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From Sustainability-Oriented Innovation to Circular Outcomes: Evidence from SMEs

Doli Muhammad Ja'far Dalimunthe[1], Arif Qaedi Hutagalung[2], Dany Perdana Sitompul[3], Muhammad Dharma Tuah Putra Nasution[4]
[1234]Universitas Sumatera Utara, North Sumatera, Indonesia
Correspondence: dolidalimunthe@usu.ac.id[1]

Abstract

Sustainability transitions in small and medium-sized enterprises (SMEs) depend on more than innovation intent — they require business models capable of translating that intent into product-level outcomes. This study tests an integrated model linking sustainability-oriented innovation (SOI), sustainable business model innovation (SBMI), barriers to the circular economy (B-CE), and sustainable product innovation performance (SPIP), with market performance (MP) as the downstream outcome. B-CE is positioned as both a suppressor of business model renewal and a moderator of the link between renewal and product-level output. Survey data from 280 Indonesian SMEs across sectors were analyzed using PLS-SEM. All eight hypotheses were supported ($p < 0.001$), with large effect sizes across the endogenous constructs ($R^2 = 0.646–0.719$). The study's principal contribution lies in empirically specifying SBMI as a necessary mediator between innovation orientation and product outcomes — a relationship prior literature had proposed conceptually but never tested within an integrated, SME-level model. B-CE operates in a dual capacity: as a direct suppressor of SBMI ($\beta = -0.519$) and as a moderator weakening the SBMI–SPIP relationship ($\beta = -0.288$), with the conditional slope falling from 0.717 under low-barrier conditions to 0.141 under high-barrier conditions. Structural relationships remained broadly consistent across sectors — manufacturing, service, and trading — and firm size, with only two of eighteen multigroup comparisons reaching significance. For managers and policymakers, cultivating sustainability orientation without reconfiguring value architecture is unlikely to yield measurable gains, and reducing circular economy barriers matters as much as direct innovation investment.

KEYWORDS

SMEs; sustainability-oriented innovation; sustainable business model innovation; circular economy; sustainable product innovation performance.

Introduction

Small and medium-sized enterprises occupy a central position in most economies, contributing substantially to employment, product innovation, and domestic market development. Yet their movement toward sustainable practice involves more than incremental efficiency gains. It requires rethinking how firms create, deliver, and capture value, from product design through supplier and distributor network governance, under constraints that are characteristic of the SME context: limited capital, technical capability gaps, and supply chain coordination that is often fragile (Dey et al., 2022; Holzer et al., 2021; Takacs et al., 2022). Research indicates that circular economy (CE) adoption in SMEs is associated with environmental performance improvements, including waste reduction, energy efficiency, and better design outcomes, but these benefits are not automatic; they depend on organizational readiness and ecosystem support (Dey et al., 2022; Kirchherr et al., 2018). The relevant question, then, is not simply whether SMEs adopt CE practices, but *how* sustainability orientation converts into measurable business model renewal and product innovation output.

Prior empirical work has examined pairwise relationships between many of these constructs: SOI and competitive performance (Hermundsdottir & Aspelund, 2021), SBMI and firm-level outcomes (Bashir et al., 2022), and B-CE as a threshold condition for circular adoption (Kirchherr et al., 2018; Takacs et al., 2022). A broader body of meta-analytic work has also established that eco-innovation and green innovation are positively associated with firm performance at the aggregate level (Hizarci-Payne et al., 2021; Liao et al., 2021; Zheng & Iatridis, 2022), but this evidence does not isolate whether business model renewal is a necessary intermediate structure, nor whether the translation from business model change to product-level outcomes is contingent on the barrier environment. What has not been examined jointly is the full conversion chain from innovation orientation through business model renewal to product-level and market outcomes, with circular economy barriers modeled simultaneously as both an antecedent and a moderator. This gap is consequential because testing pairwise links or aggregate firm-level outcomes independently cannot reveal whether orientation alone is sufficient, how strongly barriers attenuate the translational efficiency of business model renewal, or whether these patterns hold across sectors and size contexts. The present study addresses this gap by integrating SOI, SBMI, B-CE, SPIP, and MP into a single testable model, tested in the Indonesian SME context, an institutional setting characterized by early-stage circular economy policy development, fragmented reverse logistics infrastructure, and a predominantly micro and small enterprise base, conditions that make the barrier moderation question particularly acute.

At the capability level, sustainability-oriented innovation (SOI) provides a mechanism for embedding environmental, social, and economic goals across the full innovation cycle, from initial ideation through post- launch evaluation, while involving suppliers, customers, and communities in the process (Adams et al., 2016; Klewitz & Hansen, 2014). Viewed through the dynamic capabilities' lens, SOI strengthens a firm's capacity to sense opportunities and risks, mobilize resources and alliances in response, and reconfigure assets and processes as conditions change (Teece, 2007; Teece et al., 1997). Firms with stronger SOI are conceptually better positioned to redesign their business logic toward more sustainable arrangements (Bocken et al., 2014; Geissdoerfer et al., 2018). Firm- level empirical evidence is broadly consistent with this: sustainability-oriented innovation tends to be positively associated with performance, though effect sizes vary with industry context and implementation approach (Hermundsdottir & Aspelund, 2021; Zheng & Iatridis, 2022). Resilience itself has been conceptualized as a second-order dynamic capability in SME contexts, emerging when firms systematically develop sensing and adaptive capacities in response to environmental disruption (Khurana et al., 2022).

Sustainable business model innovation (SBMI) provides the organizational framework through which that orientation is translated into practice: how offerings are designed, how operations and partnerships are configured, and how revenue and cost mechanisms are aligned with environmental, social, and economic objectives (Bocken et al., 2014; Schaltegger et al., 2016). For business model change to become visible in the market, however, it must ultimately be reflected at the product level. This is where sustainable product innovation performance (SPIP) becomes relevant: it captures innovation output across three dimensions, environmental (design for repair, reuse, and recycling, and resource efficiency), social (safety and accessibility), and economic (lifecycle cost and market acceptance), offering a concrete downstream measure of whether sustainability orientation actually reaches product design and performance attributes (Calik, 2024). Linking SOI, SBMI, and SPIP within a single model makes it possible to assess whether a more sustainable orientation and value architecture consistently produce product attributes that customers and markets find meaningful.

This conversion process, however, is conditioned by barriers to the circular economy (B-CE), which span financing and capabilities, technology and infrastructure, market conditions, supply chain coordination, and regulatory and social factors (Holzer et al., 2021; Kirchherr et al., 2018; Takacs et al., 2022). These barriers do not only delay business model change; they also erode the quality of its translation to the product level, for instance when the absence of reverse logistics infrastructure makes take-back programs operationally infeasible, or when demand uncertainty weakens the commercial case for circular product variants. For this reason, B-CE is positioned in the present model as a dual conditioning variable: as a predictor that suppresses business model renewal intensity, and as a moderator that weakens the association between business model renewal and product-level output (Mishra et al., 2022).

Three objectives guide the analysis: (i) to examine how sustainability-oriented innovation is associated with business model renewal and, through it, with product innovation output; (ii) to assess the extent to which circular economy barriers suppress business model renewal and attenuate its association with product-level outcomes; and (iii) to draw applied implications for managerial support and policy design.

The contributions are theoretical, methodological, and contextual. Theoretically, the study's primary novelty lies in the empirical specification of SBMI as a necessary mediating mechanism between SOI and SPIP, a relationship that dynamic capabilities theory implies but has not previously been tested within an integrated model that also accommodates barrier moderation. A secondary theoretical contribution is the modeling of B-CE as simultaneously an antecedent and a moderator, extending its conceptual role beyond the threshold condition typically assumed in prior work. Contextually, the study provides the first multi-sector, multi-size-category evidence on these relationships in an Indonesian SME setting, a context analytically important for its combination of high enterprise density and underdeveloped circular infrastructure. Methodologically, it offers a replicable analytical protocol for testing these inter-construct relationships in SME samples. Practically, the findings provide targeted guidance on how SME owners, support organizations, and policymakers might prioritize interventions in capabilities, partnerships, and enabling conditions so that sustainability orientation more reliably converts into products that the market values.

Literature Review And Hypothesis Development

Sustainability-Oriented Innovation

Sustainability-oriented innovation (SOI) refers to the organizational capacity to embed environmental, social, and economic objectives across all stages of the innovation process, from idea generation and portfolio selection through development, launch, and post-launch evaluation, while engaging relevant stakeholders and linking activities to measurable performance indicators (Adams et al., 2016; Klewitz & Hansen, 2014). This framing positions SOI as more than a set of green practices or incremental process improvements; it represents a reorientation of how innovation is defined, prioritized, and measured, such that economic value creation proceeds alongside environmental improvement and social benefit (Adams et al., 2016).

In the SME context, SOI tends to manifest through co-creation and partnership arrangements with suppliers, customers, or local communities; attentiveness to market signals for environmentally preferable and inclusive solutions; and the routine incorporation of environmental and social metrics into project review cycles (Baxter & Chipulu, 2023; Klewitz & Hansen, 2014). The construct can be assessed reliably using standardized instruments; operationalization details for this study are provided in the Method section.

