

Green HRM, Innovation Capability, and Sustainable Performance in Traditional Food-Processing MSMEs

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ABSTRACT

Purpose – This study examines whether owner-led Green Human Resource Management (Green HRM) is associated with perceived comparative Sustainable Business Performance through Green Innovation Capability in traditional food-processing MSMEs in Ponorogo, Indonesia.

Design/methodology/approach – A cross-sectional key-informant survey produced 301 eligible key-informant responses under a one-response-per-firm protocol; firm-level uniqueness could not be independently verified due to the absence of business identifiers in the exported dataset. PLS-SEM was estimated using SmartPLS 4 (Ringle et al., 2024). A disjoint two-stage higher-order specification represents Green HRM through four first-order dimensions and Sustainable Business Performance through economic, environmental, and social dimensions. Nonparametric bootstrapping used 3,000 resamples.

Finding/Results – Green HRM was positively associated with Green Innovation Capability ($\beta = 0.599$), Green Innovation Capability was positively associated with Sustainable Business Performance ($\beta = 0.347$), and the direct Green HRM–Sustainable Business Performance association remained positive ($\beta = 0.484$). The indirect association was 0.208, which supported complementary partial statistical mediation. The model explained 35.8% of Green Innovation Capability and 55.6% of Sustainable Business Performance.

Originality/Value – The study refines prior Green HRM research by examining informal owner-led workforce practices, distinguishing a repeatable capability from realized green innovation output, and evaluating multidimensional perceived sustainable performance in resource-constrained traditional food-processing MSMEs.

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1. Introduction

Small food-processing firms face environmental pressures in everyday operations because production relies on ingredients, water, energy, packaging, hygiene practices, and the handling of residual materials. Micro and small industries also remain economically significant in Indonesia, while food-related businesses form an important part of local enterprise activity in Ponorogo (BPS-Statistics Indonesia, 2025; Ponorogo Regency Government, 2023, 2024). These characteristics make the sector a useful setting for examining whether owner-led workforce practices, organizational capability, and perceived business outcomes are statistically associated under limited organizational resources.

Green Innovation Capability refers to the repeatable ability that an organization has to recognize environmental problems, using knowledge and resources to find solutions to those problems. Unlike green innovation output, this attribute reflects the potential that a company has to find solutions (Ferraro et al., 2025; Sharma & Vredenburg, 1998; Singh et al., 2022).

A further issue concerns how performance is measured. Sustainable Business Performance cannot be reduced to one number, whether financial or environmental. Elkington's (1997) triple-bottom-line framework measures economic, environmental, and social outcomes together, precisely because collapsing them into one distorts what is actually happening.

Numerous studies have explored the link between Green HRM, green innovation, and firm performance (Dumont et al., 2017; Ahmad et al., 2022; Singh et al., 2020; Zhao et al., 2024). Within the context of SMEs, studies that evaluated the link between Green Dynamic Capabilities, green innovation, and firm performance found similar results to those described for large firms (Singh et al., 2022). Finally, a study of firms within Indonesia that is focused upon the food and agro-industrial sectors found that the factors that drive green innovation within those industries are also related to sustainability outcomes from those industries (Indrawati et al., 2025; Lestari & Sunyoto, 2023; Najib et al., 2021; Rustiarini et al., 2022; Susanty et al., 2022; Wijaya et al., 2025). Recent SME evidence across developing-economy contexts similarly reports links among Green HRM, green innovation, and business, green, or sustainable performance (Azam & Jamil, 2024; Makumbe, 2024; Wang & Makhbul, 2024; Fuad et al., 2025; Srijani et al., 2025; Yuliza & Musa, 2025). A 2025 meta-analytic SEM synthesizing 137 empirical studies further confirms partial mediation of the Green HRM–sustainable business performance relationship through green innovation (Bindeeba et al., 2025). The broad mediation logic is therefore not unprecedented. The remaining gap is more specific: Green HRM is still frequently represented as a formal large-firm bundle; innovation capability is often conflated with realized innovation output; and sustainable performance is commonly reduced to one outcome. Limited evidence explains how informal owner-led workforce routines are statistically linked to a repeatable environmental innovation capability and multidimensional performance in traditional food-processing MSMEs.

What the existing literature leaves unresolved is not simply whether Green HRM is associated with performance in MSMEs, but whether the association is statistically consistent with a theorized organizational pathway specifically, one in which informal owner-led practices are associated with a repeatable firm-level capacity for environmental problem-solving, which in turn is associated with perceived comparative performance outcomes. Whether that pathway reflects a genuine conversion process or a co-occurring pattern cannot be determined from cross-sectional data; the present study tests the statistical consistency of the pathway rather than the causal mechanism itself. Prior mediation studies have tested Green Innovation as an output count or behavioral frequency, not as a recurring organizational capability with

identifiable sub-processes. This distinction matters because capability is antecedent to output: a firm that has produced one green product change has not necessarily developed the diagnostic, experimental, and learning routines needed to generate the next one. The present study therefore specifies Green Innovation Capability as a theoretically proposed intervening construct and tests whether the cross-sectional covariance structure is consistent with the NRBV-based mediation logic. Because Green HRM and capability reflect current conditions while performance is a retrospective 12-month comparison, the data cannot show that practices developed capability or that capability produced subsequent performance. The study does not claim to demonstrate a causal conversion process; it claims to show that the pattern of associations is consistent with one. That distinction matters because the theoretical argument and the statistical test answer different questions, and conflating them overstates what a single cross-sectional survey can establish.

This study addresses this narrower gap by distinguishing three constructs with different referents and time orientations: Green HRM as routine workforce-management practices, Green Innovation Capability as a current repeatable organizational ability, and perceived comparative Sustainable Business Performance as economic, environmental, and social outcomes over the previous 12 months. The study draws primarily on the Natural Resource-Based View (NRBV), with the Ability-Motivation-Opportunity (AMO) framework used selectively to explain the workforce-practice mechanism. The objective is to examine the statistical associations among Green HRM, Green Innovation Capability, and Sustainable Business Performance, and to test whether Green Innovation Capability statistically mediates part of the Green HRM-performance association in traditional food-processing MSMEs in Ponorogo.

Table 1. Positioning against the closest literature

Study stream	Upstream factor	Intervening mechanism	Outcome	Difference addressed here
Green HRM and green innovation	Formal or general Green HRM	Green innovation output or behavior	Environmental/organizational performance	Informal owner-led practices and capability are separated from realized output
SME green dynamic-capability research	Stakeholder or strategic pressures	Green dynamic capability and innovation	Firm or environmental performance	Green HRM is positioned as the upstream workforce-mobilization architecture
Indonesian e-food-sector innovation research	Leadership, e-commerce, or organizational conditions	Innovation adoption/capability	Business or sustainable performance	Traditional food-processing, worker-management routines, and triple-bottom-line performance are jointly modeled

Study stream	Upstream factor	Intervening mechanism	Outcome	Difference addressed here
Present study	Owner-led Green HRM	Repeatable Green Innovation Capability	Perceived economic, environmental, and social performance	Contextual and conceptual refinement rather than a first-ever mediation claim

Source: Authors' compilation from the cited literature.

2. Literature Review & Hypothesis Development

2.1 Natural Resource-Based View and the proposed mediation logic

The resource-based view attributes differences in firm performance to resources and capabilities that are valuable and difficult to replicate (Barney, 1991). The natural resource-based view (NRBV) extends this argument by treating environmental constraints and opportunities as conditions that can stimulate capabilities in pollution prevention, product stewardship, and sustainable development (Hart, 1995; Hart & Dowell, 2011). For small food processors, the relevant issue is not simply whether environmental practices exist, but whether people, knowledge, and operating routines are organized into a repeatable capacity that can generate useful outcomes.

The Ability-Motivation-Opportunity (AMO) framework is drawn on here as a secondary and interpretive lens rather than a co-equal structural theory alongside the NRBV. Within the NRBV-based proposed mediation logic, AMO provides conceptual vocabulary for the employee-level channels consistent with a pattern in which owner-led practices plausibly operate: practical environmental instruction from the owner-manager can strengthen workers' ability to recognize and act on waste and resource-use concerns; recognition and corrective feedback can sustain the motivation to contribute ideas and effort to environmental improvement; and participation in small-scale trials can create opportunity structures consistent with a pattern in which workers' individual operational knowledge may be associated with collective capability. This borrowing is deliberately partial. The three AMO components are not operationalized as latent variables in the structural model, nor are they tested as separable causal mechanisms, because doing so would require individual-level data from multiple workers per firm a design incompatible with the firm-level key-informant approach used here. The present study therefore uses AMO to interpret the plausible workforce-practice rationale at the employee level while NRBV provides the firm-level logic connecting people-management routines to organizational capability and performance outcomes. Contemporary AMO research additionally cautions that the three elements should not be treated as a single automatic formula, because their effects depend on how practices are enacted and interpreted in specific organizational contexts (Bos-Nehles et al., 2023), a caution that reinforces the interpretive rather than structural role assigned to AMO in this study.

2.2 Owner-led Green HRM in traditional food-processing MSMEs

Green HRM integrates environmental objectives into the management of people (Renwick et al., 2013). Tang et al. (2018) validated five formal domains: recruitment and selection, training, performance management, pay and reward, and involvement, while earlier conceptual work linked human-resource dimensions with environmental-management development (Jabbour & Santos, 2008). For owner-managed traditional food-processing MSMEs, however, formal recruitment systems are often less observable and less central than everyday environmental

guidance, monitoring, feedback, recognition, and worker participation. The present operationalization therefore retains the behavioral core of Green HRM while contextualizing it to informal small-firm management.

