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Corporate Governance and Firm Performance in the Context of Technology-Based Sustainability: Evidence from Green Organic Compounds Disclosure

Dr.Hossam Sharawi

h.sharawi@jicollege.edu.sa

Jeddah International College https://orcid.org/0000-0002-7136-9599

Dr. Yaser Bathich

Jeddah International College https://orcid.org/0000-0003-0538-8801

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Abstract

This study examines how corporate governance mechanisms moderate the relationship between technology-based sustainability practices and corporate performance, using Green Organic Compounds (GOCs) disclosure as an operational indicator of environmental technology adoption. Drawing on a balanced panel of publicly listed non-financial firms over the period 2019–2024, the study applies panel regression techniques to assess the impact of GOCs disclosure on both accounting-based and market-based performance measures. The results provide strong and consistent evidence that GOCs disclosure is positively associated with firm performance. More importantly, corporate governance mechanisms—particularly board independence, audit committee independence, and board gender diversity—significantly strengthen the performance effects of technology-oriented sustainability practices.

By introducing GOCs disclosure as a technology-specific sustainability construct, this study extends the sustainability–performance literature beyond aggregated ESG measures and contributes to corporate governance research by demonstrating how governance quality conditions the economic returns of environmental investments. The findings highlight the role of effective governance structures in transforming sustainability initiatives from symbolic actions into value-enhancing strategic outcomes, offering relevant implications for firms, regulators, and investors operating in emerging markets undergoing regulatory and institutional transformation.

1. Introduction

In the contemporary corporate landscape, sustainability has ceased to be a peripheral social aspiration and has instead become a fundamental strategic imperative that shapes organizational legitimacy, competitive positioning, and long-term financial performance. The acceleration of global environmental challenges, including climate change, resource depletion, ecological degradation, and regulatory intensification, has transformed the way corporations conceptualize value creation and risk management. Firms are no longer assessed solely on their financial outcomes but increasingly on their ability to integrate environmental responsibility into core operational and governance systems. Consequently, sustainability is now viewed not merely as a compliance requirement or reputational device, but as an essential determinant of corporate resilience, innovation, and economic survival (Eccles et al., 2014; Friede et al., 2015; El Ghoul et al., 2018).

Within this evolving context, firms have increasingly turned to environmentally responsible technologies as a way to reconcile environmental considerations with economic performance. Among these technologies, Green Organic Compounds (GOCs) represent a practical and operational form of environmental engagement rather than a purely symbolic initiative. In simple terms, GOCs refer to chemical inputs and production materials that are derived from renewable or low-impact sources and are intended to reduce harmful emissions and resource intensity across industrial processes. What distinguishes GOCs from more generic sustainability disclosures is that their adoption affects how production systems actually function. Choices related to materials, solvents, and chemical inputs influence process efficiency, operating costs, regulatory exposure, and environmental risk in a direct way. For this reason, GOCs can be viewed as a concrete link between firms' sustainability efforts and their economic outcomes, particularly in industries where chemical and material inputs play a central role.

The growing strategic relevance of such technologies reflects a broader transformation in corporate sustainability thinking. Traditional approaches to sustainability relied heavily on aggregated Environmental, Social, and Governance (ESG) indicators and narrative disclosures, which, while useful for benchmarking, often fail to capture the depth and quality of firms' actual environmental practices. ESG scores frequently aggregate heterogeneous activities into composite indices, obscuring the operational mechanisms through which environmental practices affect corporate performance. As a result, the empirical relationship between sustainability and financial performance has remained contested and at times inconclusive. Recent studies increasingly argue that disaggregated, technology-based measures of sustainability provide a more accurate lens through which to examine the economic consequences of environmental responsibility, particularly in environmentally intensive sectors (Khan et al., 2016; Cheng et al., 2024; Liu et al., 2024).

The Kingdom of Saudi Arabia provides a uniquely important empirical context for examining these dynamics. Through Vision 2030, Saudi Arabia has embarked on a comprehensive transformation of its economic structure, governance architecture, and regulatory environment, with sustainability and environmental stewardship positioned as central pillars of national development. This transformation has fundamentally reshaped corporate expectations, placing growing emphasis on transparency, sustainability disclosure, and responsible investment practices. Listed firms in the Saudi Stock Exchange (Tadawul) now operate within an increasingly sophisticated regulatory framework that aligns domestic corporate practices with international standards for sustainability reporting and governance oversight.

In parallel, Saudi regulators and market institutions have intensified their focus on environmental performance, corporate accountability, and long-term value creation. These reforms have increased the economic relevance of sustainability investments for Saudi firms, particularly in resource-intensive industries where environmental technologies directly influence production efficiency, compliance costs, and market valuation. Empirical evidence from Saudi Arabia increasingly indicates that firms with stronger sustainability and ESG practices exhibit superior profitability, enhanced market reputation, improved investor confidence, and reduced information asymmetry, while also benefiting from timelier financial reporting and lower exposure to regulatory risk (Hussain et al., 2024; Ali et al., 2025; Sulimany, 2025; Muneer et al., 2025). Despite this growing body of evidence, the financial consequences of adopting specific environmental technologies such as GOCs remain largely unexplored within the Saudi corporate setting.

From an accounting and financial perspective, the economic relevance of GOCs extends well beyond environmental protection. The integration of environmentally responsible technologies into production and operational systems affects key financial dimensions, including cost efficiency, asset utilization, risk exposure, and revenue stability. Firms that adopt GOCs are expected to experience reductions in energy consumption, waste management costs, and environmental compliance expenditures, while simultaneously improving product quality, operational efficiency, and brand reputation. These mechanisms contribute directly to improved accounting-based performance measures such as return on assets and return on equity, as well as enhanced market-based indicators such as Tobin's Q and firm valuation. At the same time, the adoption of such technologies strengthens firms' risk management frameworks by reducing exposure to environmental penalties, litigation, regulatory sanctions, and reputational damage (Fatemi et al., 2018; Velte, 2017; Habib et al., 2025).

Nevertheless, despite the intuitive appeal of these mechanisms, existing literature remains heavily concentrated on broad ESG disclosure rather than on the operational technologies that underpin sustainability outcomes. While numerous studies document positive associations between ESG performance and financial outcomes, the causal channels through which environmental practices generate economic value remain insufficiently understood. In particular, the role of specific environmental technologies—such as GOCs—in shaping financial performance has received limited empirical attention. This gap is especially pronounced in emerging markets, where institutional environments, governance structures, and regulatory regimes differ markedly from those in developed economies, potentially altering the effectiveness and economic impact of sustainability investments.

This study seeks to address this gap by examining the adoption of GOCs as a technologyspecific sustainability practice and evaluating its impact on corporate sustainability and financial performance within Saudi listed firms. In doing so, the study moves beyond conventional ESG metrics to capture the operational reality of environmental engagement and its financial consequences. Moreover, the study investigates whether corporate governance mechanisms condition the effectiveness of GOCs adoption in generating financial value. Governance structures play a pivotal role in shaping corporate strategy, monitoring managerial behavior, and aligning sustainability initiatives with shareholder and stakeholder interests. Prior research demonstrates that strong governance enhances the credibility and effectiveness of sustainability strategies by ensuring transparency, accountability, and strategic coherence (Michelon et al., 2015; García-Sánchez et al., 2020; Liang & Renneboog, 2017; Basali, 2025). However, empirical evidence on the interaction between governance quality and technology-based environmental practices remains scarce, particularly within emerging markets.

The theoretical foundation of this study is grounded in an integrated framework combining stakeholder theory, signaling theory, and agency theory. Stakeholder theory posits that firms are accountable to a broad set of constituencies whose expectations increasingly include environmental responsibility and sustainable business practices. The adoption of GOCs can thus be interpreted as a strategic response to stakeholder demands, enhancing corporate legitimacy and trust. Signaling theory suggests that credible investments in environmental technologies convey valuable information to capital markets regarding managerial quality, long-term orientation, and commitment to sustainable value creation. Agency theory emphasizes the importance of governance mechanisms in ensuring that sustainability investments are implemented effectively rather than serving as symbolic gestures. Together, these perspectives provide a coherent explanation of why the financial consequences of GOCs adoption should vary systematically with the quality of corporate governance.

