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Green Entrepreneurial Orientation and Environmental Sustainability in Manufacturing SMEs The Mediating Role of Green Innovation and the Moderating Role of Green Organizational Culture

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Abstract

Manufacturing small and medium-sized enterprises (SMEs) in emerging economies face increasing pressure to pursue entrepreneurial growth while minimising environmental degradation under resource constraints. Although green entrepreneurial orientation (GEO) is increasingly recognised as a strategic driver of environmental sustainability, the mechanisms through which it translates into sustainability outcomes and the organisational conditions that facilitate this process remain insufficiently understood. Drawing on the Natural Resource-Based View and Dynamic Capabilities Theory, this study examines the mediating role of green innovation in the relationship between GEO and environmental sustainability among manufacturing SMEs in Ghana, while investigating the moderating role of green organisational culture in the relationship between GEO and green innovation. A quantitative, explanatory cross-sectional survey design was employed, using a structured questionnaire administered to owner-managers and senior managers of manufacturing SMEs. The hypothesised relationships were examined using structural equation modelling, with bootstrapping applied to assess indirect and conditional indirect effects. The study advances sustainable entrepreneurship research by integrating strategic entrepreneurial orientation, innovation-based mechanisms and organisational culture into a moderated mediation framework. The framework provides a theoretically grounded explanation of how environmentally oriented entrepreneurial strategies may be translated into sustainability outcomes through green innovation and how organisational culture may shape this process. Practically, the study offers a basis for managers and policymakers to strengthen environmental values, support green innovation and develop organisational capabilities that align entrepreneurial initiatives with sustainability objectives. The findings are intended to inform strategies for advancing environmental sustainability among resource-constrained manufacturing SMEs in emerging economies.

1. Introduction

Environmental sustainability has become an increasingly important strategic concern for manufacturing firms because industrial production is associated with resource consumption, waste generation, emissions, and other environmental externalities. Manufacturing firms are consequently required to reconsider how products are designed, resources are utilized, production processes are organized, and environmental responsibilities are incorporated into strategic decisions. For small and medium-sized enterprises (SMEs), this transition is particularly challenging because environmental investments may compete with immediate operating requirements, working-capital needs, and other business priorities. The strategic implications of environmental sustainability are particularly relevant in emerging economies, where firms must pursue industrial development while responding to environmental pressures and capability constraints. In Ghana, research has examined environmental management, green innovation, and sustainability practices in manufacturing firms, demonstrating the relevance of organizational and innovation-related mechanisms to environmental outcomes (Dzage et al., 2024; Afum et al., 2020). More recent research has also investigated sustainable manufacturing practices among Ghanaian SMEs, indicating that sustainability outcomes may emerge through combinations of

organizational practices, enabling conditions, and innovation-related activities rather than from a single strategic initiative (Edu et al., 2025).

Within this context, green entrepreneurial orientation (GEO) offers a potentially important explanation for differences in how firms identify and pursue environmentally oriented business opportunities. GEO reflects an organization's strategic disposition toward identifying environmental opportunities, developing environmentally beneficial innovations, anticipating emerging ecological demands, and accepting calculated risks associated with green business initiatives. It extends the entrepreneurial orientation perspective by placing environmental considerations within the firm's strategic opportunity-seeking and innovation activities. However, adopting a green entrepreneurial orientation does not necessarily guarantee improvements in environmental sustainability. Strategic intentions must be converted into practical changes in products, processes, technologies, and resource-utilization routines. Firms may recognize environmental opportunities without possessing the resources, technical knowledge, organizational coordination, or employee commitment required to implement them. This distinction is important because recent synthesis research indicates that the relationship between GEO and green innovation is stronger and more consistent than its relationship with broader sustainable performance outcomes, which vary across settings (Bindeeba et al., 2026).

Green innovation may therefore provide an important explanatory mechanism. Through green product innovation, firms may develop products that require fewer environmentally harmful materials or generate less waste over their life cycles. Through green process innovation, firms may reduce energy consumption, material losses, emissions, and production waste. Green innovation can thus represent the operational pathway through which an entrepreneurial orientation becomes environmentally consequential. Nevertheless, the extent to which GEO produces green innovation may depend on the organizational environment in which entrepreneurial initiatives are implemented. Green organizational culture, reflected in shared environmental values, norms, priorities, and routines, may encourage employees and managers to support environmental experimentation and incorporate sustainability into operational decisions. In organizations where environmental responsibility is embedded in everyday practices, green entrepreneurial initiatives may be more readily translated into innovation. Conversely, where environmental responsibility is viewed primarily as a compliance obligation, entrepreneurial initiatives may encounter limited internal support.

These arguments suggest that a model incorporating both mediation and moderation may provide a more informative explanation of the GEO–environmental sustainability relationship than a direct-effects model alone. The mediating role of green innovation addresses the question of how GEO may relate to environmental sustainability, while the moderating role of green organizational culture addresses when GEO is more likely to generate green innovation. Two complementary theoretical perspectives underpin this argument. The Natural Resource-Based View (NRBV) explains how environmentally oriented capabilities and practices can contribute to firm-level environmental performance and longer-term competitive advantage (Hart, 1995). Dynamic Capabilities Theory (DCT) explains how organizations sense opportunities, mobilize resources, and reconfigure their capabilities in response to changing

technological and environmental conditions (Teece et al., 1997). Together, these theories provide a basis for examining how GEO, green innovation, and organizational culture may interact in resource-constrained manufacturing SMEs. The proposed research is relevant to Ghana because existing studies have already investigated green innovation and environmental management in Ghanaian manufacturing contexts. Accordingly, the contribution should not be framed simply as filling a geographical gap. Instead, it lies in examining a theoretically specified conditional mechanism: whether green innovation explains the relationship between GEO and environmental sustainability and whether green organizational culture strengthens the translation of GEO into green innovation. This is a proposition to be tested rather than a result assumed in advance.

The study therefore seeks to answer the following research questions:

1. What is the relationship between green entrepreneurial orientation and environmental sustainability among manufacturing SMEs in Ghana?
2. Does green innovation mediate the relationship between green entrepreneurial orientation and environmental sustainability?
3. Does green organizational culture moderate the relationship between green entrepreneurial orientation and green innovation?
4. Does the indirect relationship between green entrepreneurial orientation and environmental sustainability through green innovation vary according to green organizational culture?

The study proposes an integrated model that connects entrepreneurial strategic posture, innovation-based environmental change, and an internal organizational boundary condition. Its theoretical contribution lies in explaining not only whether GEO is associated with environmental sustainability, but also the organizational process and conditions through which that association may emerge.

2. Literature review and hypothesis development

2.1. Green entrepreneurial orientation

Entrepreneurial orientation describes a firm's strategic posture toward opportunity recognition, innovation, proactive market engagement, and calculated risk-taking (Lumpkin & Dess, 1996). GEO applies this orientation to environmentally related opportunities and strategic decisions. It concerns the extent to which firms prioritize environmental considerations when identifying opportunities, developing products, improving production processes, and committing resources to green initiatives. GEO should be distinguished from environmental management practices. Whereas GEO represents a strategic orientation, environmental management practices refer to specific activities through which environmental objectives are pursued. Similarly, GEO differs from green innovation: the former reflects a firm's strategic disposition, while the latter represents the innovations that may result from that disposition. A firm with a strong GEO may proactively identify opportunities to reduce material waste, redesign products, explore cleaner production technologies, or develop environmentally preferable

offerings. Such initiatives can expose the firm to uncertainty because green technologies may require new knowledge, investments, and adjustments to existing routines. Entrepreneurial willingness to experiment and act proactively may nevertheless support the identification and exploitation of these opportunities. However, GEO should not automatically be equated with superior environmental performance. An entrepreneurial orientation may stimulate the pursuit of opportunities without guaranteeing their successful implementation. This distinction provides the conceptual foundation for examining green innovation as a mediating mechanism.

