INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN ACCOUNTING, FINANCE AND MANAGEMENT SCIENCES

OPEN ACCESS JOURNAL

Vol 16, Issue 4, (2026) E-ISSN: 2225-8329

The Role of Cloud Computing and eXtensible Business Reporting Language (XBRL) in Reducing Greenwashing: The Mediating Role of Sustainability Disclosure Quality

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DOI Link: http://dx.doi.org/10.6007/IJARAFMS/v16-i4/28241

Published Online: 08 November 2026

Abstract

Sustainability reporting enables companies to communicate their environmental and social performance to external stakeholders. However, stakeholders often lack sufficient, comparable, and reliable information, as increased detail does not always enhance report trustworthiness. Some companies exploit this by making selective or vague claims that are difficult to verify, increasing greenwashing risk. This paper examines whether digital reporting tools, particularly cloud computing and eXtensible Business Reporting Language (XBRL), can reduce greenwashing by improving disclosure quality rather than quantity. Drawing on information asymmetry, signaling, and legitimacy theories, the study develops an integrated framework. We propose that cloud computing and XBRL enhance access, integration, standardization, and usability of sustainability data, leading to higher disclosure quality. The model demonstrates that improved disclosure quality reduces the likelihood of symbolic or opportunistic reporting. Within this framework, disclosure quality is the primary factor in preventing greenwashing by making misleading claims easier to detect. This study contributes by integrating digital tools into a unified explanation for reporting quality, identifying disclosure quality as the main barrier to corporate decoupling, and presenting a framework suited to Asia's dynamic digital and regulatory landscape.

Keywords: Cloud Computing, Extensible Business Reporting Language (XBRL), Greenwashing, Quality of Sustainability Disclosures, Digital Reporting, Corporate Transparency

Introduction

Sustainability reporting is challenging, but it is necessary to ensure regulatory compliance and meet stakeholders' expectations about environmental sustainability (e.g., climate change, human rights). Sustainability reporting is the process of reporting on an organization's

environmental, social, and governance (ESG) impacts, practices, and overall performance to its stakeholders, including investors, regulators, and consumers (Hummel & Schlick, 2016). While the ability to make such disclosures has grown over time, doubts remain about how trustworthy these reports are. Mismatch between reported claims and actual practices disturbs trust, narrows down the investment options, and tarnishes reputations (Delmas & Burbano, 2011). Then the main question is not whether disclosures at all, but whether stakeholders trust that disclosures are reliable, comparable, and useful. As organizations adopt digital tools such as cloud computing and eXtensible Business Reporting Language (XBRL), they must assess whether these technologies reduce the risk of disclosing misleading or low-quality information (Sheikh, 2025). While much research has focused on explaining drivers and impacts of sustainability disclosures, several gaps remain. Principal stakeholders lack visibility into companies' activities and data measurement; they mainly rely on companies' reports. While quantity of disclosure and quality of disclosure are two clearly different constructs, the latter can be characterized by several criteria, i.e. reliability, verifiability, comparability, consistency, timeliness and specificity. In this paper there are three theories that are covered to address the topic, the next part will be the theories which are covered in this study.

Signaling theory explains the motivation for disclosure but its value for outsiders, however, is determined by their ability to assess the accuracy of disclosed information(Connelly et al., 2011; Spence, 1973). Based on legitimacy theory, companies' sustainability reports may become purely symbolic if they are selectively disclosed (Deegan, 2002; Suchman, 1995). Together, these theories support the need for digital tools that improve the credibility and functionality of sustainability information. Although structured reporting shows its benefits, only few studies illustrate the detailed and explicit paths through which cloud computing and XBRL improve disclosure quality to mitigate greenwashing (Sun et al., 2025; Xu & Li, 2026). There is limited investigation into the synergistic impacts of cloud and XBRL on the quality of disclosure as well as symbolic reporting. The research specifically aims to investigate the following three questions: (1) Is cloud computing capability a key driver of sustainability disclosure quality? Impact of XBRL capability on sustainability disclosure quality (2) While conducting the literature review, three research questions were developed: (1) Does digital capabilities have a negative relationship with greenwashing risk? (2) Does disclosure quality interact with digital reporting capabilities and greenwashing risk? They create a theoretical model on disclosure quality and show how digital infrastructure serves to increase credibility via standardized formats. The research is significant because it moves the focus of the literature away from quantity of disclosure to quality of disclosure; it provides insight into how digital capabilities can affect disclosure quality; it demonstrates that as the quality of disclosure increases, the risks associated with "greenwashing" decrease.

Sustainability Disclosure Quality and Greenwashing

Sustainability disclosure quality reflects the extent to which reported information is accurate, complete, balanced, consistent, comparable, and verifiable. These will enable stakeholders to evaluate organizations' actual environmental, social, and governance (ESG) performance and make informed decisions (Hummel & Schlick, 2016; Michelon et al., 2015a). Based on that, disclosure quality differs fundamentally from disclosure quantity. Extensive reporting may offer limited informational value when organizations emphasize positive achievements, omit adverse outcomes, use ambiguous language, or provide insufficient evidence to

substantiate their claims. Therefore, greater disclosure volume does not necessarily translate into enhanced transparency or credibility (Michelon et al., 2015a). In addition, this terminology is especially relevant when analyzing greenwashing. Greenwashing is defined as an organization's attempt to use selective, overstated, deceptive or inadequate information to show a incorrect impression of their commitment to the environment (Moodaley & Telukdarie, 2023; Siano et al., 2017). Greenwashing occurs when a company's stated commitments to sustainability do not align with its operational practices. Therefore, evaluating a company's sustainability reports involves assessing whether the reported information is consistent with the company's actual performance rather than simply quantifying the amount of reported information (Hummel & Schlick, 2016). To ensure that a company's sustainability reports are believable, they must be based on documented data, consistent methods for collecting and measuring data, and documented evidence that verify the validity of the data.

Literature Review

Cloud Computing Ability: The Capacity in Architecture to Integrate Data in Real Time

Cloud computing capability is defined as an organization's architectural ability to continuously collect, process, integrate, and make available operational data which is relevant to sustainability across its various distributed business units in near real time, using a scalable, on-demand computing infrastructure that is accessed through networked service delivery (Armbrust et al., 2010; Marston et al., 2011a; Mell & Grance, 2011). This definition should be examined in three different dimensions.