This contextualization is consistent with small-firm HRM research. HRM in small firms is commonly ad hoc and informal, while limited resources and owner centrality shape both the selection and implementation of people-management practices (Kroon et al., 2013; Mayson & Barrett, 2006). The concept of informality does not imply the absence of HRM; rather, HRM principles are incorporated within SMEs in various contexts. The present model therefore excludes formal green recruitment and emphasizes four practices that can be enacted credibly in micro and small businesses: green training and guidance, green monitoring and feedback, green recognition, and green employee involvement.

Hence, there is a positive expectation between Green HRM and Green Innovation Capability as employees are well versed in the constraints and inefficiencies within the production system. Guidance makes environmental priorities understandable and develops problem-solving ability; monitoring and feedback reveal deviations and learning needs; recognition motivates contribution; and involvement creates opportunities for workers to propose, test, and routinize improvements. Most studies on environmental training show that the training is beneficial to firms as they advance towards more mature environmental management practices (Jabbour, 2013; Jabbour et al., 2010). Studies on Green Human Resource Management reach the same conclusion from a different angle: firms that embed environmental responsibility into their HR practices tend to see better environmental performance outcomes (Ren et al., 2021). Recent meta-analytic and SME evidence also supports a positive Green HRM–green innovation relationship (Bindeeba et al., 2025; Shahzad et al., 2025).

H1: Green Human Resource Management is positively associated with Green Innovation Capability in traditional food-processing MSMEs.

2.3 Green Innovation Capability and Sustainable Business Performance

In this article, Green Innovation Capability denotes a repeatable firm-level capacity for environmental problem solving. It includes detecting waste or resource-use problems, obtaining and integrating relevant knowledge, adapting feasible solutions to the firm's constraints, running manageable trials, evaluating outcomes, coordinating implementation, incorporating successful changes into routine work, and applying lessons to later improvements. This dimension is about organizational potential, not past output. It asks what a firm is positioned to do next, independent of whatever green products or processes it has already introduced. That distinction matters: a firm can have a strong green innovation track record and still lack the internal capacity to push further, and vice versa (Chen et al., 2012; Ferraro et al., 2025; Sharma & Vredenburg, 1998; Singh et al., 2022).

Cost savings and waste reduction form another dimension of the Sustainable Business Performance framework, and they clearly affect both economic and environmental performance. The other benefits are intangible, for example safer working environments or better relationships with the communities where firms operate, and these fall under the social dimension (Abdul-Rashid et al., 2017; Ar, 2012; Lestari & Sunyoto, 2023; Rustiarini et al., 2022). Studies of SMEs and manufacturing firms support a link between green innovation and Sustainable Business Performance in all three dimensions (Abdul-Rashid et al., 2017; Lestari & Sunyoto, 2023; Rustiarini et al., 2022).

H2: Green Innovation Capability is positively associated with Sustainable Business Performance in traditional food-processing MSMEs.

2.4 Direct and indirect effects of Green HRM

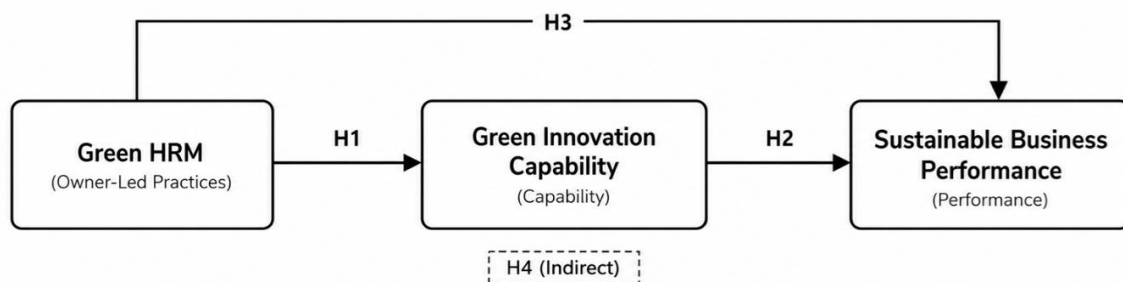
Green HRM may also be directly associated with sustainable performance, independently of the capability pathway. Clear expectations and corrective feedback have a fairly direct effect: fewer routine errors, less wasted material, fewer unsafe practices. Employee behaviours like improved inter-personal relationships, less waste occurrences, and more careful handling of materials might also be linked to recognition and involvement. These behaviours might also be linked to environmental, social and economic performance without being linked to the statistical relationship mediated by Green Innovation Capability (Paillé et al., 2014; Yong et al., 2020; Zhao et al., 2024).

H3: Green Human Resource Management is positively associated with Sustainable Business Performance in traditional food-processing MSMEs.

The NRBV-based model additionally proposes an indirect statistical association. A significant indirect association would be consistent with, but would not verify, the NRBV-based mediation logic, because the cross-sectional design cannot establish temporal order.

H4: Green Innovation Capability statistically mediates the association between Green Human Resource Management and Sustainable Business Performance in traditional food-processing MSMEs.

Figure 1. Conceptual model of owner-led Green HRM, Green Innovation Capability, and Sustainable Business Performance.



H1–H3 represent direct hypothesized associations; H4 represents the indirect association through Green Innovation Capability as mediator. Theoretical basis: Natural Resource-Based View (Hart, 1995; Sharma & Vredenburg, 1998) with AMO Framework as secondary interpretive lens (Bos-Nehles et al., 2023).

Source: Authors' conceptualization based on the cited literature.

3. Methodology

3.1 Research design and setting

The study used a quantitative, cross-sectional key-informant survey to evaluate associations among firm-level constructs. The intended analytical unit was the individual business, with recruitment materials explicitly stating that only one knowledgeable respondent per registered business unit should participate. Three procedural controls were built into the data-collection protocol to reduce the risk of multiple submissions from a single business in the absence of a formal sampling register. Safeguards included explicit single-respondent instructions in recruitment materials, a prior-participation screening item, and platform-level resubmission restrictions. These controls reduce, but cannot eliminate, the possibility of responses from the same business submitted through different devices or access points. Statistical pattern checks on the final export confirmed that no exact duplicate 41-item

response profile existed among the 311 raw submissions and no full straight-line response was detected. These checks address the most readily identifiable forms of duplication but do not establish firm-level uniqueness: two respondents from the same business operating different devices could produce non-identical response profiles that pass both screens. Without business identifiers, enumerator codes, or auditable recruitment logs, the 301 eligible submissions cannot be independently verified as 301 distinct firms. The study therefore treats the final N as 301 eligible key-informant responses collected under a one-response-per-firm protocol. Associations reported in the findings describe patterns within that sample of responses, not confirmed relationships across 301 independently verified businesses.

Respondent knowledgeability was assessed through a structured eligibility screen. Inclusion required the respondent to identify as the owner, owner-manager, or principal manager of the business; report at least one year of direct management involvement; and confirm adequate familiarity with workers, production routines, environmental changes, and business performance during the prior 12 months. This approach follows established key-informant practice for MSME research where formal organizational hierarchies are absent and a single person typically holds operational authority across all relevant domains (Kumar et al., 1993). Self-confirmed competence is not, however, externally validated competence, and the three respondent roles in this sample — owner (37.5%), owner-manager (49.2%), and principal manager (13.3%) — are not identical in ownership stake or formal authority. Whether they are sufficiently equivalent in knowledge accuracy to justify pooling is an empirical question the present study cannot resolve through the available data. The supplementary controlled model entered respondent role as a covariate; it did not reach conventional significance as a predictor of either endogenous construct, which is consistent with equivalence but falls short of a formal test of it.

Eligibility required that the principal production activity was located in Ponorogo; the business produced or processed food rather than operating only as a reseller, distributor, or repacker; the business had operated for at least two years and remained active; at least one active worker other than the respondent was employed, including regularly involved family workers; the business was independently managed or possessed local authority over workers and production; and the product satisfied at least two of five traditionality criteria. Respondents also had to be owners or principal managers with at least one year of management involvement and sufficient knowledge of workers, production, environmental improvements, and performance during the previous 12 months.

3.2 Sampling, data collection, and screening

The minimum sample size was determined prospectively using GPower (version 3.1; Faul et al., 2009), following the linear multiple regression procedure recommended for PLS-SEM by Hair et al. (2022). The critical structural equation was the one with the greatest number of incoming paths—Sustainable Business Performance, receiving paths from both Green HRM and Green Innovation Capability. An a priori power analysis was conducted using the F-test procedure for linear multiple regression (fixed model, R^2 deviation from zero). A conservative small effect size of $f^2 = 0.035$ was specified, with $\alpha = 0.05$, desired statistical power of 0.80, and a maximum of two predictors. GPower returned a minimum required sample size of 279. This statistical minimum was rounded up to a planned minimum of 280 eligible responses, while recruitment continued beyond that threshold to accommodate anticipated exclusions arising from the pre-specified eligibility, traditionality, and completeness screening criteria. The

realized analytical sample of 301 eligible key-informant responses therefore exceeded the planned minimum.

Criterion-based purposive recruitment was used because the study required a specialized population and knowledgeable key informants. Participants were recruited through purposive outreach and respondent referral within local MSME networks in Ponorogo. Because the exported dataset did not retain recruitment-source identifiers or complete recruitment logs, the number of respondents obtained from each recruitment route could not be independently verified. No single comprehensive and current sampling frame covering all traditional food-processing MSMEs in Ponorogo was available. Therefore, these recruitment approaches were considered the most feasible means of reaching the intended population. Because the total denominator of the target population could not be precisely established, a conventional response rate could not be computed, and population-representative inference is not warranted.

Data were collected using Google Forms from May 30 to July 28, 2026. Before accessing the survey, prospective participants saw an information page describing the study's purpose, the voluntary nature of participation, confidentiality protections, and their right not to participate. Participants had to give explicit informed consent before proceeding to the questionnaire; those who did not consent could not access the survey. Eligibility also required self-confirming that they were at least 18 years old. No individual respondent or business was identified in the study reports. This study did not undergo formal institutional ethics review, and no exemption determination was obtained before data collection. Ethical safeguards were limited to voluntary participation, explicit informed consent, an age-eligibility confirmation (18 years or older), and the absence of respondent or business identifiers in the reported data. No institutional ethics approval is claimed.