2.2. Environmental sustainability in manufacturing SMEs

Environmental sustainability at the firm level concerns the extent to which organizational activities minimize environmental harm and support the responsible use of natural resources. In manufacturing, relevant indicators include reductions in production waste, energy consumption, emissions, hazardous materials, and water consumption, alongside improvements in recycling, material efficiency, and pollution prevention. Environmental sustainability should be conceptually distinguished from broader sustainable performance, which may include economic and social dimensions. This study focuses specifically on the environmental dimension to maintain alignment between the theoretical framework and the dependent variable. Manufacturing SMEs may face competing pressures when pursuing environmental improvements. Cleaner technologies can require upfront expenditure, while environmental benefits may accrue over time. Limited access to finance, technical expertise, and specialized equipment can constrain implementation. At the same time, resource-efficiency improvements may reduce operating losses and encourage firms to identify innovative production methods. Research in Ghana has linked green manufacturing and environmental management practices with firm sustainability outcomes, while studies of Ghanaian manufacturing firms have also considered the role of green innovation in environmentally oriented business practices (Afum et al., 2020; Dzage et al., 2024). These studies establish the relevance of the setting but also underscore the importance of specifying how strategic orientations are converted into operational environmental improvements.

2.3. Green innovation as a mediating mechanism

Green innovation encompasses the development or implementation of products, processes, and associated practices that reduce environmental harm relative to relevant existing alternatives. Green product innovation may involve recyclable materials, reduced packaging, longer product durability, or designs that reduce resource use. Green process innovation may involve cleaner production, energy-efficient machinery, improved waste recovery, and more efficient resource utilization. From an NRBV perspective, green innovation represents a means through which firms pursue pollution prevention and more environmentally responsible production (Hart, 1995). From a dynamic capabilities perspective, it can reflect the application of organizational knowledge and resources to new environmental opportunities (Teece et al., 1997). GEO may stimulate green innovation by encouraging firms to identify environmental opportunities and allocate attention to novel solutions. Firms that proactively search for green opportunities and accept calculated risks may be more willing to experiment with cleaner technologies and alternative materials. Such firms may also be more likely to explore product redesign

and process improvements that are not immediately available through established operating routines. Evidence from related studies supports the relevance of green innovation in entrepreneurial and sustainability relationships. For example, research on SMEs in Jordan has examined green product innovation as a mediator between green entrepreneurial orientation, green transformational leadership, and firm performance, although the estimated mediation was not statistically significant at the conventional 5% level in that study (Abu-Rumman et al., 2022). Research on Ghanaian SMEs has also examined innovation as a mechanism through which environmentally oriented practices relate to firm outcomes (Appiah et al., 2024).

These findings suggest that the mediating role of green innovation should be tested directly rather than presumed. GEO may generate environmental benefits through innovation, but some benefits may also arise through direct improvements in environmental awareness, resource allocation, or operational discipline. Consequently, the proposed model allows both a direct GEO–environmental sustainability relationship and an indirect relationship through green innovation. Green innovation is expected to be positively associated with environmental sustainability because environmental product and process improvements can reduce resource losses, prevent pollution, and improve the environmental efficiency of production activities.

The following hypotheses are proposed:

H1: Green entrepreneurial orientation is positively associated with environmental sustainability among manufacturing SMEs in Ghana.

H2: Green entrepreneurial orientation is positively associated with green innovation among manufacturing SMEs in Ghana.

H3: Green innovation is positively associated with environmental sustainability among manufacturing SMEs in Ghana.

H4: Green innovation mediates the relationship between green entrepreneurial orientation and environmental sustainability among manufacturing SMEs in Ghana.

2.4. Green organizational culture as a moderator

Organizational culture comprises shared assumptions, values, and norms that shape how organizational members interpret situations and behave (Schein, 2010). Green organizational culture refers more specifically to shared organizational commitments that prioritize environmental responsibility in decision-making, work practices, and resource use. A green organizational culture may be reflected in management support for environmental initiatives, employee participation in environmental improvement, the incorporation of ecological priorities into operational decisions, and the reinforcement of environmentally responsible practices. It is important to distinguish this construct from formal environmental management systems: policies and certifications may be present without environmental values becoming embedded in employees' everyday behaviour. Green organizational culture may

moderate the GEO–green innovation relationship by creating an internal environment that supports the implementation of green entrepreneurial initiatives. GEO encourages firms to identify and pursue opportunities, but converting those opportunities into innovations requires coordination, experimentation, and participation across organizational functions.

Where green values are strongly embedded, employees may be more willing to contribute ideas, share environmental knowledge, accept changes in established routines, and support investments in cleaner production. Managers may also be more likely to prioritize green initiatives when allocating organizational attention and resources. Green organizational culture can therefore reinforce the translation of GEO into green innovation. Conversely, a weak green culture may limit the realization of GEO's innovation potential. Even when managers express a strong entrepreneurial commitment to environmental sustainability, employees may resist new procedures, environmental objectives may receive insufficient operational attention, and green initiatives may be displaced by short-term priorities. This argument is consistent with DCT because organizational routines and shared values can influence the firm's ability to mobilize and reconfigure resources in pursuit of emerging opportunities. It is also consistent with the NRBV because an environmental orientation may produce greater value when supported by organizational practices that enable pollution prevention and environmentally responsible innovation. The proposed moderation is specifically located on the GEO–green innovation path. This placement avoids assuming that green organizational culture moderates every relationship in the model. The research will test whether culture strengthens the relationship between strategic orientation and innovation rather than simply correlating with environmental performance.

H5: Green organizational culture positively moderates the relationship between green entrepreneurial orientation and green innovation, such that the relationship is stronger at higher levels of green organizational culture.

2.5 Theoretical foundations

The study integrates two theories: the Natural Resource-Based View and Dynamic Capabilities Theory. They are complementary but perform different explanatory functions. The NRBV explains why environmentally oriented capabilities and innovations may contribute to environmental sustainability, while DCT explains how firms translate a strategic orientation into innovation under different organizational conditions.

2.5.1. Natural Resource-Based View

Hart (1995) developed the NRBV to extend resource-based thinking by explicitly incorporating the natural environment into explanations of firm strategy and competitive advantage. The theory identifies pollution prevention, product stewardship, and sustainable development as interrelated strategic capabilities through which firms may respond to environmental constraints and create value. The NRBV is relevant to the present study because GEO represents an orientation toward environmental opportunities, while green innovation provides a potential mechanism for converting that orientation into environmentally

beneficial products and production processes. A firm that identifies waste reduction as an entrepreneurial opportunity may introduce cleaner manufacturing methods, redesign products to reduce material consumption, or adopt technologies that improve energy efficiency. These activities are consistent with the NRBV's emphasis on pollution prevention and environmentally responsible production.