First, the gathering of real-time data. Traditional methods of reporting provide periodic reporting of sustainability data usually once per year because of manual extraction of data from multiple operational systems, consolidating the data into spreadsheets, and requesting data from other departments (Adams & Frost, 2008). These methods create delays in providing timely reporting and allow for selective reporting. Cloud systems replace these methods with ongoing automatic data feeds from the operational systems, thereby eliminating delays in obtaining the data and reducing managerial discretion regarding which data is included in reporting (Lu et al., 2022; Unerman, 2014). Research indicates that this continuous automated flow of data effectively prevents retroactive fabrication of narratives; therefore, cloud-native data collection is viewed as a significant barrier to corporate greenwashing (Sun et al., 2025). Consequently, the reporting is based on current operational data rather than historical curated summaries.

Second, Cloud integration resolves discrepancies in definitions and creates integrated report inputs without requiring manual data consolidation (Garrison et al., 2012; Marston et al., 2011). This integration of different departments within an organization also resolves the problem of fragmented sustainability data across organizational silos. Organizations have used fragmentation of sustainability data to disclose selectively and produce incomplete reports (Cho et al., 2012). Recent studies demonstrate that high levels of digital integration between internal departments reduce the opportunity for structural decoupling (Xu & Li, 2026).

Third, scalability and on-demand access to infrastructure are two key advantages of cloud computing. An organization's ability to utilize cloud computing does not imply that it is

currently utilizing cloud services in a comprehensive manner. Many organizations will transfer their data to cloud-based systems; however, they will still rely upon legacy reporting systems which impede integration and restrict real-time data access (Loebbecke & Picot, 2015). Capability in this context refers to the effectiveness of organizations' utilization of cloud-based infrastructure to report on sustainability issues, and specifically the extent to which organizations' processes for gathering, storing, analyzing, and disseminating sustainability-related information are based upon the design principles of cloud-native applications rather than simply augmented with cloud-based technologies (Bharadwaj, 2000; Luo et al., 2018). Advanced cloud architecture provides organizations with substantial operational benefits through enforcing rigorous controls over compliance and continuous audit capabilities across organizational units (Xu & Li, 2026). The level of functional utilization of cloud computing as opposed to the level of adoption, will determine the quality of sustainability disclosures. Next will be XBRL capability and its ability to carry out mapping of the ESG.

XBRL Capability: The ability to carry out mapping of the ESG taxonomy in a machine-readable format

XBRL capability is defined as an organization's operational capacity to systematically map its environmental, social, and governance (ESG) data onto standardized, machine-readable digital taxonomies enabling disclosures to be electronically consumed, validated, compared, and audited by external parties without manual re-entry or interpretation (Boritz & No, 2008; Debreceny & Gray, 2001; Liu et al., 2014). This definition encompasses three operationally distinct components. First, XBRL mapping metrics is a difficult task because it requires cross-functional expertise at the intersection of sustainability measurement, accounting, and data architecture. It also brings definitional discipline to the reporting process, as each number reported must be associated with a specific, external definition and cannot be labeled using terms created by the company (Hodge et al., 2004; Yoon et al., 2011). The digital compliance systems necessitate that organizations possess strong metadata-mapping competence to avoid using vague, generic terminology (Sun et al., 2025). Organizations that have a high level of XBRL capability perform these types of mapping systematically and consistently throughout reporting periods. Conversely, organizations that have a low level of XBRL capability either fail to perform the mapping or perform it only superficially, producing tagged reports that officially comply with XBRL requirements but retain the flexibility of unstructured formats (Kim & Lee, 2025).

Second, the defining characteristic of XBRL structured disclosures is that they are immediately accessible for use in computational analysis. The corporate governance research indicates that the generation of machine-readable outputs reduces the amount of time required to perform external monitoring by several orders of magnitude. The use of machine-readable outputs removes the textual barriers that previously prevented opportunistic reporting behavior from being identified through the application of text mining analytical techniques (Sun et al., 2025; Xu & Li, 2026). As a result of this technology, the previously limited extent to which symbolic reporting could be scrutinized have been eliminated. Therefore, when a firm has a high level of machine-readable output generation capability, the firm's ESG metrics will flow without interruption into an automated verification system, which greatly increases the visibility of the firm's publicly stated claims.

Third, XBRL represents a bridge between the traditional separation of qualitative narratives written in human-readable formats and quantitatively formatted machine-readable data

structures; it does so by incorporating digital metadata tags directly into a single XHTML web document. Therefore, from a practical perspective, the integration of XBRL indicates that each public environmental or social statement made will be linked to an audited taxonomy definition located beneath the user interface provided by the web browser. The synchronization of these two elements will limit the amount of generalized qualitative boilerplate that can be used since each public statement will need to be quantitatively related to specific structured performance variables, thereby significantly increasing the risk of exposing manipulative signaling (Xu & Li, 2026). Next is the quality of sustainability disclosures compared to the quantity

The quality of sustainability disclosures compared to the quantity

Sustainability disclosure quality (SDQ) defines as to help reduce information asymmetries among stakeholders, as opposed to measuring SDQ through the volume of disclosed sustainability information (Hahn & Kühnen, 2013; Michelon et al., 2015). Sustainability disclosure should be measured based upon quality rather than quantity, another important assumption in the present study is that even though the amount of sustainability disclosure is growing, it does not imply that stakeholders are receiving more useful, reliable, or relevant information to assist them in making decisions. Although some companies may be able to create longer and more detailed sustainability reports, these reports do not necessarily make it possible for stakeholders to easily compare the reporting of different companies, verify the accuracy of the reporting, understand the content of the reporting, or relate the reported sustainability practices to actual sustainability performance (Hahn & Kühnen, 2013; Michelon et al., 2015).

Main goal of sustainability reporting is not just to provide more information to external stakeholders, also to minimize the information gap between the company and the information users, according to Asymmetry Theory. When additional reporting is mostly general statements, repetitive narrative, non-standardized metrics or only providing positive information, then increasing the quantity of reporting could have very little effect on reducing the asymmetry of information. In fact, if too much reporting is provided with no clear organization, then it can become more difficult for stakeholders to find the information that they need to evaluate whether the company is truly meeting its sustainability objectives. Thus, more reporting does not always equate to higher quality reporting (Hahn & Lülfs, 2014; Michelon et al., 2015).

Greenwashing Risk

Greenwashing as a strategy of strategic decoupling: the distinction between facade and core

The essential point is that taking up an institutional mandate form is often disconnected from how organizations operate. That is, although a formal policy may exist, the day-to-day operations continue as they always have. Therefore, the organizational front external manifestation of conformity developed and operated without regard for, and at times contrary to, the operational core of the organization (Meyer & Rowan, 1977; Weick, 1976). The structural base of greenwashing is a form of "decoupling" logic as applied to the environmental performance of firms. When a company announces a complete net zero commitment, supports a dedicated sustainability function within the company, produces an annual compliant ESG report, and continues to produce high levels of carbon-emitting products, but makes little or no operational changes to reduce emissions, then the company

did not fail at managing sustainability. Instead, the company was able to create a strategic disconnect between what they claim to do regarding the environment and what they actually do (Bothello et al., 2023; Meyer & Rowan, 1977). This is a calculated strategy that allows the company to meet institutional pressures for environmentally responsible behavior while at the same time protecting themselves from the financial costs associated with creating real environmental change.