The dynamic capabilities framework offers a useful account of why SOI functions as a lever for more fundamental organizational change. Firms with well-developed SOI tend to be more capable of sensing sustainability- related opportunities and risks, mobilizing the resources and alliances needed to respond, and reconfiguring assets, processes, and value networks as conditions shift (Teece, 2007; Teece et al., 1997). These capabilities often underpin transitions toward new business model configurations, such as moving from outright product sales toward use-based service arrangements, establishing take-back and refurbishment schemes, or capturing value from residual materials, which are among the core patterns of sustainable business model innovation (Bocken et al., 2014; Geissdoerfer et al., 2018).

Evidence from review and synthesis studies indicates that sustainability-oriented innovation is generally associated with competitive performance, though the magnitude of this association varies with industry context and implementation approach (Hermundsdottir & Aspelund, 2021). This body of evidence is consistent with the view that firms with an internalized sustainability orientation are better positioned to redesign their value logic toward more sustainable arrangements. The following hypothesis is proposed on this basis: H1. *Sustainability-oriented innovation is positively associated with sustainable business model innovation.*

Sustainable Business Model Innovation

Sustainable business model innovation (SBMI) refers to substantive changes in the way a firm creates, delivers, and captures value, configured to align with environmental, social, and economic objectives. Such changes extend beyond process efficiency to the underlying value logic: what is offered, how it is produced and delivered, with whom the firm partners, and how revenue streams and cost structures are organized (Geissdoerfer et al., 2018; Mignon & Bankel, 2023; Schaltegger et al., 2016). The literature has identified a range of practical archetypes, including material and energy efficiency, waste valorization, renewable resource substitution, service and use-based models, sufficiency strategies, and social value orientation, each offering a pathway for translating sustainability objectives into operational decisions (Bocken et al., 2014).

From an activity-system design perspective, SBMI requires coherence and complementarity among its constituent elements. A customer-facing repair service proposition, for example, presupposes operational support in the form of reverse logistics, material traceability, and appropriate partnership contracts. When one element of the business model is updated without corresponding adjustments to others, the resulting inconsistencies tend to undermine the durability of the initiative (Bocken et al., 2014; Zott et al., 2011; Zott & Amit, 2010). Piecemeal additions are generally insufficient; systemic reconfiguration is the more reliable path to embedding sustainability in the core business logic. Collaborative approaches in which firms partner with supply-chain actors or ecosystem participants to share the investment and risk of model redesign have also received increasing attention (Ciulli et al., 2022).

Validated instruments for assessing the degree to which business model changes have integrated environmental, social, and economic goals are available and have been applied in SME contexts (Bashir et al., 2022).

Systematic measurement matters here because SBMI typically emerges from many interrelated decisions spanning offering design, partner management, and lifecycle pricing, making informal assessment unreliable.

The SME context introduces specific constraints that bear on SBMI. Limited access to financing and technical capabilities, the absence of reverse logistics infrastructure, fragmented coordination across supply chains, uncertain demand for circular products and services, and regulatory ambiguity can each prevent the systemic fit that SBMI requires (Holzer et al., 2021; Kirchherr et al., 2018; Takacs et al., 2022). Under these conditions, managers tend to narrow the scope of change, defer take-back programs, or revert to conventional sales models, reducing the effective intensity of business model renewal. The following hypothesis is proposed: H2. *Barriers to the circular economy are negatively associated with sustainable business model innovation.*

Barriers to the Circular Economy

In the SME context, barriers to the circular economy (B-CE) are the internal and external constraints that impede the design, adoption, and scaling of circular practices. Cross-national evidence indicates that these barriers operate at three levels: micro (firm and product level, encompassing resource limitations, organizational risk aversion, and benefit uncertainty), meso (cluster and supply-chain level, encompassing coordination challenges and infrastructure gaps), and macro (policy, standards, and market demand dynamics) (Kirchherr et al., 2018). Systematic measurement of circular economy progress has itself been identified as a challenge, with more than 60 distinct indicators documented across the literature, underscoring the complexity of tracking circular transitions (De Pascale et al., 2021). A recurring pattern in this literature is the combination of weak consumer demand and organizational caution in contexts where policy support remains underdeveloped, a combination that consistently slows adoption across sectors including, notably, extractive and resource-intensive industries (Kirchherr et al., 2018; Osei et al., 2023).

At the internal level, the most commonly reported constraints are limited capital for upfront investments such as refurbishment lines and disassembly equipment, and skills gaps in sustainable design. At the supply-chain level, reverse logistics coordination raises transaction costs and introduces negotiation risk. At the institutional level, regulatory uncertainty and inadequate baseline infrastructure redirect managerial attention toward short-term compliance rather than longer-term circular system development (Holzer et al., 2021; Takacs et al., 2022). Multi-case evidence indicates that without take-back partners, reconditioning facilities, and service contracts, business model changes do not automatically translate into production-ready product specifications, producing a gap between value promise and actual design (Guldmann & Huulgaard, 2020). Sector-specific analyses, including studies of technical textiles, confirm that combinations of these barriers delay transitions and constrain output at the product level (Hartley et al., 2022). Systematic reviews focused on SMEs reinforce these findings, identifying barriers as a primary determinant of environmental innovation adoption rates (Passaro et al., 2023).

Mechanistically, B-CE weakens two prerequisites for improved sustainable product innovation performance.

First, it constrains design capabilities, including modularity, repairability, and disassembly feasibility, by making the necessary investment and expertise difficult to secure. Second, it disrupts collaborative development with suppliers and logistics providers, limiting access to circular materials and take-back infrastructure. The net effect is that improvements along environmental (material and energy efficiency, waste reduction), social (safety and accessibility), and economic (lifecycle cost, market acceptance) dimensions of product innovation are smaller than they would otherwise be. On this basis, the following hypothesis is proposed: H3. *Barriers to the circular economy are negatively associated with sustainable product innovation performance.*

Sustainable Product Innovation Performance

Sustainable product innovation performance (SPIP) captures innovation outcomes at the product level across three domains that are directly relevant to customers and markets: environmental (energy and water efficiency, waste and emissions reduction, and design for repair, reuse, and recycling), social (safety, comfort, and accessibility), and economic (use value, customer acceptance, and lifecycle cost efficiency). By operating at this level, SPIP provides a concrete measure of the extent to which sustainability orientation actually reaches product design and performance attributes (Calik, 2024).

The circular design literature identifies specific technical pathways through which SPIP scores improve. End- of-life-conscious decisions, including design for disassembly and modular architecture, facilitate repair and upgrading, extend product lifespans, and reduce after-sales service costs. Composite indicators such as the Product Repairability Index (PRI) integrate spare part availability, disassembly ease, repair instruction clarity, and self- diagnostic capability to assess product repairability; higher PRI values have been associated with better environmental outcomes and smoother customer service experiences (Ruiz-Pastor & Mesa, 2023). Related work has linked specific design features to repair behavior in practice (Barros & Dimla, 2023), documented the socioeconomic conditions that shape whether repair actually occurs (Parajuly et al., 2024), and shown that neglecting end-of- life conditions typically produces suboptimal disassembly recommendations relative to lifecycle-aware approaches (Formentini & Ramanujan, 2023).

The conceptual link between business model change and product-level outcomes rests on the proposition that SBMI reconfigures the value proposition, value creation and delivery processes, and value capture mechanisms in ways that favor more circular design choices, including material selection, modular architectures for repair and upgrade, design-for-disassembly, take-back and refurbishment services, and lifecycle-informed pricing (Bocken et al., 2016; Geissdoerfer et al., 2018). When SBMI is functioning effectively, product attributes along environmental, social, and economic dimensions are expected to improve accordingly.

Quantitative evidence across studies provides corroborating support for this direction. Two large meta-analyses found that eco-innovation is positively associated with organizational performance, with stronger effects when innovation is integrated into strategy and operations, a characteristic associated with SBMI (Hizarci-Payne et al., 2021; Zheng & Iatridis, 2022). More recent meta-analytic work on green innovation further confirms this directional pattern, though effect sizes vary with innovation type and measurement approach (Liao et al., 2021; Rahmani et al., 2024). The circular business model literature provides complementary grounding: a review of circular business model configurations demonstrates that value architecture redesign is central to realizing sustainability-aligned product outcomes (Geissdoerfer et al., 2020). Most of this evidence operates at the firm level, so it is treated here as indicative of the expected direction rather than as direct evidence at the product level. On these grounds, the following hypotheses are proposed: H4. *Sustainable business model innovation is positively associated with sustainable product innovation performance.*

H5. *Sustainability-oriented innovation is positively associated with sustainable product innovation performance, mediated by sustainable business model innovation.*

The rationale for H5 follows from the preceding sections: SOI embeds sustainability objectives in the innovation process; SBMI translates that orientation into value architecture and design decisions; and SPIP captures whether those decisions reach the product attributes that customers experience. The path from SOI to SPIP is therefore expected to operate through, rather than independently of, business model renewal.