The theory also suggests that environmental improvements need not be separated from strategic business objectives. Improved resource efficiency can reduce waste and operating losses, while product stewardship can encourage firms to consider environmental impacts beyond immediate production activities. However, the realization of these benefits depends on the firm's capacity to implement appropriate practices. Within the proposed framework, the NRBV primarily explains the relationship between green innovation and environmental sustainability. It also supports the argument that a green entrepreneurial orientation can direct managerial attention toward environmental opportunities. The study extends this reasoning by examining whether green innovation statistically mediates the GEO–environmental sustainability relationship in manufacturing SMEs. An important qualification is that the NRBV does not imply that every green initiative automatically creates environmental or competitive benefits. Some innovations require substantial investments, and their effectiveness may depend on implementation quality and operational conditions. The theory therefore supports the proposed relationships without predetermining their empirical significance.

2.5.2. Dynamic Capabilities Theory

Dynamic Capabilities Theory builds on the proposition that firms operating in changing environments need more than existing resources; they must also develop processes for integrating, building, and reconfiguring internal and external competences (Teece et al., 1997). Teece (2007) further explains dynamic capabilities through the interrelated activities of sensing opportunities and threats, seizing opportunities, and transforming organizational resources and routines. This perspective is particularly relevant to manufacturing SMEs facing environmental, technological, and market changes. GEO may encourage managers to sense opportunities for environmentally preferable products and processes. Green innovation may represent a way of seizing these opportunities through new technologies, production methods, and product designs. The implementation of these innovations may require firms to transform established routines, coordinate employees, and reallocate resources.

Green organizational culture may condition this process. Shared environmental values can influence whether employees support experimentation, whether managers prioritize green initiatives, and whether environmental objectives are integrated into ordinary operating decisions. A supportive culture may therefore help the organization convert entrepreneurial intent into green innovation. The theoretical contribution is not that organizational culture is automatically a dynamic capability. Rather, green organizational culture is conceptualized as an organizational condition that may facilitate or constrain the deployment of capabilities. Its moderating role is a proposition derived from the application of DCT to the study's context, not a claim that culture and dynamic capabilities are synonymous.

2.5.3. Integrating the two theories

The theories are integrated through a sequence of strategic orientation, innovation, and environmental outcomes.

Model component	Primary theoretical explanation	Role in the study
Green entrepreneurial orientation	NRBV and DCT	Environmental opportunity-seeking and strategic direction
Green innovation	NRBV and DCT	Translation of environmental opportunities into products and processes
Environmental sustainability	NRBV	Environmental outcome of innovation and resource-use improvements
Green organizational culture	DCT-informed organizational condition	Boundary condition supporting or constraining innovation

The NRBV provides the environmental-strategy logic: firms can improve their relationship with the natural environment through pollution prevention and environmentally responsible innovation. DCT supplies the process logic: firms must identify opportunities, mobilize resources, and adapt organizational routines to implement those innovations. Their integration generates a testable argument. GEO may be associated with environmental sustainability because it directs firms toward green opportunities, but this association may be partly transmitted through green innovation and contingent on whether the organizational culture supports environmental experimentation and implementation. This integration also offers a basis for explaining variation across firms. Two SMEs may display similar levels of GEO but differ in green innovation because their internal cultures differ. Similarly, two firms may invest in green innovation but obtain different environmental outcomes depending on implementation quality and the environmental effectiveness of their innovations. The study consequently uses the NRBV and DCT to explain distinct components of one conceptual model rather than treating them as interchangeable explanations.

Green Organizational Culture

2.6 Hypothetical Model for the Study

Green Innovation

H5

H4 H3

H2

Green Entrepreneurial Orientation

Environmental Sustainability

H1

3. Research Methodology

3.1 Research philosophy, approach and design

This study adopted a positivist research philosophy and a deductive approach to examine the relationships among green entrepreneurial orientation (GEO), green innovation (GI), green organisational culture (GOC), and environmental sustainability (ES) in manufacturing small and medium-sized enterprises (SMEs) in Ghana. Positivism provided an appropriate philosophical foundation for examining theoretically derived relationships through the systematic measurement of latent constructs and statistical analysis of empirical observations. The deductive approach enabled hypotheses to be developed from the Natural Resource-Based View (NRBV) and Dynamic Capabilities Theory (DCT) and subsequently evaluated using empirical data. A quantitative explanatory survey design was employed. Primary data were collected through a structured questionnaire administered to organisational representatives of manufacturing SMEs. The manufacturing SME constituted the unit of analysis, whereas the individual organisational representative served as the unit of observation. The study employed a cross-sectional design, with data collected at a single point in time. Although this design facilitated the examination of relationships among the study constructs across a relatively large sample, it does not establish temporal precedence or definitive causality. Consequently, the findings are interpreted as statistical associations consistent with the proposed theoretical framework rather than conclusive evidence of causal effects.

The target population comprised manufacturing SMEs operating in Ghana. The study analysed 832 valid responses obtained from organisational representatives of eligible manufacturing SMEs. The eligibility criteria required participating firms to satisfy the study's definition of an SME, operate within the manufacturing sector, and have an organisational representative sufficiently knowledgeable about the firm's entrepreneurial orientation, innovation practices, organisational culture, and environmental activities. A stratified random sampling technique was employed to enhance the representation of different manufacturing subsectors within the target population. The manufacturing SMEs were classified into relevant subsectors, including food and beverage processing, textiles and garments, wood and furniture processing, chemicals and pharmaceuticals, metal fabrication, and other manufacturing activities. Eligible firms were subsequently selected through random sampling within each stratum to ensure that the different segments of the manufacturing population were represented. Within each selected firm, an organisational representative with sufficient knowledge of the firm's strategic direction, innovation activities, organisational culture, and environmental practices was selected to complete the questionnaire. This approach ensured that the responses were obtained from individuals familiar with the organisational issues examined in the study. The final sample of 832 respondents was established after the returned questionnaires had been screened for completeness, eligibility, and response quality.

The manuscript should report the number of questionnaires distributed, returned, excluded during screening, and retained for analysis, together with the response rate. It should also explain the sample-size determination procedure and the basis for considering the final sample adequate for the proposed covariance-based structural equation modelling.

The study operationalised GEO, GI, GOC, and ES using multi-item measurement scales adapted from relevant literature. The selection of measurement items was guided by the conceptual definitions of the constructs and their established operationalisation in previous empirical studies. The questionnaire items were designed to capture organisational representatives' assessments of their firms' environmental strategic orientation, innovation activities, cultural attributes, and environmental performance. GEO captured the firm's environmental innovativeness, environmental proactiveness, and willingness to undertake environmental risks. GI reflected green product and process innovations intended to reduce the environmental burden of business activities. GOC represented the extent to which environmental values, managerial support, and employee norms were embedded in organisational practices. ES focused on firms' environmental performance concerning resource efficiency, waste reduction, emissions reduction, and pollution prevention.

Table 1
Operationalisation of the study constructs

Construct	Dimensions	Measurement focus
Green entrepreneurial orientation (GEO)	Environmental innovativeness, environmental proactiveness, and environmental risk-taking	The firm's propensity to pursue environmental opportunities, develop green solutions proactively, and commit resources to uncertain environmental initiatives.
Green innovation (GI)	Green product innovation and green process innovation	The introduction of environmentally preferable product designs and production processes that reduce resource consumption, waste, emissions, or pollution.
Green organisational culture (GOC)	Shared environmental values, management support, and employee environmental norms	The extent to which environmental responsibility is embedded in organisational values, managerial decisions, and employee practices.
Environmental sustainability (ES)	Resource efficiency, pollution prevention, waste reduction, and emissions reduction	The firm's environmental performance concerning material and energy use, production waste, emissions, and pollution prevention.

Source: Developed by the researcher based on the conceptual framework and relevant measurement literature.