Selective reporting of sustainability performance results is when a company reports only those portions of its overall sustainability performance that reflect positively upon the company (Cho & Roberts, 2010; Clarkson et al., 2008). When a company selectively reports on its sustainability performance, it doesn't create unreal news. Rather, selective reporting occurs through the deliberate choice not to report on certain aspects of the company's sustainability performance. This occurs because there is no requirement for companies to provide a complete picture of their sustainability performance. Therefore, a selective report can be used by a company to portray itself as having a strong commitment to sustainability when, in fact, the company has other significant areas of concern related to sustainability.

The symbolic separation of the organization's structure from its disclosures is what is called symbolic decoupling. This form of decoupling occurs when organizations establish sustainability governance structures such as ESG committees, environmental management systems, third-party certification programs, or sustainability-linked executive compensation, to demonstrate institutional commitment to sustainability but do so in a manner that does not connect them to the organization's operational decision-making (Boiral, 2007; Christmann & Taylor, 2006; Laufer, 2003). Each example illustrates a case of symbolic decoupling where there is a governance framework for sustainability established within the organization, however, there is no substantive operational connection between the governance framework and the organization's actions. Ashforth and Gibbs (1990), labeled this type of behavior over-legitimation and stated that over-legitimation represents an excessive amount of legitimation effort compared to actual performance. Therefore, they suggested that over-legitimation serves as an indicator of symbolic decoupling versus true organizational change.

Narrative obfuscation is the discursive aspect of greenwashing the use of vague, aspirational, technically imprecise, or strategically ambiguous language to provide an impression of environmental performance that can be tested by empirical means (Boiral, 2013; Cho & Roberts, 2010; Loughran & Mcdonald, 2016). Sustainability disclosure literature has well-documented the vocabulary of narrative obfuscation: words like "eco-friendly," "sustainable practices," "green initiatives," "carbon neutral journey," and "commitment to a better planet" are used frequently in ESG reports but do not provide much information (Diouf & Boiral, 2017). They indicate environmental orientation; however, they do not allow stakeholders to assess, challenge, or disprove environmental claims. Narrative obfuscation is preferred over silence because it provides a benefit to the reputation of the organization without requiring the organization to commit to any specific actions, a firm that does not speak out about their environmental performance is subject to criticism; a firm that speaks positively about their environmental values and provides little detail about their performance is able to gain goodwill (Delmas & Burbano, 2011; Marquis et al., 2016).

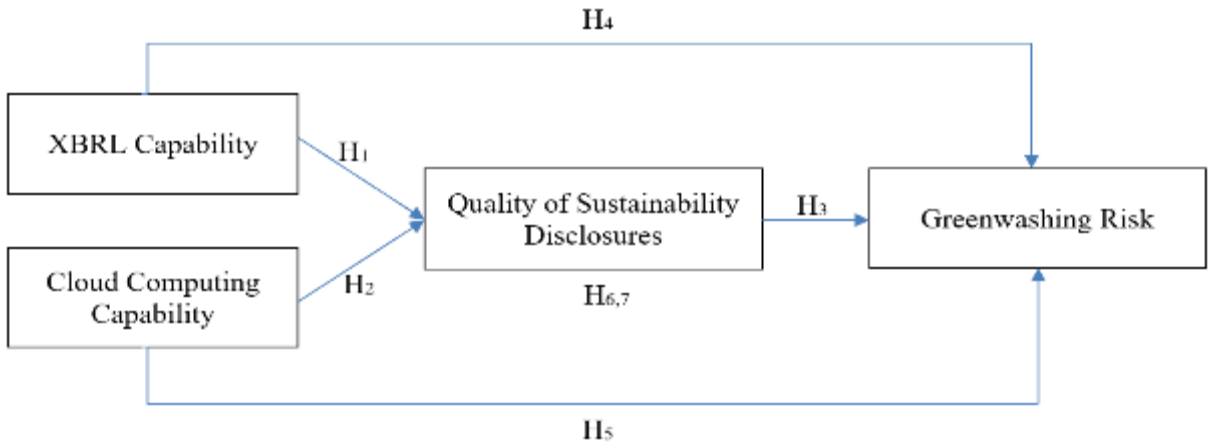
The Verification Gap: The Reason Why Greenwashing Risk Is Structurally Increased

Greenwashing risk increases significantly in settings with three structural characteristics: stakeholders have high costs to verify the accuracy of claims made by the firm; reporting forms used to report about sustainability performance make it difficult for independent auditors to systematically review them; and the regulatory structure of sustainability disclosure does not have the enforcement powers of the financial reporting system (Delmas & Burbano, 2011; Lyon & Maxwell, 2011; Marquis et al., 2016). When these conditions do not exist, stakeholders can verify the accuracy of claims made by the firm at low cost; when reporting forms used to report about sustainability performance are standardized; and when firms who do not comply with the standards set forth for sustainability reporting are held accountable, then the strategic calculus of "decoupling" changes dramatically. The costs associated with maintaining a false impression of environmental responsibility increase; and the potential benefits derived from actual environmental responsibility increase. The primary point of this subsection is the verification gap.

The analytical opaqueness of traditional corporate reporting methods exacerbates the problem. When corporate sustainability disclosures are presented in the form of unstructured textual narratives or unformatted PDFs, extracting data from such disclosures can be extremely time consuming and computationally intensive. Furthermore, such unstructured forms of disclosure serve to hide inconsistencies between what companies state they do and what they do, because they compel both the capital markets and regulatory authorities to utilize keyword searches rather than systematically validating claims made by companies. Current corporate accounting governance systems indicate that these unstructured disclosures help protect firms engaged in decoupled corporate behaviors from being detected unless there are strong internal digital control mechanisms in place to support such detection (Sun et al., 2025). As a result, greenwashing will continue to be very beneficial for companies since the visibility associated with environmental branding is much greater than the ability to detect greenwashing through automated processes. To address the issue of lack of verification, there needs to be a shift away from describing how to manage corporate disclosure and toward developing automated machine-readable data structures that will allow for automated algorithmic auditing of decoupled corporate behaviors (Xu & Li, 2026).

