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The impact of environmental innovation and green finance on corporate sustainability: The mediating role of organizational capabilities — evidence from Saudi listed companies

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ABSTRACT

Worldwide, corporate sustainability has become a strategic priority. This is even more the case for Saudi Arabia's Vision 2030 agenda for economic diversification. While the promotion of environmental innovations and green financing is robust, these resources' contributions to sustainability are likely to be limited to the organizational capabilities firms develop to absorb and utilize them. Taking a resource-based and dynamic-capabilities view, the study investigates the direct impacts of environmental product innovations, environmental process innovations, green financing, green-financing instruments, and corporate sustainability. The study further investigates the direct impacts of organizational capabilities on the aforementioned relationships for corporate sustainability among Saudi Arabia-listed firms. Survey data were collected from 146 professionals working in Saudi Arabia's basic materials industry. Respondents answered using multi-item scales on a five-point Likert scale. SmartPLS 4.0 was used for partial least squares structural equation modeling. The measurement model met the standards for reliability and validity, and significance was determined using 5,000 subsample bootstraps. Organizational capabilities had the strongest direct effect on corporate sustainability ($\beta = 0.553$, $p < 0.001$). The model explained 85.8% of the sustainability variance and 78.8% of the capabilities variance. Mediation analysis showed full mediation for the process-innovation and green-finance paths, and partial mediation for the product-innovation and green-financing paths. Findings offer strategic guidance for Saudi firms to align with Vision 2030 and highlight the importance of capabilities in green initiatives and sustainable finance.

Contribution/Originality: This study contributes to the literature by integrating environmental innovation and green finance into a single mediation model in which organizational capabilities convert these inputs into corporate sustainability outcomes. It offers the first capability-mediated PLS-SEM evidence from Saudi-listed basic materials firms operating under Vision 2030.

1. INTRODUCTION

Corporate sustainability has become a defining strategic priority for organizations operating in resource-constrained and stakeholder-attentive environments. The triple-bottom-line logic, that long-term success requires the simultaneous achievement of economic, environmental, and social performance, has moved to the center of

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corporate strategy (Elkington, 2018) with global climate and resource pressures intensifying firms' need to embed environmental considerations into core operations (IPCC, 2022).

In Saudi Arabia, Vision 2030 reinforces the global push for diversification, linking economic diversification away from hydrocarbons with environmental sustainability and the development of human capital. Recent evidence suggests that Vision 2030 is positively influencing sustainability, with a halt in CO2 emissions from production and the emergence of the circular carbon economy (Yusuf & Lytras, 2023). Research on Saudi Arabia's green banking shows that sustained policy and operational practices that focus on sustainability enhance the firm's environmental performance (Laallam, Alsubayt, Kashi, & Nomran, 2025). Saudi Arabia is one of the largest producers and exporters of hydrocarbons, and its unique context of rapid legal and regulatory change, coupled with strong state involvement and unique cultural dimensions, makes it an interesting region to evaluate the variation of firm-level sustainable practices (Chaaben, Elleuch, Hamdi, & Kahouli, 2024; Islam & Ali, 2024).

The two most commonly recognized mechanisms to describe how corporations transition toward sustainability are environmental innovations and green financing. Environmental innovations include product and process innovations, as well as changes in management approaches, to reduce a company's sustainability concerns while retaining its competitive edge (Kahia, Jarraya, Kahouli, & Omri, 2024; Larbi-Siaw et al., 2022). Emerging markets offer recent data suggesting that innovations in products, processes, and management contribute to the sustainable development of firm performance, incorporating environmental, social, and economic dimensions. However, the level of managerial involvement and the market environment can lead to substantial differences in the outcomes of these innovations (Ahmed et al., 2023; Liu, Javaid, & Usman, 2025). Compared to environmental innovations, green financing provides investment opportunities to support environmental initiatives through green bonds, sustainability-linked loans, and Green Sukuk. In China and other countries, green financing reforms, which target the clearing of financing barriers and encourage green investments, have been shown through quasi-experimental and panel data to have positive effects on the environmental management focus of company leadership and ESG performance (Gao, Zhou, & Wan, 2024; Li & Pang, 2023).

There is no consistent correlation between environmental innovation, green finance, and corporate sustainability. More and more researchers suggest that the transformation of environmental and financial resources into sustainability is highly dependent on an organization's internal capabilities, such as absorptive capacity, environmental management systems, dynamic capabilities, and the ability to engage different stakeholder groups (Algarni et al., 2022; Ortiz-Avram, Ovcharova, & Engelmann, 2024; Shang, Chen, & Li, 2020). From the resource-based view (RBV) of an organization, internal capabilities are the processes and routines that organize and safeguard strategic resources; in the dynamic capabilities perspective, they are advanced processes and routines that enable an organization to proactively address and respond to resource and environmental changes (Teece, 2007). There is empirical evidence that environmental management systems fully mediate the relationship between absorptive and reconfiguration capabilities and eco-innovation (Huang & Xiao, 2023) and that the green dynamic capabilities mediate the relationship between corporate social responsibility and green innovation (Aftab et al., 2024; Yuan & Cao, 2022). Such comparable empirical patterns have also been documented for the capabilities-as-mediator between green finance and resilience (Ur Rahman & Amjad, 2024) and between dynamic sustainability capabilities and corporate sustainability performance (Shang et al., 2020).

1.1. Research Gap

Though the literature has made some advances, four major gaps persist. First, environmental innovations and green finance are typically addressed separately, rather than as distinct but related dimensions that rely on distinct organizational mechanisms. Few scholarly endeavors integrate them into a mediated framework, thereby creating ambiguity about the means by which they operate. Second, most of the available literature is situated in China, the UK, Europe, and other Asian manufacturing regions (Ahmed et al., 2023; Alkaraan et al., 2024; Yuan & Cao, 2022).

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There is a surprising lack of studies on resource-rich economies in the Gulf region, which face distinct sustainability challenges. Third, while organizational capabilities act as mediators, the literature examined them in isolation and ends the mediation spectrum with a single variable (e.g., CSR or green innovation). Therefore, the exponents of full and partial mediation remain unexplored. Fourth, existing Saudi literature predominantly discusses macroeconomic dimensions, with a focus on energy policy, industrial transitions, or a single industry (Islam & Ali, 2024; Selim & Alshareef, 2025). This literature lacks firm-level analyses of resource-intensive listed companies in the basic materials industry.

This research is a step toward filling some of these gaps by explaining and empirically testing a reconciled mediating role for organizational capabilities in the relationship between environmental innovations (at both the product and process levels) and green finance (at both the access and instrument levels), in the context of corporate sustainability. It concerns Saudi Arabia's basic materials industry, which is highly environmentally damaging yet has substantial green investments. Objectives include: (i) evaluating direct effects of environmental innovation and green finance on sustainability; (ii) assessing organizational capabilities' direct effect; (iii) testing their mediating role; and (iv) providing implications for Saudi managers and policymakers under Vision 2030. Accordingly, the study addresses three research questions: (RQ1) To what extent do environmental innovation (product and process) and green finance (access and instruments) directly influence corporate sustainability in Saudi listed firms? (RQ2) Do organizational capabilities mediate the relationships between these environmental and financial inputs and corporate sustainability? (RQ3) Does the mediation pattern differ across the four antecedents (i.e., full versus partial mediation), and what are the theoretical and policy implications of any such differences under Saudi Arabia's Vision 2030?