The measurement scales were adapted from established studies on environmental entrepreneurship, green innovation, green organisational culture, and environmental performance. Green entrepreneurial

orientation (GEO) was measured using items adapted from Jiang et al. (2018), capturing the firm's environmental innovativeness, proactiveness, and risk-taking orientation. Green innovation (GI) was operationalised through green product and process innovation, drawing on the measurement approach of Chen et al. (2006). Green organisational culture (GOC) captured shared environmental values, management commitment, and employee environmental norms, using items adapted from established research on organisational environmental culture. Environmental sustainability (ES) was assessed using indicators of environmental performance, including resource efficiency, waste reduction, emissions control, and pollution prevention, drawing on established environmental performance measures, including Melnyk et al. (2003) and Daily et al. (2007). The questionnaire contained 32 measurement items, comprising eight items for each of the four constructs (GEO, GI, GOC, and ES), in addition to questions capturing organisational and respondent characteristics. The measurement items were adapted to reflect the operational and institutional characteristics of manufacturing SMEs in Ghana while preserving the conceptual meaning of the original constructs. [Specify the response scale actually used, for example, a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

Before estimating the measurement and structural models, the dataset was screened to establish its completeness, consistency, and suitability for covariance-based structural equation modelling. The screening procedures examined missing observations, duplicate responses, unusual response patterns, potential outliers, and the distributional properties of the observed variables. The distributional properties of the observed variables were assessed to determine their suitability for the selected estimation procedure. Relevant assumptions, including multivariate normality where required by the estimation method, were examined before model estimation. The study also considered potential common-method variance arising from the use of a structured questionnaire completed by individual organisational representatives. The manuscript should identify the procedural measures and statistical diagnostics actually applied rather than claiming that common-method bias was absent solely on the basis of a single diagnostic test. The measurement model was evaluated before examining the hypothesised structural relationships. Internal consistency reliability was assessed using Cronbach's alpha and composite reliability (CR), while convergent validity was examined using standardised factor loadings and average variance extracted (AVE). Discriminant validity was assessed using the Fornell–Larcker criterion and the heterotrait–monotrait ratio (HTMT), where appropriate.

The hypothesised relationships were examined using covariance-based structural equation modelling (CB-SEM) in Analysis of Moment Structures (AMOS). CB-SEM was selected because the study sought to evaluate theoretically derived relationships among latent constructs, assess the adequacy of the proposed measurement model, and examine the structural relationships within a unified analytical framework. The structural analysis proceeded after the measurement model had demonstrated acceptable reliability and validity. The structural model was assessed using standardised path coefficients, their associated standard errors, critical ratios, and probability values. The explanatory power of the model was also examined. Overall model fit was evaluated using the chi-square statistic and complementary fit indices, including the comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), and standardised root mean square residual (SRMR). The

values obtained and the criteria used to interpret model adequacy were reported in the results section. The direct relationships between GEO and ES, GEO and GI, and GI and ES were examined through the estimated structural paths. The mediating role of GI was evaluated by estimating the indirect relationship between GEO and ES through GI.

Green organisational culture was specified as a moderator of the relationship between GEO and GI. This specification reflects the study's theoretical argument that an organisational culture supportive of environmental responsibility strengthens the association between a firm's environmental entrepreneurial orientation and its engagement in green innovation. The moderation hypothesis was assessed by incorporating a GEO × GOC interaction term into the structural relationship predicting GI. The study further examined whether GOC conditioned the indirect relationship between GEO and ES through GI. This moderated mediation hypothesis was assessed using the index of moderated mediation, with its statistical significance evaluated through bootstrap confidence intervals. Evidence of moderated mediation was established where the confidence interval for the index excluded zero. This procedure enabled the study to determine whether the indirect GEO–ES association through GI varied according to the level of GOC. The final structural model therefore specified GEO as the predictor, GI as the mediator, ES as the outcome, and GOC as the moderator of the first-stage relationship between GEO and GI. This specification ensured consistency between the theoretical framework, research hypotheses, analytical procedures, and interpretation of the empirical findings.

4. Results

Table 2
Composite reliability and convergent validity results

Construct	Items	Mean loading	Cronbach's Alpha	CR	AVE	√AVE
Green Entrepreneurial Orientation (GEO)	8	0.785	.924	0.928	0.616	0.785
Green Innovation (GI)	8	0.720	.901	0.896	0.519	0.720
Green Organizational Culture (GOC)	8	0.784	.917	0.927	0.615	0.784
Environmental Sustainability (ES)	8	0.735	.914	0.904	0.540	0.735

4.1 Measurement Model Assessment: Reliability and Convergent Validity

The measurement model was assessed to establish the internal consistency reliability and convergent validity of green entrepreneurial orientation (GEO), green innovation (GI), green organisational culture (GOC), and environmental sustainability (ES). As reported in Table 2, Cronbach's alpha coefficients

ranged from 0.901 to 0.924, while composite reliability (CR) values ranged from 0.896 to 0.928. These values generally exceed the recommended threshold of 0.70, indicating satisfactory internal consistency reliability across the four constructs. The average variance extracted (AVE) values ranged from 0.519 to 0.616, exceeding the minimum recommended threshold of 0.50. Specifically, GEO recorded an AVE of 0.616, followed by GOC (0.615), ES (0.540), and GI (0.519). These results indicate that the constructs explain more than half of the variance in their respective indicators, although GI demonstrates comparatively weaker convergent validity than the other constructs. The reported mean factor loadings ranged from 0.720 to 0.785, suggesting generally satisfactory indicator performance at the construct level. However, because mean loadings do not reveal the performance of individual indicators, the standardised loading of each item should also be examined to identify any indicators that may require further assessment. Overall, the reported reliability and AVE statistics provide preliminary evidence that the measurement model demonstrates acceptable internal consistency and convergent validity. Nevertheless, the underlying item-level estimates and reliability calculations should be verified before these conclusions are finalised.

Table 2.1
Exploratory Factor Analysis

Extraction Sums of Squared Loadings			**Rotation Sums of Squared Loadings**		
Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
10.022	31.318	31.318	5.278	16.494	16.494
4.912	15.351	46.669	5.109	15.966	32.459
3.053	9.541	56.210	4.916	15.364	47.823
2.072	6.476	62.686	4.756	14.863	62.686

Potential common method bias was assessed using Harman’s single-factor test. The unrotated exploratory factor analysis extracted four factors with eigenvalues greater than one, collectively accounting for 62.686% of the total variance. The first unrotated factor accounted for 31.318% of the variance, which is below the commonly applied 50% threshold. This result suggests that a single factor did not account for the majority of the variance in the measured items, providing preliminary evidence that common method bias may not be a dominant concern in the dataset.

