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Circular Economy Implementation in Water Hyacinth Craft SMEs for Sustainable Business

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ABSTRACT

This study examines the application of a green business model based on circular economy principles to water hyacinth craft micro, small, and medium enterprises (MSMEs) in Central Java, Indonesia. Environmental concerns continue to rise and the traditional craft industry has the potential for sustainable transformation. However, empirical studies on the influence of green business models on the competitiveness of MSMEs in the context of developing countries are still limited. The researchers used Smart Partial Least Squares Structural Equation Model 4.0 **(Smart-PLS 4.0)** to analyse data from 148 water hyacinth craft MSMEs in Demak, Semarang, and Sukoharjo Regencies. The results show that green business models significantly enhance the sustainable competitiveness of MSMEs through three key mediators: green entrepreneurial orientation, environmentally friendly collaboration, and green innovation. Green innovation is the most crucial mediator linking sustainability orientation to competitive advantage. In contrast, government policy support does not significantly moderate this relationship, indicating a gap between policy instruments and the reality of MSMEs. These **findings** enrich the theory of sustainable business models by demonstrating the circular economy mechanisms of resource-constrained MSMEs. Practically, **this study provides** insights for MSME practitioners and policymakers in developing countries to integrate environmental sustainability and business viability.

1. INTRODUCTION

Industrial activities have caused severe environmental degradation that threatens ecosystem stability and future generations [1]. Large corporations have begun adopting sustainable practices, yet MSMEs, which represent over 90% of global businesses, remain behind in sustainability adoption, especially in developing countries where resource constraints limit green transformation. Indonesia illustrates this condition with 64.2 million MSMEs that contribute 60% of GDP and employ 97% of the workforce, but their environmental impacts remain largely unmanaged [2]. Most MSMEs still operate without integrating environmental considerations into their business models, creating both sustainability challenges and untapped opportunities for transformation.

This local condition reflects a larger global sustainability challenge highlighted in SDGs 12 (Responsible Consumption and Production) [3], which emphasizes reducing waste and promoting efficient resource use. The water hyacinth craft sector aligns naturally with SDGs 12 due to its reliance on renewable raw ma-

terials and low waste production processes [4]. Furthermore, by reducing the spread of invasive aquatic plants known contributors to greenhouse gas emissions, this MSME ecosystem also contributes to SDGs 13 (Climate Action) through mitigation of ecological pressures. These connections position the study not only within Indonesia's sustainability transition but also within broader international debates on circular production systems and climate-resilient economic development [5].

Water hyacinth craft MSMEs have strong potential to implement sustainable business practices because the raw material helps control plant overgrowth, uses renewable resources, produces minimal waste, and requires low energy due to traditional production techniques [6]. Despite these advantages, several barriers hinder their ability to transform into green businesses, including limited knowledge of sustainability and weak innovation capabilities [7], restricted access to financing for green technology, insufficient marketing and branding strategies, and lack of collaboration with supporting stakeholders [8]. In Central Java, where water hyacinth crafts are widely produced, favourable natural conditions and skilled artisans exist, yet many MSMEs still operate at a subsistence level and lack competitiveness in higher-value markets [9].

Current literature on sustainable business models still presents three major gaps. Unlike most circular economy studies that focus on large firms or technologically advanced sectors, this study provides novelty by demonstrating how circular economy mechanisms operate within resource-constrained traditional craft MSMEs [10, 11]. This contribution extends existing frameworks by showing that sustainability-driven competitiveness can emerge even in low-technology industries through entrepreneurial orientation and environmentally friendly collaboration.

Empirical evidence on the operationalisation of circular economy principles in resource-constrained MSMEs remains limited, especially in traditional craft industries [12, 13]. The mechanisms that explain how green business models generate competitive advantage for MSMEs, including the mediating roles of entrepreneurial orientation, collaboration, and innovation, have not been deeply examined [14, 15]. The effectiveness of government policy support for MSME green transformation also requires further investigation, particularly in developing-country institutional contexts [16, 17]. This study has three main research questions:

- How do green business models influence sustainable competitiveness among traditional craft MSMEs?
- What are the key mediating mechanisms which link green business orientation to competitive outcomes?
- To what extent does government policy support moderate these relationships?

This study provides three key contributions. Theoretically, the researchers extend the theory of sustainable business models to the context of MSMEs by identifying and testing key mediating mechanisms. Empirically, the researchers present the implementation of green business models in water hyacinth craft MSMEs and offer insights into the transformation of traditional industries [18]. Practically, the researchers offer actionable guidance for MSME practitioners and policymakers in developing countries seeking to balance environmental sustainability with economic viability.

2. LITERATURE REVIEW

2.1. Green Business Model

Green business models balance economic viability with environmental sustainability, where [19] describe them as mechanisms that address environmental and social challenges while creating stakeholder value. [20] highlight six components that integrate sustainability across business operations, moving beyond greenwashing toward genuine transformation. [21] explain that successful implementation requires individual, organisational, and institutional support, which is crucial for resource-constrained but agile MSMEs. Entrepreneurial characteristics such as environmental awareness, sustainability commitment, and risk tolerance influence adoption decisions, while institutional factors including regulations, incentives, and support systems shape the feasibility of transitioning to green business models.