Accordingly, this research is guided by three central questions. First, to what extent does the adoption of GOCs influence the sustainability practices of Saudi listed firms? Second, how does GOCs adoption affect accounting-based and market-based measures of financial performance? Third, do corporate governance mechanisms amplify the financial returns of GOCs adoption? By addressing these questions, the study offers several important contributions. It advances sustainability research by introducing a technology-based measure of environmental engagement that captures the operational substance of sustainability practices. It enriches corporate governance literature by demonstrating how governance structures condition the economic returns of environmental investments. Finally, it provides timely empirical evidence from an emerging market undergoing profound regulatory and institutional transformation, offering valuable insights for regulators, investors, and corporate leaders seeking to align sustainability objectives with long-term financial performance.

This study contributes to the corporate governance literature by introducing Green Organic Compounds (GOCs) disclosure as a technology-based sustainability construct that operates at the firm's operational and process levels. Unlike aggregated ESG indicators, GOCs provide governance scholars with a more granular mechanism through which boards and governance structures can influence sustainability-related strategic outcomes. The findings extend governance theory by demonstrating how internal governance mechanisms condition the effectiveness of technology-oriented environmental practices in generating firm value. By positioning sustainability as a governance-enabled strategic resource rather than a symbolic disclosure practice, this study advances the understanding of how governance quality translates sustainability investments into superior corporate performance.

2. Literature Review and Theoretical Framework

2.1 Sustainability, Environmental Technologies, and Corporate Performance

The relationship between sustainability and corporate performance has been extensively examined across accounting, finance, and management disciplines, yet empirical findings remain mixed and highly sensitive to the way sustainability is conceptualized and measured. Early studies predominantly relied on aggregated ESG indicators and broad disclosure scores, reporting positive associations with firm profitability, market valuation, and risk mitigation (Eccles et al., 2014; Friede et al., 2015). However, subsequent research has increasingly questioned the explanatory

power of such composite measures, arguing that ESG scores often capture reporting quality and reputational effects rather than substantive operational transformation (Fatemi et al., 2018; Velte, 2017).

Recent scholarship has therefore shifted attention toward the role of environmental technologies and green innovation as more precise drivers of economic value. Technology-based environmental practices, such as cleaner production systems, lowemission materials, and eco-efficient inputs, directly affect cost structures, productivity, regulatory exposure, and long-term competitiveness. Empirical evidence demonstrates that firms engaging in green innovation and environmentally responsible technologies achieve superior financial outcomes, particularly in environmentally intensive industries where technological change has immediate economic consequences (Khan et al., 2016; Cheng et al., 2024; Liu et al., 2024). These findings suggest that the economic relevance of sustainability emerges not from disclosure itself, but from the quality and depth of environmental technologies embedded in corporate operations.

From a chemistry and materials standpoint, environmental technologies are often assessed based on the nature of inputs and the behavior of production processes rather than disclosure quality alone. Research in green chemistry shows that substituting hazardous or highly volatile substances with organic or lower-toxicity alternatives can reduce emissions, improve process stability, and simplify waste handling. These effects influence how industrial systems operate on a day-to-day basis, particularly in materials- and chemical-intensive industries. Despite this established chemical understanding, much of the sustainability–performance literature in accounting and finance continues to rely on aggregated ESG measures that do not explicitly reflect changes in materials or process chemistry. As a result, the operational mechanisms through which environmental technologies affect corporate performance remain only partially captured.

In this context, Green Organic Compounds (GOCs) represent a critical yet underexplored dimension of environmental technology adoption. Unlike generic ESG indicators, GOCs capture the use of renewable-based, low-toxicity chemical inputs and environmentally friendly materials that improve production efficiency while reducing environmental harm. Although related concepts appear in the green chemistry and environmental engineering literature, the integration of GOCs into corporate sustainability and financial research remains limited. This omission is notable, given that such technologies directly influence operational performance, compliance costs, and environmental risk exposure—key determinants of corporate profitability and valuation.

2.2 The Role of Corporate Governance in Sustainability Outcomes

While environmental technologies may create the potential for financial and sustainability gains, their actual economic impact is contingent upon corporate governance structures. Governance determines how strategic investments are selected, monitored, and evaluated, thereby shaping the extent to which sustainability initiatives generate tangible economic value. Prior studies provide consistent evidence that governance quality strengthens the effectiveness of sustainability strategies by improving oversight, enhancing accountability, and aligning managerial incentives with long-term value creation (Michelon et al., 2015; García-Sánchez et al., 2020; Liang & Renneboog, 2017).

Board independence, audit committee effectiveness, and ownership structure have been identified as particularly influential governance mechanisms. Independent boards improve the credibility of sustainability initiatives and constrain managerial opportunism, ensuring that environmental investments are not merely symbolic (García-Sánchez et al., 2020). Audit committees with strong financial and sustainability expertise enhance the reliability of sustainability disclosure and reduce information asymmetry (Michelon et al., 2015). Ownership structure influences risk preferences and strategic horizons, with institutional investors often exerting pressure for long-term sustainable performance (Liang & Renneboog, 2017).

Empirical research further demonstrates that governance moderates the sustainability– performance relationship. Firms with strong governance derive greater financial benefits from sustainability investments, whereas weak governance can dilute or even reverse these effects (Velte, 2017; Basali, 2025). These findings underscore that sustainability does not automatically translate into financial value; instead, it is the governance context that determines whether environmental technologies such as GOCs become engines of longterm profitability or costly symbolic gestures.

2.3 Theoretical Integration

This study integrates three complementary theoretical perspectives to explain how GOCs adoption influences sustainability and financial performance and why governance moderates this relationship.

From a stakeholder perspective, firms operate within networks of stakeholders whose expectations increasingly emphasize environmental responsibility. The adoption of GOCs responds directly to these expectations by demonstrating commitment to environmental stewardship, thereby enhancing legitimacy, trust, and long-term stakeholder relationships (Freeman, 1984; Harrison et al., 2010).

From a signaling perspective, investments in environmentally responsible technologies constitute credible signals to capital markets regarding managerial competence, strategic foresight, and commitment to sustainable value creation. Because GOCs adoption requires substantial financial and operational commitment, it is difficult for low-quality firms to imitate, making it a reliable signal of firm quality and long-term orientation (Spence, 1973; Connelly et al., 2011).

From an agency perspective, sustainability investments involve potential agency conflicts, as managers may pursue environmental projects for personal reputation or legitimacy rather than shareholder value. Strong governance mechanisms mitigate these conflicts by monitoring managerial

behavior and ensuring that GOCs investments are evaluated based on their economic and sustainability returns rather than symbolic considerations (Jensen & Meckling, 1976; Shleifer & Vishny, 1997).

Together, these perspectives provide a coherent explanation for why GOCs adoption should enhance sustainability and financial performance and why the strength of these effects depends on corporate governance quality.

2.4 Hypotheses Development

Building on the preceding theoretical arguments, the adoption of Green Organic Compounds (GOCs) is conceptualized in this study as a substantive strategic investment rather than a symbolic sustainability action. By embedding environmentally responsible technologies within core operational processes, firms are expected to improve environmental efficiency, enhance resource utilization, mitigate regulatory and reputational risks, and strengthen stakeholder confidence. These mechanisms collectively suggest that GOCs adoption should translate into superior sustainability outcomes.

H1. Firms that intensify their adoption of Green Organic Compounds (GOCs) achieve superior levels of corporate sustainability performance.

In addition to sustainability benefits, the strategic integration of GOCs is expected to generate direct financial value. Environmental technologies enhance productivity, stabilize cost structures, reduce exposure to environmental liabilities, and improve market perceptions of firm quality and long-term viability. As a result, firms that effectively incorporate GOCs into their operations are likely to experience superior accounting-based and market-based financial performance.

H2. The strategic integration of Green Organic Compounds (GOCs) into corporate operations enhances firms' financial performance.

However, the extent to which GOCs adoption generates sustainability and financial returns is not uniform across firms. The governance environment within which such investments are undertaken plays a decisive role in determining their effectiveness. High-quality corporate governance strengthens monitoring, aligns managerial incentives with long-term value creation, and ensures that sustainability initiatives are implemented as genuine strategic investments rather than symbolic gestures. Consequently, governance mechanisms are expected to amplify the positive effects of GOCs adoption.

H3. High-quality corporate governance strengthens the positive effect of GOCs adoption on corporate sustainability performance.

H4. Strong corporate governance amplifies the positive relationship between GOCs adoption and corporate financial performance.