Screening rules were established before structural analysis. A response was excluded when any mandatory eligibility item was not satisfied, fewer than two of five pre-specified traditionality characteristics were selected, the respondent indicated that the business had participated previously, a core item was missing, or a core score fell outside the intended range. Traditionality was assessed using five characteristics (association with Ponorogo, East Java, or Indonesian culinary traditions; use of traditional recipes, ingredients, or flavors; use of traditional or intergenerational knowledge, skills, or production methods; having cultural or social significance, or being associated with specific consumption customs; and having long been known or consumed by the community), with a minimum threshold of two satisfied characteristics. A single-cue screen would have excluded too much of the working population this study targets. The threshold includes producers that are traditional producers, which is also the inclusionary threshold for other studies on Indonesia's MSMEs (Najib et al., 2021; Rustiarini et al., 2022). The threshold is an operational classification decision, not a universal definition of traditional food processing. Of the 301 eligible key-informant responses, most fell in the mid-range of the traditionality scale. The largest group, 193 responses (64.1%), satisfied three characteristics. Another 98 (32.6%) satisfied two. Very few reached the higher end: 7 responses (2.3%) satisfied four characteristics and 3 (1.0%) satisfied five. Responses qualifying on only two characteristics represent the minimum threshold for inclusion. Those qualifying on four or five may reflect a considerably deeper embeddedness in traditional structures. Whether that difference matters substantively is something future work with a wider range of traditionality scores could examine. To check whether this heterogeneity affected the main structural estimates, a multi-group analysis compared eligible responses from lower-traditionality businesses (two characteristics) against higher-traditionality businesses (three to

five characteristics). Eligible responses were also grouped by the BPS size classification reported for each business: micro (fewer than five workers, excluding the respondent) and small (five to nineteen workers). The primary structural model was re-estimated within each stratum where cell size allowed. Results are reported in the Data-analysis procedure section. Ten responses were excluded for one or more non-mutually exclusive reasons. The final analytical sample contained 301 complete eligible key-informant responses under a one-response-per-firm protocol. This figure exceeded the planned minimum of 280, which was derived from a prospective G*Power analysis as described at the opening of this section. The export retained no business identifiers, recruitment logs, enumerator codes, or completion durations. No post-hoc reconstruction of firm-level uniqueness from original recruitment records was possible, because those records were not retained. Statistical pattern checks could not confirm that each response came from a distinct firm, and no case was removed on the basis of influential or unusual patterns alone. All sample-size statements in this article therefore refer to eligible key-informant responses, not to verified unique businesses.

3.3 Measurement

All substantive measures used five-point response scales. Green HRM was operationalized with 15 items across four dimensions adapted from Green HRM theory and measurement research (Ahmad, 2015; Renwick et al., 2013; Tang et al., 2018) and environmental-training research (Jabbour, 2013; Jabbour et al., 2010). Green training and guidance contained four items; green monitoring and feedback, four; green recognition, three; and green employee involvement, four. The scale anchors ranged from 1 (not applied at all) to 5 (consistently applied). The items were rewritten for owner-led informal work settings and excluded recruitment because recruitment is episodic and often absent in micro firms.

Before field deployment, items were reviewed by two subject-matter experts for construct relevance, contextual fit, and linguistic accessibility in the owner-managed MSME setting. All items were translated into Indonesian via a sequential back-translation procedure. A cognitive pre-test with eight excluded Ponorogo MSME owner-managers produced four item revisions — two Green HRM items simplified, one GIC item reanchored to firm level, one SBP item clarified — with no items dropped.

Green Innovation Capability was measured with ten adapted items spanning nine functionally distinct sub-processes: problem recognition, information acquisition, knowledge integration, solution adaptation, experimentation, outcome evaluation, coordination, routinization, and organizational learning. The items that were included in the development of the Environmental Innovation Capability construct were rooted in research on environmental capabilities within management science journals (Sharma & Vredenburg, 1998), green dynamic capabilities within SMEs (Singh et al., 2022), environmental innovation capabilities within small businesses (Ferraro et al., 2025), and innovation and performance within food sector MSMEs in Indonesia (Wijaya et al., 2025). Treating ten items across nine subprocesses as a single reflective dimension requires more than adequate AVE and reliability. Three item-level diagnostics informed this decision. GIC dimensionality was evaluated using a range of complementary diagnostics: item loadings, inter-item correlations, cross-loadings, HTMT, principal component analysis, and parallel analysis. Full results are in the Measurement-model assessment section

The case for a single dimension rests on how these subprocesses actually operate in micro food-processing firms, not only on the psychometrics. In these settings, the owner who spots a waste problem is typically the same person who looks for a practical fix, runs a small trial,

and folds a successful result into daily routine. The nine subprocesses happen within one person or a very small group, in close sequence, and they rarely harden into separate organizational functions — the structure that would motivate treating them as distinct dimensions (Ferraro et al., 2025; Sharma & Vredenburg, 1998). The construct reflects the overall depth of that integrated capacity rather than discrete proficiency at each stage. The unidimensional reflective specification is treated here as a measurement proposal grounded in this particular sample and context. It is not presented as a settled architecture, nor as one that should transfer automatically to other settings.

Response anchors ranged from 1 (very low capability) to 5 (very high capability). A source-to-domain mapping is provided in the Appendix.

Sustainable Business Performance was measured with 16 items across three dimensions: economic performance (five items), environmental performance (six items), and social performance (five items). Because formal financial and operational records are rarely maintained in micro and small enterprises operating in semi-formal settings (Cantele & Zardini, 2018), a comparative self-report approach was adopted. Respondents assessed current business conditions against the same business approximately 12 months earlier, using anchors from 1 (much worse) to 5 (much better). Three design features partially managed retrospective recall and social desirability bias: a concrete 12-month comparison anchor, explicit framing that declines are as informative as improvements, and positioning performance items last in the survey sequence after 25 operational items. Despite these measures, single-informant retrospective performance assessment remains subject to perception and recall limitations, and objective or multi-source validation — through production cost records, waste-volume data, or external assessor ratings — is a clear priority for future research.

Reflective and formative specifications were assigned following MacKenzie et al.'s (2005) four criteria: whether the dimensions share a common cause, whether removing one alters the construct's meaning, whether covariation is expected, and whether the dimensions are interchangeable. Green HRM was retained as a reflective higher-order construct in the primary model, though the authors treat this as a theoretically contestable choice rather than a settled one. The reflective designation rests on one specific theoretical claim: that the four practice dimensions — training and guidance, monitoring and feedback, recognition, and employee involvement — are expressions of a shared owner-level environmental orientation, such that an owner-manager who consistently applies one tends to apply the others. That covariation is theoretically motivated, not assumed. At the same time, a formative reading is defensible: each dimension covers distinct behavioral territory, and removing any one would narrow the behavioral scope of owner-led Green HRM rather than simply reduce scale reliability. The formative/composite sensitivity model was estimated to test whether structural conclusions hold across measurement architectures; the consistent path directions across both models demonstrate robustness, not that the reflective specification is conceptually correct. The appropriate measurement architecture for multi-domain Green HRM constructs in informal MSME settings remains an open empirical question.

Sustainable Business Performance was specified as formative. The economic, environmental, and social dimensions define the construct jointly rather than reflect a shared cause — each dimension captures variance the other two do not, and a firm can improve on one while the remaining two stay flat or decline. Removing any one dimension would narrow what "sustainable performance" means in this study, not simply reduce scale reliability; that asymmetry is the formative criterion (MacKenzie et al., 2005). The three first-order dimension

scores accordingly served as formative indicators of the SBP composite at Stage 2, with outer weights and VIF values reported alongside the structural results. This mixed reflective-formative specification replaces the all-reflective model in the original submission. The formative/composite Green HRM specification served as a sensitivity check.

Table 2. Construct operationalization

Construct	Dimensions / indicators	Response frame
Green HRM	Training and guidance (4); monitoring and feedback (4); recognition (3); employee involvement (4)	1 = not applied at all to 5 = applied consistently
Green Innovation Capability	Problem recognition, knowledge acquisition/integration, adaptation, experimentation, coordination, routinization, and learning (10)	1 = very low capability to 5 = very high capability
Sustainable Business Performance	Economic (5), environmental (6), and social performance (5)	1 = much worse to 5 = much better compared with 12 months earlier

Source: Authors' measurement design.

3.4 Data-analysis procedure

PLS-SEM was estimated using SmartPLS 4 (Ringle et al., 2024), following a disjoint two-stage higher-order specification.

Because SBP was specified as formative at Stage 2, AVE and HTMT are not applicable at the composite level and were not assessed there. Formative adequacy was evaluated through collinearity and outer weight significance (Hair et al., 2022). VIF values for the three dimension indicators ranged from 1.28 to 1.57, all below the 5.0 threshold. Bootstrapped outer weights were positive and statistically supported for all three dimensions: Economic Performance ($w = 0.40$, $t \approx 4.48$, 95% CI [0.22, 0.57]), Environmental Performance ($w = 0.51$, 95% CI [0.33, 0.68]), and Social Performance ($w = 0.37$, 95% CI [0.17, 0.58]). The results indicate that each dimension contributed independently to the composite consistent with the expectation, under a triple-bottom-line formulation, that no one facet of sustainable performance should dominate the others.