The circular economy redefines the linear system into a regenerative model that keeps resources in productive use, with [22] identifying seven core elements such as sustainable inputs, circular design, clean production, product replenishment, dismantling, repair, and recycling. [23] emphasise that implementing circular economy principles requires cross-sector collaboration, especially for MSMEs that need supportive policies and partnerships to overcome resource limitations and adopt comprehensive circular practices.

2.2. Principles of Circular Economy

The circular economy is a paradigm that transforms the linear take-make-dispose economic model into a regenerative system. This system keeps the materials and the products in the productive use as long as possible. [22] conducted a meta-analysis of 221 circular economy definitions and identified seven core operational elements: sustainable input management, circular product design, clean production and manufacturing processes, product replenishment systems, systematic dismantling protocols, repair mechanisms, and recycling and remanufacturing capabilities.

Implementing circular economy principles requires a collaborative ecosystem approach that transcends organisational boundaries. [23] state that implementing a circular economy requires a cross-sectoral collaborative ecosystem approach. MSMEs require policy support and collaboration to overcome resource limitations in implementing a comprehensive circular economy [24].

2.3. Environmentally Friendly Collaboration

Green collaborations are strategic partnerships that aim to reduce carbon footprints, minimise waste, and protect natural resources as noted by [25]. They rely on shared environmental commitment, trust, communication, and organisational capacity as stated by [26]. The benefits of their innovation are well documented, and highlight that environmental innovation is more effective when stakeholders combine complementary resources, making collaboration invaluable for MSMEs seeking access to knowledge, markets, and funding.

In the water hyacinth craft sector, such collaboration provides important advantages. MSMEs gain policy support from government agencies as mentioned by [27], technology transfer and innovation development from research institutions as noted by [28], and market access and sustainability certification from non profit organisations. Collaboration with fellow MSMEs further enhances knowledge sharing and collective sustainability efforts, consistent with findings by [29, 30].

2.4. Green Entrepreneurship Orientation

Green entrepreneurial orientation refers to entrepreneurial behaviour that prioritises environmental sustainability in business operations as explained by [31]. The construct includes proactive environmental leadership that anticipates sustainability challenges, green risk-taking through environmentally oriented investments, and ongoing green learning that involves continuously seeking and applying environmental knowledge. These dimensions form a strategic mindset that guides entrepreneurs toward environmentally responsible business practices.

Green entrepreneurial orientation has been shown to shape business performance in multiple contexts. [32] emphasise that sustainable entrepreneurship requires balancing economic, environmental, and social objectives, a challenge that is intensified for resource-constrained MSMEs that often prioritise short-term gains. Despite these constraints, adopting a green entrepreneurial orientation helps MSMEs build sustainable competitive advantage by integrating environmental considerations into decision-making [33], enabling them to identify emerging opportunities while supporting broader environmental protection goals [34].

2.5. Green Innovation

Green innovation refers to creating new products and services or modifying existing ones to improve environmental performance as noted by [35]. The literature outlines three types of green innovation, which include incremental green product innovation that provides modest improvements, radical green product innovation that involves major redesign, and green product system innovation that enables broader system level transformation. These categories reflect the diverse pathways firms can adopt to achieve environmental progress [36].

Green innovation is strongly associated with positive business outcomes. [37] found that both green process and green product innovation enhance financial performance, showing that environmental efforts can generate economic benefits. [38] also reported that firms with higher levels of green innovation tend to be more profitable even under environmental uncertainty, highlighting its dual role as a sustainability strategy and a risk management mechanism. For MSMEs facing competitive markets, green innovation becomes a key differentiation tool by meeting consumer demand for sustainable products, strengthening brand loyalty, and supporting premium pricing opportunities.

2.6. Government Policy Support

Government policy support is crucial for enabling sustainability transitions in MSMEs. This support can include green regulations, environmental subsidies, tax incentives, eco-labelling programs, or access to

green financing [39]. The effectiveness of these policies depends on their accessibility, relevance, and suitability to the local realities of MSMEs.

In many developing countries, including Indonesia, a disconnection between policy design and the needs of MSMEs undermines policy outcomes [40]. Although support mechanisms exist, their implementation is hampered by bureaucratic complexity, lack of reach, and gaps in MSME awareness. Therefore, this study models government policy support as a moderating factor that can strengthen or weaken the impact of green business models on entrepreneurial orientation and collaboration.

2.7. Competitiveness of MSMEs

MSME competitiveness refers to the ability of micro, small, and medium enterprises to compete effectively through strategic differentiation, operational efficiency, and focused market positioning as explained by [41]. Competitiveness is reflected in several dimensions that include improving operational efficiency, enhancing product quality, strengthening market orientation, and advancing business model innovation. Prior studies have identified multiple determinants, and [42] found that competitiveness is shaped by access to financing, the development of marketing capabilities, and the extent of technology adoption. For creative MSMEs operating within the Industry 4.0 landscape, [43] highlight the importance of innovation capabilities and digital transformation to maintain a strong competitive position.