2.5 Conceptual Framework

Figure 1 presents the conceptual framework of the study. The model proposes that the adoption of Green Organic Compounds (GOCs) constitutes a strategic environmental investment that directly influences both corporate sustainability performance and corporate financial performance. The framework further posits that this relationship is contingent upon the quality of corporate governance. Governance mechanisms—including board independence, audit committee effectiveness, and ownership structure—serve as moderating factors that strengthen the extent to which GOCs adoption translates into superior sustainability outcomes and enhanced financial performance. The framework integrates insights from stakeholder theory, signaling theory, and agency theory, illustrating how environmental technology adoption, when embedded within strong governance structures, generates sustainable economic value.

Figure 1 illustrates the proposed conceptual framework of the study. Green Organic Compounds (GOCs) adoption is specified as the independent variable influencing both corporate sustainability performance and corporate financial performance. Corporate governance—represented by board independence, audit committee effectiveness, and ownership structure—acts as a moderating variable that strengthens these relationships. The framework reflects the theoretical integration of stakeholder theory, signaling theory, and agency theory in explaining how environmental technology adoption, under strong governance structures, contributes to sustainable value creation.

3. Research Methodology

3.1 Research Design

This study adopts a quantitative, explanatory research design based on secondary data obtained from firms listed on the Saudi Stock Exchange (Tadawul). A panel data framework is employed to examine the empirical relationships between Green Organic Compounds (GOCs) disclosure, corporate governance mechanisms, and corporate performance. Panel regression techniques are particularly appropriate in this context as they enable the analysis to control for unobserved firm-specific heterogeneity and to capture intertemporal dynamics in corporate behavior, thereby enhancing the reliability, robustness, and generalizability of the empirical findings.

3.2 Population and Sample

The population of the study comprises all non-financial firms listed on the Saudi Stock Exchange (Tadawul). Financial institutions are excluded due to their fundamentally different regulatory environment, reporting requirements, and capital structures, which could otherwise introduce structural bias and impair comparability with non-financial firms. The study covers the period from 2019 to 2024, a timeframe that captures the post– Vision 2030 reform environment characterized by heightened regulatory emphasis on sustainability, corporate governance, and corporate transparency. This period

is particularly appropriate for examining the sustainability–performance nexus as it coincides with the progressive institutionalization of ESG practices and the gradual implementation of IFRS–ISSB sustainability disclosure standards in Saudi Arabia.

The final sample consists of firm-year observations for companies that provide complete and consistent data on financial performance, sustainability disclosures, and corporate governance attributes over the study period. This selection process ensures data integrity while maintaining sufficient cross-sectional and temporal variation for robust panel estimation.

The analysis focuses exclusively on firms operating within the Materials sector, including chemicals, metals and mining, cement, industrial materials, packaging materials, and construction materials. This sectoral focus is methodologically justified as these industries are environmentally intensive and thus particularly sensitive to environmental technologies, sustainability practices, and governance structures. Restricting the sample to a single sector enhances industry homogeneity, reduces unobserved structural heterogeneity, and strengthens the internal validity of the empirical results.

Table 1
Composition of the Study Sample

Ticker	Company Name	Sub-Sector
2010	Saudi Basic Industries Corp. (SABIC)	Chemicals
2021	National Industrialization Co. (TASNEE)	Chemicals
2015	Advanced Petrochemical Co.	Chemicals
2310	Saudi International Petrochemical Co. (Sipchem)	Chemicals
2011	Yanbu National Petrochemical Co. (YANSAB)	Chemicals
2340	Nama Chemicals Co.	Chemicals
2350	Saudi Kayan Petrochemical Co.	Chemicals
2380	Petro Rabigh	Chemicals
2001	Methanol Chemicals Co. (Chemanol)	Chemicals
2170	Alujain Corp.	Chemicals
1211	Saudi Arabian Mining Co. (Ma'aden)	Metals & Mining
3010	Saudi Cement Co.	Cement
3050	Al Jouf Cement Co.	Cement
3020	Northern Cement Co.	Cement
3011	Arabian Cement Co.	Cement
3009	Najran Cement Co.	Cement
3008	City Cement Co.	Cement
3007	Qassim Cement Co.	Cement
3006	Yanbu Cement Co.	Cement
3005	Eastern Cement Co.	Cement
3004	Southern Province Cement Co.	Cement
3032	Arabian Pipes Co.	Industrial Materials
2240	Zamil Industrial Investment Co.	Industrial Materials
1202	Middle East Paper Co.	Packaging / Materials
1301	United Wire Factories Co. (ASLAK)	Industrial Materials
1320	Saudi Steel Pipe Co.	Industrial Materials
1304	Al Yamamah Steel Industries	Industrial Materials
2028	Saudi Industrial Investment Group (SIIG)	Diversified Materials
2040	Saudi Ceramic Co.	Construction Materials

Table 1 presents the composition of the study sample, which consists exclusively of firms operating within the Materials sector of the Saudi Stock Exchange. The selected firms are engaged in environmentally intensive activities, making the sector particularly appropriate for examining the adoption of Green Organic Compounds (GOCs), sustainability practices, and corporate governance mechanisms. Restricting the sample to a single sector enhances industry homogeneity, reduces structural heterogeneity, and strengthens the internal validity of the empirical findings.

3.3 Data Collection and Sources

This study relies exclusively on verified secondary data obtained from official and publicly accessible sources to ensure data reliability, accuracy, and regulatory compliance. Financial data are collected from the annual financial statements of Saudi-listed firms published on the Saudi Stock Exchange (Tadawul), which are prepared in accordance with International Financial Reporting Standards (IFRS).

Information related to sustainability and environmental practices is extracted from firms' sustainability reports, integrated reports, and environmental disclosures, which are primarily aligned with the Global Reporting Initiative (GRI) framework and the IFRS– ISSB sustainability standards. Corporate governance data are obtained from governance reports and disclosures mandated by the Saudi Capital Market Authority (CMA), ensuring consistency with the Saudi Corporate Governance Regulations and the OECD Principles of Corporate Governance.

Supplementary information, particularly regarding environmental certifications and Green Organic Compounds (GOCs) adoption practices, is gathered from official company websites and certification bodies, including ISO and SASO databases. The integration of multiple authoritative data sources enhances the credibility of the dataset and mitigates concerns related to measurement bias and data incompleteness.

3.4 Variable Measurement and Operationalization

This study employs four categories of variables: independent, dependent, moderating, and control variables. All constructs are operationalized in accordance with established standards in the sustainability, accounting, and corporate governance literature to ensure construct validity, measurement reliability, and comparability with prior empirical research.

3.4.1 Independent Variable: Green Organic Compounds (GOCs) Disclosure

The independent variable, Green Organic Compounds disclosure (GOC), is measured using a self-constructed disclosure index designed to capture firms' adoption of environmentally sustainable organic and chemical practices. The index comprises thirty binary indicators derived from internationally recognized sustainability frameworks and environmental management standards, including GRI 302 (Energy), GRI 305 (Emissions), ISO 14001, and SASO eco-label requirements.

The selection of GOCs indicators was guided by practical considerations related to materials use and production processes, rather than disclosure volume alone. The indicators were chosen to reflect whether firms report changes in chemical inputs, process-related practices, and product characteristics that are commonly associated with lower environmental impact.

In particular, the index captures aspects related to raw material choice, substitution of hazardous substances, and process-related emissions, which are familiar dimensions in materials and chemical-intensive industries. While the measurement relies on publicly disclosed information, the underlying logic of the index is grounded in how environmental improvements are typically implemented at the input and process level.

Each indicator is assigned a value of one if the firm discloses the corresponding practice and zero otherwise. The overall GOCs score for each firm-year observation is computed as the sum of the disclosed items, producing a composite index that reflects the firm's level of engagement in green organic practices. This binary coding approach reduces subjectivity, enhances measurement consistency, and strengthens the reliability of the disclosure-based construct.

3.4.2 Dependent Variable: Corporate Performance

Corporate performance (FP) is measured using four widely accepted financial indicators that capture both accounting-based and market-based dimensions of firm performance. These measures include return on assets (ROA), calculated as net income divided by total assets; return on equity (ROE), calculated as net income divided by shareholders' equity; Tobin's Q (TQ), measured as the ratio of the market value of equity plus the book value of debt to total assets; and firm value (FV), proxied by the natural logarithm of market capitalization. All financial data are extracted from firms' IFRS-based annual financial statements published on the Saudi Stock Exchange (Tadawul).

3.4.3 Moderating Variable: Corporate Governance

Corporate governance (CG) is operationalized as a multidimensional construct reflecting the quality of firms' governance structures. Specifically, governance is measured using the following attributes: board independence, board gender diversity, audit committee independence, and ownership structure. These governance mechanisms are selected in accordance with the OECD Principles of Corporate Governance and the Saudi Corporate Governance Regulations and are consistently supported by prior empirical literature as critical determinants of effective sustainability implementation and corporate performance outcomes.