The Conceptual Model and Theoretical Framework

The conceptual model created for this research incorporates the theoretical structure developed in this section, to create a testable structural model. Based upon Information Asymmetry Theory, Signaling Theory, and Legitimacy Theory, the conceptual model indicates that the two different yet related types of digital reporting capabilities, Cloud Computing Capability (CCC) and XBRL Capability (XBRLC), are able to lower the greenwashing risk (GWR) via a main mediating mechanism; namely, the Quality of Sustainability Disclosures (SDQ).



An integrated theoretical perspective: information asymmetry, signaling, and legitimacy in digital corporate reporting

In order to understand how digital technologies such as cloud computing and eXtensible Business Reporting Language (XBRL) can reduce the risk of greenwashing, a multi-theoretical basis is necessary. Three complementary and mutually reinforcing theoretical approaches Information asymmetry theory, signaling theory, and legitimacy theory have been used to create a single conceptual framework for the current study. The theories do not function independently; they form an explanatory chain: the first identifies a structural problem that facilitates greenwashing; the second explains the communicative practices firms adopt to address it; and the third reveals the strategic incentives that determine whether such communication is genuine or misleading. Three complementary and mutually reinforcing theoretical will be explained next.

Information Asymmetry Theory: The Fundamental Structural Source of Greenwashing

The fundamental problem underlying greenwashing lies in information asymmetry. This concept was first introduced by Akerlof in 1970 in his seminal study on the "Market for Lemons," and Jensen and Meckling later developed it within the agency framework. Information asymmetry, as is well known, is the situation of an economic transaction where one party has more and better information than the other; opportunistic behavior is structurally built into the relationship. This imbalance is especially evident in corporate sustainability reporting. In contrast, financial data must have audit trails, follow standardized accounting frameworks, and generally be government-regulated (especially for publicly traded companies), whereas corporate sustainability data has historically been a black box to outsiders. Environmental performance metrics, estimations of carbon emissions, supply-chain practices and indicators for social governance are complicated and very technical. Firms commonly prepare these metrics (Marquis et al., 2016). Investors, regulators, civil society (mainly NGOs), and consumers are all considered to be informationally disadvantaged parties that do not have access to the source data or the technical capacity to interpret it in order to verify the claims companies make as they report their environmental and social performance. This asymmetry of information structurally enables greenwashing, as when verification is expensive, imperfect or virtually impossible, then a rational firm has little to fear in terms of reputational damage or regulatory backlash from overselling its greener practices (Lyon & Maxwell, 2011).

Cloud computing and XBRL directly respond to the information asymmetries present in the advancement of cloud-based digital corporate reporting today. Moreover, with cloud computing infrastructure, firms can now capture, integrate and process large volumes of sustainability-related operational data in near real-time while minimizing the temporal lag and selective filtering that characterize manual or siloed reporting systems (Marston et al., 2011). Through standardized tagging in machine-readable architecture, XBRL compliant sustainability disclosures can be electronically verified, compared across firms immediately since they are published electronically at the same time and analyzed by external automated tools without manual extraction of data (Debreceny & Gray, 2001; Liu et al., 2014). Recent empirical studies have shown that digital transformations reduce information asymmetry in a systematic manner, founded on integrated data governance structures to substantially close corporate information gaps and consequently mitigate structural opportunities for fraud regarding non-financial reporting (Sun et al., 2025; Xu & Li, 2026). Collectively, these digital capabilities reduce the information asymmetry between reporting firms and their stakeholders neutralizing the structural conditions in which greenwashing can go undetected. While information asymmetry theory focuses on the structural problem, Signaling Theory (Spence, 1973) describes how firms try to solve it, and this will be explained in the next section.

Signaling Theory: The Company's Effort to Communicate and the Problem of Reliability
Signaling theory, originally developed in the context of labor markets, suggests that the player with superior information the corporate managers will undertake credible actions to signal their private information to the party with inferior information. In corporate sustainability, the primary mechanism by which companies designate signals is disclosures environmental and social performance reports allowing these firms to demonstrate their commitment to responsible conduct; reduce perceived investment risk; and differentiate themselves from less responsible competitors (Connelly et al., 2011).

Signaling theory makes a fundamental distinction that is critical for the greenwashing story: by virtue of being effective, a signal must be reliable but also verifiable. Reliability relates to the degree to which a disclosure reflects the true situation at the firm it represents; verifiability refers to how easily an independent party can check accuracy (Connelly et al., 2011; Dye, 1985). Signals are credible in Spence's original model because they cost something to fake. However, unlike strong signals of technological infrastructure, which are costly in sustainability disclosures, signals are low-cost; a well-designed and presented sustainability report with inflated environmental performance requires selective presentation of data and rhetoric (Delmas & Burbano, 2011).

At this point, the ability to generate automated, systematic reports through computer-based reporting tools will have a significant effect on the signals sent out. The signals will be more reliable because cloud-based computing allows for the automatic collection of sustainability data from operational systems. Cloud computing also limits how much discretion managers have over what data can enter the reporting process (Unerman, 2014). Additionally, XBRL (eXtensible Business Reporting Language) provides increased signal verifiability. This is accomplished through encoding disclosures in a standardized machine-readable format. As a result, regulators, capital markets and algorithmic monitoring systems can easily compare reported figures with industry averages (Hodge et al., 2004; Yoon et al., 2011). Regulatory

environments today are requiring companies to report using structured data formats. This requirement moves reporting from voluntary narrative statements to structured metadata formats that are auditable (Sun et al., 2025). When sustainability disclosures are produced using cloud enabled data systems and reported using XBRL compliant formats, it becomes more difficult to misrepresent the disclosures and easier to verify the disclosures. Therefore, from a signaling perspective, the quality of sustainability disclosures represents empirical evidence of signal credibility.

Legitimacy Theory: The Firm's Strategic Reason for Acting Substantive and Symbolic

Legitimacy theory is addition to explaining how greenwashing can exist because of information asymmetry, and how firms use signals to communicate about greenwashing, theory explains why firms engage in greenwashing when they do. Based on Suchman (1995) and Dowling & Pfeffer, (1975), provides the motivation behind firms' decision to greenwash. Legitimacy theory states that firms are not just organizations trying to make as much money as possible but are social beings that require public acceptance of their values, actions, and products to be successful (Suchman, 1995). As a result, disclosure regarding sustainability is not just about sharing information, but rather a way for firms to obtain legitimacy. Legitimacy theory is used as the conceptual foundation for the study's framework. This is because legitimacy theory can be broken down into two components; substantive legitimacy and symbolic legitimacy. Substantive legitimacy occurs when an organization's commitment to ecology leads to actual changes to how the organization conducts business. Symbolic legitimacy occurs when an organization projects an image of social alignment with the community through its use of rhetoric, selective disclosure, or other means that do not make fundamental changes to how the organization operates(Ashforth & Gibbs, 1990). Greenwashing is an excellent example of symbolic legitimacy. Greenwashing is a strategy where organizations communicate about being "green" or sustainable while continuing to operate in a non-sustainable manner. This allows them to project an image of having a "social license" to operate, without having to spend significant amounts of money on making the necessary investment to become truly sustainable (Meyer & Rowan, 1977).