Market Performance

Market performance refers to the commercial outcomes most directly associated with product activity, including sales growth, market share, new product launch success, and customer retention and loyalty. These indicators are widely used as market-based outcome measures in the strategic marketing literature (Katsikeas et al., 2016; Morgan et al., 2009). Alignment between marketing and sales functions has been identified as a boundary condition for translating product-level value propositions into realized commercial outcomes (Homburg & Jensen, 2007), a consideration particularly relevant in SME contexts where these functions often overlap. They represent the point at which value constructed at the product level through SPIP and at the business model level through SBMI meets customer preferences and competitive dynamics.

From the customer experience side, SPIP captures product benefits across environmental, social, and economic domains, such that higher SPIP scores reflect products that are more resource-efficient, safer, easier to maintain, and more valuable over their lifecycle. These characteristics tend to lower total cost of ownership, strengthen quality and safety perceptions, and improve post-purchase experiences, a set of effects generally associated with higher adoption rates, repeat purchase, and recommendation behavior (Calik, 2024). The circular design literature has articulated the underlying mechanisms: repairability features, design-for-disassembly, repair and remanufacturing services, and take-back schemes extend product useful life and raise service readiness, reinforcing the value proposition perceived by customers (Bocken et al., 2016; Formentini & Ramanujan, 2023).

From the business model side, SBMI reconfigures value logic in ways that guide more circular design choices and influence how products are brought to and sustained in the market (Geissdoerfer et al., 2018). Prior work has linked stronger SBMI orientation with better firm-level performance, consistent with the conceptual pathway from value architecture change to market outcomes (Bashir et al., 2022). Two meta-analyses provide broader corroboration: eco-innovation is positively associated with firm performance, with effects that tend to be stronger when innovation is embedded in strategy and operations (Hizarci-Payne et al., 2021; Zheng & Iatridis, 2022); meta- analytic evidence on green innovation reinforces this directional finding across a wider range of innovation types and contexts (Liao et al., 2021; Rahmani et al., 2024). As before, these findings operate primarily at the firm level and are used here to support the expected direction rather than as direct product-level evidence.

It is also worth noting that circular economy barriers can attenuate these pathways. Financing and capability constraints, absent reverse logistics infrastructure, fragmented supply chain coordination, and regulatory ambiguity can reduce the quality of SBMI implementation, limiting how fully intended product attributes are realized and slowing diffusion to early adopters (Kirchherr et al., 2018; Takacs et al., 2022). This provides additional motivation for examining the moderating role of B-CE in the overall model. The following hypotheses are proposed: H6. *Sustainable product innovation performance is positively associated with market performance.*

H7. *Sustainable business model innovation is positively associated with market performance.*

H8. *Barriers to the circular economy negatively moderate the relationship between sustainable business model innovation and sustainable product innovation performance.*

Methods

Research Design

The study employed a cross-sectional survey design with a theory-driven associational explanatory orientation, targeting SMEs that had developed or brought to market at least one new product in the twelve months preceding data collection. Partial least squares structural equation modeling (PLS-SEM) was used for parameter estimation, an approach suited to research that prioritizes variance explanation and prediction over global model fit, and that involves constructs measured by validated reflective scales of moderate sample size (Hair et al., 2019; Sarstedt et al., 2022). Because data were collected at a single point in time, all reported relationships are associational; causal interpretation remains limited by design, and directional claims rest on theoretical reasoning and prior literature rather than observed temporal precedence.

Population, Sampling, and Inclusion Criteria

The target population comprised manufacturing and service SMEs operating in Indonesia across sectors that commonly engage in product-level innovation, including fashion and apparel, food and beverage, furniture, light components, consumer electronics, and household goods. The unit of analysis was the individual firm, represented by a single key informant per organization: the owner or the functional manager most directly responsible for innovation decisions and product performance assessments. Inclusion required that a firm had been in operation for at least twelve months, employed a minimum of five people, had undertaken at least one product innovation or variant launch in the preceding year, and had an eligible informant willing to participate. Sampling proceeded through stratified purposive selection, with stratification by sector and firm size (micro, small, and medium), to ensure adequate representation across subgroups for the planned multigroup analysis. The target sample size was set at 250–300 completed responses.

Because the sampling was purposive and restricted to firms with recent product innovation activity, the sample is not statistically representative of the full Indonesian SME population. Findings should be interpreted as reflective of the studied segment: innovation-active SMEs across three sectors, and generalization beyond this boundary requires replication in other institutional and sectoral contexts.

Constructs, Scales, and Operationalization

Five constructs were measured using validated instruments drawn from recent literature. All scales were translated into Bahasa Indonesia using a back-translation procedure (Brislin, 1970), with minor wording adaptations made to improve clarity for the local SME context. The adaptations did not alter the substantive content of any indicator.

Sustainability-oriented innovation (SOI) was measured with the 15-item scale developed by (Baxter & Chipulu, 2023), which assesses the degree to which environmental, social, and economic objectives are embedded across the stages of the innovation process. Sustainable business model innovation (SBMI) was operationalized using a 5-item scale representing three dimensions of value creation, delivery, and capture, adopted from (Bashir et al., 2022). Barriers to the circular economy (B-CE) were measured with 10 items spanning seven barrier dimensions, adopted from (Mishra et al., 2022). A complete mapping of each item to its corresponding barrier dimension is provided in Appendix Table A1.

Sustainable product innovation performance (SPIP) was assessed using the 6-item scale developed by (Calik, 2024), which captures product-level sustainability outcomes across environmental, social, and economic dimensions. The original scale uses a 5-point response format; in this study it was standardized to a 7-point format for consistency across constructs, with proportional anchor mapping. The rationale for this standardization is to minimize construct- level response scale heterogeneity, which can inflate or deflate inter-construct correlations when scales differ substantially in range. Proportional anchor mapping preserves the ordinal structure and relative spacing of response categories across the two formats. Structural equivalence between the two versions was verified by comparing factor loadings, reliability coefficients (CA and CR), AVE, and HTMT values; differences across all indicators were less than 0.03, and no psychometric threshold was violated in either version (results summarized in the Scale Equivalence for SPIP subsection below and reported in full in Appendix Table A2).

Market performance (MP) was operationalized with 4 items adapted from (Katsikeas et al., 2016; Vorhies & Morgan, 2005), covering sales growth, market share, product launch success, and customer retention relative to main competitors. All items were rated on a 7-point Likert scale (1 = strongly disagree to 7 = strongly agree), with the exception of B-CE items, for which anchors reflected barrier intensity (1 = not at all a barrier to 7 = a very strong barrier).

Data Collection

Prior to the main survey, a pilot test was conducted with 32 SMEs meeting the inclusion criteria but excluded from the final sample. The pilot assessed item readability, estimated completion time, and provided preliminary reliability estimates. Results are reported in the Results section (Section 4.2). Based on pilot feedback, the wording of three items was revised to improve contextual clarity; no items were removed.

The main questionnaire was distributed electronically through industry associations, local government SME agencies, and cluster community networks. To address non-response bias, two follow-up reminders were sent at one- week intervals, and a summary of aggregate findings was offered to participating firms as an incentive. All respondents received a participant information sheet, provided informed consent before proceeding, and were assured of anonymity and data confidentiality.

Common method bias (CMB) was addressed at two levels. Procedurally, the instrument was designed to increase psychological distance between constructs by varying item wording and randomizing item order within construct blocks, in line with procedural remedies recommended for survey-based research (Fuller et al., 2016). Statistically, CMB was assessed using the full collinearity VIF procedure recommended by (Kock, 2015): if all construct- level VIF values fall below 3.3 in a fully saturated collinearity model, CMB is considered unlikely to represent a dominant threat to the findings. These procedural and statistical measures reduce but do not eliminate same-source bias; residual CMB cannot be ruled out entirely in single-informant, cross-sectional survey data, and this is acknowledged as a limitation in the Limitations and Future Research subsection.

Measurement Model Evaluation

The measurement model was evaluated following current PLS-SEM practice. Indicator reliability was assessed by outer loadings, with a threshold of ≥ 0.70. Internal consistency was examined using Cronbach's alpha (CA) and Composite Reliability (CR), both evaluated within the recommended range of 0.70–0.95 to avoid concerns about inflated reliability. Convergent validity was assessed via Average Variance Extracted (AVE ≥ 0.50; (Fornell & Larcker, 1981)). Discriminant validity was evaluated primarily using the Heterotrait–Monotrait ratio (HTMT < 0.85–0.90; (Henseler et al., 2015)), with the Fornell–Larcker criterion applied as a supplementary check.

Structural Model Evaluation

Predictor collinearity was examined using VIF values, with a threshold of < 3.3 for all predictor-outcome combinations. Path coefficients were estimated via bootstrapping with 5,000 subsamples and are reported with the bootstrapped mean (M), standard deviation (SD), t-value, two-tailed p-value, and 95% confidence interval for each path. Model explanatory power was assessed using R^2 for endogenous constructs and Cohen's f^2 for the local effect size of individual predictor paths, with conventional thresholds of small ($f^2 = 0.02$), medium ($f^2 = 0.15$), and large (f^2 355 = 0.35) (Hair et al., 2019). In-sample predictive relevance was quantified using Q^2 via blindfolding. Out-of-sample predictive relevance was assessed using PLSpredict, which compares the RMSE and MAE of the PLS model against a naïve linear model (LM) benchmark for each endogenous construct indicator; a PLS model producing lower RMSE and MAE than the LM baseline for the majority of indicators is considered to demonstrate adequate out-of- sample predictive relevance (Shmueli et al., 2019).