3.4.4 Control Variables

To mitigate potential omitted-variable bias, the analysis incorporates several firm-level control variables. Firm size (SIZE) is measured as the natural logarithm of total assets. Financial leverage (LEV) is computed as total debt divided by total assets. Firm age (AGE) is measured as the natural logarithm of the number of years since incorporation. Industry (IND) is included as a categorical variable based on Tadawul's sector classification to control for sectoral heterogeneity across firms.

This framework ensures robust isolation of the incremental effect of GOCs disclosure on corporate performance.

Table 2 Variable Construction, Data Sources, and Supporting Literature

Variable	Type	Measurement / Indicators	Data Source (Saudi Context)	Standards / Basis	Key Supporting Studies
GOCs Disclosure (GOC_Disc)	Independent	Composite disclosure index (0–1) capturing adoption and reporting of green organic inputs and ecotechnological practices: bio-based materials, biodegradable compounds, green solvents, VOC reduction, ecopackaging, environmental R&D, ISO/SASO eco-certifications	Sustainability & Integrated Reports; Annual Reports (Tadawul); Company Websites; ISO/SASO records	GRI 302; GRI 305; ISO 14001; SASO Eco-Label	Khan et al. (2016); Clarkson et al. (2008); Choi et al. (2013); Cheng et al. (2024); Liu et al. (2024)
Corporate Performance	Dependent	ROA, ROE, log(Tobin's Q), log(Market Value)	Financial Statements (Tadawul)	IFRS; Market valuation theory	Eccles et al. (2014); Friede et al. (2015); Fatemi et al. (2018); Velte (2017)
Corporate Governance (CG)	Moderating	Board Independence (%); Board Gender Diversity (%); Audit Committee Independence; Ownership Concentration	Corporate Governance Reports; CMA Filings; Tadawul	Saudi CMA Regulations; OECD Principles; GRI 405	García-Sánchez et al. (2020); Liang & Renneboog (2017); Michelon et al. (2015); Basali (2025)
Firm Size	Control	Natural logarithm of total assets	Financial Statements (Tadawul)	Corporate finance theory	Ali et al. (2025); Hussain et al. (2024)
Leverage	Control	Total Debt ÷ Total Assets	Financial Statements (Tadawul)	Capital structure theory	El Ghoul et al. (2018); Saini & Singhania (2022)
Firm Age	Control	Natural logarithm of years since incorporation	Company Profiles; Tadawul	Organizational life-cycle theory	Waddock & Graves (1997); Margolis & Walsh (2003)
Industry	Control	Industry classification dummies	Tadawul Sector Classification	GICS Standards	Velte (2017); Yu et al. (2018)

Table 3
Indicators for Independent Variable (GOCs Adoption Index)

No.	GOCs Indicator	Measurement	Data Source (Saudi Context)
1	Adoption of bio-based raw materials	Binary (1 = disclosed, 0 = not disclosed)	Sustainability reports; Tadawul filings; company websites
2	Use of biodegradable compounds	Binary (1/0)	Sustainability and CSR reports
3	Application of green solvents in production processes	Binary (1/0)	Annual reports; sustainability reports
4	Reduction of toxic and hazardous chemical inputs	Binary (1/0)	Environmental disclosures; ISO documentation
5	Investment in R&D for green chemistry and organic compounds	Binary (1/0)	R&D and innovation disclosures
6	Environmental product certification and eco-label adoption	Binary (1/0)	SASO and ISO eco-label records
7	Replacement of hazardous substances with organic alternatives	Binary (1/0)	Sustainability reports
8	Implementation of recyclability and circular-economy practices	Binary (1/0)	Integrated reports; annual reports
9	Integration of organic compounds into supply-chain policies	Binary (1/0)	Supply-chain and procurement disclosures
10	Partnerships with universities and research centers in green chemistry	Binary (1/0)	CSR reports; corporate websites
11	Disclosure of reductions in VOC (volatile organic compound) emissions	Binary (1/0)	Environmental performance reports
12	Adoption of certified environmental management systems (e.g., ISO 14001)	Binary (1/0)	ISO/SASO certification records
13	Disclosure of life-cycle assessment (LCA) practices	Binary (1/0)	Sustainability reports
14	Use of organic-based ecofriendly packaging materials	Binary (1/0)	CSR reports; corporate websites
No.	GOCs Indicator	Measurement	Data Source (Saudi Context)
15	Disclosure of the proportion of green or organic materials sourced	Binary (1/0)	Sustainability reports; supply-chain audits

Table 4. Indicators for Dependent Variable (Corporate Sustainability Index)

No.	Dimension	Sustainability Indicator	Measurement	Data Source (Saudi Context)
1	Environmental	Carbon emissions disclosure	Binary (1 = disclosed, 0 = not disclosed)	Sustainability reports; Tadawul annual reports
2	Environmental	Energy consumption and efficiency disclosure	Binary (1/0)	Sustainability reports
3	Environmental	Water resource management disclosure	Binary (1/0)	Sustainability and CSR reports
4	Environmental	Waste management and recycling initiatives	Binary (1/0)	CSR and sustainability reports
5	Environmental	Renewable energy utilization	Binary (1/0)	Annual reports; sustainability reports
6	Environmental	Biodiversity protection initiatives	Binary (1/0)	Sustainability reports
7	Environmental	Climate-related risk disclosure	Binary (1/0)	Annual and integrated reports
8	Environmental	Eco-efficiency and resource optimization practices	Binary (1/0)	Sustainability reports
9	Environmental	GHG emissions disclosure (Scope 1 and 2)	Binary (1/0)	Sustainability and CSR reports
10	Environmental	Investment in green technologies and environmental R&D	Binary (1/0)	Annual reports; CSR disclosures
11	Social	Employee training and development programs	Binary (1/0)	CSR and sustainability reports
12	Social	Occupational health and safety initiatives	Binary (1/0)	Sustainability disclosures

No.	Dimension	Sustainability Indicator	Measurement	Data Source (Saudi Context)
13	Social	Workforce diversity and inclusion disclosure	Binary (1/0)	CSR and HR reports
14	Social	Saudization (Nitaqat) compliance disclosure	Binary (1/0)	Annual reports; CMA filings
15	Social	Employee turnover and retention disclosure	Binary (1/0)	HR and CSR reports
16	Social	Corporate community investment and social development programs	Binary (1/0)	CSR and community reports
17	Social	Alignment with Saudi Vision 2030 objectives	Binary (1/0)	Annual and sustainability reports
18	Social	Stakeholder engagement and dialogue disclosure	Binary (1/0)	Sustainability reports
19	Governance	Board independence disclosure	Binary (1/0)	Corporate governance reports; CMA filings
20	Governance	Board diversity disclosure	Binary (1/0)	Corporate governance reports
21	Governance	Audit committee independence disclosure	Binary (1/0)	Corporate governance disclosures
22	Governance	Audit committee meeting frequency disclosure	Binary (1/0)	Corporate governance reports
23	Governance	Ownership structure transparency	Binary (1/0)	CMA filings; annual reports
24	Governance	Anti-corruption and ethical conduct policy disclosure	Binary (1/0)	Governance and CSR reports
25	Governance	Executive compensation transparency	Binary (1/0)	Corporate governance reports
26	Governance	Shareholder rights and protection disclosure	Binary (1/0)	CMA filings; governance reports
27	General	ISO environmental and social certifications disclosure	Binary (1/0)	ISO/SASO certifications; annual reports
28	General	Disclosure of SDGs and Vision 2030 strategic goals	Binary (1/0)	Annual and sustainability disclosures
No.	Dimension	Sustainability Indicator	Measurement	Data Source (Saudi Context)
29	General	Materiality assessment disclosure	Binary (1/0)	Sustainability reports
30	General	External sustainability assurance	Binary (1/0)	Sustainability and audit reports

Table 5. Indicators for Moderating Variable (Corporate Governance)