For water hyacinth craft MSMEs, competitiveness can be strengthened by adopting a green business model that emphasises environmental sustainability as a core differentiator. This strategic approach enables MSMEs to appeal to environmentally conscious consumers and enter premium market segments where sustainability attributes are valued, thereby enhancing both market position and long-term business resilience.

2.8. Theoretical Framework and Hypothesis Development

Based on the Resource-Based View (RBV) and Strategic Entrepreneurship Theory, the research propose that green business models influence MSMEs' competitiveness through internal capabilities (green entrepreneurial orientation) and external relationships (green collaboration), both of which are facilitated by innovation capabilities.

The RBV suggests that sustainable competitive advantage stems from valuable, rare, inimitable, and organised resources. In the context of MSMEs, green entrepreneurial orientation is one such strategic resource. Strategic Entrepreneurship Theory emphasises the importance of opportunity-seeking and advantage-seeking behaviours for firm performance [44].

Green business models provide a strategic framework that requires proactive environmental leadership, risk-taking for sustainability investments, and continuous environmental learning [45]. The implementation of a green business model creates an organisational context that encourages and rewards entrepreneurial behaviour focused on environmental opportunities and challenges. MSMEs adopting a green business model must develop entrepreneurial capabilities to identify environmental opportunities, take risks on environmental investments, and continuously learn about environmental developments and best practices. Thus, the first hypothesis emerges.

H1: Green business models have a positive effect on green entrepreneurial orientation.

Implementing green business models requires partnerships with stakeholders who share environmental commitments [46]. Green business models require resources, knowledge, and capabilities which individual MSMEs lack, creating incentives for collaborative relationships with suppliers, customers, government agencies, and environmental organizations. The complexity and scope of environmental challenges addressed through green business models exceed the capabilities of individual organizations, making collaboration essential for successful implementation. Based on this theoretical foundation, the second hypothesis is:

H2: Green business models have a positive influence on environmentally friendly collaboration.

Entrepreneurial orientation drives innovation through proactivity, risk-taking, and innovativeness [33]. Green entrepreneurial orientation extends this relationship to environmental innovation by focusing entrepreneurial behaviour on environmental opportunities and challenges. MSMEs with a strong green entrepreneurial orientation are more likely to invest in environmental research and development, experiment with environmental technologies and practices, and develop innovative solutions to environmental problems [19]. Based on this theoretical framework, the study proposes the third hypothesis:

H3: Green entrepreneurial orientation has a positive effect on green innovation.

Collaborative partnerships provide access to complementary resources and knowledge necessary for innovation [27]. Green innovation often requires diverse knowledge, capabilities, and resources spread across

multiple organisations rather than concentrated within individual MSMEs. Green collaborations enable MSMEs to access external expertise, research capabilities, funding, and market opportunities, which enhance their innovation capabilities and success rates. Based on this theoretical foundation, the study proposes the fourth hypothesis:

H4: Environmentally friendly collaboration has a positive effect on green innovation

Innovation creates differentiation and competitive advantage, particularly when addressing market demand for sustainability [47]. Green innovation enables MSMEs to develop unique products, services, or processes that address customers' environmental concerns while providing economic benefits. This differentiation may lead to premium prices, increase customer loyalty, and create barriers to competitive imitation. Based on this theoretical foundation, the study formulated the fifth hypothesis:

H5: Green innovation has a positive effect on the competitiveness of MSMEs.

A proactive environmental orientation enables MSMEs to identify and exploit sustainability-related opportunities [48]. A green entrepreneurial orientation combines traditional entrepreneurial capabilities with an environmental focus, creating unique competencies for identifying environmental opportunities, developing environmental solutions, and building relationships with environmentally conscious stakeholders. Based on this theoretical foundation, the sixth hypothesis is:

H6: Green entrepreneurial orientation has a positive effect on the competitiveness of MSMEs.

Strategic partnerships provide access to resources, markets, and legitimacy that enhance competitive positioning [49]. Green collaborations enable MSMEs to access environmental expertise, funding, market opportunities, and credibility that support competitive advantage. These partnerships can provide economies of scale, risk sharing, and access to resources that individual MSMEs cannot achieve independently. Based on this theoretical framework, the study proposes the following seventh hypothesis:

H7: Environmentally friendly collaboration has a positive effect on the competitiveness of MSMEs.

Supportive policies provide incentives and reduce barriers to entrepreneurial environmental behaviour [50]. Government policies can influence the costs, risks, and benefits associated with implementing green business models through regulations, incentives, funding programs, and institutional support. Policy support can enhance the relationship between green business models and entrepreneurial orientation by reducing implementation barriers and rewarding environmental behaviour. Based on this theoretical foundation, the study proposes the eighth hypothesis:

H8: Government policy support moderates the relationship between green business models and green entrepreneurial orientation.