Mediation and Moderation Testing

The indirect effect of SOI on SPIP through SBMI was estimated using bootstrapped indirect effects (5,000 subsamples). The relative magnitude of mediation was characterized using Variance Accounted For (VAF), a descriptive index for distinguishing partial mediation (VAF 20–80%) from full mediation (VAF > 80%). VAF was treated as a supplementary descriptor rather than a definitive criterion, consistent with current methodological guidance (Hair et al., 2019). It should be noted that "full mediation" in the present model specification refers to paths where no direct exogenous-to-outcome effect was specified; VAF reaching 100% on these paths is therefore a structural property of the model rather than independent confirmation of complete mediation in a broader theoretical sense.

The moderation of B-CE on the SBMI → SPIP path was modeled using a product-indicator approach. All component variables were mean-centered prior to forming the interaction term. Statistical significance was evaluated via bootstrapping, and conditional slopes were computed at three levels of B-CE (M − 1SD, M, and M + 1SD) to support substantive interpretation of the moderation effect.

Robustness Check

Structural heterogeneity across subgroups was examined through multigroup analysis (MGA), with groups defined by sector (manufacturing, services, and trading) and firm size (micro, small, and medium). Before comparing path coefficients across groups, measurement invariance was verified using the three-step MICOM procedure (Henseler et al., 2016). MICOM was applied to establish that observed differences in path coefficients, if any, reflect genuine structural variation rather than differences in how the constructs are measured across groups.

Research Ethics

All procedures complied with institutional ethics guidelines. Respondents received full information about the purpose and scope of the study before participating, provided written informed consent, and retained the right to withdraw at any point without consequence. No personally identifiable information was retained beyond the data collection phase.

Result and Discussion

Sample Characteristics

The final dataset comprised 280 valid responses from SMEs across three sectors in Indonesia. All respondents met the inclusion criteria: a minimum of twelve months in operation, at least five employees, and at least one product innovation activity in the preceding year. Respondent and firm profiles are summarized in Table 1 and Table 2.

The respondent profile shows a predominance of male respondents (56.4%) within the 31–50 age bracket (65.0%), with bachelor's degree holders representing the largest educational category (49.6%). Business owners accounted for 60.0% of respondents and functional managers for the remaining 40.0%, suggesting that informants generally had direct authority over the innovation decisions being assessed. At the firm level, the sample is reasonably distributed across sectors, with manufacturing (36.4%), services (35.0%), and trading (28.6%) each well represented.

The majority of firms had been operating for more than four years (82.9%), and 44.3% reported launching at least one new product in the preceding twelve months.

Pilot Test

A pilot test was conducted with 32 SMEs that met the inclusion criteria but were excluded from the main sample. The average completion time was 18 minutes, which was considered appropriate for an instrument covering five constructs. Item readability was rated favorably (mean readability score 4.3 out of 5.0), and no items were flagged as substantially ambiguous. Preliminary Cronbach's alpha values for each construct are reported in Table 3.

All alpha values exceeded 0.70, indicating adequate internal consistency at this stage. Based on pilot respondent feedback, the wording of three items was revised to improve clarity for the local SME context (one SOI item, one B-CE item, and one SPIP item), without altering the substantive content of the indicators. No items were eliminated.

Measurement Model

The overall PLS-SEM path structure, including all latent constructs, reflective indicators, direct paths, the moderation term (B-CE × SBMI), and the interaction term, is presented in Figure 1. This diagram serves as the structural reference for the measurement and path-level results reported in the following subsections.

Table 1. Respondent Profile

Characteristic	Category	*n*	%
Gender	Male	158	56.4
	Female	122	43.6
Age	20–30 years	52	18.6
	31–40 years	94	33.6
	41–50 years	88	31.4
	> 50 years	46	16.4
Education	Senior high school	58	20.7
	Diploma	47	16.8
	Bachelor's	139	49.6
	Postgraduate	36	12.9
Role	Business owner	168	60.0
	Functional manager	112	40.0

Indicator reliability, internal consistency, and convergent validity were assessed following established PLS- SEM guidelines: outer loadings ≥ 0.70, Composite Reliability (CR) within the range of 0.70–0.95, and Average Variance Extracted (AVE) ≥ 0.50 (Fornell & Larcker, 1981). Full results are reported in Table 4.

All outer loadings fell within the range of 0.809 to 0.903, exceeding the 0.70 threshold. Cronbach's alpha values ranged from 0.916 to 0.968 and CR values from 0.940 to 0.971, both within the recommended 0.70–0.95 range. AVE ranged from 0.688 to 0.798 across all five constructs, satisfying the convergent validity criterion (Fornell & Larcker, 1981).

Discriminant Validity

Discriminant validity was assessed using two complementary approaches: the Heterotrait–Monotrait ratio (HTMT) and the Fornell–Larcker criterion. HTMT was treated as the primary criterion, given evidence that it is more sensitive than the traditional AVE-diagonal approach in detecting discriminant validity failures (Henseler et al., 2015), The HTMT ratios are presented in Table 5.

The highest HTMT values were observed for the SBMI–MP pair (0.849) and the SPIP–MP pair (0.840). Both approach but remain below the 0.85 threshold, so discriminant validity is not violated. These elevated values reflect the conceptual proximity of business model renewal and product innovation performance to market outcomes, a theoretically expected pattern given that SBMI and SPIP are hypothesized as direct antecedents of MP, rather than a measurement flaw. The proximity warrants interpretive care but does not undermine the distinctiveness of the constructs. HTMT values for the interaction term (BCE × SBMI) against all other constructs were markedly low (0.029–0.347), indicating that the interaction term does not overlap with its component predictors at the construct level.

As a supplementary check, the Fornell–Larcker criterion was also evaluated (Table 6). The square root of each construct's AVE (diagonal values, bold) exceeded its correlations with all other constructs, providing additional support for discriminant validity across all pairs.

The diagonal values range from 0.829 (SOI) to 0.894 (MP) and exceed all corresponding off-diagonal entries without exception. The BCE–SPIP correlation (−0.690) and the SBMI–MP correlation (0.780) is among the highest off-diagonal values, though both remain below the respective diagonal entries, so the Fornell–Larcker criterion is not violated.

Scale Equivalence for SPIP

The original SPIP instrument developed by (Calik, 2024) uses a 5-point response scale. In this study, all constructs were standardized to a 7-point scale for consistency. Table 7 compares key psychometric indicators between the original 5-point version and the adapted 7-point version used here; full details are provided in Appendix Table A2.

Differences across all indicators are less than 0.03, and no psychometric threshold is violated in either version.

The adaptation from 5-point to 7-point response anchors does not appear to have materially altered the measurement structure of the SPIP construct.

Collinearity and Common Method Bias

Table 8 reports two sets of VIF values: predictor VIF values at the indicator level, used to check for structural collinearity, and full collinearity VIF values at the construct level, used to assess the risk of common method bias (CMB) following the procedure described by (Kock, 2015). These are conceptually distinct concerns: structural collinearity addresses whether predictors are sufficiently independent for stable coefficient estimation, while CMB concerns whether shared response tendencies inflate all inter-construct correlations artificially.

All predictor VIF values fall below 3.3, indicating that structural collinearity is not strongly indicated in this model. Full collinearity VIF values at the construct level also remain below 3.3 for all constructs, suggesting that CMB is not strongly indicated as a dominant threat to the validity of the findings (Kock, 2015). These assessments are procedural rather than definitive; residual same-source bias cannot be ruled out entirely in cross-sectional, single- informant survey data.

Hypothesis Testing

Path coefficients and significance levels were estimated via bootstrapping with 5,000 subsamples in SmartPLS.
Table 9 presents result for all direct effects, mediation paths, serial mediation paths, and moderation effects, together with VAF values used to characterize the type of mediation on each path.

All six direct-effect hypotheses were supported at $p < 0.001$. SOI was positively associated with SBMI ($\beta = 0.566$, H1), and BCE was negatively associated with both SBMI (β =.−0.519, H2) and SPIP ($\beta = -0.449$, H3). SBMI showed positive associations with SPIP ($\beta = 0.429$, H4) and with

Table 2. Firm Profile

Characteristic	Category	*n*	%
Sector	Manufacturing	102	36.4
	Services	98	35.0
	Trading	80	28.6
Firm size	Micro (5–9 employees)	96	34.3
	Small (10–49 employees)	112	40.0
	Medium (50–249 employees)	72	25.7
Years in operation	1–3 years	48	17.1
	4–7 years	89	31.8
	8–12 years	86	30.7
	> 12 years	57	20.4
Annual revenue	< IDR 300 million	74	26.4
	IDR 300M – 2.5 billion	118	42.2
	> IDR 2.5 billion	88	31.4
Innovation activity	New product	124	44.3
	Product variant/modification	98	35.0
	Both	58	20.7

Note: Firm-size classification follows Indonesian Law No. 20/2008 on MSMEs. Sector and size distributions reflect the stratified purposive sampling applied during recruitment.