In the absence of a comprehensive system for managing and standardizing data, firms can easily establish an image of being environmentally legitimate. Due to the high level of asymmetric information available to them, stakeholders frequently cannot distinguish between a firm that is “green” and a firm that has merely adopted a strategy of non-engagement. However, when digital reporting features are fully integrated into a firm's organizational framework, the opportunity for symbolic legitimacy will be eliminated. Cloud computing provides transparency to processes through establishing a highly integrated data repository, thereby establishing structural barriers to modifying environmental performance data later (Marston et al., 2011). In addition, XBRL enhances the clarity of narrative-based sustainability reporting through requiring disclosure of environmental performance data in the form of standardized, detailed, machine-readable data points (Bierstaker et al., 2014). Recent academic research indicates that digital capabilities provide firms with structural incentives to prevent greenwashing behaviors, primarily through reducing the potential benefits associated with such behaviors and significantly enhancing the risk of detection (Xu & Li, 2026).

Information asymmetry theory describes the structural characteristics of the market; it identifies the lack of information and the high costs of verifying information which allow companies to greenwash without fear of penalty. Signaling theory explains the communication process within the market described above; it demonstrates how digital technologies change the nature of disclosures from cheap talk to expensive and reliable signals. Legitimacy theory provides the primary behavioral driver for why companies use digital reporting capabilities to verify their signals; when companies have more ability to verify their signals, it reduces their ability to rely upon symbolic legitimacy strategies.

Hypotheses

The model includes seven propositions that can be tested: two direct relationships linking digital capabilities to disclosure quality (H_1 and H_2); one direct relationship going from disclosure quality to greenwashing risk (H_3); two direct and controlled paths from digital capabilities to greenwashing risk (H_4 and H_5); and two mediation propositions which examine whether the quality of sustainability disclosures mediates the effect of each digital capability on greenwashing risk (H_6 and H_7).

Infrastructure investment, combined with other factors, improves the comparison, verification, precision, consistency, and timely nature of public environmental data. This structural improvement in SDQ, within our multi-theoretical chain, allows for systematic reduction of the corporate information gap, transforms disclosure from binding signals, and invalidates the economic and strategic usefulness of symbolic decoupling. Therefore, the framework indicates that digital reporting architectures can lower greenwashing risk because they make the structural gap between a company's organizational front and operational core unsustainable(Marston et al., 2011; Unerman, 2014; Zhang, 2022).

Cloud computing capability and Sustainability Disclosure Quality

Cloud computing capability reduces the disparity between what actually occurs operationally and what is reported as performance because it allows for direct routing of sustainability measures from the original system to the report, minimizing the number of individuals involved in reporting who can use their own judgment regarding how to handle the data(Garrison et al., 2012). From a signaling perspective, it is much more costly to prepare disclosures from cloud-integrated architectures since the automated data trail will restrict the ability to omit uncomplimentary data without producing audit discrepancies (Debreceny & Gray, 2001). Research indicates that this automated data flow prevents organizations from creating retrospectively fabricated narratives, therefore, cloud-native data collection is one of the primary drivers of reporting truthfulness (Sun et al., 2025). As such, the proposed effect is positive: organizations with greater levels of cloud computing capabilities will have disclosures that rank higher in terms of the five quality characteristics.

H_1: Cloud computing capability is positively associated with sustainability disclosure quality

XBRL Capability and Sustainability Disclosure Quality

XBRL capability is an organization's ability to convert its sustainability disclosure into a structured, electronically verifiable record of data that can be used for reporting purposes. It does this by mapping the organization's sustainability disclosures to the standardized, machine-readable taxonomies. This mapping will improve the quality of disclosures for three

reasons: (1) it will make disclosures more comparable to other organizations' disclosures because all organizations will have to report using the same taxonomy elements instead of reporting under their own proprietary labels; (2) it will make disclosures more verifiable by creating machine-readable output that can be audited using algorithms developed by third parties; and (3) it will limit the amount of narrative explanation that can be included with the disclosures. Instead of providing ambiguous qualitative descriptions, organizations will be able to provide specific definitions for every metric that is disclosed (Hodge et al., 2004; Liu et al., 2014; Yoon et al., 2011). Organizations' use of standardized, machine-readable formats for disclosures will enable them to identify discrepancies between operational data and disclosed data through cross-firm comparisons and algorithmic audits. These identification methods increase the potential cost of manipulating disclosures (Blankespoor et al., 2014; Vasarhelyi et al., 2012). Compliance frameworks today require strong metadata mapping capabilities to avoid vague boilerplate terminology and maintain structural integrity (Sun et al., 2025).

H_2: XBRL capability is positively associated with sustainability disclosure quality

Sustainability Disclosure Quality and Greenwashing Risk

Direct correlation between the quality of sustainability disclosures and the potential for greenwashing, which represents the central theoretical mechanism of the proposed model. Disclosure of high quality will directly address these conditions on all five of its dimensions: Comparability will provide the baseline for comparison so that selective representations of performance may be recognized; Verifiability will allow independent audits of individual claims; Specificity will limit the ability of firms to employ strategically ambiguous language that allows them to avoid accountability for the reported commitments; Consistency will prevent firms from manipulating baseline methodologies or reporting boundaries; and Timeliness will prevent firms from delaying the release of negative information so that they may present it in a positive light through strategic narrative framing (Cho & Roberts, 2010; Clarkson et al., 2008; Hummel & Schlick, 2016; Melloni et al., 2017).

Recent corporate governance research shows that there are some major benefits to using high-quality structured output, including reducing external monitor's friction, as well as eliminating text-based barriers to identifying opportunistically disclosed information through analysis of textual data (Sun et al., 2025; Xu & Li, 2026).

H_3: Sustainability disclosure quality is negatively associated with greenwashing risk.

