 2019); (ii) Design/Testing) experimentation culture and predictive modeling translate concerns into alternative framings with measurable hypotheses, enhancing construction quality (Li & Kannan, 2014; Wedel & Kannan, 2016); (iii) Evaluation/Learning) governed outcome metrics and triangulated perceptions/behaviors tighten evaluation and support knowledge codification. ESG performance acts as a signal amplifier in this pipeline: where outcomes are stronger, the marginal informativeness of a high-transparency, analytics-tested message is higher (Li & Kannan, 2014; Wedel & Kannan, 2016). This specification integrates legitimacy and signaling perspectives by positing that analytics maturity reduces noise and aligns communicative acts with institutionalized expectations for transparency, while performance confers the costliness that underwrites credible signals (DiMaggio & Powell, 1983). The model also links micro-level message features (clarity, balance, verifiability) to macro outcomes (reputation, market reactions) through measurable intervening perceptions (knowledge, trust), aligning with process models of CSR communication (Kim, 2019) and value-relevance evidence on disclosure attributes (Du et al., 2010). By centering capability as a configurational resource rather than

as a single technology the study invites configurational theorizing (capability + performance + transparency) where specific combinations yield superior outcomes, thereby extending resource-based arguments into the ESG communications arena (Akter et al., 2016).

Several constraints delimit inference. First, the design has been cross-sectional; while we have implemented robustness checks and triangulated a behavioral subsample, causal direction cannot be definitively established firms with effective communication may be more likely to invest in analytics, not only the reverse (Germann et al., 2013). Longitudinal field experiments would address this asymmetry. Second, measures have combined perceptual Likert scales with standardized indices; although reliability and validity diagnostics have been strong, common-method variance remains a possibility, even with procedural/statistical remedies (Lock & Seele, 2016). Third, ESG performance has been normalized across providers; differences in methodology could introduce noise that attenuates moderation estimates (Kotsantonis et al., 2016). Fourth, assurance was not modeled explicitly; given evidence that assurance influences credibility and investor processing (Simnett et al., 2009), future models should include assurance level and provider type as moderators or instruments. Fifth, the sample skews multinational; small, domestic organizations with emergent ESG programs may exhibit different capability–effectiveness dynamics or different channel mixes (Morsing & Schultz, 2006). Finally, our advanced analytics construct aggregates predictive, causal, and automation practices; precision could improve by distinguishing their separate contributions and by incorporating model quality indicators (e.g., lift, ATE estimates with overlap diagnostics). These limitations temper causal claims but do not undermine the central pattern: capability and transparent, evidence-rich design have co-varied with higher ESG communication effectiveness, especially where performance has been stronger.

Three lines of inquiry follow. (i) Causal identification and experiments). Randomized message tests at scale varying transparency features (specificity, negative acknowledgement), assurance badges, and data-link granularity can estimate average and heterogeneous treatment effects on trust and engagement; pairing these with firm-level instruments (e.g., exogenous audit adoption) would strengthen causal claims (Li & Kannan, 2014; Scherer & Palazzo, 2011). (ii) Mechanism unpacking). Multi-method designs that combine surveys with process tracing in analytics pipelines could quantify how much of capability’s effect flows through better content selection (materiality alignment), framing (clarity, balance), or targeting (audience fit). Incorporating validated credibility scales and knowledge measures would tighten mediation tests (Lyon & Montgomery, 2015). (iii) Institutional and assurance contexts). Cross-country comparisons featuring regulatory shocks or mandatory reporting introduce natural experiments to test how coercive and normative pressures shape the analytics–communication link (DiMaggio & Powell, 1983). Further, modeling assurance (presence, level, provider) as a moderator of analytics returns could clarify whether external verification complements or substitutes for analytics maturity in driving perceived effectiveness (Reimsbach et al., 2017). Additional opportunities include the role of readability engineering (sentence-level clarity, data-footers, provenance links) in digital channels; the interplay of privacy-by-design with measurement richness (Wedel & Kannan, 2016); and the financial materiality of ESG message variants tracked through event-study designs (Du & Yu, 2020). Advancing these threads would convert the present correlational map into a guidebook of causal levers what to measure, test, and change so that organizations can systematically translate analytics capability and credible performance into communicative effectiveness that stakeholders can recognize and verify.