Policy frameworks facilitate stakeholder coordination and reduce transaction costs for environmental collaboration [51]. Government policies can support collaborative relationships through funding for collaborative projects, platforms for stakeholder interaction, and regulatory frameworks that encourage or require collaboration. Policy support can reduce coordination costs and provide incentives for collaborative environmental activities. Based on this theoretical foundation, the study formulated the ninth hypothesis:

H9: Government policy support moderates the relationship between green business models and green collaboration.

The conceptual model is illustrated in the following Figure 1, which highlights the hypothesised direct, indirect, and moderating relationships.

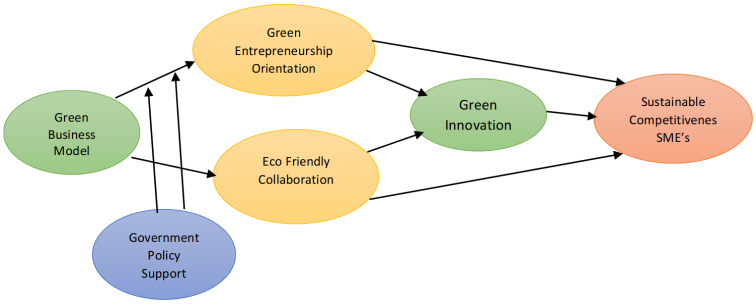

Figure 1. Conceptual Model

3. RESEARCH METHODOLOGY

3.1. Research Design

This study applied a quantitative approach with a cross-sectional survey design to examine the relationship between green business models, environmentally friendly collaboration, green entrepreneurial orientation, green innovation, government policy support, and MSME competitiveness. Smart Partial Least Squares 4.0 (Smart PLS-SEM 4.0) was used as an analytical technique because it is suitable for exploratory research, theory development, and complex models with multiple mediators and moderators [52].

This methodological design advances prior MSME-focused green business studies by incorporating a sequential mediation structure (GEO → GI and EFC → GI), which allows the model to capture how internal entrepreneurial capabilities and external collaborative dynamics interact to shape green innovation. Earlier SME sustainability studies typically examined direct relationships, whereas the present model uncovers layered causal chains that better reflect the complexity of traditional craft MSMEs. The inclusion of a moderating variable Government Policy Support also provides a new empirical lens for testing whether institutional mechanisms strengthen or weaken sustainability-driven behavioural pathways among MSMEs.

3.2. Research Location and Population

This research involved traditional craft MSMEs that use water hyacinth Eichhornia crassipes as raw material in Central Java, specifically in Semarang, Demak, and Sukoharjo, which are recognised as regional craft centres according to [53]. These MSMEs operate in informal environments with limited resources as noted by the World Economic Forum, 2024, making them a relevant context for examining sustainable business model transformation in developing countries as highlighted by [43]. Despite facing challenges in adopting sustainable practices, traditional craft MSMEs in Indonesia hold strong potential for green business model innovation supported by [51].

The study population included all registered water hyacinth craft MSMEs across the three districts, and purposive sampling was applied to target this specific sector. A total of 148 MSMEs participated in the survey, ensuring adequate representation for analysing sustainability related business transformations within the water hyacinth craft industry.

3.3. Data Collection

Primary data were obtained using a structured questionnaire distributed through face-to-face interviews and online communication (WhatsApp, Google Forms), depending on accessibility and respondent preferences [31]. The unit of analysis was the owner or manager of each MSME, as they are responsible for strategic decisions related to business orientation, collaboration, innovation, and external policy engagement.

Prior to full distribution, the questionnaire was piloted on 15 MSME representatives to ensure the clarity, relevance, and internal consistency of the measurement items. Feedback from the pilot study resulted in minor revisions to the language and wording of the items. The questionnaire consisted of several sections measuring different constructs: green business models, green collaboration, green entrepreneurial orientation, government policy support, green innovation, and MSME competitiveness. Each construct was measured using several indicators derived from relevant literature and validated through pilot testing [54].

3.4. Data Analysis

The collected data were analysed using SEM PLS to assess validity and test the hypotheses through outer and inner model evaluation. The outer model assessment included average variance extracted, loading factors, and the Fornell Larcker criterion, while reliability was measured using composite reliability as noted by [45]. Model fit evaluation covered R^2, predictive relevance Q^2, the significance of path coefficients, and effect size f^2 to examine the relationships among green business models, environmentally friendly collaboration, green entrepreneurial orientation, government policy support, green innovation, and MSME competitiveness as explained by [46].

PLS SEM was chosen instead of covariance based SEM because it is suitable for complex models, small to medium sample sizes, and non normal data distributions, which commonly characterise MSME research in developing countries. [46] affirm that PLS SEM provides strong validity under these conditions, making it appropriate for analysing the constructs in this study.