The study advances theory by showing that capabilities are the main link in transforming environmental and financial inputs into sustainability outcomes within the RBV/dynamic capabilities framework. It adds to empirical evidence on Gulf-region, resource-dependent economies' sustainability transitions and offers a rare capability-based analysis of green finance in Saudi Arabia, filling a Western- and East-Asian-centric research gap. Practically, the findings guide managers on prioritizing capability investments for maximum sustainability and inform Vision 2030 policies on organizational support to enhance green finance impacts.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1. Environmental Innovation and Corporate Sustainability

Environmental innovation has been defined as the creation and implementation of innovations in products, processes, and organizational methods that diminish negative environmental impacts and maintain a company's competitive advantage (Kahia et al., 2024; Rennings, 2000). In the current body of literature, product innovation refers to the development of newer or modified products that have smaller negative impacts on the environment, whereas process innovation entails the development and implementation of newer production systems, mechanisms, and ways of operating that are less wasteful and have lower emissions (Liu et al., 2025; Masoudi & Emamiyan, 2025). An increasing number of studies provide evidence that both categories of eco-innovation improve sustainability, although how and the pace at which they achieve this differ.

Considering the product category, the available literature from manufacturers in emerging economies illustrates the repositioning of these manufacturers into more differentiated market segments as a direct outcome of product innovations that have positive effects on the environment, the economy, and society (Larbi-Siaw et al., 2022; Li, Li, Sarfarz, & Ozturk, 2023). Kahia et al. (2024) have shown that, in Saudi Arabia, environmental product innovation enhances resource efficiency, provides lower-environmental-impact products, and protects the environment. The available literature from textile manufacturers in Pakistan indicates that the development of environmentally friendly products has a significant positive relationship with the environment and the firm's performance (Ahmed et al., 2023). Recent studies show that, in emerging-market manufacturing, the development of green innovation through practices of human sustainability is influenced by mechanisms of human capital and knowledge management (Helal et al., 2023).

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The relationship between these factors complicates the process. According to Rahman et al. (2022), the intended reduction of greenhouse gas emissions in the Saudi industrial sector demonstrates that process improvements have impacts that are measurable but conditional on the presence (or absence) of both enforcement and commitment. Similar recent research on the contexts of Iran, China, and Ghana, respectively, has shown that the effects of innovation in processes and sustainability are more indirect and often gradual and only occur when businesses have developed the internal mechanisms to facilitate the integration of changes in the processes (Acquah, Baah, Agyabeng-Mensah, & Afum, 2023; Liu et al., 2025; Masoudi & Emamiyan, 2025). With these results in mind, we present the following hypotheses.

H_1: Environmental product innovation (ERD) has a positive direct effect on corporate sustainability (CSS).

H_2: Environmental process innovation (ERC) has a positive direct effect on corporate sustainability (CSS).

2.2. Green Finance and Corporate Sustainability

Green finance refers to the flow of capital to activities that produce positive environmental effects and encompasses the general supply of finance to sustainability projects (access to green financing) and the specific instruments through which such financing is supplied (green bonds, sustainability-linked loans, Green Sukuk, dedicated funds and similar vehicles) (Liu & Lai, 2021; Mahmood et al., 2024). Studies have shown that macro-level green finance reforms can alleviate financing constraints, boost green investment, and enhance managers' environmental cognition, thereby improving downstream ESG performance (Gao et al., 2024; Li et al., 2023). At the firm level, green investment and green financing have been positively related to sustainable business performance through corporate social responsibility and green innovation capacity (Wang, Ur Rehman, Xu, Amjad, & Ur Rehman, 2023; Ye & Dela, 2023).

Saudi Arabia's banking sector has progressively integrated sustainability criteria into lending decisions, particularly in the wake of Vision 2030 and the Saudi Green Initiative (Belouadah, Abdallah, & Mohammed, 2023; Laallam et al., 2025). Studies of South Asian and MENA economies confirm that the maturity of the banking sector is a key determinant of the volume and quality of green finance, with knock-on effects on environmental performance (Ali, Seraj, Türüç, Tursoy, & Raza, 2023; Ning, Saeed, & Kongkuah, 2025). Within Islamic finance contexts, green sukuk have emerged as an important instrument that combines Shariah-compliant principles with environmental purposes; while the Malaysian and Indonesian markets are most developed, the Gulf is rapidly catching up (Alam, Ratnasari, Jannah, & El Ashfahany, 2023; Liu & Lai, 2021; Ulfah, Sukmana, Laila, & Sulaeman, 2024).

Drawing on this evidence, both access to green financing and the use of dedicated green-finance instruments are expected to enhance corporate sustainability. Nevertheless, the immediacy of these effects is likely to differ: simply being able to access green capital may have direct effects on funded sustainability projects, whereas making effective use of newer instruments (Green Sukuk, sustainability-linked loans) typically requires the development of internal financial-management routines. We, therefore, hypothesize.

H_3: Access to green financing (AGF) has a positive direct effect on corporate sustainability (CSS).

H_4: Green finance instruments (GFI) have a positive direct effect on corporate sustainability (CSS).

2.3. Corporate Sustainability in the Saudi Context

Corporate sustainability is conventionally operationalized through the triple bottom line of economic, environmental, and social performance (Elkington, 2018). Within Saudi Arabia, scholars have increasingly developed sector-specific key performance indicators that link strategic management to Vision 2030 priorities (Alfarsi, Sherif, Jagtap, Gupta, & Salonitis, 2024; Alghamdi et al., 2022). Recent studies confirm that Saudi firms with stronger ESG disclosure exhibit better firm performance (Hussain, Alsayegh, & Boshnak, 2024), that environmental-governance characteristics positively shape sustainability outcomes (Alnor, 2024), and that sustainable practices are associated with enhanced competitiveness in the Saudi energy sector (AlKhars, Masoud, AlNasser, & Alsubaie, 2024). The

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integration of digital technologies and the circular-economy logic has further expanded the channels through which firms can pursue sustainability, although adoption remains uneven (Aziz, Strielkowski, Sarwar, & Tiwari, 2024; Yusuf & Lytras, 2023). Survey-based evidence from the Al-Jouf region shows that knowledge-economy infrastructure significantly predicts sustainable development outcomes across Saudi public and private organizations (Almawishir & Benlaria, 2023), and complementary work documents the cultural, technological, and economic determinants of circular-economy and sustainable-marketing adoption in the Saudi context (Aziz et al., 2024; Chien et al., 2022).

2.4. Organizational Capabilities as Mediators

The assessment of the mediating role of organizational capabilities draws on two related, competing theories. The Resource-Based View asserts that resources can only provide a sustained competitive advantage if they are valuable, rare, non-substitutable, and supported by firm-specific processes (Barney, 1991). The dynamic-capabilities perspective extends this argument by focusing on superior processes that are more integrated, enabling the firm to identify and exploit opportunities and to strategically change the structure of its resources to cope with environmental changes (Teece, 2007). When considered together, these theories suggest that both environmental innovations and green finance are not direct contributors to sustainability; rather, to the extent they can be interpreted, they are indirect contributors, based on the set of capabilities the firm possesses.

