THE IMPACT OF LEAN, GREEN, AND AGILE SUPPLY CHAIN PRACTICES ON SUPPLY CHAIN RESPONSIVENESS AND ITS INFLUENCE ON GREEN COMPETITIVE ADVANTAGE: A QUANTITATIVE ANALYSIS OF INDONESIAN SMEs

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Abstract

This study aims to examine the influence of Lean Supply Chain Practices (LSCP), Green Supply Chain Practices (GSCP), and Agile Supply Chain Practices (ASCP) on Green Competitive Advantage (GCA) in Small and Medium Enterprises (SMEs) in Bangkalan and Sampang districts, Indonesia. Additionally, the research explores the mediating role of Supply Chain Responsiveness (SCR) in strengthening the relationship between these practices and GCA. A quantitative approach was employed using a structured questionnaire distributed to 499 SME managers in the targeted regions. Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with WarpPLS software, testing both direct and indirect relationships among variables. Judgment sampling was applied to select respondents, ensuring relevance to the research context. The findings indicate that LSCP, GSCP, and ASCP significantly enhance Green Competitive Advantage through their direct effects. Furthermore, SCR was found to mediate the relationships between these practices and GCA, demonstrating its critical role in facilitating adaptability and responsiveness to market changes. This study fills a gap in the literature by integrating three supply chain practices (Lean, Green, and Agile) in a single model, emphasizing the role of SCR as a mediating variable, which has been underexplored in the context of SMEs. The study's findings have practical implications for SMEs, suggesting that integrating these supply chain practices can improve their sustainability and competitiveness. Future research should consider expanding the model to include other mediators or moderating factors, such as digital transformation.

Keywords: Lean Supply Chain Practices; Green Supply Chain Practices; Agile Supply Chain Practices; Supply Chain Responsiveness; Green Competitive Advantage

INTRODUCTION

In the face of intensifying global competition, achieving sustainable competitive advantage is critical for Small and Medium Enterprises (SMEs) to survive and thrive in a rapidly changing market. One of the key ways SMEs can secure this competitive advantage is by adopting efficient, environmentally-friendly, and adaptable supply chain practices (Chavez et al., 2021; Kumar & Choudhary, 2023). Lean Supply Chain Practices (LSCP), Green Supply Chain Practices (GSCP), and Agile Supply Chain Practices (ASCP) are three pivotal approaches that have been widely recognized for their potential to enhance operational efficiency, minimize environmental impacts, and increase flexibility in responding to market dynamics (Jin & Lu, 2020; Lee et al., 2022; Xie & Wang, 2023).

In Indonesia, SMEs face significant challenges in maintaining their competitiveness. These challenges stem from limited resources and a lack of responsiveness in their supply chains, which hinders their ability to adapt to shifting customer demands and market changes (Suharto & Tan, 2021). Supply Chain Responsiveness (SCR) plays a crucial role in determining an SME's ability to quickly adjust to changes in demand and the dynamics of the market (Wang & Ng, 2022). This study, therefore, investigates the mediating role of SCR in strengthening the relationship between LSCP, GSCP, and ASCP with Green Competitive Advantage (GCA) in SMEs located in Bangkalan and Sampang districts of East Java.

Despite various studies highlighting the individual benefits of each supply chain practice, there remains a gap in understanding how these practices can work synergistically to maximize sustainable competitiveness in SMEs, especially in developing regions with resource constraints (Chavez et al., 2018; Park et al., 2020). This research aims to fill that gap by offering a comprehensive model that integrates LSCP, GSCP, and ASCP in the context of SCR, providing valuable insights for SMEs seeking to improve their competitiveness in an increasingly sustainable and dynamic market environment (Furqon et al., 2024).

Through a quantitative approach, the study will utilize Partial Least Squares Structural Equation Modeling (PLS-SEM) with WarpPls software to analyze data from 499 SME managers in the target regions. By exploring the direct and indirect relationships among the variables, the research will offer practical recommendations for SMEs on how to leverage supply chain practices for achieving long-term sustainability and competitive advantage (Hair et al., 2021).