The reflective or formative designation for each higher-order construct was determined before analysis using MacKenzie et al.'s (2005) four criteria: shared causation, meaning-alteration upon indicator removal, expected covariation, and indicator interchangeability. Green HRM is specified as reflective on the theoretical ground that its four dimensions are expected to manifest a common owner-level environmental orientation. This designation is treated as contestable: the four dimensions cover distinct behavioral territory, and a formative reading, in which they jointly constitute Green HRM without requiring a shared latent cause, is equally defensible. The formative/composite sensitivity analysis tests robustness across architectures, not conceptual correctness of the primary specification. SBP fails the reflective test on the third and fourth criteria: economic, environmental, and social performance need not move together, and each dimension adds substantive content the other two do not cover. SBP was therefore specified as a formative higher-order construct at Stage 2, with the three first-order dimension scores as formative indicators. Structural estimates from this revised specification are reported

in the main results; Appendix Table A2 confirms they are substantively consistent with the original all-reflective estimates.

In Stage 1, eight reflective first-order constructs were estimated: Green Training and Guidance, Green Monitoring and Feedback, Green Recognition, Green Employee Involvement, Green Innovation Capability, Economic Performance, Environmental Performance, and Social Performance. In Stage 2, the Green HRM was represented by the four Green HRM dimension scores, while the Sustainable Business Performance was represented by the scores for the economic, environmental, and social performance scores. The structural model specified Green HRM → Green Innovation Capability, Green Innovation Capability → Sustainable Business Performance, and Green HRM → Sustainable Business Performance. As a supplementary analysis, Green Innovation Capability was also modeled separately as a predictor of Economic Performance, Environmental Performance, and Social Performance to check whether the association observed for the formative SBP composite was concentrated in a single first-order dimension. These dimension-specific models were treated as secondary analyses and did not replace the formative SBP specification used in the primary structural model.

Measurement assessment included outer loadings, Cronbach's alpha, composite reliability, average variance extracted (AVE), and the heterotrait-monotrait ratio (HTMT; Henseler et al., 2015). Structural assessment included inner VIF values, path coefficients, specific indirect effects, R-squared, f-squared, and an out-of-sample predictive assessment using PLSpredict with ten-fold cross-validation. SmartPLS 4 applied nonparametric bootstrapping with 3,000 resamples and percentile 95% confidence intervals.

Predictive relevance was assessed using PLSpredict with ten-fold cross-validation (Shmueli et al., 2019). Q^2_{predict} values were examined together with indicator-level prediction errors. For each endogenous-construct indicator, PLS prediction errors were compared with those from a linear-model (LM) benchmark using RMSE and MAE. Indicator-level results in Appendix Table A4 constitute the primary PLSpredict assessment, while Table 8 provides a concise summary of explanatory power and aggregate prediction-error performance.

PCA-OLS, mean-score OLS, influence-based robustness checks, and a Python Mode A implementation produced directionally consistent structural estimates. The separate formative GIC sensitivity analysis also preserved path direction but produced materially smaller GIC-related coefficients, as reported below. A supplementary controlled model entered four covariates — management tenure, workforce size, market reach, and worker composition — as direct predictors of both endogenous constructs. All three primary paths remained positive and statistically supported (all $p < 0.001$), and no control variable reached conventional significance as a predictor of both constructs simultaneously. Controlled R^2 values (GIC = 37.2%; SBP = 57.1%) were marginally above the uncontrolled estimates, confirming that firm characteristics contribute modest incremental variance without altering the primary conclusions.

Several procedural and statistical steps were used to reduce and assess common method variance (CMV) risk (Podsakoff et al., 2003). Construct sections used distinct instructional text and varied response anchors — behavioral frequency for Green HRM, capability level for GIC, and comparative change for SBP — reducing uniform acquiescence bias (Chang et al., 2010). Sections were sequenced predictor-to-mediator-to-outcome, with eligibility items separating substantive blocks, and respondents were reminded that no answer was more correct than another. The first principal component accounted for 44.1% of total indicator variance, while full-collinearity VIF values ranged from 1.79 to 2.19 (Kock, 2015). The Harman-type first-

component variance and full-collinearity VIF are supplementary sensitivity indicators only. Because all focal constructs were reported by the same respondent in a single survey, these diagnostics cannot demonstrate that common-method bias was controlled, and the reported associations may be inflated by shared-method variance. To address concerns about the dimensionality of Green Innovation Capability, a principal component analysis of the ten GIC indicators was conducted prior to the PLS model. The first component had an eigenvalue of 7.75 and explained 77.46% of the total item variance; the second component had an eigenvalue of 0.48. A parallel analysis confirmed that only one component exceeded the corresponding random-data eigenvalue. These results are consistent with the unidimensional treatment in the primary model. A second order formative sensitivity analysis was also conducted by considering the nine GIC subprocesses as parts of a higher order construct. The path relationships were still positive across the structure, but the path sizes in the formative sensitivity model were notably smaller than in the primary reflective model. For instance, the path size between GIC and SBP dropped from 0.347 in the primary model to 0.175 in the formative sensitivity model. The indirect path size from Green HRM through GIC to SBP dropped from 0.208 to 0.093. The reduction in path sizes suggests that the strength of the path from GIC is sensitive to the way Green Innovation Capability is defined. The sensitivity analysis does show consistency in the direction of the relationships across alternative definitions, but it does not indicate that the size of the mediation path is constant across definitions.

Before interpreting the multi-group results, measurement invariance was assessed via the MICOM procedure using the exact group definitions applied in the subgroup analyses. For traditionality, eligible responses were split into a lower-traditionality group of businesses meeting exactly two characteristics ($n = 98$) and a higher-traditionality group of businesses meeting three to five characteristics ($n = 203$). For the firm-size comparison, responses from micro businesses with fewer than five workers ($n = 132$) were contrasted with those from small businesses with 5–19 workers ($n = 148$). All tests used 5,000 permutations. Configural invariance was established by holding indicators, data treatment, and measurement specifications constant across groups. Compositional invariance held for Green HRM, Green Innovation Capability, and Sustainable Business Performance in both comparisons, and the observed differences in composite means and variances fell within their respective 95% permutation intervals. Full measurement invariance was therefore supported for both splits, justifying the subsequent multi-group comparisons.

Two additional subgroup analyses addressed the heterogeneity within the traditionality threshold. First, a multi-group analysis in SmartPLS 4 compared path estimates for lower-traditionality respondents (two characteristics satisfied; $n = 98$) against higher-traditionality respondents (three to five characteristics; $n = 203$). The primary model was re-estimated separately for the micro-business stratum (fewer than 5 workers; $n = 132$) and the small-business stratum (5–19 workers; $n = 148$). The 21 eligible responses from businesses with 20 or more workers were set aside. That cell size was too small to support a stable subgroup comparison, so treating it as a separate stratum would have produced unreliable estimates. These analyses test whether the main associations hold across the range of traditional embeddedness and firm size captured by the sample rather than treating the threshold group as internally homogeneous. Product category was not retained as a structured variable in the exported dataset. That omission ruled out a subgroup comparison by product category: reconstructing categories from the original source records was not feasible after the fact. As a result, the heterogeneity analyses were confined to the pre-observed traditionality and

workforce-size strata. Replication studies should pre-specify product-category codes and retain them in the analytic dataset from the outset.

4. Result and Discussion

4.1. Results

4.1.1 Data screening and sample

The raw dataset contained 311 submissions. Ten responses were excluded on one or more pre-specified grounds (see Table 3). The final analysis used 301 complete eligible key-informant responses collected under a one-response-per-firm protocol. Exact duplicate 41-item profiles and full straight-lining were absent from the export, but firm-level uniqueness cannot be independently confirmed without business identifiers — a constraint acknowledged in the research design section and discussed further under limitations. All 41 core indicators were within the intended 1-5 range.

Table 3. Profile of the analytical sample (n = 301)

Characteristic	Category	n	%
Respondent role	Owner-manager	148	49.2
Respondent role	Owner	113	37.5
Respondent role	Principal manager	40	13.3
Management tenure	1 to <5 years	132	43.9
Management tenure	5 to <10 years	98	32.6
Management tenure	10 years or more	71	23.6
Workers besides respondent	1-4	132	43.9
Workers besides respondent	5-9	101	33.6
Workers besides respondent	10 or more	68	22.6
Worker composition	Family and nonfamily	145	48.2
Worker composition	Family only	96	31.9
Worker composition	Nonfamily only	60	19.9
Market reach	Village/district or regency	153	50.8
Market reach	Inter-regency	91	30.2
Market reach	Interprovincial/national+	57	18.9
Monthly sales	Below Rp25 million	122	40.5
Monthly sales	Rp25 to <50 million	106	35.2
Monthly sales	Rp50 million or more	68	22.6
Monthly sales	Undisclosed	5	1.7
Traditionality score	2 characteristics	98	32.6
Traditionality score	3 characteristics	193	64.1

Characteristic	Category	n	%
Traditionality score	4 characteristics	7	2.3
Traditionality score	5 characteristics	3	1.0
Firm size (BPS classification)	Micro (< 5 workers)	132	43.9
Firm size (BPS classification)	Small (5–19 workers)	148	49.2
Firm size	20+ workers	21	7.0

Source: Authors' survey data.

Table 4. Screening and exclusion flow

Stage / reason	N	Note
Raw submissions	311	Google Forms export
Excluded submissions	10	Reasons were non-mutually exclusive
Core item missing	6	All excluded
Fewer than two traditionality characteristics	5	Pre-specified operational rule
Prior business participation reported	4	Potential duplicate-business screening
Other eligibility/competence failures	8 reason occurrences	Location, age, active production, independence, or respondent competence
Final analytical sample	301	Complete eligible responses

Source: Authors' screening and data audit.

4.1.2 Measurement-model assessment

The measurement model showed satisfactory internal consistency and convergent validity across all first-order constructs. Indicator loadings ranged from 0.814 to 0.917, and all indicators were retained. Cronbach's alpha ranged from 0.863 to 0.961, the Dijkstra–Henseler rho_A coefficient ranged from 0.868 to 0.963, composite reliability ranged from 0.916 to 0.966, and AVE ranged from 0.741 to 0.785. The consistent ordering of $\alpha \leq \rho_A \leq CR$ across all constructs is in line with Mode A estimation and heterogeneous loadings, as rho_A provides a more precise estimate of the upper bound of reliability than does Cronbach's alpha but falls short of the ceiling that composite reliability reaches (Dijkstra & Henseler, 2015; Hair et al., 2022).