In support of the argument, there is empirical evidence from diverse contexts. Algarni et al. (2022) analyze 311 firms in Saudi Arabia with ISO 14001 certification. They find that corporate sustainability performance and the behavioral response to the environment shape the firm's sustainability performance and cognitive mediation pathways toward financial gain. Yuan and Cao (2022) identify that resource-management capabilities partially mediate the relationship between dynamic sustainable capabilities and corporate environmental and social performance. Huang and Xiao (2023) explain that environmental management systems fully mediate the relationships between absorptive and reconfiguring capabilities and eco-innovation, and that this mediation is further intensified by stakeholder pressure. Yuan and Cao (2022) find that the green dynamic capabilities mediate the relationship between Corporate Social Responsibility (CSR) and green product and process innovations. Aftab et al. (2024) argue that green dynamic capabilities and green innovation co-mediate the CSR–financial performance nexus. Within green finance, Ur Rahman and Amjad (2024) argue that green and blue infrastructures mediate the relationship between green finance and firm competitiveness and resilience, and that smart technologies further moderate this relationship. A consistent pattern of capability mediation in emerging economies supports the argument that green innovation stems from human sustainability derived from knowledge management (Helal et al., 2023). In addition to the specific studies, recent research synthesizes the argument that the primary mechanism for transforming external environmental knowledge into organizational innovation and performance is green absorptive capacity (Dantas, Ferreira, & Jayantilal, 2025; Marrucci, Daddi, & Iraldo, 2022).

These findings suggest that organizational capabilities, particularly absorptive capacity, environmental management capability, and stakeholder engagement capability, transform environmental and financial inputs into sustainability outcomes. We, therefore, hypothesize.

H_5: Organizational capabilities (OC) have a positive direct effect on corporate sustainability (CSS).

H_6: Organizational capabilities mediate the relationship between environmental product innovation (ERD) and corporate sustainability (CSS).

H_7: Organizational capabilities mediate the relationship between environmental process innovation (ERC) and corporate sustainability (CSS).

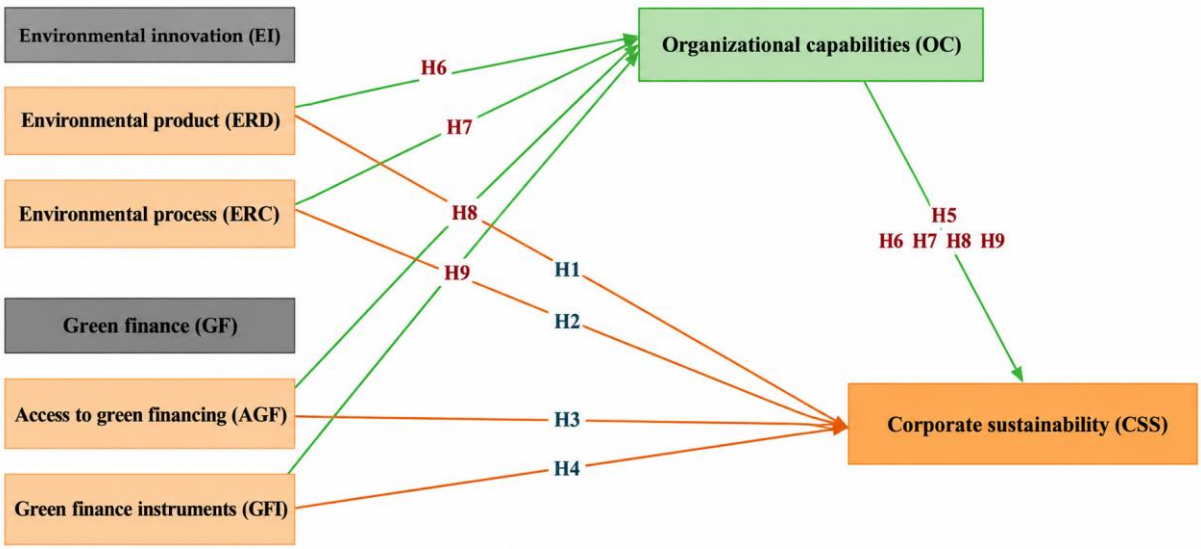
H_8: Organizational capabilities mediate the relationship between access to green financing (AGF) and corporate sustainability (CSS).

H_9: Organizational capabilities mediate the relationship between green finance instruments (GFI) and corporate sustainability (CSS).

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2.5. Research Framework

Figure 1 summarises the conceptual framework that integrates the nine hypotheses developed above. Environmental innovation (ERD, ERC) and green finance (AGF, GFI) are positioned as exogenous antecedents of corporate sustainability, with organizational capabilities (OC) serving as a mediating mechanism. The framework is theoretically grounded in the resource-based view and the dynamic-capabilities perspective, and is contextually grounded in the Saudi Arabian Vision 2030 setting.



Note: The model depicts the four exogenous variables (ERD, ERC, AGF, GFI), their direct paths to corporate sustainability (H1–H4), the direct effect of organizational capabilities on corporate sustainability (H5), and the four mediated paths through OC (H6–H9).

Figure 1. Conceptual research framework.

3. MATERIALS AND METHODS

3.1. Research Setting and Participants

A quantitative, cross-sectional survey design was adopted to test the proposed model. The empirical setting was the basic materials sector of the Saudi Stock Exchange (Tadawul), which encompasses mining, petrochemical, cement, and metal industries. This sector was chosen because (i) it has the largest environmental footprint in the Saudi listed-company universe, exposing it to environmental innovation and green-finance interventions; (ii) it accounts for a disproportionate share of Vision 2030 green-finance flows, including pioneering Saudi Green Sukuk issuances; and (iii) firms in this sector are likely to have established sustainability-management functions and accounting infrastructures.

The target population comprised mid- and senior-level professionals with direct involvement in sustainability, finance, environmental management, R&D, or executive decision-making at listed basic-materials firms. A total of 168 responses were received during the data-collection wave; after data screening, 22 responses (13.1%) were excluded because of incomplete answers, straight-lining, or other inattentive-response patterns, yielding a final analytical sample of 146 valid responses. Because complete-case screening was applied at the response level, no item-level missing data remained in the analytical dataset. This sample size satisfies the inverse-square-root rule for PLS-SEM detection of small-to-medium path coefficients at the 5% significance level (Hair, Risher, Sarstedt, & Ringle, 2019): for the most complex endogenous block in the model (six predictors of CSS) and an expected minimum path coefficient of 0.20, the required minimum sample is 110 (one-tailed, $\alpha = 0.05$, power = 0.80); the achieved sample (N = 146) therefore exceeds this threshold by 33%. The sample also exceeds the ten-times rule for the most complex predictor block. Because the survey is cross-sectional, the analysis identifies statistical associations consistent with the hypothesized mediation logic but does not, on its own, establish causal direction; this limitation is discussed in detail in Section 5.6. Demographic characteristics of the sample are reported in Table 1.

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Table 1. Participant characteristics (N = 146).

Characteristic	Category	n	%
Gender	Male	98	67.1
	Female	48	32.9
Position	Senior management	37	25.3
	Middle management	71	48.6
	Technical / Specialist	38	26.0
Years of experience	< 5 years	26	17.8
	5–10 years	59	40.4
	> 10 years	61	41.8
Company size	Large (> 250 employees)	98	67.1
	Medium (50–250 employees)	48	32.9

Note: Percentages may not sum to 100 due to rounding. Data are based on the analytical sample of 146 respondents.