Table 2.2
Fornell–Larcker Discriminant Validity

Construct	GEO	GI	GOC	ES
GEO	**0.785**			
GI	0.633	**0.720**		
GOC	0.271	0.050	0.784	
ES	0.410	0.308	0.424	**0.735**

Table 2.3
HTMT Results

Construct	GEO	GI	GOC	ES
GEO	—	0.409	0.057	0.422
GI	0.409	—	0.273	0.634
GOC	0.057	0.273	—	0.309
ES	0.422	0.634	0.309	—

Discriminant validity was examined using the Fornell–Larcker criterion and the heterotrait–monotrait ratio (HTMT). Under the Fornell–Larcker criterion, the square root of each construct's AVE should exceed its correlations with the other constructs. The diagonal values reported in Table 2.2 correspond to the square roots of the AVE values presented in Table 2, ranging from 0.720 for GI to 0.785 for GEO, 0.784 for GOC, and 0.735 for ES. The HTMT results in Table 2.3 range from 0.057 to 0.634. The largest reported ratio is between GI and ES (HTMT = 0.634), followed by GEO and ES (0.422), GEO and GI (0.409), and GI and GOC (0.273). The remaining ratios are comparatively low. All reported HTMT values fall below the commonly used threshold of 0.85, providing preliminary evidence that the constructs are empirically distinguishable. However, the unusually low HTMT value between GEO and GOC (0.057) warrants verification against the original item-level data and output. Where available, bootstrapped HTMT confidence intervals would provide additional evidence for assessing discriminant validity. Taken together, the HTMT results are consistent with acceptable discriminant validity, subject to verification of the reported estimates and reconciliation of the correlation matrix.

Table 2.4
Model Fit Results

Fit index	Reported result
Chi-square (χ^2)	466.749
Degrees of freedom (df)	458
χ^2/df	1.019
CFI	.999
TLI	.999
RMR	.005
SRMR	.045
GFI	.967
AGFI	.962

The overall model fit statistics are presented in Table 2.4. The chi-square statistic was 466.749 with 458 degrees of freedom, yielding a chi-square-to-degrees-of-freedom ratio of 1.019. The reported CFI and TLI values were both 0.999, while GFI and AGFI were 0.967 and 0.962, respectively. The RMR was 0.005, and the SRMR was 0.045. The chi-square-to-degrees-of-freedom ratio, CFI, and TLI indicate close correspondence between the proposed model and the observed covariance structure. Similarly, the SRMR of 0.045 is below the commonly applied threshold of 0.08, while the GFI and AGFI values indicate satisfactory fit under conventional guidelines. The RMR value is also low, although its interpretation depends on the scale of the observed variables. Collectively, these indices suggest that the specified model fits the observed data well.

4. Discussion

The results indicate a positive and statistically significant relationship between green entrepreneurial orientation (GEO) and green innovation (GI). This finding suggests that manufacturing SMEs with a stronger environmental entrepreneurial orientation tend to report greater engagement in green innovation. Firms that prioritise environmental opportunities, proactively respond to ecological challenges, and are willing to commit resources to environmentally oriented initiatives may be better positioned to introduce greener products and production processes. This result is consistent with the argument that environmental entrepreneurial orientation provides a strategic foundation for developing innovation capabilities. Guo et al. (2020), for example, found a positive relationship between GEO and both incremental and radical green innovation, highlighting the importance of organisational learning in translating environmental orientation into innovative outcomes. Similarly, Coelho et al. (2024), examining industrial SMEs in Portugal, found that GEO positively influenced green product and process innovation.

From the perspective of the Natural Resource-Based View (NRBV), the finding suggests that an environmental orientation can support the development of firm-specific capabilities directed towards pollution prevention, product stewardship, and environmentally sustainable operations. From a Dynamic Capabilities Theory (DCT) perspective, GEO may help firms identify emerging environmental opportunities, commit resources to green initiatives, and reconfigure existing processes to accommodate environmental priorities. These interpretations are consistent with the observed association, although the cross-sectional results do not establish the temporal sequence of these processes. The finding is particularly relevant to Ghanaian manufacturing SMEs, where the translation of environmental priorities into practical innovation may be important for improving resource efficiency and responding to changing stakeholder expectations.

Green innovation exhibits a positive and statistically significant relationship with environmental sustainability. Among the two direct relationships leading to environmental sustainability in the reported model, this is the larger coefficient, suggesting that green innovation is an important correlate of environmental sustainability among the sampled manufacturing SMEs. The finding indicates that the development and implementation of environmentally oriented products and processes are associated with stronger environmental sustainability outcomes. Green innovation may enable firms to reduce material and energy consumption, minimise waste, improve production efficiency, and limit pollution. Such practices are consistent with the NRBV, which positions pollution prevention and environmentally responsible product development as potential sources of organisational capability and competitive advantage (Hart, 1995). From this perspective, environmental sustainability may be associated not merely with a firm's strategic intentions but also with the extent to which those intentions are reflected in its products, processes, and operational practices. The result also aligns with Coelho et al. (2024), who found that green product and process innovation positively contributed to sustainability performance among industrial SMEs in Portugal. Their findings support the broader argument that environmental entrepreneurial orientation is more likely to translate into sustainability benefits when it is accompanied by the implementation of green innovations.

The results indicate a positive and statistically significant direct relationship between GEO and ES. This finding suggests that manufacturing SMEs with stronger green entrepreneurial orientation tend to report better environmental sustainability, even when green innovation is included as a separate predictor in the model.The finding is consistent with the NRBV, which emphasises the strategic importance of environmental capabilities and pollution-prevention practices, and with DCT, which highlights firms' ability to identify environmental opportunities and adapt their resource configurations in response to changing conditions. A green entrepreneurial orientation may encourage firms to integrate environmental considerations into strategic decisions, allocate resources to environmental initiatives, and respond proactively to ecological challenges. These activities may be associated with sustainability practices beyond the specific innovations captured by the GI construct. The result is broadly consistent with the systematic review by Ameer and Khan (2022), which synthesises research on GEO and corporate environmental performance, and with empirical evidence from Coelho et al. (2024) linking GEO to sustainability outcomes through green product and process innovation.

The model reports a positive and statistically significant indirect effect of GEO on ES through GI. Taken at face value, this result suggests that green innovation may provide an important pathway connecting green entrepreneurial orientation with environmental sustainability. The proposed mechanism is theoretically plausible. GEO represents a strategic orientation towards environmental opportunities and proactive environmental action, whereas GI reflects the translation of that orientation into green products and processes. When firms implement innovations that reduce resource consumption, waste, emissions, or pollution, their environmental priorities may become more closely associated with environmental sustainability outcomes. This interpretation is consistent with the NRBV's emphasis on environmentally oriented capabilities and with DCT's focus on converting strategic opportunities into organisational action. The finding also resonates with Guo et al. (2020), who identified supply chain learning as a mechanism linking GEO to green innovation, and Coelho et al. (2024), who examined the contribution of green product and process innovation to the relationship between GEO and sustainability performance. Nevertheless, the reported indirect-effect estimate requires verification before the mediation conclusion is finalised.

The structural model reports a positive and statistically significant interaction between GOC and GEO in predicting GI. According to the figure, this interaction represents the moderating effect of green organisational culture on the GEO → GI relationship. The positive interaction coefficient suggests that the relationship between GEO and GI becomes stronger as GOC increases, provided that the interaction has been correctly specified and the variables have been coded and scaled appropriately. Substantively, this interpretation implies that an environmental entrepreneurial orientation may be more closely associated with green innovation when environmental values, managerial support, and employee norms are embedded in the organisation. This argument is consistent with the view that organisational culture shapes the extent to which strategic priorities become established organisational practices. A supportive green culture may reinforce environmental experimentation, facilitate employee participation in green initiatives, and encourage the sharing of knowledge relevant to product and process improvements. Conversely, where environmental values are weakly embedded in organisational routines, a firm's green entrepreneurial orientation may not be translated as consistently into innovation activities.

Related research supports the relevance of organisational culture and green innovation in environmental management. Imran and Jingzu (2022), for example, examined relationships among green organisational culture, green innovation, and environmental performance, providing a relevant empirical foundation for considering culture within models of green innovation and organisational outcomes. From an NRBV perspective, green organisational culture may help embed environmental priorities in organisational routines, thereby supporting the development and use of environmental capabilities. From a DCT perspective, such a culture may facilitate the organisational learning and internal coordination needed to identify and implement green innovations. The present interaction result is consistent with this interpretation, although it does not independently establish the precise organisational processes responsible for the moderation effect. Two methodological qualifications are necessary.