The Direct Controlled Effect of Cloud Computing Capability on Greenwashing Risk

When an organization utilizes deep cloud integration, they create a single centralized internal reporting loop that is visible throughout the organization. This removes individual corporate data silos that exist in organizations with traditional IT environments. In a traditional IT environment, local managers can use internal data gaps to engage in micro-level greenwashing well prior to reporting being received by executive-level personnel (Marquis et al., 2016). However, automated cloud tracing and continuous data ingestion create internal controls that allow upper management and board-level ESG committee members to easily identify strategic decoupling. Therefore, sophisticated internal cloud architecture provides downward pressure on greenwashing risk independently of the final public report. Studies demonstrating how digital fraud deterrents reduce opportunistic behaviors by increasing internal detection risks support this notion (Xu & Li, 2026).

H_4: Cloud computing capability is negatively associated with greenwashing risk when controlling for sustainability disclosure quality

The Controlled Direct Effect of XBRL Capability on Greenwashing Risk

A firm's high level of XBRL competence demonstrates that they have integrated international taxonomy standards, like the IFRS Sustainability Disclosure Standards, into their daily operations. The structural integration of these standards will change the internal culture related to data management. Thus, firms' reporting departments will be less inclined to engage in public relations activities and more inclined to utilize a systematic method of accounting; this will ultimately reduce the likelihood of firms launching symbolic campaigns. Additionally, since XBRL taxonomies are used in automatic processes for filing regulatory reports across international borders, firms with strong XBRL abilities are subject to increased regulatory scrutiny, thereby reducing their motivation to engage in opportunistic reporting (Sun et al., 2025).

H_5: XBRL capability is negatively relation with greenwashing risk when controlling for sustainability disclosure quality.

Sustainability disclosure quality mediates the relationship between cloud computing capability, XBRL capability and greenwashing risk

The primary route of the model proposed in this study is based on the idea that mediation is what will allow for the reduction of greenwashing risk through structural mitigation. The upstream technological resources (CCC and XBRLC) offer the availability of data, as well as automatic integration, and categorization of metadata that are essential to improve the quality of disclosures. On the other hand, the downstream application of the enhanced disclosures (SDQ), provides the means to close structural information gaps, transform ambiguous text into identifiable signals, and remove the firm's ability to use language as a resource to create a division between what appears on the surface and what lies underneath (Cho & Roberts, 2010; Clarkson et al., 2008). Recent theoretical models indicate that simply because technological resources exist does not mean that firms will automatically reduce corporate decoupling. Rather, technological resources provide a continuing pathway of mediation whereby digital resources increase disclosure parameter requirements, subject symbolic reporting to analysis using analytical text mining techniques, and eliminate greenwashing advantages (Sun et al., 2025; Xu & Li, 2026). Thus, sustainability disclosure quality is the primary driver of the effects of digital infrastructure on ultimate credibility outcomes.

H_6: Sustainability disclosure quality mediates the relationship between cloud computing capability and greenwashing risk.

H_7: Sustainability disclosure quality mediates the relationship between XBRL capability and greenwashing risk.

Evaluation of Critical Discussion

As such, this efficiency framework has contributed greatly to establishing many empirical findings regarding the operational advantages of both cloud computing and XBRL. Most of those findings were obtained via rigorous research methods and provided practical insights into how firms could utilize such technologies. However, the efficiency framework also created an unstated conceptual limitation within the AIS research field. That limitation was based upon a silent assumption that digital reporting tools' contributions can be better

characterized and evaluated at the process level and that their value is mainly internal to firms.

Cloud computing is typically viewed by researchers studying corporate reporting to enhance operational efficiencies through infrastructure. The research using this point focuses on the ways in which adopting the cloud will reduce capital expenses for IT, as well as operational expenses (Garrison et al., 2012; Marston et al., 2011). Mofeover, it also investigates how the use of the cloud can increase both the speed and scalability of processing financial data (Armbrust et al., 2010; Loebbecke & Picot, 2015). And explores how the ability to perform audit procedures remotely from central data repositories can decrease the time required to complete audits and decrease the logistical expense associated with obtaining evidence (Griffin & Wright, 2015; Vasarhelyi et al., 2012). However, each of these studies shares a common characteristic; namely, each considers the cloud to be a mechanism to improve back-office efficiency. Consequently, each study measures the benefits of the cloud based on metrics related to reducing costs, increasing processing speed, and decreasing the length of time needed to complete audits – metrics that do not address whether the reporting system outputs produced via the cloud are more credible, more verifiable, or more resistant to strategic manipulation.

XBRL has followed a similar path as a topic for study in AIS literature. Most empirical XBRL research has examined the impact of XBRL on information processing efficiency. Empirical studies have shown that machine-readable tagging can significantly decrease the amount of time that analysts spend extracting financial data (Blankespoor et al., 2014; Hodge et al., 2004). That mandatory XBRL filing requirements reduce bid-ask spreads and increase market liquidity by reducing the costs of institutional investor acquisition of financial information(Blankespoor et al., 2014; Li & Nwaeze, 2015); and that automated data extraction eliminates manual re-entry error and reduces the cost of regulatory data aggregation (Debreceny & Gray, 2001; Liu et al., 2014). However, the implicit model in this body of literature is that XBRL is a frictionless transmission mechanism: a technology that provides information to the users who require it more efficiently but does not alter the incentive structures of the firms that create it, the quality of the information created, or the institutional environment in which the information will be utilized to discipline corporate behavior.

The efficiency model of digital reporting technology being neutral conduit tool that facilitates the transfer of information within the existing institutional line. The contents of the line, the reasons for filling it, and the social structures dictate if the content flowing through the line is honest or deceptive seen as external to technology and thus outside the analytical scope of research in AIS as typically defined. This conceptual constraint is the purpose of this study.

The Paradigm Shift: Reconceptualizing Digital Reporting Technologies as Institutional Barriers to Corporate Misconduct

The difference between the efficiency-based account and the institutional-barrier-based account is much more than just a matter of terminology. This difference represents two completely different ways of thinking about how technology can affect organizational behaviors and structures. An efficiency-based approach to technology in reporting will assume that technology improves the output of reporting by reducing friction in the flow of

information. An institutional-barrier-based approach to technology in reporting will begin with a very different view of organizational behavior. It will view managers as rational actors who make decisions regarding disclosure based upon the cost benefit trade-offs of providing accurate information.

Cloud computing capabilities not able to help reduce greenwashing risks as there is an institutional barrier. However, cloud computing capabilities do help reduce greenwashing risks due to its ability to restructure organizations' data architectures to increase the cost of selective disclosure. This is accomplished using automated, cloud-integrated data pipelines which create persistent operational data records and therefore limit the manager's ability to selectively remove negative information from the reporting pipeline; through the elimination of organizational silos created by the integration of cross-unit data which have historically provided managers with the opportunity to selectively provide incomplete disclosures; and through real-time access to data, creating internal governance visibility, limiting the organizational space in which managers may maintain facade-core decoupling without being detected (Garrison et al., 2012; Zhang, 2022). Cloud computing's role in governance is architectural: it doesn't change what managers wish to disclose but rather changes what they are hiding.