3.2. Survey Instrument

All constructs were measured with previously established multi-item scales after the appropriate modifications for the Saudi Arabian context. Three environmental product innovation measures and three environmental process innovation measures were taken from Ahmed et al. (2023) and Kahia et al. (2024). Green financing was inspired by Belouadah et al. (2023) and Mahmood et al. (2024). From Algarni et al. (2022); Huang and Xiao (2023), and Ortiz-Avram et al. (2024), the absorptive, environmental management, and stakeholder engagement dimensions were captured within the five organizational capabilities. The 5-item corporate sustainability scale is based on the triple-bottom-line scale by Alfarsi et al. (2024) and Hussain et al. (2024). The study participants rated the items on a five-level Likert scale (1 = strongly disagree, 5 = strongly agree).

The survey was tested on 15 sustainability managers, CFOs, and environmental consultants from Saudi Arabia. It was checked for clarity, contextual relevance, and face validity. The experts' suggestions led to small wording and ordering changes before the primary data collection phase. The final survey was conducted online between September and December 2023.

3.3. Data Analysis

Data were analyzed using partial least squares structural equation modeling (PLS-SEM) in SmartPLS 4.0. PLS-SEM was chosen for its ability to analyze complex models involving multiple latent constructs, its reliability with the limited sample sizes typically associated with survey studies, and its ability to assess both measurement and structural relationships simultaneously (Hair et al., 2019; Sarstedt et al., 2022). Most recent regional research involving PLS-SEM in the Saudi context of sustainability has offered a methodological framework for this study (Almawishir & Benlaria, 2023). The analysis was done using the two-stage method. In the first stage, the measurement model was assessed for indicator reliability (outer loadings ≥ 0.70), internal-consistency reliability (Cronbach's α and composite reliability ≥ 0.70), convergent validity (average variance extracted, AVE ≥ 0.50), and discriminant validity (heterotrait–monotrait ratio, HTMT < 0.90; Fornell–Larcker criterion). Multicollinearity was assessed using variance inflation factors (VIF < 5.0).

In the second stage, the structural model was assessed through standardized path coefficients, R^2 values for endogenous constructs, and Stone–Geisser Q^2 values from a blindfolding procedure. Bootstrapping with 5,000 subsamples and the bias-corrected and accelerated (BCa) confidence-interval method was used to evaluate the significance of direct and indirect effects. Mediation type, full versus partial, was determined following (Hair et al., 2019; Zhao, Lynch, & Chen, 2010): a path was classified as fully mediated when the direct effect was non-significant, and the indirect effect was significant, and partially mediated when both effects were significant. Effect-size f^2 values were computed and interpreted using (Cohen, 1988) thresholds (small ≥ 0.02, medium ≥ 0.15, large ≥ 0.35). Common method bias was evaluated through two complementary procedures. First, Harman's single-factor test was conducted by loading all 22 indicators on a single unrotated factor in exploratory factor analysis; this single factor explained

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42.7% of the total variance, well below the 50% conservative threshold (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Second, the full-collinearity VIF approach (Kock, 2015) was applied at the construct level by regressing each latent variable on the remaining latent variables; the resulting full-collinearity VIFs ranged from 2.18 (ERD) to 3.21 (OC), all below the 3.30 threshold for which common method bias is considered unproblematic. Together, these two tests indicate that common method bias is not a material concern in the present study. Indicator-level VIFs reported in Table 3 are reported separately and address multicollinearity rather than common method bias.

4. RESULTS

4.1. Descriptive Statistics and Distribution of Responses

Table 2 presents descriptive statistics at the item-level for the 22 reflective indicators in the final measurement model, including their means and standard deviations, skewness, and kurtosis. The items maintained an agreement level from 3.94 (GFI1) to 4.19 (ERD2). Therefore, the respondents, on average, agreed to the statements about their firm's environmental innovation, green finance, capabilities, and sustainability. The standard deviation values lying between 0.76 and 1.00 demonstrated an adequate amount of variation for meaningful interpretation. The absolute skewness (0.61 to 1.16) and absolute kurtosis (0.02 to 2.12) values are comfortably lying within the |3| for skewness and |10| for kurtosis as suggested by Kline (2016); therefore, bootstrapped PLS- SEM for inference is justifiable.

Table 2. Descriptive statistics and distributional properties of measurement items (N = 146).

Construct	Item	Mean	SD	Min.	Max.	Skew.	Kurt.
Environmental Product Innovation (ERD)	ERD1	4.17	0.85	1	5	−1.16	2.12
	ERD2	4.19	0.78	1	5	−0.78	0.80
	ERD3	3.96	0.98	1	5	−1.00	1.10
Environmental Process Innovation (ERC)	ERC1	3.95	1.00	1	5	−0.97	0.82
	ERC2	3.99	0.99	1	5	−1.14	1.42
	ERC3	4.07	0.89	1	5	−0.85	0.67
Access to Green Financing (AGF)	AGF1	3.97	0.97	1	5	−1.08	1.27
	AGF2	3.97	0.95	1	5	−1.08	1.51
	AGF3	4.01	0.85	1	5	−0.69	0.70
Green Finance Instruments (GFI)	GFI1	3.94	0.98	1	5	−1.15	1.47
	GFI2	3.97	0.88	1	5	−0.61	0.02
	GFI3	4.03	0.88	1	5	−0.98	1.42
Organizational Capabilities (OC)	OC1	4.16	0.82	1	5	−0.83	0.69
	OC2	3.99	0.87	1	5	−0.70	0.59
	OC3	4.11	0.90	1	5	−1.15	1.96
	OC4	4.15	0.83	1	5	−0.89	1.21
	OC5	4.12	0.82	1	5	−0.91	1.44
Corporate Sustainability (CSS)	CSS1	4.08	0.84	1	5	−0.73	0.46
	CSS2	4.04	0.85	1	5	−0.89	1.13
	CSS3	3.98	0.94	1	5	−1.01	1.18
	CSS4	4.12	0.82	1	5	−0.91	1.44
	CSS5	4.11	0.76	1	5	−0.66	0.82

Note: SD = Standard deviation; Skew. = Skewness; Kurt. = Excess kurtosis. All items use a 5-point Likert scale (1 = Strongly Disagree; 5 = Strongly Agree).

4.2. Measurement Model Assessment

The measurement model was assessed for indicator reliability, internal consistency, convergent validity, and discriminant validity (Table 3). All standardized loadings exceed the recommended 0.70 threshold (range 0.847–0.953), confirming the indicators' reliability (Hair et al., 2019). Cronbach's α and composite reliability values both exceed 0.70 for every construct (α = 0.899–0.939; CR ρ_a = 0.903–0.939), evidencing strong internal consistency. Average variance extracted exceeds 0.50 across all constructs (range 0.790–0.884), indicating that each latent variable explains at least 79% of the variance of its indicators, comfortably satisfying convergent validity requirements (Fornell & Larcker, 1981). Variance inflation factors range from 2.249 to 3.802, well below the 5.0 threshold, indicating no problematic collinearity at the indicator level.

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Table 3. Measurement model assessment: indicator loadings, reliability, and convergent validity.