For Green Innovation Capability specifically, item-level diagnostics are reported separately because the construct spans nine conceptually distinct subprocesses and the unidimensional reflective specification requires more than summary reliability evidence. Outer loadings for the ten GIC items ranged from 0.814 to 0.917. Inter-item correlations ranged from 0.672 to 0.844 ($M = 0.750$), with no pair falling below 0.672 — no item cluster was detached from the others. Cross-loadings confirmed that each GIC item loaded at least 0.19 points higher on GIC than on any other construct in the model. A principal component analysis of the ten items returned

one component with eigenvalue above 1.0 (eigenvalue = 7.75, 77.46% of variance explained); the second component eigenvalue was 0.48, below the parallel-analysis reference value. Taken together, these diagnostics support the unidimensional treatment used in the primary model.

Table 5. Measurement-model assessment

Construct / dimension	Items	Cronbach alpha	rho_A	Composite reliability	AVE	Decision
Green Training and Guidance	4	0.898	0.901	0.929	0.766	Retained
Green Monitoring and Feedback	4	0.892	0.895	0.926	0.758	Retained
Green Recognition	3	0.863	0.868	0.916	0.785	Retained
Green Employee Involvement	4	0.893	0.896	0.926	0.758	Retained
Green Innovation Capability	10	0.961	0.963	0.966	0.741	Retained
Economic Performance	5	0.924	0.927	0.944	0.771	Retained
Environmental Performance	6	0.943	0.946	0.955	0.778	Retained
Social Performance	5	0.926	0.929	0.944	0.773	Retained

Note. rho_A (Dijkstra & Henseler, 2015) relaxes the equal-loading assumption underlying Cronbach's alpha; all values fall between alpha and CR, consistent with Mode A reflective estimation.

Source: Authors' SmartPLS 4 output.

Discriminant validity was evaluated among the five reflective constructs: the four Green HRM first-order dimensions and Green Innovation Capability. Because Sustainable Business Performance was specified as a formative higher-order construct at Stage 2, AVE and HTMT are conceptually inapplicable at the SBP composite level and SBP is excluded from this assessment. Formative adequacy for SBP — evaluated through outer weights and collinearity — is reported in the Data-analysis procedure section and confirmed in the structural results. For the five reflective constructs, all square roots of AVE exceeded the corresponding inter-construct correlations, and all HTMT ratios fell below 0.85, supporting discriminant validity.

Table 6. Discriminant-validity assessment — reflective constructs only

Construct	GTG	GMF	GRC	GEI	GIC
Green Training & Guidance (GTG)	0.875				
Green Monitoring & Feedback (GMF)	0.633	0.871			
Green Recognition (GRC)	0.516	0.535	0.886		

Construct	GTG	GMF	GRC	GEI	GIC
Green Employee Involvement (GEI)	0.495	0.635	0.555	0.871	
Green Innovation Capability (GIC)	0.498	0.544	0.383	0.511	0.861

Note: Diagonal values are square roots of AVE. Lower-triangle values are inter-construct correlations. HTMT ratios (upper triangle, not shown) were all below 0.85 for Green HRM dimensions and below 0.90 for GIC, confirming discriminant validity among all reflective constructs. Sustainable Business Performance was specified as a formative higher-order construct at Stage 2; AVE and HTMT are conceptually inapplicable at the composite level and are therefore excluded from this table. Formative adequacy for SBP is reported separately through outer weights and collinearity diagnostics.

Source: Authors' SmartPLS 4 output.

The discriminant-validity assessment in Table 6 is confined to the five reflective constructs, consistent with the mixed measurement architecture of the model. Because SBP was specified as formative at Stage 2, AVE and HTMT are conceptually inapplicable at the composite level and were not assessed there. Formative adequacy was evaluated on two grounds: collinearity among the three dimension indicators and the statistical significance of their outer weights (Hair et al., 2022). VIF values ranged from 1.28 to 1.57, all below 5.0. Bootstrapped outer weights were positive and statistically supported: Economic Performance ($w = 0.40$, 95% CI [0.22, 0.57]), Environmental Performance ($w = 0.51$, 95% CI [0.33, 0.68]), and Social Performance ($w = 0.37$, 95% CI [0.17, 0.58]). No dimension dominated the composite and none was statistically inert — each facet carried independent variance in the SBP score, consistent with the triple-bottom-line premise that economic, environmental, and social performance are distinct and should not be reduced to a single latent source.

Table 6A. Stage-2 Green HRM Higher-Order Measurement Results

Green HRM dimension	Stage-2 loading
Green Training and Guidance (GTG)	0.805
Green Monitoring & Feedback (GMF)	0.861
Green Recognition (GRC)	0.790
Green Employee Involvement (GEI)	0.820

Composite reliability = 0.891; AVE = 0.672.

Note: Green HRM was specified as a reflective higher-order construct at Stage 2 using the four first-order dimension scores. All Stage-2 loadings exceeded 0.70. Composite reliability and average variance extracted also exceeded the commonly applied thresholds of 0.70 and 0.50, respectively, indicating satisfactory internal consistency and convergent validity at the higher-order level.

Source: Authors' SmartPLS 4 output.

In Stage 2, every one of the four dimensions of Green HRM was found to load significantly on the reflective higher order construct (all loadings between 0.790 and 0.861). Green Monitoring and Feedback had the highest loading, then Green Employee Involvement, Green Training and Guidance and finally Green Recognition. The higher order construct also displayed acceptable convergent validity (AVE = 0.672) and acceptable internal consistency (composite reliability = 0.891). Evidence was therefore found to support the integrity of the reflective specification of Green HRM within the main model. However, this does not imply that the

reflective model is the only theoretically possible model of Green HRM. Therefore the alternative formative model is included as a sensitivity analysis.

4.1.3 Structural model and hypothesis testing

All focal associations were positive and statistically supported. Green HRM was associated with Green Innovation Capability ($\beta = 0.599$, bootstrap SE = 0.045, 95% CI [0.515, 0.685], $p < 0.001$). Green Innovation Capability was associated with Sustainable Business Performance ($\beta = 0.347$, bootstrap SE = 0.069, 95% CI [0.210, 0.474], $p < 0.001$). The direct Green HRM–Sustainable Business Performance association remained positive ($\beta = 0.484$, bootstrap SE = 0.064, 95% CI [0.356, 0.608], $p < 0.001$). The specific indirect association was 0.208 (bootstrap SE = 0.043, 95% CI [0.125, 0.294], $p < 0.001$), supporting complementary partial statistical mediation.

Table 6B. Structural sensitivity under the alternative formative GIC specification

Effect	β	Bootstrap SE	t	p	95% CI
Green HRM $\rightarrow$ GIC	0.530	0.046	11.53	<0.001	[0.457, 0.636]
GIC $\rightarrow$ SBP	0.175	0.068	2.56	0.011	[0.058, 0.325]
Green HRM $\rightarrow$ SBP	0.516	0.061	8.42	<0.001	[0.380, 0.618]
Green HRM $\rightarrow$ GIC $\rightarrow$ SBP	0.093	0.039	2.38	0.017	[0.032, 0.183]

Source: Authors' SmartPLS 4 output

Under the alternative formative specification, the GIC–SBP association remained positive and statistically significant ($\beta = 0.175$, SE = 0.068, $p = 0.011$, 95% CI [0.058, 0.325]). The specific indirect effect through GIC was similarly positive and significant ($\beta = 0.093$, SE = 0.039, $p = 0.017$, 95% CI [0.032, 0.183]). Both estimates, however, were noticeably smaller than those produced under the primary reflective specification. The sensitivity analysis suggests that the direction of the GIC pathway holds across specifications, but its magnitude does not. How the capability construct is measured appears to matter – not trivially, but enough to affect the size of the indirect effect in a meaningful way. Readers should therefore be cautious about placing too much weight on the specific magnitude of the mediating pathway until the measurement question is better resolved.

Table 6C. MICOM assessment for the traditionality and firm-size groupings

Group comparison	Construct	Original correlation (c)	5% permutation quantile	Compositional invariance	Mean difference	95% permutation interval	Variance difference	95% permutation interval	Conclusion
Lower vs higher traditionality	Green HRM	0.999	0.992	Yes	-0.496	[-0.674, 0.620]	2.784	[-3.135, 3.656]	Full
	GIC	1.000	1.000*	Yes	-0.309	[-0.679, 0.655]	2.177	[-3.617, 3.797]	Full

Group comparison	Construct	Original correlation (c)	5% permutation quantile	Compositional invariance	Mean difference	95% permutation interval	Variance difference	95% permutation interval	Conclusion
Micro vs small firms	SBP	0.998	0.984	Yes	-0.372	[-0.697, 0.666]	1.002	[-3.293, 3.581]	Full
	Green HRM	0.995	0.992	Yes	0.001	[-0.607, 0.620]	-1.844	[-3.239, 3.051]	Full
	GIC	1.000	1.000*	Yes	0.217	[-0.638, 0.623]	-0.087	[-3.450, 3.556]	Full
	SBP	0.999	0.983	Yes	0.253	[-0.626, 0.650]	-1.768	[-3.166, 3.163]	Full

Source: Authors' permutation-based MICOM analysis.

Note: MICOM was assessed using 5,000 permutations. Full measurement invariance was concluded when compositional invariance was established and the observed differences in composite means and variances fell within their respective 95% permutation intervals. Values reported as 1.000 are rounded to three decimal places.