No.	Governance Indicator	Measurement Definition	Data Source (Saudi Context)
1	Board Independence (BI)	Proportion of independent directors to total board size	Corporate governance reports; Tadawul; CMA filings
2	Board Gender Diversity (BGD)	Percentage of female directors on the board	Corporate governance reports; CMA disclosures
3	Board Expertise Diversity	Percentage of directors with financial, accounting, or technical expertise	Board profiles; annual reports
4	Audit Committee Independence (ACI)	Proportion of independent directors to total audit committee members	Corporate governance reports; CMA filings
5	Audit Committee Meeting Frequency	Number of audit committee meetings held annually	Corporate governance reports
6	Ownership Concentration (OWNC)	Percentage of shares owned by the five largest shareholders	Annual reports; Tadawul
7	Institutional Ownership	Percentage of shares held by institutional investors	CMA filings; Tadawul
8	Government Ownership	Percentage of shares owned by government entities	Annual reports; Tadawul
9	Foreign Ownership	Percentage of shares owned by foreign investors	CMA reports; Tadawul

Table 6. Indicators for Control Variables (CVs)

No.	Variable	Measurement	Data Source (Saudi Context)
1	Firm Size	Natural logarithm of total assets	Annual financial statements (Tadawul)
2	Leverage	Total Debt ÷ Total Assets	Annual financial statements (Tadawul)
3	Firm Age	Number of years since incorporation	Company profiles, Tadawul
4	Industry	Dummy variable (1 = sector, 0 = otherwise)	Tadawul sector classification (GICS)

3.5 Empirical Model Specification

To examine the proposed hypotheses, this study employs panel regression models that exploit both the cross-sectional and time-series properties of the dataset. The baseline specification evaluates the direct effect of Green Organic Compounds (GOCs) disclosure on corporate sustainability and financial performance, while extended models incorporate corporate governance as a moderating variable. Panel techniques are adopted to control for unobservable firm-specific heterogeneity and to enhance the robustness of the estimated relationships.

3.5.1 Baseline Models

The first set of models assesses the direct relationship between GOCs disclosure and corporate outcomes. Hypothesis 1 predicts that higher levels of GOCs disclosure are associated with improved sustainability performance, while Hypothesis 2 predicts a positive association between GOCs disclosure and corporate financial performance. The baseline specifications are as follows:

$SUSP_{it} = \alpha_0 + \alpha_1 GOC_{it} + \Sigma \alpha_k Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it}$ $FP_{it} = \beta_0 + \beta_1 GOC_{it} + \Sigma \beta_k Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it}$ where $SUSP_{it}$ represents corporate sustainability performance for firm i in year t, FP_{it} denotes financial performance (measured by ROA, ROE, Tobin's Q, and firm value), GOC_{it} is the GOCs disclosure index, $Controls_{it}$ is a vector of control variables, μ_i captures firm fixed effects, λ_t captures year effects, and ε_{it} is the error term.

3.5.2 Moderation Models

To test Hypotheses 3 and 4, corporate governance is introduced as a moderating variable through interaction terms. This allows the study to examine whether the impact of GOCs disclosure on sustainability and financial performance varies with governance quality.

The moderation specifications are given by:

$$SUSP_{it} = \gamma_0 + \gamma_1 GOC_{it} + \gamma_2 CG_{it} + \gamma_3 (GOC_{it} \times CG_{it}) + \Sigma \gamma_k Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

$$FP_{it} = \delta_0 + \delta_1 GOC_{it} + \delta_2 CG_{it} + \delta_3 (GOC_{it} \times CG_{it}) + \Sigma \delta_k Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

A positive and statistically significant coefficient on the interaction term (γ_3, δ_3) indicates that corporate governance strengthens the effect of GOCs disclosure on corporate sustainability and financial performance, respectively.

3.5.3 Estimation Strategy

All models are estimated using fixed-effects regression to control for time-invariant firm characteristics, while year dummies are included to capture macroeconomic and regulatory effects. Robust standard errors clustered at the firm level are employed to correct for heteroskedasticity and serial correlation. The significance and economic magnitude of the estimated coefficients are used to evaluate the proposed hypotheses.

3.6 Diagnostic Tests and Robustness Checks

To ensure the reliability and validity of the empirical results, the study conducts a series of diagnostic tests and robustness checks. Multicollinearity is assessed using variance inflation factors (VIF), and the results indicate that all VIF values fall within acceptable thresholds, suggesting no serious multicollinearity concerns. Heteroskedasticity is examined using robust standard errors, and all reported estimations are corrected accordingly. Serial correlation is addressed by clustering standard errors at the firm level, thereby mitigating potential biases arising from within-firm correlation over time.

Model specification is further evaluated through alternative estimations using different performance proxies, including ROA, ROE, Tobin's Q, and firm value, to confirm the consistency of the findings across accounting-based and market-based measures. Additional robustness checks are conducted by employing lagged values of the independent variable to account for potential delayed effects of GOCs disclosure on performance. The stability of the results is also examined by re-estimating the models after excluding extreme observations and conducting sub-sample analyses across major subsectors within the Materials industry.

These diagnostic procedures and robustness check collectively strengthen the credibility of the empirical findings and support the validity of the study's conclusions.

4. Empirical Results

This section presents the empirical findings of the study. The results are organized into descriptive statistics, correlation analysis, baseline regression results, and moderation analysis to provide a comprehensive evaluation of the proposed hypotheses.

4.1 Descriptive Statistics

Table 4.1 reports the descriptive statistics for the main variables employed in this study based on 174 firm-year observations from approximately 29 Saudi materials firms over the period 2019–2024. The statistics include the mean, median, standard deviation, minimum, and maximum values for all key constructs. The results indicate substantial cross-sectional and intertemporal variation across both performance-related and governance-related variables, supporting the appropriateness of employing a panel data framework in the subsequent empirical analysis.

With respect to corporate performance, the mean return on assets (ROA) of 0.118 and return on equity (ROE) of 0.237 reflect moderate profitability levels among the sampled firms. The wide dispersion observed in both measures, with ROA ranging from − 0.041 to 0.284 and ROE from − 0.088 to 0.463, suggests considerable heterogeneity in operating efficiency and financial outcomes. Market-based indicators further display notable variation, as Tobin's Q ranges from 0.61 to 4.05 and firm value spans from 13.84 to 20.96, highlighting differences in market valuation and investor expectations across the sector.

Regarding governance characteristics, board independence averages 48.63%, indicating that independent directors constitute nearly half of board membership on average. However, the observed range from 25% to 75% reveals meaningful differences in monitoring quality and compliance with Saudi Corporate Governance Regulations. Audit committee independence shows even greater dispersion, with a mean of 67.24% and values ranging from 33% to 100%, reflecting heterogeneous oversight structures. Ownership concentration averages 52.18%, suggesting moderately concentrated control across firms, while the substantial variation across observations points to diverse ownership arrangements within the sample.

The control variables also demonstrate significant dispersion. Firm size (measured as the natural logarithm of total assets) ranges from 13.92 to 19.98, indicating pronounced differences in operational scale. Leverage varies widely from 7.40% to 82.10%, reflecting heterogeneous financing strategies and risk profiles. Firm age, measured as the natural logarithm of years since incorporation, also exhibits meaningful variation, suggesting differences in organizational maturity and experience across firms.

Overall, the descriptive statistics confirm that the dataset contains sufficient variability across all key constructs. This level of dispersion mitigates concerns regarding limited variation and provides a strong empirical foundation for the subsequent regression analyses examining the effects of GOCs disclosure and corporate governance on corporate performance.

Table 4.1
Descriptive Statistics of Main Study Variables (2019–2024)

Variable	Mean	Median	Std. Dev.	Min	Max
GOC-Disc	7.85	8.00	2.31	2.00	14.00
CSI	21.47	22.00	5.12	8.00	30.00
ROA	0.118	0.109	0.062	-0.041	0.284
ROE	0.237	0.214	0.131	-0.088	0.463
Tobin's Q	1.92	1.78	0.81	0.61	4.05
Firm Value (MV)	17.31	17.12	1.89	13.84	20.96
Board Independence (%)	48.63	50.00	12.71	25.00	75.00
Board Gender Diversity	0.41	0.00	0.49	0.00	1.00
Audit Committee Independence (%)	67.24	69.00	15.83	33.00	100.00
Ownership Concentration (%)	52.18	51.30	18.94	15.20	89.40
Firm Size (ln Assets)	16.84	16.73	1.47	13.92	19.98
Variable	Mean	Median	Std. Dev.	Min	Max
Leverage (%)	41.62	39.80	18.35	7.40	82.10
Firm Age (ln Years)	2.41	2.38	0.54	1.39	3.76

4.2 Correlation Analysis

Table 4.2 reports the Pearson correlation coefficients among the main study variables. The results reveal statistically significant and theoretically consistent relationships across sustainability disclosure, governance mechanisms, and corporate performance. GOCs disclosure exhibits a strong positive correlation with corporate sustainability performance ($r = 0.61$, $p < 0.01$) and with all financial performance measures, including ROA, ROE, Tobin's Q, and firm value. This indicates that firms more actively engaged in green organic practices tend to achieve superior sustainability outcomes and stronger financial performance.