CONCLUSION

The study concludes that ESG-oriented brand communication is most effective when three ingredients align: (1) a robust business analytics capability that institutionalizes high-quality data, cross-functional teaming, and a culture of experimentation; (2) message architectures that privilege transparency and verifiability clear targets, baselines, and balanced disclosure of progress and challenges; and (3) credible ESG performance that lends costliness and therefore believability to the claims being communicated. Across a multi-industry, cross-sectional, multi-case sample, analytics capability has explained the largest share of variance in Likert-rated communication effectiveness, with advanced practices predictive modeling, causal testing/A-B experimentation, and automation adding incremental lift beyond foundational governance, skills, and tooling. The payoff to capability has been context-sensitive: firms with stronger ESG performance have realized steeper returns to analytics, indicating

that analytical precision amplifies the credibility of already substantive outcomes rather than compensating for their absence. In parallel, message transparency/quality has shown a stable, positive association with perceived effectiveness independent of analytics and performance, underscoring that evidence-rich content remains a non-negotiable pillar of persuasion and understanding. Psychometric checks have supported measurement integrity, model diagnostics and robustness analyses have sustained the core pattern across specifications, and a behavioral subsample has linked perceived credibility to engagement, aligning perceptions with observable responses. Taken together, these results integrate previously disparate insights into a coherent operating model: sensing (listening and materiality analytics) feeds design (transparent narratives tested through experiments and predictive tools), which in turn feeds evaluation (perception and behavior metrics with governance and audit trails), all conditioned by real performance that constrains and legitimizes communicative claims. For practitioners, the conclusion is pragmatic: invest first in governed data pipelines and cross-functional processes that shorten the loop from signal detection to message decision; codify a transparency checklist and link claims to traceable metrics; and align analytics roadmaps with ESG accounting so that what is measured, modeled, and messaged is consistent across systems of record. For scholars, the contribution is an integrated account in which analytics capability functions as a configurational resource whose value depends on transparent design choices and credible outcomes, offering a scaffold for causal tests that move beyond correlation. While the cross-sectional design limits causal certainty and the operationalization of advanced analytics aggregates heterogeneous practices, the convergent evidence across methods and checks strengthens confidence in the central claim: organizations that pair disciplined analytics with frank, verifiable ESG communication and that can point to underlying performance achieve higher effectiveness as judged by clarity, credibility, trust impact, and engagement intent. This synthesis positions analytics-enabled transparency not as a communications veneer but as an institutional capability that, when matched with real progress, reliably improves how stakeholders receive, evaluate, and act upon ESG information.

RECOMMENDATIONS

The study recommends that organizations operationalize ESG-oriented brand communication through a staged capability build that begins with governed data foundations and culminates in closed-loop learning across channels. First, formalize data governance and lineage for all ESG claims: appoint data owners for each metric (e.g., Scope 1-3, safety, DEI), register sources of truth, implement change logs, and maintain audit trails so that any published figure is traceable end-to-end. Second, establish a cross-functional operating model that joins Sustainability/ESG, Corporate Communications, Marketing, Analytics/BI, Legal, and IT Security through a RACI that clearly specifies who senses issues, who designs message variants, who approves evidence, and who publishes; bake this into a fortnightly cadence with pre-read dashboards. Third, build the analytics backbone before fancy tools: a semantic metrics layer (consistent definitions), a feature store for audience/issue attributes, and an experimentation platform to run A/B and quasi-experiments on disclosures, headlines, and evidence blocks. Fourth, codify and enforce a transparency checklist for every disclosure: time-bound target + baseline, method link or footnote, acknowledgement of constraints or negative variance, and where feasible third-party assurance or verification badges; require that social posts and microsites inherit the same evidentiary references to prevent greenwashing drift. Fifth, align performance accounting with messaging by integrating the ESG controller's work with comms briefs; preview upcoming KPI releases with communications so that message design is synchronized with report cycles and regulatory calendars. Sixth, institute measurement and learning that mixes perception and behavior: a lightweight Likert 1-5 stakeholder pulse (credibility, clarity, trust impact, intent to engage) after major ESG announcements; channel analytics normalized by impressions; and simple-slopes/segmentation views that reveal where messages resonate (industry, region, stakeholder type). Seventh, professionalize readability and accessibility: adopt plain-language standards, narrative templates that surface numbers early, alt-text for figures, localization guidelines for key markets, and a glossary for materiality topics; test comprehension alongside click metrics. Eighth, harden privacy and ethics-by-design: minimize personal data, set role-based access, log model use, and publish brief data sheets/model cards for any predictive scoring used in audience targeting; conduct bias screens before deployment. Ninth, invest in people and rituals: upskill comms teams in basic statistics and experiment interpretation, coach

sustainability leads on narrative clarity, and grant analysts editorial seats so evidence influences the creative process; run quarterly post-mortems to harvest learnings into a playbook. Tenth, plan for assurance escalation: start with internal controls and limited assurance on the most decision-relevant metrics, then expand coverage as data maturity grows; make assurance scope explicit in communications to calibrate stakeholder expectations. Finally, structure funding and OKRs around capability outcomes, not tool counts: targets could include percentage of claims with traceable baselines, share of ESG posts with experiment results, average credibility score ≥ 4.0 , and reduction in ad-hoc data requests; review these in an executive dashboard so leadership sees ESG communication as a governed, test-and-learn system that compounds over time.

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