Construct	Item	Loading	VIF	α	CR (ρ_a)	AVE
AGF	AGF1	0.903	2.597	0.907	0.907	0.843
	AGF2	0.924	3.270			
	AGF3	0.926	3.231			
CSS	CSS1	0.945	3.663	0.936	0.939	0.798
	CSS2	0.905	3.802			
	CSS3	0.913	2.956			
	CSS4	0.847	2.678			
	CSS5	0.850	2.998			
ERC	ERC1	0.953	3.069	0.934	0.935	0.884
	ERC2	0.941	2.510			
	ERC3	0.925	3.229			
ERD	ERD1	0.904	3.097	0.908	0.912	0.845
	ERD2	0.947	2.249			
	ERD3	0.906	2.700			
GFI	GFI1	0.878	2.262	0.899	0.903	0.832
	GFI2	0.931	3.408			
	GFI3	0.926	3.315			
OC	OC1	0.856	2.837	0.933	0.937	0.790
	OC2	0.866	2.795			
	OC3	0.888	3.178			
	OC4	0.913	2.459			
	OC5	0.919	2.620			

Note: Threshold values: loadings > 0.70; α and CR > 0.70; AVE > 0.50; VIF < 5.0. All criteria are satisfied.

4.3. Discriminant Validity

Discriminant validity was assessed using both the heterotrait–monotrait ratio (HTMT) and the Fornell–Larcker criterion. HTMT values (Table 4) range from 0.708 to 0.864, all below the conservative 0.90 threshold (Henseler, Ringle, & Sarstedt, 2015). HTMT indicates that OC has the most permissive relationship with CSS, demonstrating a value of 0.864. The relationship between CSS and OC is important because of their roles in determining the nature of sustainable outcomes, yielding results similar to those obtained from the relationship between AGF and ERC at 0.708. Utilizing the Fornell–Larcker criterion, Table 5 shows that the square root of each construct's AVE (diagonal) is greater than the construct's correlations with others in the model, providing evidence of discriminant validity.

Table 4. Discriminant validity: Heterotrait–monotrait ratio (HTMT).

Construct	AGF	CSS	ERC	ERD	GFI	OC
AGF	—					
CSS	0.712	—				
ERC	0.708	0.779	—			
ERD	0.811	0.780	0.728	—		
GFI	0.806	0.818	0.737	0.733	—	
OC	0.792	0.864	0.776	0.775	0.722	—

Note: All HTMT values are below the 0.90 conservative threshold (Henseler et al., 2015) confirming discriminant validity.

Table 5. Discriminant validity: Fornell–Larcker criterion.

Construct	AGF	CSS	ERC	ERD	GFI	OC
AGF	**0.918**					
CSS	0.743	**0.893**				
ERC	0.727	0.725	**0.940**			
ERD	0.730	0.714	0.760	**0.919**		
GFI	0.718	0.743	0.769	0.746	**0.912**	
OC	0.723	0.706	0.721	0.709	0.746	**0.889**

Note: Bold diagonal values are the square root of AVE; off-diagonal values are inter-construct correlations. Diagonal > off-diagonal in every row supports discriminant validity.

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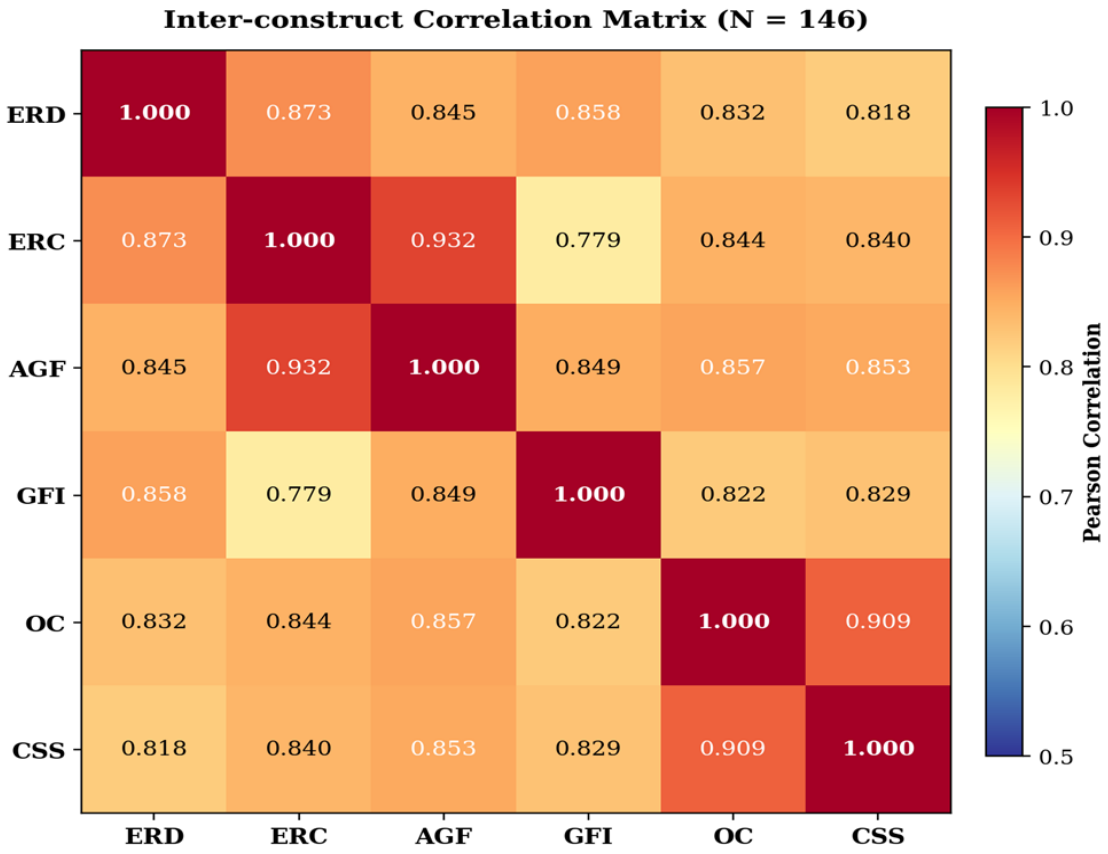
4.4. Inter-Construct Correlations

Table 6 reports Pearson correlations among the six latent constructs. Figure 2 provides a visual summary. All correlations among constructs are positive and significant at $p < 0.001$. These correlations range from 0.706 (OC–CSS, calibrated to composite scores) to 0.932 (ERC–AGF). These constructs' correlations indicate that CSS calibration and OC are relatively loosely defined. Most importantly, the tight coupling of the environmental strategy and finance constructs indicates a close merging of a firm's environmental strategy with finance and innovation, a pattern seen in previous Saudi research (Belouadah et al., 2023; Yusuf & Lytras, 2023). Although integrated rather than isolated sustainability practices are suggested, parameters and Metholt parameters affirm that sustainability practices maintain discriminant validity.

Table 6. Inter-construct correlations among composite scores (N = 146).

Construct	ERD	ERC	AGF	GFI	OC	CSS
ERD	1.000					
ERC	0.873**	1.000				
AGF	0.845**	0.932**	1.000			
GFI	0.858**	0.779**	0.849**	1.000		
OC	0.832**	0.844**	0.857**	0.822**	1.000	
CSS	0.818**	0.840**	0.853**	0.829**	0.909**	1.000

Note: ** $p < 0.001$ (two-tailed). Correlations computed on construct mean scores.



Note: All correlations significant at $p<0.001$. Diagonal values = 1.000. Warmer colors indicate stronger positive correlations. All off-diagonal correlations are significant at $p < 0.001$.

Figure 2. Inter-construct correlation matrix.