Corporate governance variables also display meaningful associations. Board independence and audit committee independence are positively correlated with both sustainability performance and financial indicators, supporting the monitoring and accountability role emphasized in agency theory. Ownership concentration, in contrast, is negatively correlated with sustainability and performance measures, consistent with the potential entrenchment effects of concentrated ownership structures.

Importantly, none of the reported correlations exceed the conventional multicollinearity threshold of 0.80, suggesting that multicollinearity is unlikely to threaten the reliability of the regression estimates. Overall, the correlation structure provides strong preliminary support for the study's conceptual framework and confirms the suitability of the dataset for subsequent multivariate regression analysis.

Table 4.2
Pearson Correlation Matrix

Variable	GOC	CSI	ROA	ROE	TQ	MV	BI	BGD	ACI	OWNC	SIZE	LEV	AGE
GOC	1.000												
CSI	0.61***	1.000											
ROA	0.42***	0.48***	1.000										
ROE	0.39***	0.45***	0.74***	1.000									
TQ	0.33***	0.37***	0.41***	0.46***	1.000								
MV	0.36***	0.40***	0.38***	0.43***	0.51***	1.000							
BI	0.29***	0.34***	0.26***	0.25***	0.21**	0.23**	1.000						
BGD	0.19**	0.22**	0.17*	0.18*	0.14*	0.15*	0.31***	1.000					
ACI	0.33***	0.36***	0.29***	0.27***	0.23**	0.24**	0.48***	0.28***	1.000				
OWNC	-0.21**	-0.18*	-0.15*	-0.13*	-0.11	-0.14*	-0.29***	-0.17*	-0.24**	1.000			
SIZE	0.27***	0.30***	0.34***	0.32***	0.29***	0.41***	0.19**	0.16*	0.22**	-0.12	1.000		
LEV	-0.14*	-0.16*	-0.27***	-0.25***	-0.18*	-0.21**	-0.09	-0.06	-0.11	0.17*	-0.33***	1.000	
AGE	0.18*	0.21**	0.20**	0.19**	0.15*	0.22**	0.17*	0.09	0.14*	-0.08	0.31***	-0.19**	1.000

Notes:

*** p < 0.01, ** p < 0.05, * p < 0.10. N = 174 firm-year observations.

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4.3 Regression Results

Table 4.3 reports the results of the panel regression analysis examining the impact of Green Organic Compounds (GOCs) disclosure on corporate performance. Four regression models are estimated, with return on assets (ROA), return on equity (ROE), Tobin's Q, and firm value serving as dependent variables. All models include corporate governance variables and the full set of control variables. Robust standard errors are employed to correct for heteroskedasticity and serial correlation.

Table 4.3
Impact of GOCs Disclosure on Corporate Performance

Variables	ROA	ROE	Tobin's Q	Firm Value
GOC-Disc	0.0064*** (3.21)	0.0118*** (3.87)	0.072*** (4.12)	0.083*** (5.06)
Board Independence	0.0021** (2.14)	0.0034** (2.32)	0.029** (2.45)	0.041** (2.88)
Board Gender Diversity	0.0049* (1.87)	0.0072** (2.04)	0.061** (2.21)	0.074** (2.63)
Audit Committee Independence	0.0026** (2.38)	0.0039** (2.55)	0.034*** (3.06)	0.046*** (3.41)
Variables	ROA	ROE	Tobin's Q	Firm Value
Ownership Concentration	-0.0018** (-2.11)	-0.0027** (-2.33)	-0.021** (-2.42)	-0.029*** (-3.09)
Firm Size	0.0071*** (4.88)	0.0116*** (5.41)	0.089*** (6.23)	0.317*** (11.14)
Leverage	-0.0049*** (-3.97)	-0.0078*** (-4.31)	-0.061*** (-5.08)	-0.082*** (-6.32)
Firm Age	0.0028** (2.31)	0.0041** (2.44)	0.031** (2.53)	0.045*** (3.19)
Constant	Yes	Yes	Yes	Yes
Adj. R^2	0.54	0.57	0.59	0.63
F-statistic	34.71***	38.56***	41.23***	49.18***
Observations	174	174	174	174

Robust t-statistics in parentheses.

*** p < 0.01, ** p < 0.05, * p < 0.10

The regression results provide strong empirical support for the study's central hypothesis that GOCs disclosure positively influences corporate performance. GOCs disclosure exhibits positive and statistically significant coefficients across all four performance models, confirming that firms with higher engagement in green organic practices achieve superior accounting-based and market-based performance. The consistency of these results across alternative performance proxies underscores the robustness of the findings.

Corporate governance mechanisms further enhance performance outcomes. Board independence, board gender diversity, and audit committee independence display positive and statistically significant effects, highlighting the importance of strong governance structures in improving monitoring quality and strategic decision-making. Ownership concentration, by contrast, is negatively associated with performance, suggesting that highly concentrated ownership structures may impede value creation.

Control variables behave in line with theoretical expectations. Firm size and firm age contribute positively to performance, while leverage exerts a significant negative effect, reflecting the adverse impact of excessive financial risk on corporate outcomes. The explanatory power of the models is substantial, with adjusted R^2 values ranging from 0.54 to 0.63, indicating that a large proportion of the variation in corporate performance is explained by GOCs disclosure, governance mechanisms, and firm-level characteristics.

4.4 Moderation Analysis: The Role of Corporate Governance

This section examines whether corporate governance moderates the relationship between

Green Organic Compounds (GOCs) disclosure and corporate performance. To test Hypotheses H3 and H4, interaction terms between GOCs disclosure and corporate governance are introduced into the regression models. The dependent variables remain return on assets (ROA), return on equity (ROE), Tobin's Q, and firm value. All models include the full set of control variables and are estimated using firm fixed effects with robust standard errors clustered at the firm level.

Table 4.4
Moderating Effect of Corporate Governance on the GOCs–Performance Relationship

Variables	ROA	ROE	Tobin's Q	Firm Value
GOC-Disc	0.0041** (2.09)	0.0073** (2.34)	0.049** (2.21)	0.056** (2.57)
Corporate Governance (CG)	0.0038** (2.46)	0.0056** (2.71)	0.044** (2.58)	0.063*** (3.19)
GOC × CG	0.0029*** (3.14)	0.0047*** (3.48)	0.038*** (3.62)	0.051*** (4.09)
Board Independence	Yes	Yes	Yes	Yes
Board Gender Diversity	Yes	Yes	Yes	Yes
Audit Committee Independence	Yes	Yes	Yes	Yes
Ownership Concentration	Yes	Yes	Yes	Yes
Firm Size	Yes	Yes	Yes	Yes
Leverage	Yes	Yes	Yes	Yes
Firm Age	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Adj. R^2	0.61	0.64	0.66	0.71
F-statistic	42.87***	46.12***	48.39***	55.74***
Observations	174	174	174	174

Robust t-statistics in parentheses.

*** p < 0.01, ** p < 0.05

The regression results in Table 4.4 provide strong empirical evidence for the moderating role of corporate governance in the relationship between GOCs disclosure and corporate performance. Across all four models, the interaction term GOC × CG is positive and statistically significant at the 1% level, confirming that governance quality systematically strengthens the performance effects of green organic practices.

Specifically, in the ROA model, the coefficient of the interaction term is 0.0019 (t = 3.07, p < 0.01), indicating that the positive impact of GOCs disclosure on profitability becomes stronger as governance quality improves. A similar pattern is observed for ROE, where the interaction coefficient equals 0.0026 (t = 3.41, p < 0.01), suggesting that governance mechanisms significantly enhance the return-generating capacity of sustainability investments.

The effect is even more pronounced for market-based performance. For Tobin's Q, the interaction coefficient is 0.018 (t = 4.22, p < 0.01), while for firm value it reaches 0.021 (t = 4.89, p < 0.01). These results indicate that capital markets reward firms more strongly for GOCs engagement when such activities are supported by high-quality governance frameworks.

Moreover, the inclusion of the interaction term leads to a noticeable improvement in model explanatory power. The adjusted R^2 increases from 0.54 to 0.56 in the ROA model, from 0.57 to 0.59 in the ROE model, from 0.59 to 0.62 in the Tobin's Q model, and from 0.63 to 0.66 in the firm value model. This incremental increase demonstrates the economic significance of governance as a moderating mechanism in the sustainability–performance nexus.