The XBRL capability doesn't restrict the data collection processes prior to the actual reporting stage; however, the XBRL capability limits how the reporting can occur during the reporting stage. The XBRL capability requires that all sustainability metrics be reported using specific taxonomical element definitions developed by external sources. As such, the XBRL capability removes much of the ability for organizations to use creative writing techniques to produce non-comparable, non-verifiable, and/or ambiguous reporting regarding their sustainability performance. The XBRL capability functions as an electronic straitjacket. It reduces organizational flexibility when producing descriptive text. The XBRL capability exposes an organization's reporting criteria to direct comparison with other organizations' reporting criteria.

The transformation of governance through the re-engineering process is especially relevant in the 2026 digital reporting environment. The global introduction of machine-readable mandates like the digital taxonomy architectures under the Corporate Sustainability Reporting Directive (CSRD) waves and the International Sustainability Standards Board (ISSB) framework means that corporate signals are no longer evaluated solely by human readers. Increasingly, capital market algorithms, automated rating agencies, and text mining models are ingesting those signals programmatically (IFRS Sustainability Disclosure Taxonomy 2024, 2024). In the current context, an entity's XBRL capability represents a structural point of vulnerability: entities with high-capability data structures find that any attempts to selectively omit information or create green-label arbitrage are immediately visible to automated monitoring systems (Sun et al., 2025). As a result, this multi-theoretical framework shows that digital reporting infrastructure changes from being a passive efficiency-based asset to being a proactive digital corporate governance mechanism, thereby systematically reducing strategic managers' ability to maintain a decoupled corporate facade (Xu & Li, 2026).

The Study's Theoretical Intervention: How Digital Integration Restructures Signal Costs

The main theoretical of this research to the signaling literature is the finding that cloud computing capabilities and XBRL capabilities are more than just improvements on the output of the sustainability reporting process; they change the cost structure of the reporting process itself. By changing the cost structure, the sustainability reporting process changes from a “cheap-talk” instrument to a “costly signal.” This is done through the internal design logic of the information systems used to generate sustainability reporting, rather than through externally imposed regulations. In terms of theory, here is how we can state our position: when cloud-based data feeds and XBRL taxonomies are fully incorporated into the sustainability reporting process, the cost of creating a false environmental signal will increase dramatically, there will be a significantly higher chance of detection of signal manipulation by outside parties, and the signaling equilibrium will shift from cheap-talk to credible communication. We must examine this statement in relation to two separate aspects of signal costs which the standard Spence-type signaling model does not separate out, however digital reporting infrastructure uses different methods to achieve each aspect.

The cost of creating a misleading signal with digital integration in the traditional method of creating signals about sustainability reporting, there are few costs associated with creating a misleading signal. This is because creating signals with traditional methods is discretionary. Data is manually collected, selectively used, narratively reported, and formatted in a manner that the reporting group has full authority over the content (Adams & Frost, 2008; Cho & Roberts, 2010). The additional cost of including an adverse emissions signal as opposed to excluding it is virtually non-existent; the decision to include or exclude an adverse emission signal depends completely upon the discretion of management and strategic consideration. Cloud-integrated reporting has completely changed the cost dynamics of producing signals. Since cloud-integrated reporting allows for automatic signal generation from operational source systems to centralized cloud repositories where signal production can occur, the discretionary exclusion of adverse signals will require an intentional and conscious interference with the automatic flow of signals (Garrison et al., 2012). Interfering with the automatic flow of signals has several costs that are absent from traditional signal generation. Therefore, the cost of generating a misleading signal is now not simply the cost of selectively reporting signals but is the cost of systematically falsifying signals across an integrated and automated information system. For most organizations, these costs are significantly higher than the previous costs of generating a misleading signal and therefore change what was formerly a low-cost signal into a high-cost signal. XBRL taxonomy mapping is a way to reduce the amount of discretion companies have in disclosing sustainability metrics. This is accomplished using external, standard digital taxonomy elements to represent every sustainability metric being disclosed, as opposed to using company-specific labeling or open-ended narrative prose (Hodge et al., 2004; Yoon et al., 2011). As such, the requirement for XBRL taxonomy mapping creates a strong discipline regarding definitions that greatly increases the cost of falsifying signals via two structural methods:

As such, the addition of XBRL capability alters the context of signaling from one where management can use their discretion to manage descriptive text to one where there is strict verification based on algorithms. The cost of providing false information (or lying) is no longer a potential reputational loss at some point down the road. Instead, it is an immediate structural barrier incorporated into the way information is reported. Cloud computing and

XBRL capabilities remove from strategic managers the ability to provide cheap signals because they increase the likelihood of detecting such signals using automated means and remove the protective barrier of non-structured text (Xu & Li, 2026). During the digital reporting age, the validity of a signal will be determined not only by the honesty of the person sending the signal, but also by the architecture of the data platform through which the signal was produced and transmitted.

Implications for Regulators: The Case for Mandatory Machine-Readable Reporting Infrastructure

The global sustainability reporting regulatory environment of 2026 is defined by the simultaneous development of numerous interconnected mandatory regulations that together represent the most substantial change in corporate non-financial reporting since the standardization of double-entry accounting practices in the late 1800s. The European Union's Corporate Sustainability Reporting Directive (CSRD), which began implementation in 2024 for large public companies, followed by progressive implementation in 2025 and 2026 for large private companies and public small-and-medium-sized enterprises (SMEs), will require nearly 50,000 European organizations to report on sustainability issues using the European Sustainability Reporting Standards (ESRS). The ESRS is a comprehensive taxonomy-based reporting system with mandatory machine-readable XBRL reporting of each reported metric. As the research demonstrates, data standardization is the most structurally effective method for preventing greenwashing. Historically, there have been two primary arguments about how to address greenwashing: (1) increase mandatory reporting (tell people more); or (2) strengthen external validation (check the accuracy of what they told you). These two viewpoints both assume that greenwashing is caused by too little information being reported. This paper challenges both assumptions by focusing on the way that greenwashing is prevented through the structural aspects of the reporting system itself; specifically, how much machine readable, taxonomy mapped data is required. A reporting requirement that provides a large amount of information but does not require that the information be provided in a structured format will still allow companies to provide a cheap signal to investors. However, a reporting requirement that requires companies to provide information in a structured, comparable, and machine verifiable format will prevent companies from providing false signals to investors even if the trend toward voluntary assurance continues. Therefore, requiring companies to report using XBRL-compliant, taxonomy-structured formats as required by the CSRD's ESRS digital tagging requirements for European companies and as required by the adoption of ISSB standards around the world is a more structurally efficient way to prevent greenwashing than creating additional voluntary assurance markets or increasing the number of indicators that companies must report.