3.5. Measurement Instruments

All constructs were measured using validated scales from prior studies and adapted to the MSME context, with all items using a five point Likert scale. The measurement instrument was developed based on existing research and adjusted for water hyacinth craft MSMEs. Green business models were assessed through six dimensions supported by [4], while environmentally friendly collaboration was measured through four dimensions described by [29]. Green entrepreneurial orientation was assessed through three dimensions based on [9], and government policy support was measured through four dimensions referenced by He and Wang, 2023. Green innovation was measured through three dimensions proposed by [36].

MSME competitiveness was evaluated through four dimensions identified by [43]. All measurement constructs were adapted to reflect the characteristics of traditional craft MSMEs using water hyacinth, ensuring contextual relevance while maintaining consistency with established scales. This approach strengthened the validity of the instrument and ensured alignment with previous empirical research across green business models, collaboration, green entrepreneurial orientation, government policy support, green innovation, and MSME competitiveness.

4. RESULT

4.1. SME's Characteristics

Understanding respondent profiles helps clarify the contextual characteristics of water hyacinth craft MSMEs in Central Java. These characteristics provide a foundation for interpreting the results, as variations in business age and customer reach may affect sustainability adoption, innovation capacity, and competitiveness. The descriptive data in Table 1 offer a concise overview of these attributes and support the relevance of the sample to green business model analysis.

Table 1. SME's characteristics

Characteristic	Frequency	Percentage
Business Age		
$<$ 5 years	42	28.4%
5–10 years	67	45.3%
$>$ 10 years	39	26.3%
SME's Customer		
In the city	45	30.4%
Out of town	103	69.6%

Based on Table 1, most MSMEs in the sample fall within the medium business age range of 5 to 10 years with a proportion of 45.3% or 67 MSMEs, while 28.4% or 42 MSMEs have operated for less than 5 years and 26.3% or 39 MSMEs have operated for more than 10 years, indicating that they have moved beyond the startup phase but have not yet reached full business maturity. The data also show that 69.6% or 103 MSMEs serve customers outside their city, whereas only 30.4% or 45 MSMEs focus on local customers, suggesting a broad market orientation supported by the ability to utilise technology and distribution channels as well as the competitive strength of their products in wider regional markets.

4.2. Measurement Model Assessment

The measurement model was evaluated using Cronbach's Alpha, Composite Reliability CR, and Average Variance Extracted AVE, and all six latent constructs met the required thresholds with $\alpha > 0.70$, CR $>$ 0.80, AVE $>$ 0.50, indicating strong internal consistency and convergent validity. Discriminant validity was confirmed using the Fornell Larcker criterion and the HTMT ratio, ensuring that each construct represented a distinct conceptual dimension within the model, and the complete results of these validity and reliability assessments are presented in the following Table 2.

Table 2. Construct Validity and Reliability

Construct	Cronbach's Alpha	Composite Reliability	AVE
Green Business Model	0.872	0.912	0.723
Green Entrepreneurial Orientation	0.863	0.901	0.645

Construct	Cronbach's Alpha	Composite Reliability	AVE
Eco-Friendly Collaboration	0.880	0.907	0.621
Green Innovation	0.848	0.898	0.688
Government Policy Support	0.877	0.909	0.668
SME Competitiveness	0.895	0.919	0.655

All constructs met the criteria of Cronbach's Alpha above 0.70, Composite Reliability above 0.80, and AVE above 0.50, indicating strong internal consistency and reliable convergent validity, while discriminant validity measured through the HTMT ratio and the Fornell Larcker Criterion also confirmed adequate construct differentiation. These results demonstrate that the measurement instrument is statistically reliable and theoretically appropriate for assessing green business constructs in the MSME craft sector.

4.3. Results of Structural Model and Hypothesis Testing

Structural model evaluation revealed that Green Business Model (GBM) has a significant direct influence on two main mediating variables: Green Entrepreneurial Orientation (GEO) and Green Collaboration (EFC). The effect of GBM on GEO is 0.415 ($p < 0.001$), and on EFC is 0.295 ($p < 0.001$), indicating that the implementation of green business model encourages green entrepreneurial orientation and green collaboration among MSMEs. The significant path coefficients are as seen in Table 3.

Table 3. Path coefficients

Hypothesis	Path	β	t-value	p-value	Decision	f^2
H1	GBM → GEO	0.415	5.453	< 0.001	Supported	0.208
H2	GBM → EFC	0.295	3.813	< 0.001	Supported	0.095
H3	GEO → GI	0.368	5.373	< 0.001	Supported	0.162
H4	EFC → GI	0.369	5.560	< 0.001	Supported	0.163
H5	GI → SME Comp	0.354	4.123	< 0.001	Supported	0.134
H6	GEO → SME Comp	0.238	3.176	0.002	Supported	0.068
H7	EFC → SME Comp	0.308	4.593	< 0.001	Supported	0.107
H8	GPS × GBM → GEO	-0.087	1.178	0.239	Not Supported	0.008
H9	GPS × GBM → EFC	-0.054	0.847	0.398	Not Supported	0.003

Both GEO and EFC show significant positive effects on Green Innovation GI with coefficients of 0.368 and 0.369, and GI subsequently becomes a key driver of MSME Sustainable Competitiveness with a coefficient of 0.354 and p below 0.001. These findings demonstrate that green business models strongly shape internal entrepreneurial orientation and external environmental collaboration, which together enhance green innovation and ultimately strengthen the overall competitiveness of MSMEs.