Table 7. Structural-path and mediation results

Hypothesis	Path / effect	β	Bootstrap SE	t	p	95% CI	f2
H1	Green HRM -> Green Innovation Capability	0.599	0.045	13.24	<0.001	[0.515, 0.685]	0.558
H2	Green Innovation Capability -> Sustainable Business Performance	0.347	0.069	5.02	<0.001	[0.210, 0.474]	0.198
H3	Green HRM -> Sustainable Business Performance	0.484	0.064	7.57	<0.001	[0.356, 0.608]	0.372
H4	Specific indirect effect: Green HRM -> GIC -> SBP	0.208	0.043	4.83	<0.001	[0.125, 0.294]	—

Hypothesis	Path / effect	β	Bootstrap SE	t	p	95% CI	f2
—	Total effect: Green HRM -> Sustainable Business Performance	0.692	0.041	16.88	<0.001	[0.610, 0.770]	—

Source: Authors' SmartPLS 4 output.

Green HRM explained 35.8% of the variance in Green Innovation Capability, while Green HRM and Green Innovation Capability jointly explained 55.6% of Sustainable Business Performance. Effect sizes were large for H1 and H3 and moderate for H2; inner VIF = 1.54. Following Shmueli et al. (2019), predictive relevance was evaluated at the indicator level. Indicator-level Q^2_{predict} values were positive for all indicators (GIC: 0.182–0.231; SBP: 0.120–0.204), and PLS prediction errors were lower than the linear-model benchmark for 25 of 26 indicators on RMSE and for all 26 indicators on MAE, supporting a medium predictive assessment (Appendix Table A4).

Table 8. Explanatory and predictive assessment

Construct	R ²	RMSE (PLS)	RMSE (LM)	MAE (PLS)	MAE (LM)	Predictive assessment
Green Innovation Capability	0.358	0.970	0.980	0.747	0.755	Medium
Sustainable Business Performance	0.556	0.956	1.005	0.741	0.778	Medium

Source: Authors' predictive analysis based on the analytical survey data.

Note: Predictive assessment is based on indicator-level PLS_{predict} results using ten-fold cross-validation. Positive indicator-level Q^2_{predict} values indicate predictive relevance relative to the mean benchmark. PLS prediction errors were compared with a linear-model benchmark using RMSE and MAE. Full indicator-level results are reported in Appendix Table A4 and constitute the primary basis for the predictive assessment. Aggregate RMSE and MAE values are arithmetic means of the corresponding indicator-level prediction errors reported in Appendix Table A4.

4.1.4 Subgroup robustness across traditionality profiles and firm size

Full measurement invariance was confirmed for both the traditionality and firm-size groupings prior to interpreting the structural comparisons. Across the traditionality split, all three structural paths held the same direction as the full-sample model. The Green HRM–GIC coefficient was $\beta = 0.57$ in the lower-traditionality group ($n = 98$) and $\beta = 0.50$ in the higher-traditionality group ($n = 203$). The direct Green HRM–SBP coefficient was $\beta = 0.49$ and $\beta = 0.55$ respectively, while the GIC–SBP coefficient was $\beta = 0.11$ and $\beta = 0.16$ — both considerably smaller than the full-sample estimate of 0.347. Between-group permutation tests did not detect statistically significant structural differences across the three paths between the traditionality groups (all $p > .05$). Size-stratified estimates for micro and small firms followed the same directional pattern, though those comparisons carry additional uncertainty given the smaller within-group samples.

Table 8A. Multi-group analysis across traditionality and firm-size groups

Grouping	Structural path	Group 1 β	95% CI	Group 2 β	95% CI	$\Delta\beta$	Between-group permutation p
Traditionality	Green HRM $\rightarrow$ GIC	0.575	[0.399, 0.725]	0.495	[0.384, 0.599]	0.079	0.442
	GIC $\rightarrow$ SBP	0.106	[-0.100, 0.312]	0.161	[0.001, 0.323]	-0.056	0.712
	Green HRM $\rightarrow$ SBP	0.489	[0.271, 0.687]	0.546	[0.404, 0.678]	-0.058	0.654
	Green HRM $\rightarrow$ GIC $\rightarrow$ SBP (indirect)	0.061	[-0.051, 0.197]	0.080	[0.001, 0.171]	-0.019	0.830
Firm size	Green HRM $\rightarrow$ GIC	0.501	[0.370, 0.622]	0.541	[0.396, 0.667]	-0.041	0.676
	GIC $\rightarrow$ SBP	0.113	[-0.095, 0.302]	0.177	[-0.007, 0.351]	-0.064	0.653
	Green HRM $\rightarrow$ SBP	0.537	[0.372, 0.690]	0.480	[0.324, 0.636]	0.057	0.633
	Green HRM $\rightarrow$ GIC $\rightarrow$ SBP (indirect)	0.057	[-0.046, 0.154]	0.096	[0.003, 0.214]	-0.039	0.531

Source: Authors' bootstrap and permutation-based subgroup analysis.

Note: Group-specific confidence intervals were obtained from 5,000 bootstrap resamples. Between-group p-values were obtained from two-sided permutation tests with 5,000 permutations. $\Delta\beta$ represents Group 1 minus Group 2. For the traditionality comparison, Group 1 consists of eligible responses from businesses meeting exactly two traditionality characteristics, and Group 2 consists of those meeting three to five characteristics. For the firm-size comparison, Group 1 consists of eligible responses from micro-sized businesses, and Group 2 consists of responses from small businesses.

Between-group permutation tests indicated no statistically significant differences in the three structural paths across the traditionality groups (Green HRM–GIC: $p = .442$; GIC–SBP: $p = .712$; Green HRM–SBP: $p = .654$). The same pattern was observed for the firm-size comparison ($p = .676$, $.653$, and $.633$, respectively). A non-significant permutation test indicates no detectable between-group difference; it does not demonstrate that the GIC–SBP association is equally strong or reliably present within each subgroup. In fact, the 95% confidence intervals for the GIC–SBP path included zero in the lower-traditionality group ($\beta = 0.106$, [-0.100, 0.312]), the micro-business group ($\beta = 0.113$, [-0.095, 0.302]), and the small-business group ($\beta = 0.177$, [-0.007, 0.351]), and the lower bound in the higher-traditionality group was only marginally above zero ([0.001, 0.323]). Subgroup sample sizes ($n = 98$ to 203) limit statistical power to detect between-group differences, so the permutation results should be read as inconclusive rather than as evidence of equivalence.

The subgroup results support directional similarity but not stability of the capability-to-performance association. Within every stratum, the GIC–SBP coefficient was substantially attenuated relative to the full-sample estimate (0.347), and its precision was low. The full-sample GIC–SBP association should therefore not be assumed to hold with equal strength in every subgroup.

4.2. Discussion

4.2.1 Green HRM as an antecedent of Green Innovation Capability

Green HRM had the strongest structural association in the model, with Green HRM positively associated with Green Innovation Capability at $\beta = 0.599$. Green HRM also explained 35.8% of the variance in capability. This result indicates that, within the analytical sample, respondents who reported stronger owner-led guidance, monitoring, recognition, and employee involvement also reported higher Green Innovation Capability scores across the problem-recognition, experimentation, and routinization dimensions. The unexplained variance suggests that technology, finance, owner expertise, suppliers, and external support may also contribute to capability development.

4.2.2 Green Innovation Capability and sustainable performance

Green Innovation Capability was positively associated with Sustainable Business Performance at $\beta = 0.347$ after Green HRM was included in the model. Research on environmental capabilities, green innovation, and sustainable manufacturing has pointed in this direction for some time (Sharma & Vredenburg, 1998; Singh et al., 2022; Abdul-Rashid et al., 2017; Makumbe, 2024; Yuliza & Musa, 2025). Within the analytical sample, Green Innovation Capability retained a positive association with the Sustainable Business Performance composite ($\beta = 0.347$) after accounting for Green HRM scores. Three supplementary paths tested whether this association held for each performance dimension individually: GIC $\rightarrow$ Economic Performance ($\beta = 0.287$, 95% CI [0.175, 0.402], $p < .001$), GIC $\rightarrow$ Environmental Performance ($\beta = 0.357$, 95% CI [0.235, 0.482], $p < .001$), and GIC $\rightarrow$ Social Performance ($\beta = 0.338$, 95% CI [0.209, 0.462], $p < .001$). All three were significant. These paths are reported as supplementary rather than primary because SBP is specified as a formative composite rather than three separate outcomes, but they address whether the positive GIC association observed at the composite level is also evident when the three performance dimensions are examined separately. Full results are in Appendix Table A3.

4.2.3 The mediating role of Green Innovation Capability

The indirect association through Green Innovation Capability was 0.208 under the primary reflective specification (95% CI [0.125, 0.294]), and H4 was statistically supported because the interval excluded zero. The direct Green HRM–performance association remained positive at $\beta = 0.484$, indicating complementary partial statistical mediation. The indirect association represented approximately 30% of the total statistical association of 0.692. These figures, however, should not be read as stable estimates of the importance of the capability construct as an intervening variable. Under the alternative formative specification, the GIC–SBP path falls to $\beta = 0.175$ and the indirect association to 0.093, both remaining positive and statistically significant but roughly half the magnitude reported under the primary model. What the two specifications agree on is the direction of the GIC pathway. What they disagree on is its strength. The 30% figure therefore describes the distribution of the total association under one measurement assumption, not a robust estimate of how much of the association is statistically shared through capability independently of that assumption. This figure describes how the total association is distributed across the direct and indirect paths — it is a descriptive decomposition of cross-sectional co-variation, not an estimate of how much of a causal effect is transmitted through capability. The cross-sectional design cannot establish that Green HRM temporally preceded capability or that capability temporally preceded performance, so the 30% figure should not be read as the proportion of a causal effect that flows through the intermediate construct. Other possible pathways include reduced routine errors, stronger

worker commitment, safer practices, and more disciplined resource use. These pathways were not tested separately. The retrospective 12-month performance referent compounds this limitation: Green HRM and capability describe current conditions, whereas performance describes change over the preceding year. The ordering implied by the model is therefore theoretical, not observed.