MP (β = 0.469, H7), and SPIP was positively associated with MP (β = 0.454, H6).

Regarding mediation, the indirect path from SOI through SBMI to MP (H5) was significant (β = 0.265, $p < 0.001$), with a VAF of 100% within this model specification, indicating that the SOI–MP relationship is fully channeled through business model renewal in the absence of a direct SOI–MP path. The only partial mediation in the model was observed on the SBMI → SPIP → MP path (VAF = 29.3%), suggesting that SBMI is associated with market performance through both product-level innovation and through channels that do not pass through SPIP. The serial mediation paths, BCE → SBMI → SPIP → MP and SOI → SBMI → SPIP → MP, were both significant with VAF values of 100%, consistent with the absence of direct exogenous-to-outcome paths in the model.

The moderation term (BCE × SBMI) was negatively associated with SPIP (β = −0.288, $p < 0.001$, H8), indicating that higher levels of circular economy barriers are associated with a weaker relationship between business model renewal and product innovation performance. This moderation effect also propagated indirectly to MP through SPIP (β = −0.131, $p < 0.001$).

Simple Slopes Analysis

To interpret the moderation of BCE on the SBMI → SPIP path (β = −0.288, $p < 0.001$), conditional slopes were computed at three levels of BCE after mean-centering: one standard deviation below the mean (low), at the mean, and one standard deviation above the mean (high). Results are presented in Table 10.

The conditional slope declines substantially across barrier levels. At low BCE, the SBMI–SPIP association is 0.717; at high BCE, it reduces to 0.141, representing a difference of 0.576 coefficient units. This pattern suggests that the translational efficiency of business model renewal in producing product innovation outcomes varies considerably depending on the constraint environment firms face, though the cross-sectional design does not permit causal conclusions about the direction of this relationship.

Variance Explained and Effect Sizes

The explanatory power of the model was assessed using R^2 for endogenous constructs and Cohen's f^2 for the local contribution of each predictor path. Both metrics are reported together in Table 11.

The model accounts for 71.9% of the variance in SPIP and 71.7% in MP, both exceeding the substantial threshold of 0.67. SBMI's R^2 of 0.646 falls somewhat below that threshold, suggesting that predictors outside the present model also contribute meaningfully to business model renewal. At the path level, all f^2 values exceed 0.35, classifying each as a large effect. The largest local effect is observed on the SOI to SBMI path (f^2 = 0.897), and the moderation term BCE × SBMI also registers a large effect (f^2 = 0.418). The uniformly large effect sizes and high R^2 values are theoretically consistent with the conceptual proximity of the constructs in the model and the fact that the sample was restricted to innovation-active SMEs. Future studies should replicate the model in broader or more heterogeneous samples to assess whether these magnitudes generalize.

Model Fit

Although PLS-SEM does not optimize global model fit in the same way as covariance-based SEM, model fit indices were evaluated as supplementary indicators of the consistency between the model and the observed data

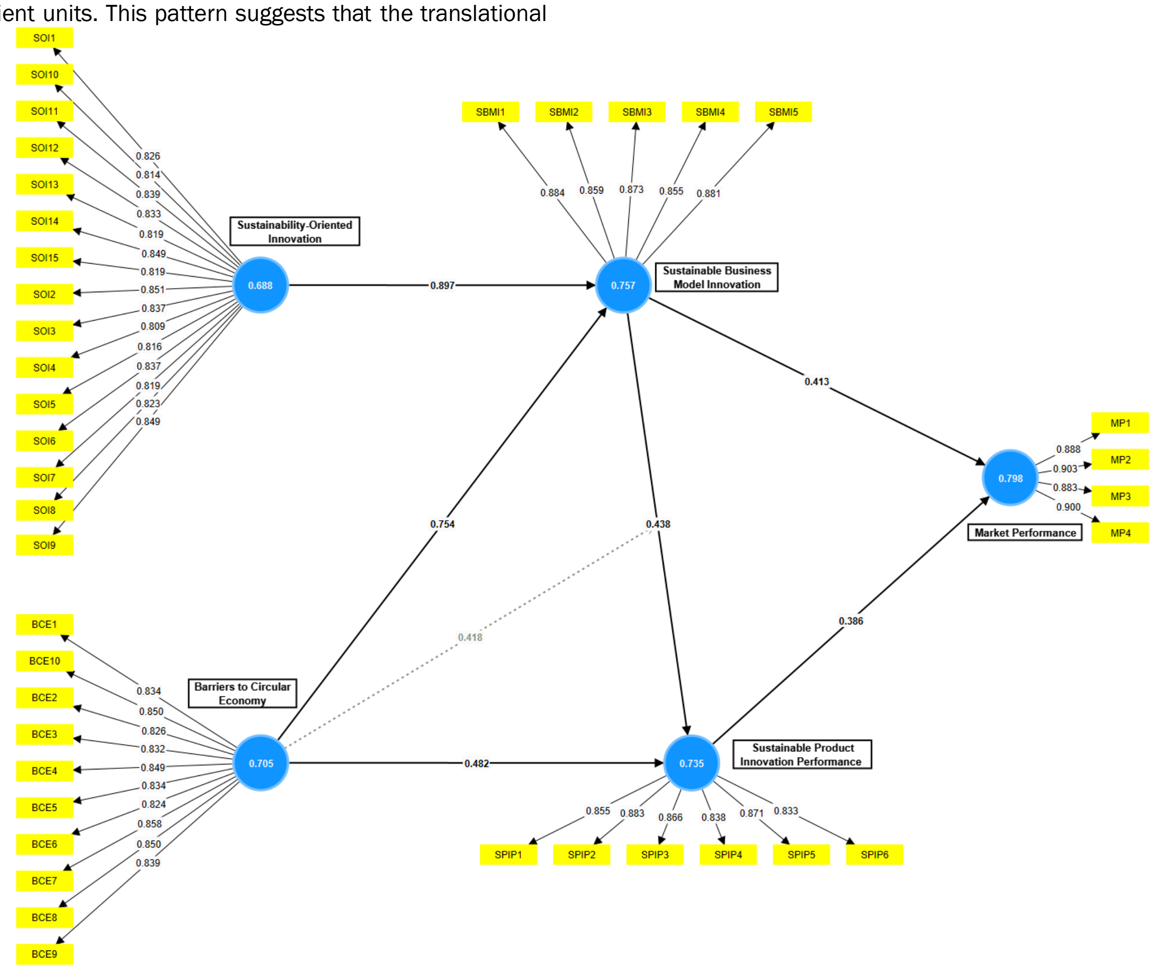

Figure 1. PLS-SEM Path Diagram

(Henseler et al., 2015). Results are reported in Table 12.

The SRMR value of 0.039 falls well below the conservative threshold of 0.08, suggesting adequate fit between the model and the observed covariance structure. NFI reached 0.913, exceeding the 0.90 acceptability threshold. The d_ULS and d_G values were within the permissible confidence interval bounds. These indices are reported as supplementary diagnostics and should not be interpreted as confirming model correctness in an absolute sense.

Predictive Relevance

Predictive relevance was evaluated using two complementary procedures: Q^2 blindfolding (in-sample) and PLSpredict (out-of-sample). Results for all endogenous constructs are summarized in Table 13.

$Q > 0.35$ = large predictive relevance (Hair et al., 2019). PLS superiority assessed by comparing RMSE and MAE against a naïve linear model (LM) baseline; PLS models with lower RMSE and MAE for the majority of indicators are considered to have adequate out-of-sample predictive relevance (Shmueli et al., 2019).

In-sample Q^2 values ranged from 0.482 to 0.565, all comfortably exceeding the large-relevance threshold of 0.35. In the out-of-sample PLSpredict assessment, the PLS model produced lower RMSE and MAE than the naïve linear model baseline for all three endogenous constructs. The consistency between in-sample and out-of- sample indicators suggests that the model's explanatory capacity is not an artifact of overfitting to the current sample, though generalizability to other populations remains a matter for future replication.

Measurement Invariance (MICOM)

Prior to comparing path coefficients across groups in the MGA, measurement invariance was verified using the three-step MICOM procedure (Henseler et al., 2016). Table 14 reports the composite equality *p* -values for all sector-by-size group pairs.