The findings of this study will not only contribute to the existing body of literature but also provide actionable strategies for SMEs to enhance their green competitiveness through better integration of lean, green, and agile supply chain practices. Moreover, it will inform policymakers and industry leaders about the critical role of SCR in fostering sustainable supply chains, particularly in resource-constrained environments.

REVIEW OF LITERATURE

Lean Supply Chain Practices (LSCP)

Lean Supply Chain Practices (LSCP) focus on enhancing operational efficiency by eliminating waste, reducing costs, and improving product quality. These practices are designed to streamline operations and focus on delivering value to customers while minimizing inefficiencies (Bottani et al., 2022). Implementing lean strategies allows companies to reduce waste through techniques such as the pull production system and

continuous improvement processes, leading to increased competitiveness and efficiency. According to Susanti & LNW (2023), adopting lean principles significantly improves resource management and enhances operational efficiency. The integration of lean and green practices also contributes to sustainable development by reducing waste and improving energy efficiency (Bottani et al., 2022).

Green Supply Chain Practices (GSCP)

Green Supply Chain Practices (GSCP) integrate environmentally friendly practices within the supply chain, focusing on reducing environmental impact through sustainable sourcing, waste management, and energy conservation (Huang et al., 2024). These practices are essential for companies seeking to align their operations with global sustainability standards and customer expectations for eco-friendly products. Alsuraihi et al. (2022) found that implementing GSCP not only improves environmental performance but also enhances brand reputation and operational efficiency. This practice allows companies to gain a green competitive advantage, differentiating themselves in markets that increasingly value sustainability (Cantele et al., 2023).

Agile Supply Chain Practices (ASCP)

Agile Supply Chain Practices (ASCP) focus on flexibility, speed, and the ability to quickly adapt to market changes or unexpected demands (Tarafdar & Qrunfleh, 2017). These practices emphasize responsiveness and the capacity to adjust operational plans to meet fluctuating customer demands or changes in market conditions. Implementing ASCP enhances supply chain responsiveness (SCRes), a critical factor in maintaining a competitive edge in dynamic markets (Sonar et al., 2022). Studies by Alfarajat (2023) and Mathiyazhagan et al. (2021) highlight the significant role of ASCP in improving responsiveness by enabling quicker adjustments in production and distribution strategies. The ability to respond to sudden changes allows firms to better meet customer needs and maintain efficiency during periods of uncertainty (Fesobi et al., 2024).

Supply Chain Responsiveness (SCRes)

Supply Chain Responsiveness (SCRes) refers to a firm's ability to respond rapidly and effectively to changes in demand or supply chain disruptions (Alfarajat, 2023). SCRes is vital in today's globalized economy, where market conditions and consumer preferences evolve rapidly. A responsive supply chain allows companies to maintain customer satisfaction by meeting their expectations for speed and customization. Implementing practices such as lean, green, and agile strategies enhances SCRes, leading to faster decision-making, improved customer service, and greater operational flexibility (Susanti & LNW, 2023). As firms adopt these strategies, they become better equipped to handle fluctuations in demand, supply disruptions, and other operational challenges (Tarafdar & Qrunfleh, 2017).

Green Competitive Advantage (GCA)

Green Competitive Advantage (GCA) refers to the ability of a company to achieve superior performance and market differentiation through environmentally sustainable practices. GCA is increasingly important as customers and regulators demand more eco-friendly products and services. Firms that integrate environmental considerations into their supply chain practices can establish a strong market presence by offering products that align with sustainability trends (Huang et al., 2024). Studies show that both Lean and Green practices contribute significantly to GCA by reducing waste, enhancing operational efficiency, and improving environmental performance (Bottani et al., 2022). Companies that prioritize sustainability in their supply chains not only comply with regulations but also

create a competitive edge by appealing to environmentally conscious consumers (Cantele et al., 2023).