4.4. The Explanatory Power of the Model

The explanatory power of the model was assessed using the R-square values to determine how well the proposed constructs account for variance in each endogenous variable. This evaluation helps clarify the strength of the relationships within the model and indicates the extent to which the green business framework can predict MSME competitiveness and its mediating factors. The R-square value indicates the explanatory power of the model:

- R^2 (MSME Competitiveness) = 0.493 (Moderate to Substantial)
- R^2 (Green Innovation) = 0.341 (Moderate)
- R^2 (Green Entrepreneurship Orientation) = 0.192 (Weak to Moderate)
- R^2 (Environmentally Friendly Collaboration) = 0.182 (Weak to Moderate)

The R square analysis indicates that the model has substantial explanatory power for the main outcome variable, showing that 49.3% of the variance in MSME Competitiveness with R square of 0.493 falls

within the moderate to substantial range. This means that the mediating variables Green Entrepreneurship Orientation, Environmentally Friendly Collaboration, and Green Innovation collectively explain nearly half of the differences in competitiveness among water hyacinth craft MSMEs. The R square values for the mediating constructs show that the Green Business Model accounts for 19.2% of the variance in Green Entrepreneurial Orientation and 18.2% of the variance in Green Collaboration, both reflecting weak to moderate explanatory power and indicating that other factors outside the model also influence these capabilities.

Green Innovation shows moderate explanatory power with an R square of 0.341, meaning that Green Entrepreneurial Orientation and Green Collaboration together explain 34.1% of the variance in innovation capability. This finding highlights that both internal entrepreneurial factors and external collaborative relationships contribute to innovation development, supporting the theoretical view that innovation arises from the interaction of internal capabilities and external environmental influences.

4.5. Mediation Effect

Mediation analysis showed several significant indirect pathways indicating that green business models contribute to MSME competitiveness through both simple mediation involving individual mediators and chain mediation involving sequential mediators, providing insight into how competitive advantage is formed within a green business framework. The results show significant mediation effects as follows:

- GBM $\rightarrow$ GEO $\rightarrow$ GI: β = 0.153, p = 0.001
- GBM $\rightarrow$ GEO $\rightarrow$ SME COMP: β = 0.099, p = 0.003
- GEO $\rightarrow$ GI $\rightarrow$ SME COMP: β = 0.130, p = 0.001
- GBM $\rightarrow$ EFC $\rightarrow$ GI: β = 0.109, p = 0.005
- GBM $\rightarrow$ EFC $\rightarrow$ SME COMP: β = 0.091, p = 0.006

Thus, GEO, EFC, and GI significantly mediate the effect of GBM on SME COMP. The chain mediation paths such as GBM $\rightarrow$ GEO $\rightarrow$ GI $\rightarrow$ SME COMP and GBM $\rightarrow$ EFC $\rightarrow$ GI $\rightarrow$ SME COMP indicate that competitiveness is not only influenced directly but also through complex and interconnected mediation paths which strengthen the position of green innovation as a strategic node in the green business ecosystem. Mediation testing revealed a significant indirect effect:

- GBM $\rightarrow$ GEO $\rightarrow$ GI $\rightarrow$ SME COMP (β = 0.054, p = 0.018)
- GBM $\rightarrow$ EFC $\rightarrow$ GI $\rightarrow$ SME COMP (β = 0.038, p = 0.038)

The mediation results show that green innovation acts as a strategic link between sustainable business orientation and competitive advantage. Green Entrepreneurship Orientation and Green Collaboration function as important channels through which green business models enhance innovation and competitiveness, indicating that internal leadership and a sustainability mindset help drive innovation that strengthens firm differentiation. In resource constrained environments, this internal motivation becomes a catalyst that turns sustainability intentions into measurable performance outcomes.

Green Collaboration combined with Green Innovation highlights the importance of external engagement and knowledge sharing, as MSMEs that work with NGOs, government agencies, or research institutions gain access to ideas and resources unavailable internally. This supports the view that innovation is shaped through networks and collaborative learning. The chain mediation pathway Green Business Model to Environmentally Friendly Collaboration to Green Innovation to MSME Competitiveness shows that green transformation among MSMEs is a layered process that depends on the synergy between internal commitment and external partnerships.

4.6. Moderation Effect

Government Policy Support, hypothesised as a moderating variable, did not show a significant effect in strengthening the relationship between GBM and the mediators (GEO and EFC). The interaction coefficient between GPS × GBM on GEO was -0.087 (p = 0.239), and on EFC was -0.054 (p = 0.398). Conditional effects analysis shows that the influence of GBM on mediators is stronger when government policy support is low and

weaker when the support is high. This suggests that the role of top-down policies is not yet aligned with the internal dynamics of MSMEs.