Most *p*-values exceed 0.05, indicating no statistically significant difference in composite scores across group pairs

Table 3. Preliminary Reliability from Pilot Test (n = 32)

Construct	α	Assessment
SOI	0.941	Acceptable
SBMI	0.893	Acceptable
B-CE	0.924	Acceptable
SPIP	0.912	Acceptable
MP	0.881	Acceptable

Table 4. Measurement Model Results

Construct	Item	Loading	CA	CR	AVE
Barriers to Circular Economy	BCE1	0.834	0.953	0.960	0.705
	BCE2	0.826			
	BCE3	0.832			
	BCE4	0.849			
	BCE5	0.834			
	BCE6	0.824			
	BCE7	0.858			
	BCE8	0.850			
	BCE9	0.839			
	BCE10	0.850			
Market Performance	MP1	0.888	0.916	0.941	0.798
	MP2	0.903			
	MP3	0.883			
	MP4	0.900			
Sustainability- Oriented Innovation	SOI1	0.826	0.968	0.971	0.688
	SOI2	0.851			
	SOI3	0.837			
	SOI4	0.809			
	SOI5	0.816			
	SOI6	0.837			
	SOI7	0.819			
	SOI8	0.823			
	SOI9	0.849			
	SOI10	0.814			
	SOI11	0.839			
	SOI12	0.833			
	SOI13	0.819			
	SOI14	0.849			
	SOI15	0.819			
Sustainable Business Model Innovation	SBMI1	0.884	0.920	0.940	0.757
	SBMI2	0.859			
	SBMI3	0.873			
	SBMI4	0.855			
	SBMI5	0.881			
Sustainable Product Innovation Performance	SPIP1	0.855	0.928	0.943	0.735
	SPIP2	0.883			
	SPIP3	0.866			
	SPIP4	0.838			
	SPIP5	0.871			
	SPIP6	0.833			

and supporting at least partial measurement invariance. One exception worth noting is the Service vs Micro comparison on the SOI construct (*p* = 0.039), which falls marginally below the 0.05 threshold. This does not invalidate the MGA but warrants interpretive caution when comparing that particular pair. Proceeding with the MGA under these conditions is reasonable, provided cross-group comparisons are treated as exploratory for the pairs with lower invariance evidence.

Multigroup Analysis (MGA)

Following MICOM verification, MGA was conducted to examine whether path coefficients differ significantly across sector subgroups (Manufacturing, Services, Trading) and firm-size categories (Micro, Small, Medium).

Bootstrapped coefficient differences and two-tailed *p*-values are reported in Table 15.

Of the 63 pairwise path-coefficient comparisons, two reached statistical significance at $p < 0.05$. The SPIP to MP path differed between Manufacturing and Small firms ($p = 0.046$), and the SOI to SBMI path differed between Services and Micro firms ($p = 0.039$). In all other comparisons, path coefficients did not differ significantly across groups, suggesting that the structural relationships in this model are broadly consistent across sectors and firm- size categories within the present sample. These two significant differences are discussed in the Discussion section.

This study began with a proposition that, while theoretically plausible, had not been subjected to direct empirical testing in an integrated multi-construct model at the SME level: that sustainability-oriented innovation does not translate into market outcomes through some direct, unmediated pathway, but must first restructure how firms organize value creation and delivery before any improvement becomes visible in product quality or commercial performance. Data from 280 Indonesian SMEs across three sectors provide broad support for this proposition and, in doing so, identify where the conversion chain is most susceptible to breakdown.

The path from SOI to SBMI ($\beta = 0.566$, $f^2 = 0.897$) is the strongest structural link in the model, and the absence of a direct SOI-to-SPIP association is consistent with theoretical expectations within the dynamic capabilities' framework. SOI operates as a sensing and reconfiguring capability: it helps firms recognize value opportunities that extend beyond operational efficiency and realign their business logic accordingly (Teece, 2007; Teece et al., 1997). The present results extend an established line of inquiry documenting how dynamic capabilities function as mechanisms for strategic adaptation in SMEs, including evidence that resilience itself can emerge as a second-order dynamic capability when firms navigate environmental disruption (Khurana et al., 2022). The data suggest that this realignment is a necessary intermediate step before orientation produces any discernible change at the product level.

This finding advances the dynamic capabilities literature specifically: it provides the first quantitative evidence that SBMI is the organizational mechanism through which SOI reaches product-level outcomes, a relationship the literature had proposed conceptually (Bocken et al., 2014; Geissdoerfer et al., 2018) but not tested against a competing direct-effect specification.

Prior studies have examined pairwise links, such as SOI and competitive performance (Hermundsdottir & Aspelund, 2021) or SBMI and firm-level outcomes (Bashir et al., 2022), without testing whether business model renewal is a *necessary* intermediate structure. Studies that have linked green innovation or eco-innovation to performance (Hizarci-Payne et al., 2021; Zheng & Iatridis, 2022) likewise operate at an aggregate level that does not isolate the product-level conversion mechanism. The absence of a statistically discernible direct SOI-to-SPIP path in the present model, combined with the strong indirect path through SBMI, offers the clearest evidence to date that orientation alone is insufficient.

This pattern is broadly consistent with (Baxter & Chipulu, 2023), who mapped the dimensionality of SOI at the project level, and speaks to the concern raised by (Klewitz & Hansen, 2014) that many SMEs remain confined to incremental innovation in the absence of a sufficiently systemic orientation. The results indicate that SMEs with more developed SOI tend also to exhibit higher levels of business model renewal, though the cross-sectional design of this study does not permit causal inference about the sequence of organizational change.

The effects of SBMI on SPIP ($\beta = 0.429$) and on MP ($\beta = 0.469$) are both statistically significant with large effect sizes, but they are structurally different. The mediation of SBMI through SPIP toward MP is partial (VAF = 29.3%), suggesting that SBMI is associated with market performance through more than one channel: one involving product-level changes, where design decisions precede market response, and another operating more directly through revised value propositions, partnership configurations, and distribution arrangements. This is broadly consistent with (Schaltegger et al., 2016), who acknowledged the multiple pathways through which business model change affects performance, though a fuller decomposition of these mechanisms would require longitudinal data.

The serial mediation from SOI through SBMI and SPIP to MP (VAF = 100% within the current model specification) is consistent with the view that there is no direct unmediated path from innovation orientation to market outcomes, at least within the present sample. The argument that sustainability cannot be effectively marketed without first being embedded in product design and the underlying business model (Bocken et al., 2014) is consistent with this pattern, though the VAF metric captures variance explained within a specific model structure and should not be read as a universal causal law.

Table 5. Discriminant Validity: HTMT Ratios

Construct	BCE	MP	SOI	SBMI	SPIP	BCE × SBMI
BCE	—					
MP	0.671	—				
SOI	0.102	0.478	—			
SBMI	0.611	0.849	0.650	—		
SPIP	0.733	0.840	0.340	0.741	—	
BCE × SBMI	0.029	0.123	0.036	0.037	0.347	—

BCE = Barriers to Circular Economy; MP = Market Performance; SOI = Sustainability-Oriented Innovation; SBMI = Sustainable Business Model Innovation; SPIP = Sustainable Product Innovation Performance. All HTMT values < 0.85; no 95% confidence interval crossed 1.00

Circular economy barriers have been positioned in prior work primarily as threshold conditions for adoption (Kirchherr et al., 2018; Takacs et al., 2022). The present data suggest that BCE may operate in both capacities: as a direct suppressor of SBMI (β = −0.519) and as a moderator that attenuates the conversion of SBMI into SPIP (β = −0.288). This dual role extends the conceptual positioning of barriers beyond adoption probability and is the study's second principal theoretical contribution. It implies that barriers are not resolved at the point of adoption; they continue to erode translational efficiency throughout the implementation process.

The simple slopes analysis illustrates the practical scale of this moderation effect. Under low-barrier conditions, a unit increase in SBMI is associated with a 0.717-unit increase in SPIP; under high-barrier conditions, the same unit increase yields only a 0.141-unit increase in SPIP, representing a difference of 0.576 coefficient units.

This variation in translational efficiency has not been modeled in prior quantitative work. (Mishra et al., 2022) developed and validated the BCE instrument specifically for SME contexts, and (Kirchherr et al., 2018) comprehensively documented the barrier landscape across European firms, but neither framework modeled barriers as moderators of the business model-to-product-outcome conversion. (Guldmann & Huulgaard, 2020), whose multi- case work documented the gap between business model intent and product-level realization, identified barriers as plausible explanatory factors but did not test their moderating role quantitatively. (Holzer et al., 2021; Takacs et al., 2022) likewise treated barriers as antecedents of adoption rather than as variables that condition how effectively adopted models translate into product outcomes. The present moderation result therefore fills a specific gap in the quantitative circular economy literature, one that case-based and qualitative work had identified but not quantitatively estimated. The finding should be interpreted cautiously given the cross-sectional design, but the magnitude of the slope difference suggests that high-barrier environments can substantially eliminate the returns to business model investment.

Beyond the moderation pathway, the direct association between BCE and SPIP (β = −0.449) suggests that barriers also constrain product innovation through mechanisms that do not pass through business model change.

Limited access to circular materials can impair design for recyclability; regulatory uncertainty can weaken the business case for R&D investment in repairability; weak demand signals can reduce the incentive to develop environmentally differentiated products. This dynamic has been described as circular capability drain (Dey et al., 2022), in which barriers erode not only adoption rates but also the organizational capabilities that have already been built. The present patterns are broadly consistent with that characterization, though the cross-sectional design limits directional conclusions.

Managing circular economy barriers may therefore need to be treated as an ongoing operational concern rather than a one-time enablement task. If the translational efficiency of SBMI varies with barrier intensity, allowing those barriers to accumulate after an initial reduction could, in principle, erode the returns to business model investment over time. Longitudinal research could productively address this question.