Taken together, the reported results present a coherent theoretical account in which green entrepreneurial orientation is positively associated with both green innovation and environmental sustainability, while green innovation is positively associated with environmental sustainability. The proposed indirect pathway further suggests that innovation may help explain how environmental entrepreneurial orientation relates to sustainability. The reported interaction also indicates that organisational culture may condition the GEO–GI relationship. These findings offer a potentially useful integration of the NRBV and DCT. The NRBV helps explain why environmental priorities and green innovation may be associated with environmental performance, while DCT provides a perspective on how firms identify environmental opportunities and reconfigure resources to respond to them. Green organisational culture may be relevant to this process because shared values and organisational routines can support or constrain the translation of strategic orientation into innovation.

5.1. Conclusions

This study examined the relationship between green entrepreneurial orientation (GEO) and environmental sustainability (ES) among manufacturing SMEs in Ghana, focusing on the mediating role of green innovation (GI) and the moderating role of green organisational culture (GOC). Drawing on the Natural Resource-Based View (NRBV) and Dynamic Capabilities Theory (DCT), the study advances an integrated explanation of how environmentally oriented entrepreneurial strategies may be translated into sustainability-related outcomes through innovation and the organisational conditions that facilitate this process.

The findings indicate that GEO is positively and significantly associated with environmental sustainability, suggesting that manufacturing SMEs with stronger environmental entrepreneurial orientations tend to report more favourable environmental sustainability outcomes. This finding highlights the relevance of incorporating environmental considerations into entrepreneurial opportunity recognition, strategic decision-making and organisational initiatives. Furthermore, the positive relationship between GEO and GI indicates that environmentally oriented entrepreneurial strategies are associated with greater engagement in green innovation. This suggests that firms demonstrating environmental proactiveness and a willingness to pursue environmentally beneficial opportunities are more likely to engage in innovation-oriented activities directed towards improving their environmental practices.

Green innovation provides an important explanatory mechanism connecting entrepreneurial environmental orientation with environmental sustainability. By facilitating improvements in products, production processes and resource utilisation, green innovation offers a pathway through which environmental entrepreneurial priorities may be translated into sustainability-related outcomes. The mediation hypothesis should, however, be interpreted in accordance with the bootstrapped indirect-effect estimates and confidence intervals obtained from the final structural model.

The findings also highlight the importance of green organisational culture as an organisational condition shaping the relationship between GEO and GI. The positive interaction between GEO and GOC indicates that the association between environmental entrepreneurial orientation and green innovation becomes stronger under more supportive green organisational cultures. This suggests that environmental entrepreneurial initiatives are more likely to translate into innovation when shared environmental values, managerial commitment and employee participation are embedded within organisational practices.

Overall, the study contributes to understanding environmental sustainability as an outcome associated not only with firms' strategic environmental orientation but also with their innovation-related capabilities and organisational conditions. For manufacturing SMEs operating under resource constraints, the findings underscore the importance of aligning entrepreneurial environmental priorities with green innovation initiatives and supportive organisational cultures. By integrating these relationships into a first-stage moderated mediation framework, the study provides a more differentiated explanation of the organisational processes through which environmental entrepreneurial orientation may be associated with sustainability outcomes.

5.2. Theoretical Implications

This study contributes to the environmental management and sustainable entrepreneurship literature by integrating the Natural Resource-Based View (NRBV) and Dynamic Capabilities Theory (DCT) to explain the relationships among GEO, GI, GOC and environmental sustainability. The theoretical contribution extends beyond examining the direct association between entrepreneurial environmental orientation and sustainability outcomes by distinguishing the innovation-based mechanism through which this relationship may emerge from the organisational condition that facilitates the development of green innovation.

First, the study extends the application of NRBV by positioning GEO as a strategic antecedent of innovation-related environmental capabilities among manufacturing SMEs. Hart (1995) identifies pollution prevention, product stewardship and sustainable development as important strategic foundations through which firms can develop environmentally oriented capabilities and competitive advantages. Building on this perspective, the findings suggest that GEO is positively associated with GI, highlighting how an environmentally oriented entrepreneurial posture can provide a strategic basis for identifying and pursuing green innovation opportunities. This relationship broadens the application of NRBV by connecting environmental entrepreneurial orientation with innovation-related organisational responses. Furthermore, the positive association between GI and ES, where confirmed by the structural estimates, reinforces the relevance of green innovation as an organisational pathway through which environmentally oriented capabilities may be associated with sustainability outcomes. The study therefore provides a basis for understanding how entrepreneurial environmental priorities and innovation-related capabilities can be integrated into an NRBV explanation of environmental sustainability.

Second, the study advances the application of DCT by highlighting the importance of organisational adaptation and resource mobilisation in translating environmental entrepreneurial opportunities into innovation-related activities. DCT emphasises firms' capacity to sense emerging opportunities and threats, seize opportunities through resource commitment and reconfigure organisational assets and routines in response to changing conditions (Teece et al., 1997). Within the proposed framework, GEO reflects an orientation towards recognising and pursuing environmental opportunities, whereas GI represents an innovation-related manifestation of organisational responses to these opportunities. The relationship between GEO and GI consequently illustrates the importance of aligning strategic environmental priorities with organisational innovation activities. By examining this relationship among resource-constrained manufacturing SMEs, the study extends the relevance of DCT to understanding how smaller firms respond to environmental sustainability demands through innovation-related organisational capabilities.

Third, the study introduces GOC as an important organisational boundary condition within the GEO–GI relationship. Although environmental entrepreneurial orientation provides a strategic direction for identifying and exploiting environmentally beneficial opportunities, the translation of these priorities into innovation may depend on the extent to which environmental values and responsibilities are embedded in organisational practices. The positive interaction between GEO and GOC, where supported by the final interaction estimates, suggests that a supportive environmental culture strengthens the association between entrepreneurial environmental orientation and green innovation. This finding extends the application of DCT by highlighting that capability development and organisational adaptation are not determined exclusively by strategic intentions but may also depend on internal cultural conditions that facilitate resource mobilisation, employee participation and innovation-oriented behaviour. Importantly, this contribution positions GOC as a moderator of the GEO–GI relationship rather than a moderator of the direct GEO–ES relationship.

Finally, by integrating mediation and moderation into a first-stage moderated mediation framework, the study provides a more comprehensive theoretical explanation of the GEO–environmental sustainability relationship. The mediating role of GI addresses the innovation-based process through which environmental entrepreneurial orientation may be associated with sustainability outcomes, while the moderating role of GOC identifies an organisational condition that may strengthen this process at its initial stage. This integration contributes to sustainable entrepreneurship literature by demonstrating the theoretical relevance of examining both the mechanisms and boundary conditions through which environmentally oriented entrepreneurial strategies are associated with environmental sustainability. The extent of the conditional indirect relationship should be interpreted according to the statistical evidence provided by the bootstrapped index of moderated mediation.

5.3. Managerial and Practical Implications

The findings offer several implications for managers of manufacturing SMEs, industry associations and policymakers seeking to strengthen environmental sustainability under resource constraints. The implications concern the strategic integration of environmental entrepreneurial priorities, the

development of green innovation and the cultivation of organisational cultures that support environmental responsibility.