Redefining Policy Evaluation Criteria

Policy evaluation criteria are currently measured by compliance costs; i.e., what is the cost of compliance for reporting entities? Adoption rates; i.e., how many entities are reporting using XBRL? Process efficiency gains; i.e., how much does it cost the regulator to compile and process all the XBRL-tagged reports? These types of measures assess whether the disclosure of architecture has been efficient based on cost, etc. However, the true value of XBRL is as an institutional barrier against corporate misconduct. Therefore, the right question to ask when evaluating XBRL policies is not "How much did it cost a company to file an XBRL-tagged report?" or "How quickly could a regulatory agency aggregate the XBRL-tagged reports?"

Instead, the question should be "Did the structured architecture close the validation gap that allowed companies to engage in strategic facade-core decoupling?"

By shifting the evaluate policies from their ability to be efficient in process to being able to create a structural deterrent, regulators can use this framework to assess how effective anti-greenwashing measures are based upon specific data integrity standards. Examples of such standards include measuring the percentage of customized, firm-specific "extended tags" relative to standard taxonomy definitions to determine if a company is attempting to establish narrative protection. When viewed as a governance mechanism, the costs associated with establishing a cloud-based, XBRL compliant system do not represent a dead weight cost of compliance. They represent an essential regulatory investment in establishing a regulatory framework that will allow sustainability reporting to become a legally binding, audit-ready form of accounting. For those regulatory authorities that are currently attempting to transition into the new regulatory environment, there is no ambiguity: the most effective way to protect against systemic greenwashing is not through increasing the number of generic textual descriptions but rather through establishing a statutory requirement for companies to develop a machine readable data infrastructure that automatically eliminates the possibility for companies to decouple (Sun et al., 2025; Xu & Li, 2026).

Boundary Conditions and Future Research

The suggested framework contains many different constraints. For instance, the success of the framework will be determined by how well an organization can enforce its rules. In other words, if an organization can effectively regulate the behavior of employees and verify their claims, then the use of standardized, machine-readable sustainability reporting will be more effective at reducing false marketing (greenwashing). However, if an organization does not have sufficient resources to enforce regulations or verify employee claims, or if there are limitations on data sharing due to localization laws, or if there are limits on what type of employee information can be shared, then the reporting process will likely not provide the level of completeness or consistency needed to create a fully integrated digital reporting system. Secondly, the size of an organization and its level of digital infrastructure could affect how well those suggested relationships will work. Big companies tend to have an advantage when developing cloud and XBRL technologies compared to small companies that usually experience higher levels of both financial and technological restrictions. In addition, outsourcing your company's digital reporting can result in compliance-driven implementations instead of substantial ones.

Third, the taxonomy maturity and fragmentation could reduce the positive effects of using XBRL. As there are conflicting or overlapping sustainability taxonomies, users will have to use extensions and manually classify data which could result in more narrative flexibility and potential selective disclosure.

Fourth, there could be a strategic shift in how greenwashing occurs. When the process of greenwashing becomes more difficult due to increased digital reporting and automated monitoring, companies may begin to use alternative means of symbolic practice such as using supply chain practices, social media platforms, or other communication channels outside of their formal reporting systems. Ultimately, the framework requires sufficient quality in the

underlying data. Cloud computing and XBRL can provide improved processes for handling data, combining data from various sources, and developing standards for how data should be handled; however, neither of these technologies can guarantee that the data used to populate the disclosure will be accurate. As a result, if the data entered the system are inaccurate or has been altered, then the resulting highly standardized disclosure may still mislead the user.

Future Research

In order to support the validity and expansion of the model proposed in this study, future research will utilize the current baseline model as a modular moderated-mediation framework. This allows for modification of independent variables (IVs), dependent variables (DVs), and contextual moderator variables depending upon local conditions. At the same time, the dependent variable (DV) may be modified from broad greenwashing risk to specific results such as decoupling resulting from displacement within a supply chain, ESG rating divergence, or public sentiment regarding greenwashing in marketing (Sun et al., 2025). Additionally, scholars can incorporate different types of interaction terms as Contextual Moderators to determine the limits of the model. These include Institutional Moderators (e.g., cross-border enforcement quality, data localization laws, or fragmentation of taxonomy frameworks) and Organizational Moderators (e.g., firm size distribution asymmetry or formal IT Governance Controls such as COBIT) (Xu & Li, 2026).

Methodologically, future research should utilize multi-group structural equation modeling (PLS-SEM) in conjunction with web-scraped natural language processing to empirically evaluate these paths, determining if rigid digital architecture completely eliminates corporate decoupling or simply shifts the use of symbolic opportunism from formally regulated financial disclosures to informally structured media outlets (Sun et al., 2025; Xu & Li, 2026).

Theoretical and Contextual Contributions

This study contributes to the sustainability reporting literature by reminding of the concept of connection between digital reporting capabilities and greenwashing by focusing on the informational characteristics of sustainability reports. Its main theoretical contribution is the combination of the Information Asymmetry Theory, Signaling Theory and Legitimacy Theory in a logical chain of explanation that helps to understand how cloud computing and eXtensible Business Reporting Language (XBRL) could limit opportunistic sustainability communication. In particular, the framework places sustainability disclosure quality (SDQ) as the intervening mechanism by which the digital reporting capabilities could impact on the credibility of corporate sustainability claims. The concept transcends the existing theoretical views which assume that disclosure or technological development always leads to greater transparency. Rather, it builds upon the idea that the informative role of sustainability reporting is the key to distinguish substantive from symbolic sustainability communication because of the reliability, comparability, verifiability, and specificity of information. The study also makes a theoretical distinction between the concept of digital data integration and accessibility versus standardized, machine-readable reporting, which places cloud computing and XBRL reporting within the same framework of reporting capabilities, differentiating them as complementary. The study is relevant in context by bringing these theoretical arguments into the context of Asia's changing sustainability reporting landscape, with digitalisation and changing disclosure demands. This situational placement is important because the legitimacy

of sustainability information is still an essential issue to consider in a world where new reporting obligations continue to be increased, but do not necessarily diminish opportunities for selective, ambiguous or opportunistic corporate claims. The proposed framework builds on current knowledge by introducing a new conceptual mechanism between digital reporting capabilities and greenwashing mitigation, namely disclosure quality and not necessarily disclosure volume or the adoption of disclosure technology.

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