Furthermore, the size of the indirect effect should be considered in light of the other specification for measuring GIC. If GIC is measured by a second-order formative composite, the value of the GIC-SBP path coefficient drops from 0.347 to 0.175 and the value of the indirect effect drops from 0.208 to 0.093. This finding suggests that the substantive size of the mediating path to some extent depends on the measurement model. For this reason, the current findings are more supportive of the direction of the path from GIC rather than a measurement-equivalent size of that path.

The subgroup results raise the possibility that pooling heterogeneous businesses may partly strengthen the full-sample GIC–SBP association by combining within- and between-group variation. The full-sample coefficient ($\beta = 0.347$) was considerably larger than every subgroup estimate (0.106–0.177), although the present analyses cannot determine how much of that difference is attributable to pooling rather than reduced precision within smaller strata. This possibility is particularly relevant because traditionality is central to the contextual identity of the study. The full-sample estimate should therefore not be interpreted as a typical within-group effect. Future studies with larger samples within each stratum should examine the capability-to-performance association separately across traditionality profiles and firm-size categories.

4.2.4 Theoretical implications

The pattern of associations is consistent with an NRBV-based mediation logic, though the cross-sectional design cannot confirm it. Under that account, owner-led Green HRM practices are theorized to organize and direct employee knowledge and effort, and Green Innovation Capability is the recurring organizational capacity that is theorized to link those practices to environmental improvements and perceived business value. What the data show is that the three constructs are associated in a pattern that does not contradict this account. The indirect path is positive and statistically supported regardless of whether GIC is specified as a reflective unidimensional factor or a formative composite of nine subprocesses. The estimated strength of that pathway is not consistent across specifications, which means the data support the direction of the NRBV-based argument more reliably than they support any particular magnitude claim about the capability mechanism. The findings therefore represent theoretical consistency, not mechanism verification. A stronger design would measure Green HRM at Time 1, Green Innovation Capability at Time 2, and objectively or independently assessed performance at Time 3. Keeping these stages separate matters because workforce practices, organizational capability, implemented innovations, and performance outcomes refer to different analytical objects a distinction consistent with research on the conditions enabling sustainable product innovation (de Medeiros et al., 2014).

The study also extends Green HRM reasoning to an owner-led and informally managed MSME context. Green HRM in such firms need not take the form of sophisticated recruitment systems, formal training modules, or written appraisal procedures. The cross-sectional associations are consistent with the interpretation that direct guidance, monitoring, recognition, and involvement can function as a coherent environmental management structure at micro-business scale, without requiring formal HR departments or written procedures

(Kroon et al., 2013; Mayson & Barrett, 2006) though confirming that interpretation requires longitudinal or multi-source data at the firm level.

Specifying outcomes across three dimensions — economic, environmental, and social — avoids the common shortcut of collapsing them into a single performance index.

Specifying SBP as formative resolves a tension that was present in the original submission. A reflective model assumes that economic, environmental, and social outcomes covary because a single latent factor drives all three which contradicts the triple-bottom-line premise that these dimensions are distinct and often move independently (Cantele et al., 2024; Elkington, 1997). A business might reduce waste substantially while revenue stays flat, or improve worker welfare while energy consumption barely shifts. The reflective model would have attributed those divergences to measurement error rather than genuine heterogeneity across outcomes. The formative specification does not. Positive outer weights across all three dimension indicators confirmed that each facet contributed independently to the composite. This confirms that no single dimension was driving the composite in isolation, but it does not establish that GIC is independently and significantly associated with each dimension as a separate outcome, a distinction that matters for interpreting the practical scope of the capability-to-performance association. For this reason, supplementary dimension-specific models were estimated separately; these analyses showed statistically supported positive GIC associations with economic, environmental, and social performance, while the formative SBP composite remained the primary outcome specification. The model still cannot tell us whether the associations unfold in the sequence the NRBV account describes — that answer requires longitudinal data. A parallel methodological note applies to Green HRM: the reflective specification adopted here rests on the expectation of a shared owner-level environmental orientation across practice dimensions, but researchers working in similar informal MSME contexts should treat this as an open theoretical question rather than a resolved one, and should test both architectures before committing to either.

4.2.5 Practical and social implications

For owner-managers in similar settings, the pattern of associations in this sample is consistent with the interpretation that consistent workforce-management practices are associated with stronger Green Innovation Capability and with a more favorable perceived comparative performance composite constructed from economic, environmental, and social dimensions. Because the primary model specifies SBP as a formative composite, dimension-specific associations were examined only in supplementary analyses. These models showed positive associations between Green Innovation Capability and Economic Performance ($\beta = 0.287$, 95% CI [0.175, 0.402], $p < .001$), Environmental Performance ($\beta = 0.357$, 95% CI [0.235, 0.482], $p < .001$), and Social Performance ($\beta = 0.338$, 95% CI [0.209, 0.462], $p < .001$). These findings should be read as secondary, cross-sectional associations, not as evidence that the three performance dimensions function as separate primary outcomes in the main model. These associations are descriptive of the analytical sample and should not be read as causal prescriptions until replicated with verified firm-level data and longitudinal designs. Whether these perceived improvements correspond to objectively measurable changes in waste volumes, energy use, revenue, or worker welfare was not assessed here and remains a question for future research using multi-source or administrative data. Practical applications may include giving workers product-specific environmental guidance, monitoring observable material or resource use, recognizing useful improvement ideas, and involving workers in small operational trials. Illustratively, these practices could address raw-material loss, water use, cooking-oil management, energy consumption, or unnecessary packaging. These examples represent

possible applications of the measured Green HRM dimensions and were not individually observed or tested. The study also did not compare workforce-based practices with technical investment; therefore, no conclusion can be made regarding which approach is more effective. Local government agencies, MSME associations, and business-support organizations may consider combining cleaner-production guidance with simple workforce-management practices, including owner-led instruction, structured feedback, worker participation, and small-scale experimentation. The effectiveness of these interventions should be evaluated through future longitudinal or field-based research.

5. Conclusion and Suggestion

The evidence shows positive cross-sectional associations among owner-led Green HRM, Green Innovation Capability, and perceived comparative Sustainable Business Performance in a sample of 301 eligible key-informant responses from traditional food-processing MSMEs in Ponorogo. Because firm-level uniqueness could not be independently verified, these associations describe patterns within the analytical sample rather than confirmed firm-level effects across 301 distinct businesses. Criterion-based purposive recruitment means these associations are specific to the purposive sample of traditional food-processing MSMEs in Ponorogo and should not be read as population-representative estimates for Indonesian food-sector MSMEs more broadly. Respondents with higher Green Innovation Capability scores reported more favorable perceived comparative performance across economic, environmental, and social dimensions. An indirectly significant relationship was also found, which suggests that some of the relationship between Green HRM and performance can be explained by Green Innovation Capability. However, this cross-sectional relationship does not provide evidence that Green HRM contributes to the development of capability over time nor that capability can transmit the effect on performance. Using SmartPLS 4 (Ringle et al., 2024), the composite PLS path model explained 35.8% of the variance in Green Innovation Capability and 55.6% of the variance in perceived comparative Sustainable Business Performance within the analytical sample. Alternative scoring, robust-regression, and influence analyses were also run, and none reversed or meaningfully undermined the primary associations.

This study makes three contributions. First, the study advances a theoretically grounded argument for Green HRM research in informal MSME contexts by positioning Green Innovation Capability as a theoretically proposed intervening construct and testing whether the associations are consistent with that logic. Distinguishing repeatable problem-solving capacity from realized innovation output, a separation prior mediation studies have not consistently maintained, sharpens the theoretical account even where the design cannot confirm its causal structure or the stability of the path magnitude across measurement specifications. The contribution is therefore a theoretical and analytical one: a more precise specification of the intervening construct and a demonstration that the direction of the GIC pathway is consistent across measurement architectures, even when its estimated strength is not. Second, it extends the NRBV-based logic to owner-led, informally managed traditional food-processing MSMEs. The cross-sectional pattern found here is consistent with direct guidance, monitoring, recognition, and employee involvement forming a coherent environmental-management structure. This is not a claim that a temporal conversion process has been demonstrated. Cross-sectional data cannot establish that, and the interpretation here stays within what the design actually supports. Third, it measures Sustainable Business Performance across economic, environmental, and social dimensions together rather than collapsing performance into a single proxy. That broader scope matters here. The primary

model linked Green HRM and Green Innovation Capability to the overall formative Sustainable Business Performance composite. In supplementary dimension-specific analyses, Green Innovation Capability was also positively associated with economic, environmental, and social perceived comparative performance, showing that the capability–performance association was not limited to a single dimension. Together, these contributions offer a theoretically grounded and contextually specific account of how informal people-management practices in micro-scale food enterprises are associated with organizational capability and perceived sustainable performance in an underrepresented regional MSME setting in Indonesia.