Moderation analysis shows that Government Policy Support (GPS) does not moderate the effect of GBM on GEO (β = –0.087, p = 0.239) or EFC (β = –0.054, p = 0.398). This implies a disconnection between policy instruments and the reality of MSMEs, particularly in rural-based craft industries. The insignificant moderating effect of Government Policy Support reveals a misalignment between top-down policy initiatives and field-level entrepreneurial dynamics. Despite the existing discourse on green policy instruments, their limited impact on strengthening internal orientation and collaboration indicates a lack of contextualization and implementation at the MSME level.

A plausible explanation for the insignificant moderating effect is that existing policies are designed too generically and do not address the specific challenges of traditional craft based MSMEs, making policy support inaccessible without localised facilities such as MSME friendly administrative processes, specialised green business advisors, or regionally adapted funding schemes. The analysis also shows a counterintuitive pattern in which the influence of Green Business Models on entrepreneurial and collaborative outcomes becomes stronger when perceived government support is low, indicating that MSMEs pursue proactive sustainability strategies out of necessity rather than incentive and rely on a bottom up approach when bureaucratic procedures or unclear policy mechanisms reduce the usefulness of government programs. These findings imply that effective policy interventions must align with real MSME conditions through participatory approaches, decentralised implementation, and capacity building efforts tailored to local contexts.

4.7. Model Fit Assessment

The overall model has adequate goodness-of-fit quality, with an SRMR value of 0.074, below the maximum threshold of 0.08. The R-square for the dependent variable Sustainable MSME Competitiveness is 0.493, indicating that almost 50% of the variability in MSME competitiveness can be explained by the constructed model.

Table 4. Model Fit

	Saturated Model	**Estimated Model**
SRMR	0.074	0.096
d_ULS	2.567	4.267
d_G	0.976	1.032
Chi-square	777.384	798.132
NFI	0.739	0.732

The assessment of model fit confirmed that the proposed structural model achieved an acceptable level of empirical adequacy. The Standardised Root Mean Square Residual (SRMR) value of 0.074 is below the generally accepted threshold of 0.08. This indicates minimal difference between the observed and predicted correlations. These results indicate that the model provides a good approximation to the observed data structure. The hypothesised paths are consistent with the empirical relationships in the dataset. Relatively high chi-square values are common in large models and do not automatically indicate poor fit in Partial Least Squares Structural Equation Modelling (PLS-SEM), which prioritises predictive relevance over precise model fit.

Additional fit indices such as d_ULS and d_G are proven to be within acceptable ranges, thus it strengthens the robustness of the model. The Normed Fit Index (NFI) of 0.732 is slightly below the conventional benchmark of 0.90, but is considered acceptable in PLS-SEM when dealing with complex models involving multiple mediators and moderating effects in the MSME context. The model captures a substantial portion of the variance in the endogenous constructs, specifically 49.3% of the explained variance in MSME competitiveness. Overall, these results indicate that the proposed model is theoretically grounded and empirically supported, making it a reliable tool for evaluating the mechanisms through which green business models influence sustainability-driven competitiveness in the traditional MSME sector.

5. DISCUSSION

This study develops a green business model based on circular economy principles for water hyacinth craft MSMEs in Semarang, Demak, and Sukoharjo. PLS SEM analysis shows that the Green Business Model significantly influences MSME competitiveness both directly and indirectly through Green Entrepreneurship

Orientation, Environmentally Friendly Collaboration, and Green Innovation. Early sustainable practices are visible among artisans in Banyubiru and Wedung who have begun using natural dyes and eco friendly packaging.

Green Entrepreneurship Orientation plays a strong role in strengthening Green Innovation, as seen among craftsmen in Sukoharjo who produce biodegradable bags and plastic free home decor. This finding aligns with [4] who state that green entrepreneurial orientation enhances success through innovation. The novelty of this study becomes clearer when compared with prior circular economy studies, which predominantly examine high-tech manufacturing or industrial ecosystems. This research expands the discourse by revealing that traditional water-hyacinth MSMEs can also develop circular value creation through low-cost innovation and informal collaborative networks. This positioning demonstrates how circular economy principles can be effectively localized within Indonesia's craft-based MSME sector, an area that remains underexplored in existing empirical works. Eco friendly collaboration is also a major driver of innovation. Artisans in Demak and Sukoharjo who collaborate with NGOs or CSR programs gain access to waste management training, green production techniques, and wider distribution networks, consistent with [33].

Green Innovation acts as a strategic bridge linking sustainability orientation with MSME competitiveness. It includes product innovation, process innovation, and marketing innovation, with some artisans in Semarang successfully entering the export market through environmental certification. Mediation analysis shows that the relationship between Green Business Models and MSME Competitiveness is significantly mediated through GEO and GI with β = 0.054 and p = 0.018 and through EFC and GI with β = 0.038 and p = 0.038, indicating that innovation arises from internal capabilities supported by external partnerships.