First, SME managers should integrate environmental considerations into strategic planning and entrepreneurial decision-making rather than treating environmental sustainability exclusively as a regulatory compliance obligation. This involves identifying environmentally beneficial business opportunities, anticipating emerging ecological requirements and evaluating investments in cleaner production technologies and resource-efficient operations. The positive association between GEO and environmental sustainability highlights the importance of developing an entrepreneurial orientation that recognises environmental considerations as part of organisational strategy. Consistent with NRBV, managers should view pollution prevention, resource efficiency and environmentally responsible product development as strategic considerations rather than merely additional operating costs (Hart, 1995).

Second, managers should prioritise green product and process innovation as an operational mechanism for translating environmental entrepreneurial priorities into practical organisational improvements. Depending on their technological capabilities and financial resources, manufacturing SMEs could invest in production technologies that reduce energy consumption, redesign products to minimise environmentally harmful materials, improve material utilisation, reuse production inputs where technically feasible and strengthen waste segregation and treatment. Such initiatives should be evaluated against their technical feasibility, expected environmental benefits, investment requirements and implications for operational efficiency. The relationship between GI and ES, where empirically supported, provides a rationale for integrating environmental innovation into production and operational improvement strategies. Managers should also establish appropriate performance indicators to assess whether innovation initiatives generate meaningful environmental improvements.

Third, manufacturing SMEs should cultivate green organisational cultures that reinforce environmental responsibility across managerial and operational activities. Senior management commitment is particularly important in communicating environmental priorities, allocating responsibilities for sustainability targets and encouraging employee participation in identifying environmental improvement opportunities. Environmental considerations can be incorporated into staff training, operational reviews, production meetings and internal performance assessments. Managers should also encourage knowledge-sharing and employee involvement in green innovation initiatives. Where GOC strengthens the GEO–GI relationship, these practices become particularly relevant because supportive organisational values and routines can facilitate the translation of environmental entrepreneurial intentions into innovation activities.

Fourth, policymakers and SME support institutions should recognise that financial and technical constraints can limit the ability of smaller manufacturers to implement environmentally oriented innovations. Targeted support could include access to cleaner-production technologies, environmental management training, technical advisory services, innovation financing and programmes that improve energy and material efficiency. Industry associations and relevant public institutions could also facilitate

partnerships between SMEs, technology providers, research institutions and larger manufacturers to improve access to environmental knowledge and innovation capabilities. Such interventions may help address the resource limitations that constrain the implementation of environmental entrepreneurial initiatives.

Finally, manufacturing SMEs should strengthen environmental performance monitoring to distinguish between the adoption of sustainability-oriented practices and actual environmental improvements. Relevant indicators may include energy consumption per unit of production, material utilisation rates, waste generated per production cycle, water consumption and emissions where reliable measurement is feasible. Integrating these indicators into routine operational reviews would allow managers to identify inefficiencies, evaluate the effectiveness of green innovation investments and make more informed decisions concerning environmental resource allocation. This approach is particularly important because environmental sustainability should be assessed through operational outcomes rather than relying exclusively on managerial perceptions of environmental responsibility.

5.4. Limitations and Suggestions for Future Research

Despite its theoretical and empirical contributions, the study has limitations that should be considered when interpreting its findings and identifying opportunities for further research.

First, the study focuses on manufacturing SMEs in Ghana. Although this setting provides relevant insights into environmental sustainability within an emerging-economy context, the findings may not be generalisable to large manufacturing corporations, service organisations or SMEs operating under different institutional, technological and economic conditions. Future studies could undertake comparative investigations across manufacturing subsectors, geographical regions and countries to establish whether the relationships among GEO, GI, GOC and environmental sustainability vary according to regulatory pressures, access to finance, technological infrastructure and market conditions.

Second, the cross-sectional research design captures the relationships among the study constructs at a single point in time. Consequently, the design does not establish temporal precedence or demonstrate that GEO precedes changes in green innovation and subsequent environmental sustainability outcomes. Although the proposed theoretical framework provides a basis for examining these relationships, causal interpretations should be treated cautiously. Future research could employ longitudinal designs to investigate whether changes in GEO are followed by changes in green innovation and subsequent environmental performance. Such studies could provide stronger evidence regarding the temporal sequence and persistence of the proposed relationships.

Third, reliance on questionnaire-based responses may introduce common-method bias and social desirability concerns, particularly where the same respondents provide information on entrepreneurial orientation, organisational culture, green innovation and environmental sustainability. Managers may overstate their firms' environmental commitments or sustainability achievements. Although appropriate statistical procedures can help assess common-method concerns, they cannot eliminate all potential

measurement biases. Future studies could employ multi-source data collection involving managers, production supervisors and employees, alongside independently documented environmental performance indicators. Combining survey responses with operational records would provide a more comprehensive assessment of the relationships among the study constructs.

Fourth, environmental sustainability may be assessed through managerial perceptions rather than independently verified environmental outcomes, depending on the measurement approach adopted. Although perceptual measures provide useful insights into organisational assessments of environmental performance, they may not fully capture actual changes in emissions, waste generation, energy consumption and resource efficiency. Future research could integrate objective environmental indicators with perceptual measures to establish whether reported sustainability improvements correspond with measurable operational changes.

Fifth, the study examines green organisational culture as a moderator of the GEO–GI relationship. However, other organisational and external conditions may also influence the extent to which environmental entrepreneurial strategies translate into green innovation. Future research could investigate the moderating roles of financial resource availability, managerial environmental commitment, technological capabilities, regulatory pressure and environmental knowledge. Comparative investigations of these conditions could provide a more comprehensive understanding of the organisational and institutional factors shaping green innovation among resource-constrained manufacturing SMEs.

Finally, future research could extend the proposed framework by examining whether the relationships vary across different categories of green innovation, including green product innovation, green process innovation and green managerial innovation. Disaggregating these dimensions may reveal whether particular innovation pathways are more strongly associated with environmental sustainability under different organisational conditions. Such investigations would provide further insights into the mechanisms through which environmentally oriented entrepreneurial strategies translate into environmental improvements across different manufacturing contexts.

Declarations

Declarations

Conflicts of Interest / Competing Interest

s: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contribution

Issah Ofori: Conceptualization, methodology, investigation, data curation, formal analysis, writing – original draft, and project administration.Stanislaus Ganyo Yaw Amegashie: Conceptualization, theoretical development, methodology, and writing – review and editing.James Peprah Adu: Data collection, investigation, validation, and writing – review and editing.Theophilus Kofi Anyanful: Methodology, formal analysis, validation, and writing – review and editing.Eric Boafo Dadzie: Supervision, validation, and writing – review and editing.All authors have read and approved the final version of the manuscript and agree to be accountable for their respective contributions.