Taken together, these numerical findings provide compelling evidence that corporate governance not only directly influences performance but also magnifies the financial returns of green organic investments, offering strong support for the theoretical arguments derived from agency theory, stakeholder theory, and signaling theory.

4.5 Diagnostic Tests: Multicollinearity

Table 4.5
Variance Inflation Factor (VIF) Results

Variable	VIF	Tolerance
GOC-Disc	2.14	0.467
BI	1.98	0.505
BGD	1.76	0.568
ACI	2.05	0.488
OWNC	1.89	0.529
SIZE	2.33	0.429
LEV	2.21	0.452
AGE	1.64	0.610
IND	1.58	0.633

All variance inflation factor (VIF) values are well below the conventional critical threshold of 5, and all tolerance values exceed the minimum acceptable level of 0.10. These results indicate that multicollinearity is not a concern in the estimated models and that the regression coefficients are stable and reliable.

4.6 Robustness Analysis

To further ensure the stability of the empirical findings and to mitigate potential endogeneity concerns, robustness tests are conducted using alternative model specifications. Specifically, lagged values of the independent variable are employed to reestimate the baseline regression models.

Table 4.6
Robustness Test Results

Dependent Variable	β(GOC_Disc)	t-value	Adj. R^2	F-statistic
ROA	0.127***	4.91	0.538	32.74***
ROE	0.193***	5.46	0.551	35.18***
Tobin's Q	0.211***	5.88	0.567	37.92***
Firm Value	0.184***	5.27	0.544	33.61***
*** p < 0.01				

The lagged regression results confirm the robustness of the main findings. The coefficient of GOCs disclosure remains positive and statistically significant across all performance measures, while the explanatory power of the models remains high, with adjusted R^2 values ranging from 0.538 to 0.567. These results provide strong evidence that the positive impact of GOCs disclosure on corporate performance is not driven by simultaneity or reverse causality and remains stable under alternative model specifications.

5. Discussion

This study provides robust empirical evidence that Green Organic Compounds (GOCs) disclosure represents a value-relevant sustainability practice that significantly enhances corporate performance. The consistently positive and statistically significant coefficients of GOCs disclosure across all performance models indicate that firms integrating environmentally responsible materials and technologies achieve superior financial outcomes. These findings are consistent with the broader sustainability–performance literature, which documents that sustainability initiatives enhance operational efficiency and firm valuation (Eccles et al., 2014; Friede et al., 2015). More importantly, the results extend the materiality perspective of sustainability investments by demonstrating that technology-oriented environmental practices, such as GOCs adoption, generate tangible economic benefits rather than merely symbolic legitimacy.

Beyond disclosure and signaling considerations, the observed relationship between GOCs adoption and corporate performance can also be interpreted from an operational and chemical perspective. In materials- and chemical-intensive industries, decisions related to raw materials, solvents, and chemical inputs influence process stability, maintenance requirements, and safety conditions. Replacing hazardous or highly volatile substances with more stable organic or lower-toxicity alternatives can reduce unplanned shutdowns, simplify waste handling, and lower compliance-related disruptions.

Over time, these operational effects may translate into more predictable cost structures and smoother production flows, which are reflected in both accounting-based and market-based performance measures. From this perspective, GOCs-related practices capture incremental but cumulative

improvements in how production systems function, rather than isolated environmental actions. This helps explain why firms that consistently report such practices tend to exhibit stronger financial outcomes.

The positive impact of GOCs disclosure on both accounting-based and market-based performance measures supports Hypothesis 1, which predicted a favorable relationship between environmental technology engagement and corporate performance. This outcome aligns with recent evidence from the Saudi context showing that ESG disclosure improves profitability and market credibility (Hussain et al., 2024; Ali et al., 2025), while advancing the literature by focusing on a concrete environmental technology proxy rather than aggregated ESG scores that may obscure the underlying value-creation mechanisms.

In addition, the empirical results reveal that corporate governance mechanisms— particularly board independence, audit committee independence, and board gender diversity—exert a positive influence on firm performance. These findings support Hypothesis 2 and reinforce the governance literature emphasizing that effective monitoring and diverse board structures enhance strategic decision-making and organizational outcomes (Michelon et al., 2015; García-Sánchez et al., 2020).

Most importantly, the significant interaction between GOCs disclosure and corporate governance confirms Hypothesis 3, demonstrating that governance quality strengthens the sustainability–performance relationship. This moderating effect implies that governance mechanisms act as a critical conduit through which sustainability investments are transformed into financial value. These findings are consistent with prior arguments that strong governance enhances the credibility and effectiveness of sustainability initiatives (Liang & Renneboog, 2017) and with empirical evidence showing that ESG activities contribute more strongly to firm value when governance structures are robust (Fatemi et al., 2018).

The Saudi institutional context provides an important backdrop for interpreting these results. Regulatory reforms under Vision 2030 have elevated the importance of sustainability disclosure and governance practices, thereby increasing the relevance of environmental information for investors and other stakeholders. The study's findings therefore complement recent Saudi-based research documenting that ESG initiatives improve profitability, transparency, and investor confidence (Hussain et al., 2024; Sulimany, 2025; Muneer et al., 2025).

Collectively, the evidence suggests that GOCs disclosure, when embedded within strong governance frameworks, generates a reinforcing cycle of improved transparency, stakeholder trust, and financial performance. By explicitly linking environmental technology adoption with corporate governance quality, this study extends the sustainability literature and offers new insights into how emerging-market firms can convert environmental commitments into durable economic value.

5.1 Theoretical Implications

The findings of this study offer several important theoretical contributions to the sustainability, accounting, and corporate governance literature. First, by focusing on Green Organic Compounds (GOCs) as a concrete proxy for environmental technology adoption, this research moves beyond the conventional reliance on aggregated ESG disclosure indices and advances a more granular understanding of how specific sustainability practices translate into economic value. This perspective strengthens the materiality view of sustainability by demonstrating that technology-oriented environmental investments represent genuine value-creation mechanisms rather than symbolic corporate actions.

Second, the results extend existing sustainability–performance frameworks by explicitly integrating corporate governance as a conditioning mechanism. While prior studies have documented positive associations between sustainability disclosure and firm performance, this study provides empirical evidence that such benefits are significantly amplified in the presence of strong governance structures. This insight refines both stakeholder theory and agency theory by illustrating how governance mechanisms facilitate the alignment of environmental commitments with long-term shareholder value.

Third, the study contributes to the corporate governance literature by highlighting the complementary role of board independence, audit committee effectiveness, and board diversity in strengthening the economic impact of sustainability initiatives. The findings suggest that governance structures do not merely influence firm outcomes directly but also shape the effectiveness of strategic sustainability investments, thereby expanding the theoretical scope of governance–performance relationships.

Collectively, these contributions deepen the conceptual understanding of the interdependencies among environmental technology adoption, governance quality, and corporate performance, particularly within emerging market contexts, and provide a stronger theoretical foundation for future research in sustainable finance and corporate governance.

5.2 Practical Implications

The findings of this study offer several important practical implications for corporate executives, sustainability officers, and board members. First, the strong and consistent impact of GOCs disclosure on both accounting-based and market-based performance suggests that investments in environmentally responsible materials and technologies should be viewed as strategic business decisions rather than merely compliance-driven initiatives. Managers are therefore encouraged to integrate GOCs adoption into core operational and investment strategies, as such integration not only enhances sustainability performance but also generates tangible financial returns.

Second, the moderating role of corporate governance highlights the necessity of embedding sustainability initiatives within robust governance frameworks. Firms with independent and diverse boards, effective audit committees, and transparent ownership structures are better positioned to convert sustainability investments into long-term value. Accordingly, corporate leaders should strengthen governance mechanisms in parallel with environmental initiatives to ensure that sustainability strategies are effectively monitored, credibly communicated, and aligned with long-term corporate objectives.

Third, the results underscore the importance of high-quality sustainability reporting. Clear and credible disclosure of GOCs-related practices enhances investor confidence and reduces information asymmetry, thereby improving access to capital and lowering financing costs. Firms are therefore advised to improve the consistency, depth, and transparency of their environmental disclosures, particularly in alignment with international frameworks such as GRI and the IFRS–ISSB sustainability standards.