Government policy support does not significantly moderate the relationship between Green Business Models and GEO or EFC, revealing a policy practice gap. Many artisans in Grogol and other subdistricts experience difficulty accessing green funding schemes and remain unaware of circular economy programs. Administrative complexity further weakens policy effectiveness and limits MSMEs' ability to benefit from these initiatives.

The findings show that successful green transformation among MSMEs relies on both internal motivation and external support systems. MSMEs in Semarang, Demak, and Sukoharjo show ecological awareness but need institution building, mentoring, and improved green innovation literacy. This study contributes theoretically by demonstrating that circular economy principles can be effectively implemented in traditional MSMEs, with the model explaining 49.3% of the variance in MSME Competitiveness. Green business model development therefore must consider local conditions, MSME adaptability, and evolving market and policy environments.

6. MANAGERIAL IMPLICATIONS

The managerial implication of this study shows that MSME owners must strengthen internal green entrepreneurial capabilities while simultaneously expanding external collaborative networks to enhance competitiveness. MSMEs need to cultivate green leadership through continuous environmental training, develop proactive opportunity seeking behaviours, and embed sustainability values into their operational decisions. Building strategic partnerships with suppliers, customers, NGOs, and community organisations is essential for gaining access to knowledge, green production techniques, and wider markets. Since green innovation is proven to be the strategic bridge between sustainability orientation and MSME competitiveness, managers should prioritise eco friendly product development, sustainable material utilisation, and green marketing strategies as core competitive tools.

Furthermore, MSMEs need to reduce their dependence on government policy support, as current policy mechanisms are not aligned with the practical realities of traditional craft-based businesses. Therefore, managers should focus on strengthening autonomous capabilities, implementing low-cost circular practices, and leveraging community-based networks to support green transformation. From a global sustainability perspective, these MSME strategies directly support SDG 12 by promoting responsible material cycles through reuse of biomass-based resources such as water hyacinth. They also advance SDG 13 by encouraging low-emission production models rooted in local materials, reducing dependence on resource-intensive industrial inputs. Strengthening MSME participation in circular practices therefore generates not only competitive advantages but also measurable contributions to international climate and sustainability agendas, reinforcing the global relevance of this study. Policymakers, in turn, should streamline access to programs, improve implemen-

tation through local facilitation, and expand capacity-building initiatives tailored to MSME needs. Creating a supportive ecosystem through reduced bureaucracy, participatory decision-making, and institutional strengthening will enable MSMEs to accelerate sustainable innovation and enhance long-term competitiveness.

7. CONCLUSION

This study investigates the influence of a green business model rooted in circular economy principles on the sustainable competitiveness of water hyacinth craft MSMEs in Central Java, Indonesia. The study applied a quantitative approach and PLS-SEM analysis on 148 MSMEs. The results confirm that the implementation of a green business model significantly improves the competitiveness of MSMEs through direct and indirect channels. Green Entrepreneurship Orientation, Eco-Friendly Collaboration, and Green Innovation serve as critical mediating mechanisms that explain how sustainability-oriented strategies interpreted into tangible business performance.

Green innovation plays a crucial mediating role as a strategic connector. This innovation transforms internal entrepreneurial orientation and external collaborative engagement into competitive advantage. The chain of mediation pathways identified through entrepreneurial orientation and collaboration highlights the multifaceted process by which sustainability becomes a source of strategic value creation in MSMEs. The moderating role of government policy support was not statistically significant, in contrast to the research expectations. This suggests that the current policy framework is ineffective in strengthening internal strategic alignment or collaborative behaviour among traditional MSMEs. This finding indicates that policy alone is insufficient to drive green transformation. Policy must be contextually embedded and responsive to the real conditions and constraints experienced by MSMEs.

This study provides strong empirical evidence that a green business model can be successfully implemented in a traditional, resource-limited industry such as water hyacinth crafts. This model is successful when supported by an entrepreneurial mindset, strategic partnerships, and innovation capabilities. The research findings support both Resource-Based Theory and Strategic Entrepreneurship Theory by underscoring the importance of intangible capabilities and strategic behaviour in building long-term sustainability and competitiveness. Sustainable transformation in MSMEs is not a passive consequence of regulation, instead it is rather the result of deliberate internal development and adaptive learning. Effective green strategies must be built from the ground up, driven by entrepreneurial leadership and supported by meaningful collaboration and innovation. MSMEs which adopt such models will be better prepared to thrive in the future green economy. This is increasingly essential due to the fact that environmental pressures and market expectations for sustainable business practices continue to increase.

8. DECLARATIONS

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Conceptualization: AU; Methodology: RI; Software: SR; Validation: BW and AU; Formal Analysis: RI and SR; Investigation: AU; Resources: RI; Data Curation: AU; Writing Original Draft Preparation: AU and BW; Writing Review and Editing: RI and SR; Visualization: AU; All authors, AU, RI, SR, and BW, have read and agreed to the published version of the manuscript.

8.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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8.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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