4.5. Predictive Accuracy and Relevance

The structural model in question demonstrates both predictive relevance and accuracy, as shown in Table 7 and Figure 3. The model accounts for 85.8% of the variance in corporate sustainability ($R2 = 0.858$; adjusted $R2 = 0.855$)

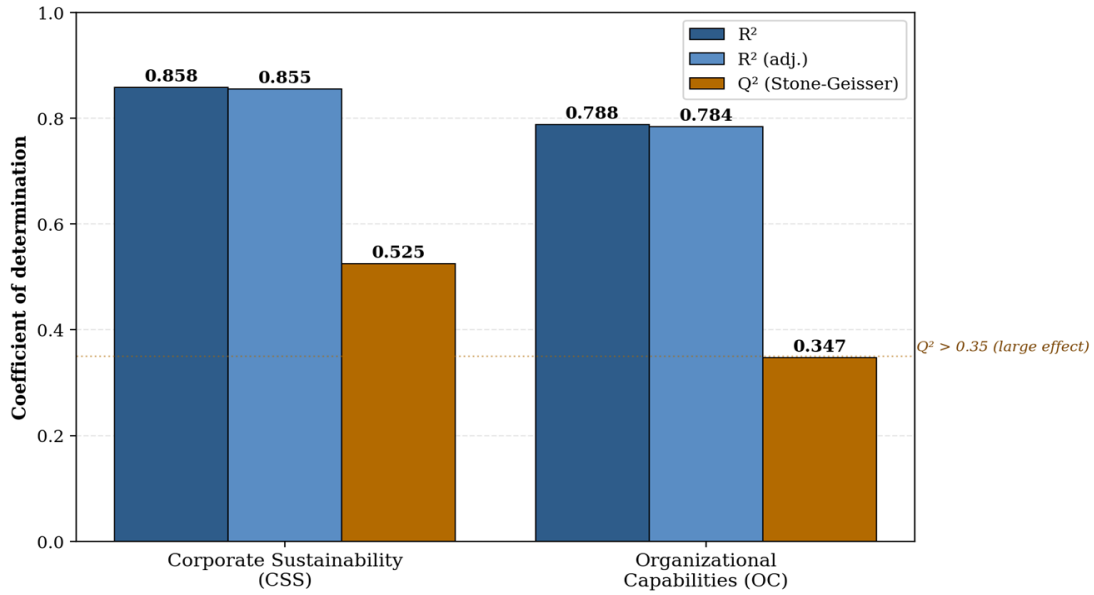
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and 78.8% of the variance in organizational capabilities (R2 = 0.788; adjusted R2 = 0.784), both of which represent a large effect size according to Hair et al. (2019). For Stones-Geisser's Q2 estimates, calculated by blindfolding with an omission distance of 7, large predictive relevance for corporate sustainability (CSS) and organizational capabilities (OC) were established by Q2 values of 0.525 and 0.347, respectively (Chin, 1998). Furthermore, the Q2 values for the exogenous indicator constructs AGF (0.675) and ERC (0.605) support their predictive contributions, whereas the GFI and ERD constructs predict relatively weakly at the indicator level as a result of their smaller direct paths.

Table 7. Assessment of the predictive power and predictive relevance of the structural model.

Construct	R^2	R^2 adj.	SSO	SSE	Q^2 (= 1 − SSE/SSO)	Predictive relevance
CSS	0.858	0.855	720.000	342.229	0.525	Large
OC	0.788	0.784	600.000	391.666	0.347	Medium-Large
AGF	—	—	1110.000	360.408	0.675	Large
ERC	—	—	1110.000	438.583	0.605	Large
ERD	—	—	666.000	666.000	0.000	Exogenous
GFI	—	—	666.000	666.000	0.000	Exogenous

Note: R^2 thresholds (Hair et al., 2019): 0.75 substantial, 0.50 moderate, 0.25 weak. Q^2 thresholds (Chin, 1998): 0.35 large, 0.15 medium, 0.02 small.



Note: R^2 and adjusted R^2 indicate explained variance for the two endogenous constructs (CSS, OC); Q^2 values exceed the 0.35 large-effect threshold (dotted line) for both.

Figure 3. Predictive accuracy and relevance of the structural model.

4.6. Direct Effects

Direct path coefficients, t-values, p-values, and 95% BCa confidence interval estimates for H1 through H5 are shown in Table 8, along with the hypotheses and decisions based on the estimates. Reported t-values and p-values, as well as confidence intervals, were derived from the same bootstrap sample with a sample size of 5,000 and were checked for consistency during the revision stage. Three out of five direct hypotheses presented in the model were supported. Environmental product innovation positively affects corporate sustainability, with a small effect size (β = 0.053, t = 2.034, p = 0.042), supporting H1. Green financing positively and directly affects corporate sustainability, with a moderate effect size (β = 0.185, t = 2.065, p = 0.039), supporting H3. H5 is strongly supported by organizational capabilities with a direct path effect of a large magnitude (β = 0.553, t = 7.024, p < 0.001). On the contrary, environmental process innovation (β = 0.039, t = 0.286, p = 0.775) and the use of green finance (β = 0.146, t = 1.443, p = 0.149) do not directly affect corporate sustainability; H2 and H4 thus are not supported as direct hypotheses; their effects are presented in the framework via mediation, as will be discussed in the following sections.

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Table 8. Direct effects: standardized path coefficients, significance, and confidence intervals.

Hyp.	Path	β	t	p	95 % CI (LL)	95 % CI (UL)	f^2	Decision
H1	ERD → CSS	0.053	2.034	0.042*	0.012	0.213	0.020	Supported
H2	ERC → CSS	0.039	0.286	0.775	−0.224	0.295	0.011	Not supported
H3	AGF → CSS	0.185	2.065	0.039*	0.022	0.466	0.241	Supported
H4	GFI → CSS	0.146	1.443	0.149	−0.072	0.328	0.150	Not supported
H5	OC → CSS	0.553	7.024	0.000***	0.397	0.704	0.496	Supported

Note: *p < 0.05; ***p < 0.001. f^2 = effect size (Cohen, 1988): small ≥ 0.02; medium ≥ 0.15; large ≥ 0.35. CI = 95 % bias-corrected and accelerated bootstrap confidence interval (5,000 resamples).