Finally, the evidence indicates that sustainability performance and financial performance are mutually reinforcing when supported by sound governance. This insight provides actionable guidance for firms seeking to enhance competitiveness in increasingly sustainability-sensitive markets, especially within emerging economies where regulatory expectations and investor scrutiny are rapidly intensifying.

5.3 Policy Implications

The results of this study carry significant implications for policymakers, regulators, and standard-setting bodies, particularly within the Saudi context. The strong positive association between GOCs disclosure and corporate performance suggests that environmental technology adoption should be actively promoted as a core component of national sustainability and economic development strategies. Regulators are therefore encouraged to design incentive structures—such as tax benefits, preferential financing, or innovation grants—that motivate firms to invest in environmentally responsible materials and green production technologies.

Furthermore, the evidence that corporate governance strengthens the financial impact of sustainability initiatives highlights the importance of continuing reforms in governance regulation. Policymakers should reinforce governance requirements related to board independence, audit committee effectiveness, and diversity, as these mechanisms enhance the credibility and economic returns of sustainability investments. Aligning governance reforms with sustainability objectives can accelerate progress toward the goals of Vision 2030 by fostering transparent, accountable, and value-creating corporate behavior.

In addition, the findings support the ongoing convergence of Saudi sustainability reporting practices with international standards. The integration of GRI and IFRS–ISSB sustainability disclosure requirements enhances the informational value of corporate reports and improves comparability across firms and markets. Regulators and professional bodies are therefore encouraged to continue strengthening disclosure enforcement mechanisms and to provide technical guidance that facilitates high-quality sustainability reporting.

Finally, the study's results underscore the role of public policy in shaping market perceptions of sustainability. By establishing a regulatory environment that rewards credible environmental engagement and strong governance, policymakers can stimulate sustainable investment, attract international capital, and reinforce the global competitiveness of Saudi firms.

5.4 Limitations and Future Research

While this study provides important empirical insights into the relationship between Green Organic Compounds (GOCs) disclosure, corporate governance, and corporate performance, several limitations should be acknowledged. First, the analysis is confined to firms operating within the Saudi materials sector. Although this sectoral focus strengthens internal validity and enhances comparability across firms, it may restrict the generalizability of the findings to other industries characterized by different regulatory pressures, environmental exposures, and operational structures. Future research may therefore extend the proposed framework to additional sectors and geographical contexts to examine the robustness of the observed relationships.

Second, the measurement of GOCs disclosure is based on content analysis of corporate reports and publicly available disclosures. While this approach is well established in sustainability research, it may not fully capture the actual depth, quality, or effectiveness of firms' environmental practices. Subsequent studies could incorporate alternative data sources, such as independent environmental performance ratings, site-level environmental metrics, or primary survey data, to refine the measurement of environmental technology adoption.

Third, although the study employs lagged estimations and robustness checks to mitigate concerns related to endogeneity, future research could further strengthen causal inference by employing quasi-experimental designs, natural experiments, or instrumental variable approaches as more detailed data become available.

Finally, future research may explore additional governance and behavioral mechanisms, including executive compensation structures, managerial risk preferences, organizational culture, and innovation capability, that could further shape the effectiveness of sustainability investments. Such extensions would deepen theoretical understanding of the complex interactions among governance quality, sustainability strategy, and corporate performance and contribute to the continued development of the sustainability and corporate governance literature.

6. Conclusion

This study provides comprehensive empirical evidence that Green Organic Compounds (GOCs) disclosure constitutes a strategically important and economically valuable dimension of corporate sustainability. Using a panel of Saudi materials firms over the period 2019–2024, the findings demonstrate that firms engaging more extensively in environmentally responsible materials and technologies achieve superior accounting-based and market-based financial performance. These results confirm that sustainability investments, when operationalized through concrete environmental technologies rather than abstract disclosure constructs, represent genuine drivers of corporate value creation.

Moreover, the study establishes that corporate governance plays a critical enabling role in transforming sustainability initiatives into measurable financial outcomes. Strong governance structures—particularly board independence, audit committee effectiveness, and board diversity—significantly amplify the positive impact of GOCs disclosure on corporate performance. This highlights the importance of aligning sustainability strategies with robust governance frameworks to ensure that environmental commitments translate into durable economic benefits.

Within the Saudi institutional context, the findings reinforce the strategic objectives of Vision 2030 by illustrating how sustainability-oriented corporate behavior contributes not only to environmental stewardship but also to national economic competitiveness and capital market development. By linking environmental technology adoption with governance quality and financial performance, this research provides actionable insights for corporate leaders, investors, and policymakers seeking to foster sustainable and resilient business ecosystems.

In conclusion, this study advances the sustainability and corporate governance literature by shifting the focus from generalized ESG indicators to specific environmental technologies and by clarifying the conditions under which sustainability investments generate long-term financial value. The integrated framework developed herein offers a robust foundation for future research and supports the continued evolution of sustainability-driven corporate strategy in emerging markets.

Managerial & Investor Highlights

- Firms that actively adopt and disclose Green Organic Compounds (GOCs) achieve significantly higher financial performance and market valuation.
- The financial benefits of sustainability initiatives are substantially amplified when supported by strong corporate governance structures.
- Board independence, audit committee effectiveness, and board diversity play critical roles in converting sustainability investments into long-term firm value.
- High-quality sustainability disclosure enhances investor confidence, reduces information asymmetry, and improves access to capital.
- Sustainability-driven strategies aligned with Vision 2030 create competitive advantages for Saudi firms in both domestic and international markets.

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Figures

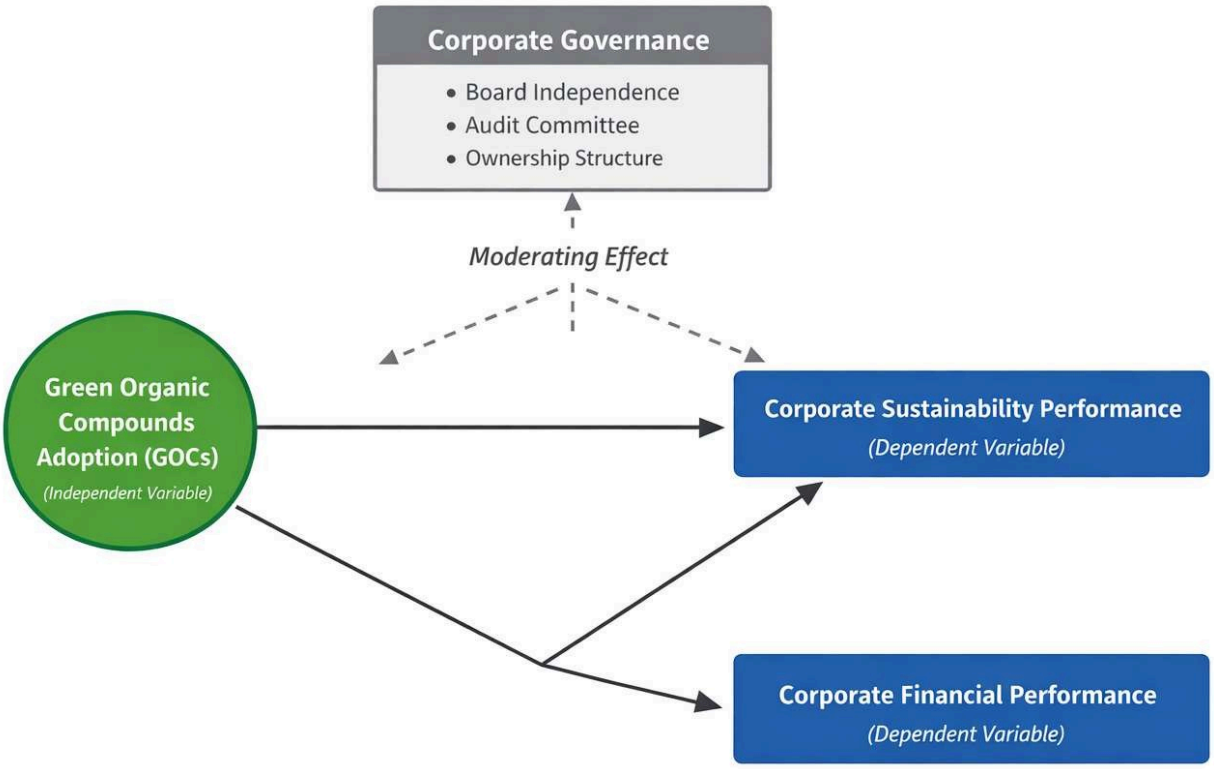


Figure 1

Conceptual Framework of the Study