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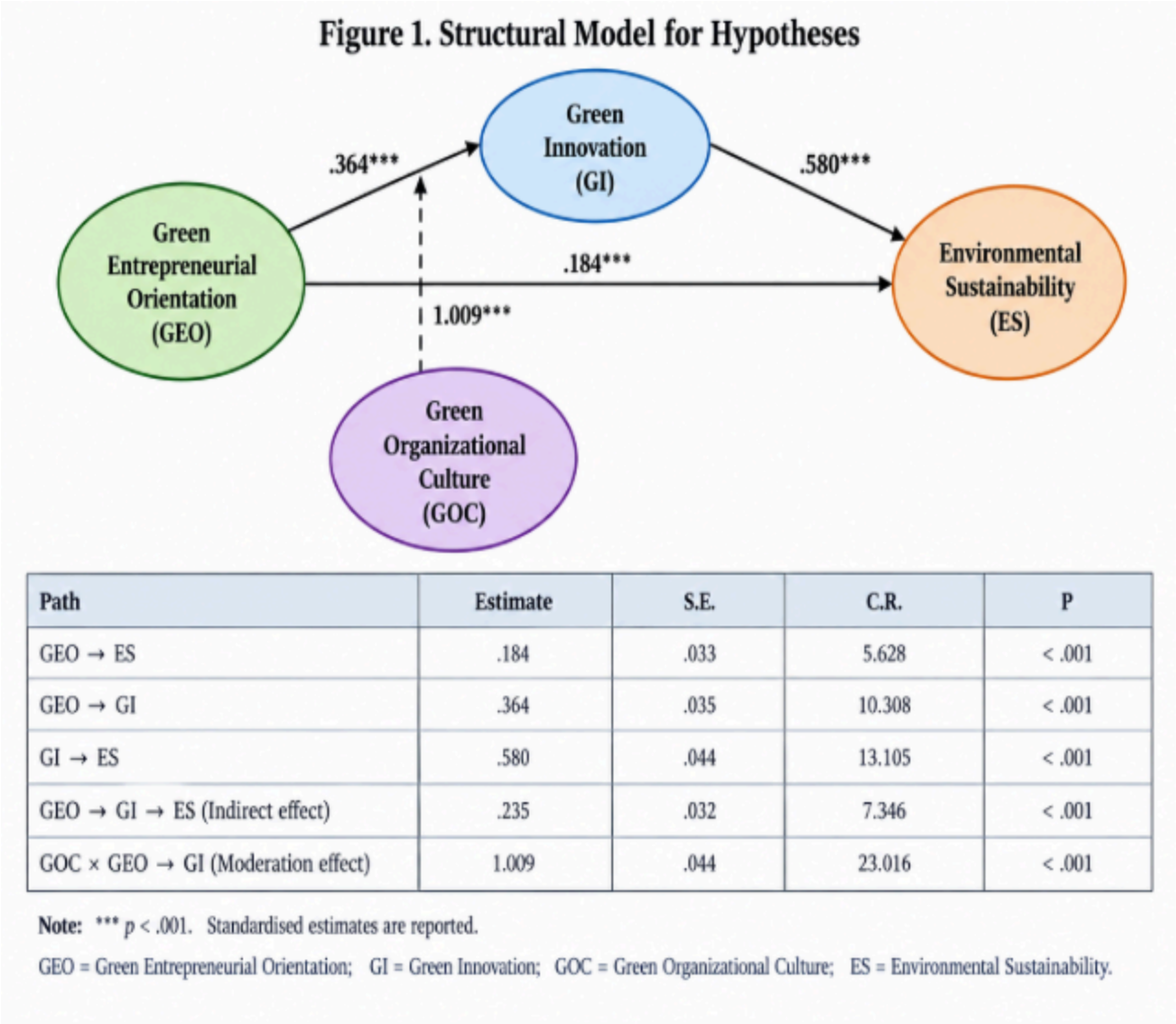
Figures



Path	Estimate	S.E.	C.R.	P
GEO → ES	.184	.033	5.628	< .001
GEO → GI	.364	.035	10.308	< .001
GI → ES	.580	.044	13.105	< .001
GEO → GI → ES (Indirect effect)	.235	.032	7.346	< .001
GOC × GEO → GI (Moderation effect)	1.009	.044	23.016	< .001

Note: *** $p < .001$. Standardised estimates are reported.

GEO = Green Entrepreneurial Orientation; GI = Green Innovation; GOC = Green Organizational Culture; ES = Environmental Sustainability.

Figure 1

See image above for figure legend

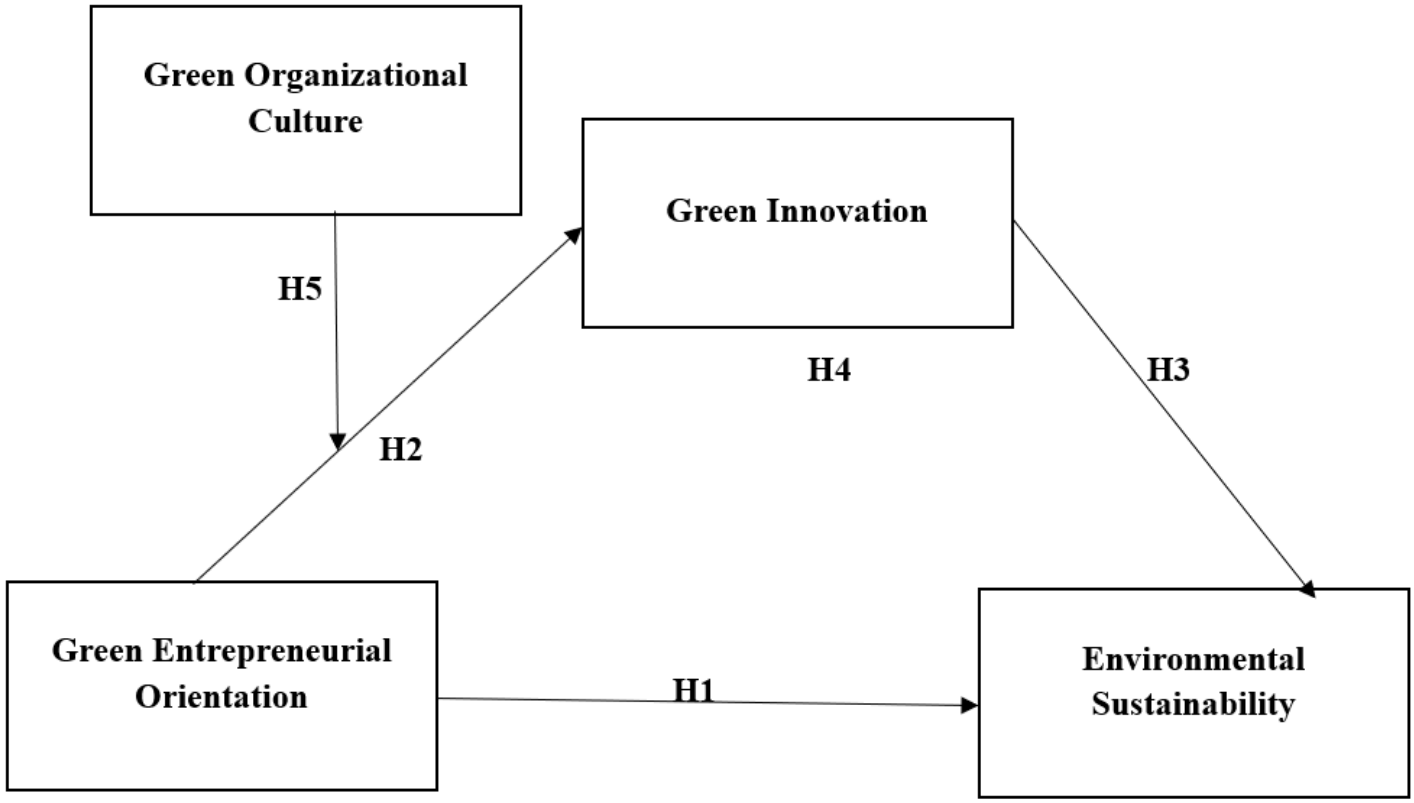


Figure 2

Unnumbered image in the 2. Literature review and hypothesis development section.