6. Limitations and Future Research

Five limitations temper these conclusions. Cross-sectional statistical mediation does not establish temporal or causal mediation. Mediation is therefore presented as theoretical consistency, not mechanism verification. All substantive measures were provided by one key informant and performance was a perceived 12-month comparison rather than audited objective performance. A more fundamental sampling-validity concern warrants explicit acknowledgment. The dataset retained no business identifiers, recruitment-source codes, enumerator records, or complete recruitment logs. The 301 eligible responses were collected under a one-response-per-firm protocol with procedural controls; explicit single-respondent instructions, a prior-participation screen, and platform-level resubmission restrictions, but these controls cannot prevent two respondents from the same business submitting non-identical profiles through different devices. The firm-level verification concern carries a direct statistical implication that warrants explicit statement. PLS-SEM bootstrapped standard errors and confidence intervals — including those reported in Table 7 — rest on the assumption that observations are statistically independent. If unidentified within-firm clustering occurred, that assumption could be violated, deflating standard errors and narrowing confidence intervals relative to what a clustering-corrected estimator would produce. The direction of the observed associations held across five independent estimation strategies and two subgroup splits, which limits but does not eliminate this concern. Readers should treat the confidence intervals in Table 7 as reflecting within-sample precision under the independence assumption, not as bounds that would necessarily hold under a design with verified unique business identifiers. The absence of exact duplicate 41-item patterns and straight-lining reduces but does not eliminate this risk. A parallel concern applies to respondent equivalence. Knowledgeability was screened through a structured eligibility protocol — not confirmed through an external audit, a second-informant cross-check, or any independent criterion. Owners, owner-managers, and principal managers are not identical in ownership stake or formal authority, and self-confirmed competence alone cannot stand in for demonstrated reporting accuracy. The respondent-role covariate in the controlled model returned no significant association with either endogenous construct, which is consistent with equivalence but is not a formal test of it. Future work using multi-informant designs, collecting responses from at least two knowledgeable persons per firm — is the appropriate design-level response to this constraint. The planned minimum of 280 was derived from a G*Power power analysis rather than from a probability-based sampling formula, so the sample should be understood as a purposive criterion-based collection rather than a statistical representation of any defined population. Replication in other regions and with probability-based sampling frames is needed before the patterns observed here can be treated as characteristic of traditional food-processing MSMEs in Indonesia generally. Control variables; management tenure, workforce size, market reach,

and worker composition, were assessed in a supplementary controlled model rather than the primary specification because the study population is relatively homogeneous on structural dimensions compared with multi-sector or multi-region samples; the controlled estimates were substantively consistent with the primary findings. The higher-order specifications used here require validation under alternative measurement models and in other samples. In particular, the reflective specification for Green HRM, retained on the theoretical ground that the four practice dimensions manifest a shared owner-level environmental orientation, is theoretically contestable, and future studies should pre-specify and justify their measurement architecture, test reflective and formative alternatives where sample size permits, and report inter-dimension covariance patterns that can inform rather than presuppose this decision. The Green Innovation Capability measure spans nine conceptually distinct subprocesses and was treated as unidimensional on contextual and empirical grounds specific to this sample. That decision should not be taken as settled. The nine subprocesses may differentiate into separable dimensions as capability develops in more mature or larger firms, and future research should test alternative second-order and formative composite specifications across varied MSME populations before treating the unidimensional structure as a general finding. Resolving the measurement question requires more than replicating the PCA and parallel analysis results in a different sample. Three types of evidence would materially advance the question. First, longitudinal data tracking the nine subprocesses at multiple time points would reveal whether they develop together or whether some consistently precede others, which would bear directly on whether a single latent factor or a formative composite better represents their structure. Second, studies sampling firms at different stages of environmental capability development, from early-adopter micro firms to more mature SMEs with dedicated environmental roles, would test whether the nine subprocesses differentiate into separable dimensions as capability matures. Third, multi-informant designs collecting subprocess-level assessments from both owners and workers would allow testing whether the covariation among items reflects a shared organizational orientation or a shared rater perspective, a distinction that psychometric analysis of single-informant data cannot resolve. Until evidence of this kind is available, the present finding should be read as showing that the direction of the GIC pathway is empirically stable, while its estimated magnitude remains contingent on a measurement question that has not been resolved. Future studies should use longitudinal designs, multi-source performance measures, and auditable recruitment records across comparative regional samples. Replication using registry-based sampling or administratively verified business identifiers is not simply a methodological upgrade; it is a validation requirement for any study that intends to treat the present findings as evidence of firm-level relationships rather than respondent-level associations. Auditable recruitment logs and a calculable response rate are prerequisites for that replication. Until such replication is available, the associations reported here should be read as a directional pattern worth investigating under more rigorous sampling conditions.

Ethics Statement

Participation was voluntary and preceded by an information page and explicit electronic informed consent. The study involved an anonymous survey of adult business owners and managers, and no sensitive personal data were collected. The study was not reviewed by an institutional ethics committee, and no exemption determination was issued before data collection. This statement is provided in accordance with the journal's ethics policy.

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Appendix

Appendix Table A1 maps each construct domain to its theoretical source, adaptation rationale, and construct boundary. Appendix Table A2 summarizes structural sensitivity across alternative estimation and measurement specifications. Path directions were consistent throughout, although the formative GIC specification produced materially smaller GIC-related coefficients. Full item texts, loading tables, audit trail, and Python code are available from the corresponding author upon request.

Appendix Table A1 → Source-to-domain and construct-boundary mapping

Domain	Item focus	Literature basis	Boundary applied
Green training/guidance	Waste, water, energy, packaging, and practical learning	Renwick et al.; Tang et al.; Jabbour	Owner-led guidance rather than formal training systems
Monitoring/feedback	Expected practice, observation, correction, and feedback	Tang et al.; Paillé et al.	Routine workforce management, not environmental performance
Recognition/involvement	Acknowledgment, ideas, trials, and worker knowledge	Renwick et al.; Dumont et al.	Motivation and opportunity practices, not innovation output
Green Innovation Capability	Recognize, acquire, integrate, adapt, experiment, evaluate, coordinate, routinize, learn	Sharma & Vredenburg; Singh et al.; Ferraro et al.; Wijaya et al.	Repeatable capacity, not counts of implemented innovations or outcomes
Sustainable Business Performance	Perceived economic, environmental, and social change over 12 months	Elkington; Cantele et al.; Abdul-Rashid et al.; Ahi et al. (2018)	Comparative perceived outcome, not current capability

Source: Authors' construct mapping based on cited literature.

Appendix Table A2 → Structural sensitivity across estimation and measurement specifications

Robustness estimator / sample	GHRM -> GIC	GIC -> SBP	GHRM -> SBP	Indirect
Python Mode A composite PLS (robustness only)	0.599	0.347	0.484	0.208
PCA-OLS two-stage	0.592	0.338	0.484	0.200
Mean-score OLS	0.597	0.349	0.481	0.209
Exclude Cook's D > 4/n	0.630	0.344	0.514	0.217
Exclude top 1% influential	0.618	0.311	0.527	0.192

Robustness estimator / sample	GHRM -> GIC	GIC -> SBP	GHRM -> SBP	Indirect
GIC second-order formative sensitivity	0.530	0.175	0.516	0.093

Note: Python Mode A estimation served as an independent robustness check; SmartPLS 4 (Ringle et al., 2024) was the primary estimation platform for all reported results. Bootstrap confidence intervals and significance tests for the formative GIC sensitivity specification are reported in Table 6B.

Source: Authors' robustness analyses.

Appendix Table A3. Supplementary Dimension-Specific Associations Between Green Innovation Capability and Sustainable Performance Dimensions

Supplementary path	β	95% CI	p
GIC → Economic Performance	0.287	[0.175, 0.402]	< .001
GIC → Environmental Performance	0.357	[0.235, 0.482]	< .001
GIC → Social Performance	0.338	[0.209, 0.462]	< .001

Appendix Table A4. Recalculated Indicator-Level Out-of-Sample Predictive Assessment

Construct	Indicator	Q ² _predict	RMSE PLS	RMSE LM	MAE PLS	MAE LM	PLS vs. LM
GIC	GIC1	0.200	0.953	0.963	0.753	0.772	Better
GIC	GIC2	0.203	0.962	0.969	0.742	0.752	Better
GIC	GIC3	0.193	0.953	0.956	0.719	0.738	Better
GIC	GIC4	0.193	0.981	0.990	0.757	0.774	Better
GIC	GIC5	0.210	0.967	0.975	0.748	0.767	Better
GIC	GIC6	0.190	0.985	1.009	0.734	0.769	Better
GIC	GIC7	0.182	0.995	1.007	0.778	0.790	Better
GIC	GIC8	0.220	0.970	0.960	0.741	0.747	Mixed
GIC	GIC9	0.231	0.964	0.977	0.745	0.760	Better
GIC	GIC10	0.189	0.969	0.991	0.751	0.772	Better
SBP	ECO1	0.188	0.954	1.010	0.745	0.785	Better
SBP	ECO2	0.143	0.962	0.999	0.767	0.791	Better
SBP	ECO3	0.196	0.938	0.983	0.726	0.754	Better
SBP	ECO4	0.143	0.957	1.011	0.772	0.825	Better
SBP	ECO5	0.120	1.022	1.072	0.799	0.825	Better
SBP	ENV1	0.165	0.938	1.008	0.713	0.774	Better
SBP	ENV2	0.195	0.923	0.990	0.712	0.759	Better
SBP	ENV3	0.171	0.932	0.995	0.714	0.758	Better

SBP	ENV4	0.148	0.946	0.995	0.714	0.760	Better
SBP	ENV5	0.143	0.951	1.010	0.739	0.782	Better
SBP	ENV6	0.185	0.949	1.009	0.722	0.774	Better
SBP	SOC1	0.167	0.980	1.020	0.754	0.787	Better
SBP	SOC2	0.202	0.935	0.962	0.717	0.745	Better
SBP	SOC3	0.204	0.950	0.974	0.749	0.767	Better
SBP	SOC4	0.181	0.957	0.974	0.747	0.754	Better
SBP	SOC5	0.161	1.007	1.065	0.766	0.811	Better

Source: Authors' recalculation from the analytical survey data using ten-fold cross-validation.

Note. Q^2_{predict} values are based on ten-fold cross-validated predictions. PLS and linear-model (LM) prediction errors are reported using RMSE and MAE. "Better" indicates that both PLS RMSE and MAE are lower than the corresponding LM benchmark; "Mixed" indicates that the two error criteria do not uniformly favor the same model.