The MGA results indicate that the structural model is largely invariant across sectors and size categories, with only two of eighteen pairwise comparisons reaching statistical significance. This cross-sector consistency is theoretically significant: it suggests that the mechanisms linking SOI, SBMI, BCE, SPIP, and MP are not confined to manufacturing contexts or specific firm-size classes, which has been a recurrent limitation in a literature that has tended to focus on single industries (Kirchherr et al., 2018; Takacs et al., 2022).

The two significant exceptions carry theoretical and practical implications that extend beyond routine anomalies. The stronger SPIP to MP relationship in Manufacturing versus Small firms reflects a pattern that warrants substantive explanation. Small manufacturing firms that succeed in improving their product's sustainability attributes appear to realize greater market rewards than micro-scale service firms, plausibly because their products carry more tangible, independently verifiable circular features, repairability scores, material certifications, disassembly specifications, that customers can evaluate and reward. In contrast, micro-scale service firms, where owner-operators commonly manage design, delivery, and sales simultaneously, may face a credibility gap in communicating sustainability attributes, or their customers may weigh these attributes less heavily than price and

Table 6. Discriminant Validity: Fornell–Larcker Criterion

Construct	BCE	MP	SOI	SBMI	SPIP
BCE	**0.840**				
MP	−0.628	**0.894**			
SOI	−0.096	0.451	**0.829**		
SBMI	−0.573	0.780	0.616	**0.870**	
SPIP	−0.690	0.775	0.324	0.685	**0.858**

Diagonal values (bold) = square root of AVE.

Table 7. SPIP Psychometric Comparison: Original (5-point) vs. Adapted (7-point) Scale

Indicator	Original 5-pt (Calik, 2024)	Adapted 7-pt (this study)	Equivalent?
Cronbach's α	0.921	0.928	Yes
Composite Reliability	0.939	0.943	Yes
AVE	0.729	0.735	Yes
Outer loading range	0.823–0.879	0.833–0.883	Yes
Max. HTMT (vs other constructs)	0.738	0.741	Yes

Table 8. Collinearity and Full Collinearity VIF

Construct	Predictor VIF range (indicators)	Full Collinearity VIF (construct)
BCE	2.678–3.197	2.847
MP	2.718–3.131	2.634
SOI	2.722–3.253	2.318
SBMI	2.466–2.964	3.102
SPIP	2.359–3.222	2.976
BCE × SBMI	–	1.143

Threshold for both assessments: VIF < 3.3 (Hair et al., 2019; Kock, 2015) reliability. The SOI to SBMI difference between Services and Micro firms points to a related constraint: even a well-developed sustainability orientation may face limits on systematic business model renewal in micro-scale contexts where organizational bandwidth is severely constrained. These findings suggest that the conversion chain is not uniformly accessible across all SME types, and that targeted external support, rather than generic innovation incentives, may be required to close this gap for the most constrained segments.

The overall pattern that emerges is more conditional than the general claim that sustainability-oriented firms perform better. Within this sample and model, the relationship between innovation orientation and market performance appears to be sequentially mediated: orientation shapes value architecture, value architecture shapes product innovation outcomes, and product innovation outcomes shape commercial performance. The strength of each link is sensitive to the constraint environment, particularly the intensity of circular economy barriers. When barriers are high, the returns to both SBMI investment and the broader conversion chain are substantially reduced.

Theoretical Implications

The findings carry several implications for theory at the intersection of dynamic capabilities, sustainable business model innovation, and circular economy research. The most direct contribution concerns the mediating architecture between innovation orientation and product performance. The present results specify SBMI as a consequential mechanism: in the absence of SBMI, the association between SOI and SPIP is not statistically discernible. This is consistent with arguments that dynamic capabilities are productive only when they find appropriate organizational expression (Teece, 2007), and implies that theoretical models linking innovation capability to performance outcomes should be more explicit about the intermediate structures through which that link operates.

The empirical contribution here lies in providing a first-time quantitative test of this mediation with product-level outcome measurement, rather than aggregate financial performance.

A second implication concerns the conceptual positioning of BCE. Modeling barriers simultaneously as antecedents and moderators rather than threshold conditions, expands the theoretical vocabulary available for circular economy research. Future frameworks may need to accommodate this dual role, particularly when modeling how institutional and infrastructural conditions interact with firm-level innovation processes at different stages of the conversion chain.

A third contribution relates to the construct of SPIP as a mediating variable. (Calik, 2024) validated SPIP as a product-level sustainability outcome measure, but its placement within a multi-construct chain had not been tested.

The present study provides evidence that SPIP functions as a meaningful intermediate outcome between business model change and market performance, rather than a simple downstream indicator. This suggests that product- level measurement deserves more attention in sustainability research, where the focus has often remained at the level of organizational capabilities or aggregate financial performance.

Finally, the cross-sector and cross-size consistency observed in the MGA results has modest implications for theory generalization. Within this sample, the structural relationships do not appear to be artifacts of a particular.

Table 9. Hypothesis Testing Results

Pathway		β	M	SD	t	p	VAF (%)	Decision
Direct effects								
BCE	→ SBMI	−0.519	−0.518	0.032	16.049	< 0.001	—	H2 supported
BCE	→ SPIP	−0.449	−0.452	0.045	10.024	< 0.001	—	H3 supported
SOI	→ SBMI	0.566	0.567	0.032	17.476	< 0.001	—	H1 supported
SBMI	→ MP	0.469	0.469	0.041	11.542	< 0.001	—	H7 supported
SBMI	→ SPIP	0.429	0.426	0.043	9.933	< 0.001	—	H4 supported
SPIP → MP		0.454	0.454	0.041	11.036	< 0.001	—	H6 supported
Mediation								
BCE	→ SPIP → MP	−0.204	−0.205	0.029	7.066	< 0.001	100%	Full*
BCE SBMI	→ → MP	−0.243	−0.243	0.026	9.430	< 0.001	100%	Full*
SOI SBMI	→ → MP	0.265	0.266	0.028	9.429	< 0.001	100%	Full*
SBMI	→ SPIP → MP	0.194	0.193	0.026	7.467	< 0.001	29.3%	Partial
Serial mediation								
BCE SBMI	→ → SPIP → MP	−0.101	−0.100	0.015	6.670	< 0.001	100%	Full*
SOI SBMI	→ → SPIP → MP	0.110	0.110	0.016	6.786	< 0.001	100%	Full*
Moderation								
BCE SBMI	× → SPIP	−0.288	−0.286	0.030	9.650	< 0.001	—	H8 supported
BCE SBMI	× → SPIP → MP	−0.131	−0.130	0.019	6.938	< 0.001	—	—

Full mediation is indicated when no direct path from the exogenous variable to the outcome was specified in the model (BCE → MP; SOI → MP), meaning all variance passes through the mediators. VAF = indirect effect / (direct effect + indirect effect) × 100%. VAF interpretation: < 20% = no mediation; 20–80% = partial; > 80% = full (Hair et al., 2019).

industry or firm-size context. Replication in other national and institutional settings would be needed before stronger generalizability claims can be made.

Managerial Implications

The findings have practical relevance for SME managers, intermediary organizations, and policymakers, though the cross-sectional design warrants caution in translating statistical associations into prescriptive advice. For SME managers, the most actionable insight concerns the relationship between orientation and action. A strong sustainability orientation is a necessary but insufficient condition for improved product innovation outcomes. Firms that invest in building SOI without also making substantive changes to their value propositions, partner relationships, and operational configurations appear unlikely to see that orientation reflected in product performance or market results. Managerial attention and investment need to move sequentially from orientation-building to business model reconfiguration, rather than treating the two as simultaneous or interchangeable activities.

The simple slopes result also have direct relevance for investment prioritization. For firms operating in high- barrier environments, business model renewal programs may yield limited returns unless accompanied by parallel efforts to address the specific barriers that constrain translational efficiency. The most binding constraints will vary by firm and context: access to financing and technical capabilities are commonly reported barriers for smaller firms, while supply chain coordination and regulatory uncertainty tend to become more prominent as firms attempt to scale circular practices. Identifying and addressing the binding constraint in a specific operating context is likely more productive than pursuing comprehensive barrier reduction across all dimensions simultaneously.

For intermediary organizations offering advisory services to SMEs, support programs that focus exclusively on raising sustainability awareness or building innovation orientation are likely to prove insufficient if they do not also help firms work through the business model changes required to convert that orientation into product- level outcomes. Support that bridges orientation and structural change, for example through business model design workshops, partnership facilitation, and access to circular economy networks, may produce more durable results than awareness-building alone. Emerging evidence also suggests that digital transformation and servitization may amplify this conversion: digital capabilities have been shown to strengthen the relationship between innovation orientation and environmental performance in manufacturing SMEs (Chen & Wang, 2024), and digital servitization offers scalable channels through which firms can communicate and realize sustainability value propositions (Tabacco et al., 2024).

For policymakers, the data point to the importance of infrastructure and regulatory clarity as enabling conditions for firm-level investment in sustainability. If the translational efficiency of business model renewal is sensitive to barrier intensity, then policy interventions that reduce friction in the operating environment, including improved access to green financing instruments, development of reverse logistics infrastructure, and greater regulatory consistency on circular product standards, may be at least as consequential as direct innovation incentives. Subsidy programs that encourage firms to invest in circular business models without addressing the structural constraints that limit their effectiveness risk producing adoption without performance improvement.