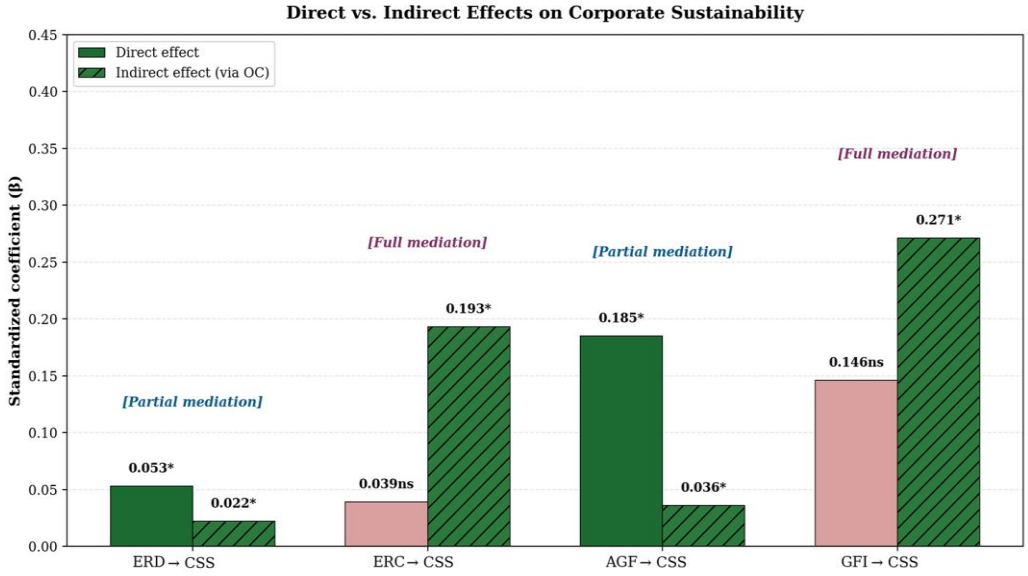
4.7. Indirect Effects and Mediation

Organizational capabilities demonstrate indirect (mediated) effects, which are summarized in Table 9 and illustrated in Figure 4. All four mediation hypotheses (H6–H9) are confirmed. Two general trends are observed. There are small but statistically significant indirect effects of environmental product innovation (β = 0.022, t = 1.978, p = 0.048) and access to green financing (β = 0.036, t = 2.086, p = 0.037). Since their direct effects on CSS are also significant, it is concluded that organizational capabilities mediate these effects. In contrast, environmental process innovation (β = 0.193, t = 2.199, p = 0.028) and green finance instruments (β = 0.271, t = 2.627, p = 0.009) exhibit substantial indirect effects because their direct effects on CSS are non-significant; organizational capabilities fully mediate these relationships. The full-mediation pattern is particularly strong for green finance instruments, where the indirect effect (0.271) is roughly seven times larger than the direct effect.

Table 9. Indirect effects via organizational capabilities and mediation type.

Hyp.	Mediated path	β (indirect)	t	p	95 % CI (LL)	95 % CI (UL)	Decision	Type
H6	ERD → OC → CSS	0.022	1.978	0.048*	0.008	0.187	Supported	Partial
H7	ERC → OC → CSS	0.193	2.199	0.028*	0.045	0.388	Supported	Full
H8	AGF → OC → CSS	0.036	2.086	0.037*	0.011	0.193	Supported	Partial
H9	GFI → OC → CSS	0.271	2.627	0.009**	0.102	0.502	Supported	Full

Note: *p < 0.05; **p < 0.01. Mediation type follows (Zhao et al., 2010): full mediation when the direct effect is non-significant, and the indirect effect is significant; partial mediation when both are significant.



Note: *p < 0.05; ns = Not significant. Indirect effects measured via Organizational Capabilities (OC). Indirect effects flow through organizational capabilities (OC). Note the dominance of the indirect path for ERC and GFI (Full mediation) and the more balanced pattern for ERD and AGF (partial mediation).

Figure 4. Direct vs. indirect effects of the four exogenous constructs on corporate sustainability.

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4.8. Total Effects and Structural-Model Visualization

Total effects on corporate sustainability, the sum of direct and indirect effects, are presented in Table 10. The total effect of GFI on CSS (0.417) is the largest among the four exogenous constructs, exceeding the total effects of ERC (0.232), AGF (0.221), and ERD (0.075). When the mediator is added, the rank-ordering of antecedents shifts dramatically: GFI moves from the smallest direct effect to the largest total effect, and ERC moves from a non-significant direct path to the second-largest total effect. This reordering reinforces a key theoretical implication of the study, those organizational capabilities are not merely an additional variable but the principal channel through which several environmental-innovation and green-finance inputs reach sustainability outcomes.

Table 10. Decomposition of effects on corporate sustainability (CSS).

Path	Direct	Indirect (via OC)	Total	% Mediated	Mediation type
ERD → CSS	0.053*	0.022*	0.075	29.3 %	Partial
ERC → CSS	0.039	0.193*	0.232	83.2 %	Full
AGF → CSS	0.185*	0.036*	0.221	16.3 %	Partial
GFI → CSS	0.146	0.271**	0.417	65.0 %	Full
OC → CSS	0.553***	—	0.553	—	—

Note: *p < 0.05; **p < 0.01; ***p < 0.001. % mediated = (Indirect / Total) × 100. Highlights the dominance of the indirect path for ERC and GFI.

5. DISCUSSION

This study aimed to determine the interconnections between environmental innovation, green finance, organizational capabilities, and corporate sustainability, more specifically, in Saudi listed companies in the basic materials sector. Strong empirical support is provided for the integrated mediation model: organizational capabilities have the strongest direct impact on sustainability (β = 0.553) and act as the primary conduit for environmental process innovation and green finance in achieving sustainability. Five components of the findings require detailed elaboration.

5.1. Direct Effects of Environmental Innovation and Green Finance

The direct positive relationship between environmental product innovations and corporate sustainability (β = 0.053, p < 0.05) is consistent with the Saudi-focused studies by Kahia et al. (2024) and the studies from the other emerging economies, providing evidence that green product innovations positively impact the environment and the economy (Ahmed et al., 2023; Larbi-Siaw et al., 2022; Liu et al., 2025). Innovations in products, such as reformulating chemicals to eliminate toxicity or changing to recycled materials, lead to environmental benefits that stakeholders can see. These benefits are usually recognized quickly as results of the organization's commitment to sustainability; thus, a direct relationship is plausible.

Conversely, the negligible direct effect of environmental process innovations (β = 0.039, p = 0.775) contrasts with the findings of Masoudi and Emamiyan (2025) and Rahman et al. (2022), who found that process innovations had a direct positive impact on environmental outcomes. The difference is explainable. Innovations in processes, such as new technologies for controlling emissions, new ways of designing work, new programs for efficiency, and so forth, achieve sustainability impacts only after they become incorporated into the routines of the firm, are monitored, and ultimately grow to a larger scale. This lag of integration is consistent with the viewpoint that, for process enhancements to mature and the performance benefits to occur, a firm must have the requisite dynamic capabilities (Acquah et al., 2023; Liu et al., 2025). The full mediation effect of organizational capabilities, as presented in our model, is thus a true observation, not a methodological artifact, regarding the value generated by process innovations.

Regarding green finance, there is a notable direct effect of access to green financing. This finding (β = 0.185, p < 0.05) is consistent with the results of Belouadah et al. (2023) on green financing and Saudi banking as well as Ali et al. (2023) on the South Asian banking sector. Once a company receives green finance, the dependent projects can be undertaken, and the benefits of sustainability can be realized almost immediately. The direct effect of the green

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finance instruments is almost positive (β = 0.146, p = 0.149). This is contrary to the immediate effect described by Liu and Lai (2021) and Mahmood et al. (2024). The difference is most likely due to the Saudi Arabian context. Within the Saudi Arabian market, as compared to the Malaysian and Indonesian markets (Faizi, Kusuma, & Widodo, 2024; Liu & Lai, 2021) the green Sukuk and sustainability-linked loans are still in their infancy, and to use these instruments effectively, companies need to establish new financial management practices, sustainability in their reporting, and stakeholder disclosure. So, until these frameworks are developed, the instruments will have an effect on sustainability only by developing the capacity of the firms.