Limitations and Future Research

Several limitations should be noted, as they define the boundaries within which the findings can be reasonably interpreted. The most consequential is the cross-sectional design. All data were collected at a single point in time, which means the directional and associational claims embedded in the hypotheses rest on theoretical reasoning and prior literature rather than observed temporal precedence. The association between SOI and SBMI, for example, is consistent with the argument that orientation drives structural change, but it is equally consistent with the reverse, whereby firms that have already reconfigured their business models come to characterize their innovation orientation as more sustainability-focused in retrospect. Longitudinal panel studies tracking the same SMEs through successive waves of data collection would allow a more rigorous test of the sequencing assumptions underlying this model.

The use of a single key informant per firm is a second limitation. Respondents were selected on the basis of their knowledge of firm-level innovation decisions, but individual perceptions may not fully capture the organizational reality of constructs like SBMI and SPIP, which

Table 10. Simple Slopes: SBMI → SPIP Conditional on BCE Level

BCE Level	BCE Value	β SBMI → SPIP
Low (M − 1SD)	−1 SD	0.717
Mean (M)	0	0.429
High (M + 1SD)	+1 SD	0.141

β at low = 0.429 + (−0.288 × −1) = 0.717; β at high = 0.429 + (−0.288 × +1) = 0.141.

Table 11. Variance Explained (R^2) and Path-Level Effect Sizes (f^2)

Construct / Path	R^2	Assessment	f^2	Assessment
Endogenous constructs				
Market Performance	0.717	Substantial	—	—
Sustainable Business Model Innovation	0.646	Approaching substantial	—	—
Sustainable Product Innovation Performance	0.719	Substantial	—	—
Structural paths				
BCE → SBMI	—	—	0.754	Large
BCE → SPIP	—	—	0.482	Large
SOI → SBMI	—	—	0.897	Large
SBMI → MP	—	—	0.413	Large
SBMI → SPIP	—	—	0.438	Large
SPIP → MP	—	—	0.386	Large
BCE × SBMI → SPIP	—	—	0.418	Large

R^2 thresholds: moderate = 0.33; substantial = 0.67 (Hair et al., 2019). f^2 thresholds: small = 0.02; medium = 0.15; large = 0.35 (Cohen, 1988).

are inherently collective phenomena. Multi- informant designs, in which at least two respondents per firm provide independent assessments subsequently compared for within-firm agreement, would improve construct validity.

The geographic scope introduces a third limitation. Indonesia has a particular institutional profile, including a relatively early stage of circular economy policy development, fragmented reverse logistics infrastructure in most regions, and a predominantly micro and small enterprise base with limited access to specialized technical expertise, that likely shapes the specific intensity and composition of circular economy barriers in ways that may not generalize to contexts with more mature sustainability governance. Comparative studies involving SMEs in different institutional environments would help identify which aspects of the present findings are context- dependent.

A fourth limitation concerns the treatment of BCE as a unidimensional composite. The instrument encompasses seven conceptually distinct barrier dimensions (Mishra et al., 2022), which are aggregated here into a single score for modeling purposes. Financial barriers may moderate the SBMI-to-SPIP relationship differently from regulatory or supply chain barriers. Future studies using multilevel or multi-component specifications of BCE would produce more targeted guidance. Finally, market performance was measured through respondent-reported perceptions relative to competitors rather than objective financial data. Perceptual measures are standard in SME research contexts where audited financial records are rarely accessible, but they introduce the possibility of self-serving bias. Studies that supplement survey-based measures with administrative or financial panel data would provide a more complete picture.

Table 12. Model Fit Indices

Index	Value
SRMR	0.039
d_ULS	1.232
d_G	0.611
Chi-square	913.717
NFI	0.913

Table 13. Predictive Relevance: Q^2 and PLSpredict

Endogenous Construct	SSO	SSE	Q^2	RMSE (PLS)	RMSE (LM)	MAE (PLS)	MAE (LM)	PLS < LM
MP	1120	487.262	0.565	0.821	1.124	0.643	0.891	Yes
SBMI	1400	724.679	0.482	0.876	1.187	0.712	0.943	Yes
SPIP	1680	830.178	0.506	0.843	1.156	0.671	0.917	Yes

Table 14. Measurement Invariance Assessment (MICOM)

MGA	BCE	MP	SOI	SBMI	SPIP
Manufacturing vs Micro	0.952	0.899	0.921	0.329	0.519
Manufacturing vs Small	0.991	0.603	0.668	0.385	0.312
Manufacturing vs Medium	0.974	0.552	0.820	0.487	0.800
Service vs Micro	0.797	0.946	0.773	0.220	1.000
Service vs Small	0.993	0.991	0.976	0.772	0.879
Service vs Medium	0.853	0.905	1.000	0.778	0.613
Trade vs Micro	0.858	0.738	0.974	0.741	0.517
Trade vs Small	0.914	0.654	0.993	0.309	0.584
Trade vs Medium	0.652	0.968	0.983	0.117	0.368

Table 15. Multigroup Analysis Results

Bootstrap MGA	BCE→SBMI	BCE→SPIP	SOI→SBMI	SBMI→MP	SBMI→SPIP	SPIP→MP	BCE×SBMI →SPIP
Difference							
Manufacturing − Medium	0.004	0.035	0.134	0.132	0.046	−0.150	−0.030
Manufacturing − Micro	0.002	0.029	0.019	0.090	0.093	−0.112	0.027
Manufacturing − Small	−0.070	−0.024	0.082	0.138	0.041	−0.217	0.072
Services − Medium	0.021	0.050	−0.062	−0.005	−0.057	0.075	−0.117
Services − Micro	0.018	0.043	−0.178	−0.047	−0.010	0.113	−0.060
Services − Small	−0.054	−0.009	−0.115	0.002	−0.062	0.008	−0.015
Trade − Medium	0.068	0.025	0.097	−0.070	0.024	0.061	0.003
Trade − Micro	0.065	0.019	−0.018	−0.112	0.071	0.099	0.061
Trade − Small	−0.007	−0.034	0.044	−0.063	0.019	−0.006	0.105
2-tailed (p value)							
Manufacturing vs Medium	0.960	0.748	0.090	0.212	0.668	0.180	0.666
Manufacturing vs Micro	0.985	0.753	0.814	0.401	0.310	0.339	0.672
Manufacturing vs Small	0.403	0.795	0.296	0.189	0.660	0.046	0.277
Services vs Medium	0.790	0.679	0.463	0.969	0.630	0.417	0.103
Services vs Micro	0.821	0.673	0.039	0.628	0.923	0.249	0.397
Services vs Small	0.517	0.934	0.173	0.979	0.562	0.931	0.826
Trade vs Medium	0.355	0.853	0.172	0.469	0.857	0.516	0.974
Trade vs Micro	0.393	0.885	0.794	0.252	0.547	0.324	0.466
Trade vs Small	0.934	0.763	0.531	0.513	0.876	0.953	0.199

Conclusion

This study examined how sustainability-oriented innovation is associated with market performance in SMEs, with sustainable business model innovation and sustainable product innovation performance as mediating structures, barriers to the circular economy as a dual conditioning construct, and market performance as the downstream commercial outcome. The structural model, estimated using PLS-SEM on data from 280 Indonesian SMEs, provides empirical support for all eight hypotheses, with consistently large effect sizes.

Three findings are most consequential. First, the study provides the first quantitative evidence that SBMI is a necessary mediating mechanism between SOI and product-level outcomes in SMEs: the SOI-to-SPIP association is not statistically discernible in the absence of business model renewal, and the SOI-to-MP relationship is fully channeled through SBMI and SPIP. Firms that build sustainability orientation without also reconfiguring their value architecture are unlikely to see that orientation reflected in product innovation or commercial outcomes. Second, B- CE operates in a dual capacity: as a direct suppressor of SBMI and as a moderator that attenuates the SBMI-to- SPIP conversion, a finding that extends the conceptual role of barriers beyond the adoption threshold typically modeled in prior work. The conditional slope analysis shows that the returns to SBMI investment range from substantial (β = 0.717) in low-barrier conditions to negligible (β = 0.141) in high-barrier conditions, a gap with direct implications for how firms and policymakers should sequence investment in structural change and barrier reduction. Third, these relationships are broadly consistent across manufacturing, service, and trading SMEs and across micro, small, and medium firm-size categories, indicating that the findings are not sector- or scale-specific within this context, though the two significant MGA exceptions highlight meaningful boundary conditions for micro-scale service firms.

For researchers, the findings point to longitudinal designs capable of testing the temporal sequence of the proposed mechanisms, cross-national comparisons that vary the institutional context systematically, and disaggregated analyses of barrier dimensions that allow more precise identification of which constraints are most binding in specific firm and market contexts. For practitioners and policymakers, the core implication is that orientation and structural change are complements rather than substitutes, and that reducing frictional constraints on circular economy practice may be as consequential for SME performance outcomes as direct innovation investment, particularly in emerging economy contexts where infrastructure and regulatory gaps amplify the barrier effect.

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