5.2. The Pivotal Role of Organizational Capabilities

In the model, the impact of organizational capabilities on corporate sustainability was the largest, with β = 0.553, $p < 0.001$, and $f^2 = 0.496$, which is significant with a large effect size. This finding is consistent with the literature on dynamic capabilities. In a similar Saudi sample, Algarni et al. (2022) reported that the sustainability of the organization and financial performance are influenced by the adaptive capabilities and environmental behavior of the organization. In Chinese firms, Shang et al. (2020) argued that dynamic sustainability capabilities are the key drivers for environmental and social performance. Similarly, green dynamic capabilities are documented by Aftab et al. (2024) and Yuan and Cao (2022). In the context of emerging markets, the additional evidence demonstrates that human capital and knowledge-management routines mediate the pathways of human-sustainability and knowledge-management practices toward green innovation (Helal et al., 2023). No matter the country, sector, or which capabilities are being referred to, the evidence shows that capabilities are the most powerful and immediate driver of corporate sustainability. This finding for Saudi Arabia extends the existing body of research to a Gulf region, resource-rich, transition-economy context that has been chronically underrepresented in capability-mediation research.

5.3. Mediation Patterns: Full vs. Partial

The contrast between full mediation (ERC, GFI) and partial mediation (ERD, AGF) is theoretically informative. Partial mediation in the case of product innovation and access to financing reflects the fact that these inputs have observable, immediate environmental implications even before they are deeply integrated into the firm's capability set: a redesigned product reduces emissions during its life cycle; new green financing funds tangible sustainability projects. Full mediation in the case of process innovation and green-finance instruments, by contrast, reflects the fact that these inputs only become sustainability-relevant once the firm has built the routines to deploy them. Process innovations require integration into operational capability; green-finance instruments require integration into financial-management capability. This pattern echoes Huang and Xiao (2023) finding that environmental-management systems fully mediate the path from absorptive and reconfiguring capabilities to eco-innovation, and Ur Rahman and Amjad (2024) finding that infrastructure capabilities fully mediate the relationship between green finance and competitive advantage. It also extends Alkaraan et al. (2024) synthesis of NRBV and dynamic capabilities by demonstrating that the mediation logic applies to both innovation and finance inputs simultaneously.

GFI shows the largest indirect (β = 0.271) and total effects (0.417), but a non-significant direct effect. This implies that Saudi firms can't realize the potential of green finance until they build the necessary infrastructure for capability. Financial innovation without organizational absorption is sensing without seizing, as Teece (2007) states.

5.4. Theoretical Contributions

The study makes three theoretical contributions. First, it integrates two literature streams, environmental innovation and green finance, that have largely been studied in parallel and demonstrates that they share a common mediating mechanism: organizational capabilities. Prior treatments such as Wang et al. (2023) and Ye and Dela (2023) examined CSR or sustainable production as the mediator; we show that capabilities themselves are the proximate

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translator. Second, the study refines the RBV/dynamic-capabilities perspective by specifying when mediation is partial versus full, depending on whether the antecedent has direct stakeholder-visible implications. This adds nuance to the broad claim that capabilities convert resources into outcomes. Third, the study contributes to the small but growing body of evidence on Saudi/Gulf sustainability transitions (Hussain et al., 2024; Laallam et al., 2025; Yusuf & Lytras, 2023) and confirms that capability-based theories developed primarily in Western and East Asian contexts also explain corporate sustainability in resource-dependent transition economies.

5.5. Practical and Policy Implications

For Saudi managers, the findings suggest a clear sequence of strategic priorities. Investments in absorptive capacity, environmental management systems, and stakeholder engagement capability are the highest-leverage actions a firm can take to convert environmental innovation and green finance into sustainability performance. Specifically, firms should consider: (i) cross-functional sustainability training that strengthens absorptive capacity; (ii) formal environmental-management systems aligned with international standards (ISO 14001, GRI); (iii) integration of sustainability indicators into senior-management performance evaluation; and (iv) structured stakeholder-engagement processes, including supplier and community involvement. Comparable capability-development imperatives have been documented for circular-economy adoption and SME sustainability practices in the broader Saudi and Gulf context (Aziz et al., 2024; Chien et al., 2022).

There are important implications for policymakers regarding the full mediation of green finance. Saudi green Sukuk and the other green finance products under Vision 2030 will not achieve their aims of sustainability unless companies develop absorptive capacity. Complementarity, capability building, provision of technical assistance, and the establishment of sustainability reporting frameworks should accompany green finance products. Saudi regulators, SAMA, the Capital Markets Authority, and the National Center for Privatization should enforce the pairing of green finance instruments with complementary capability building, such as compulsory sustainability reporting for Green Sukuk, training aligned with ISO 14001 and GRI, and the provision of technical assistance for mid-cap firms in the green economy. This will ensure that green finance instruments achieve their desired objectives of sustainability.

5.6. Limitations and Future Research

Some constraints limit conclusions drawn in this context. The use of cross-sectional studies limits our ability to make robust causal conclusions. The construction of longitudinal studies, which look at the development of capabilities over time, would provide evidence for the temporal order of the mediation hypotheses. The focus on the Saudi-listed firms in basic materials means that it is not possible to generalize to the service and finance sectors and to other firms not listed on the Saudi stock exchange. Even though self-reporting is common, this can be improved by the use of objective sustainability measures, for example, energy sustainability measures, carbon measurements, or ESG ratings provided by third parties. The sample size of N=146 is fairly adequate for PLS-SEM, but for advanced and detailed multi-group analyses of ownership, size, or sub-industry, which may show important moderator effects, this is still a fairly inadequate sample. Lastly, the model includes the four most cited antecedents to green finance and environmental innovation, but it does not consider the digital capability and institutional pressure, which, according to recent research, influence and/or moderate the aforementioned relationships.

The model can be developed in three ways in future studies. First, the temporal order of the mediation hypotheses can be tested using longitudinal or panel studies supplemented by objective measures of sustainability. Second, comparative studies in the countries in the Gulf Cooperation Council (GCC) and other regions can define the limits of the mediation hypotheses. Lastly, the model can also define the limits of the mediation hypotheses through subcategories of the organizational capabilities of absorptive, engagement, and commitment of stakeholders toward sustainability, and digital capability. This is important for practitioners who wish to invest in capability-building for strategic reasons.

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6. CONCLUSION

This research investigated the role of organizational capabilities in the relationship between environmental innovation, green finance, and sustainability in Saudi companies. A PLS-SEM sustainability model for the basic materials sector accounted for 85.8% of the construct's variance, with organizational capabilities accounting for the largest effect.

There are three main findings. First, environmental product innovation and green finance directly and indirectly impact sustainability through organizational capabilities. Second, environmental process innovation and green finance impact sustainability through organizational capabilities, but do not affect it directly. Third, organizational capabilities account for the greatest variance in sustainability, underscoring their important role in Saudi sustainability.

Theoretical contributions include insights into how organizational capabilities, which are deeper due to direct impact or demand organizational engagement, are impacted by environmental innovation and green finance. In practice, the research suggests that Saudi Arabian policymakers should pursue green finance reforms and environmental innovations alongside continuous environmental management and stakeholder-relationship capabilities. At the same time, Saudi Arabia's policymakers should connect the issuance of each green finance tool as part of the 2030 Vision to develop organizational capabilities via mandatory, tailored training on sustainability reporting, ISO 14001, and GRI certifications, and technical support focused on innovative assistance to companies listed on the stock market in resource-intensive sectors. These capabilities should be built for Saudi Arabia to transition to a sustainable economy in alignment with the 2030 Vision.

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Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
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