Relationships Among Variables

Lean Supply Chain Practices (LSCP) and Supply Chain Responsiveness (SCRes)

LSCP positively impacts SCRes by enhancing operational efficiency and allowing firms to quickly adjust their operations to meet market changes (Susanti & LNW, 2023). Lean practices reduce waste, improve processes, and enable faster response times, which is crucial in a competitive environment where speed and adaptability are essential (Villegas et al., 2024).

Green Supply Chain Practices (GSCP) and Supply Chain Responsiveness (SCRes)

GSCP enhances SCRes by incorporating sustainable practices that increase operational flexibility and efficiency (Huang et al., 2024). Green practices, such as sustainable sourcing and energy management, contribute to a responsive supply chain that can quickly adapt to changes in market demand while reducing environmental impact.

Agile Supply Chain Practices (ASCP) and Supply Chain Responsiveness (SCRes)

ASCP is directly linked to SCRes as it emphasizes the ability to respond rapidly to changes in customer demand and market conditions (Tarafdar & Qrunfleh, 2017). Agile practices improve a firm's capacity to pivot quickly, making it more responsive to the dynamic nature of the global market.

Lean Supply Chain Practices (LSCP) and Green Competitive Advantage (GCA)

Implementing LSCP enhances GCA by improving resource efficiency and reducing waste, which contributes to sustainability goals (Bottani et al., 2022). Firms that adopt lean practices are better positioned to reduce environmental impact while improving operational performance, leading to a competitive advantage in environmentally conscious markets.

Green Supply Chain Practices (GSCP) and Green Competitive Advantage (GCA)

GSCP plays a critical role in achieving GCA by integrating sustainability into operations and offering eco-friendly products that appeal to environmentally conscious consumers (Huang et al., 2024). Adopting green practices enables firms to differentiate themselves in the market and build a reputation as responsible corporate citizens.

Agile Supply Chain Practices (ASCP) and Green Competitive Advantage (GCA)

ASCP contributes to GCA by enabling firms to quickly adapt their operations to meet customer demand for sustainable products and services (Sonar et al., 2022). Agile practices allow firms to respond effectively to market shifts while maintaining their environmental commitments, enhancing their green competitive advantage.

Supply Chain Responsiveness (SCRes) and Green Competitive Advantage (GCA)

SCRes enhances GCA by allowing firms to quickly adapt to environmental changes and customer expectations, thus maintaining competitiveness in a sustainable manner (Alfarajat, 2023). A responsive supply chain supports the timely delivery of green products and services, improving both customer satisfaction and environmental performance.

RESEARCH METHOD

Research Design

This study adopts a quantitative survey approach to investigate the relationship between Lean Supply Chain Practices (LSCP), Green Supply Chain Practices (GSCP), and Agile Supply Chain Practices (ASCP), and their impact on Green Competitive Advantage (GCA) in Small and Medium Enterprises (SMEs) in Bangkalan and Sampang districts,

Indonesia. The study explores the mediating role of Supply Chain Responsiveness (SCR) in enhancing the effectiveness of these practices in promoting GCA. A structured questionnaire was used to gather data from 499 SME managers, and the collected data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with WarpPLS software. This approach allows for a robust examination of direct and indirect relationships between the variables and is well-suited for handling complex mediation models (Hair et al., 2017).

Participants/Sample

The sample for this study consists of 499 SME managers in the Bangkalan and Sampang districts. These districts were chosen due to the concentration of SMEs and their distinctive challenges regarding resource limitations and supply chain responsiveness. Participants were selected through judgment sampling, focusing on managers with significant experience in the company's supply chain operations. This selection criterion ensures that the respondents possess sufficient knowledge and experience to provide valuable insights into the research variables (Hair et al., 2017). The criteria for selecting respondents included:

1. SME managers with more than two years of experience.
2. Managers with direct involvement in supply chain management.
3. Willingness to participate in the research, ensuring active and engaged responses.

This sample size is consistent with recommendations for PLS-SEM studies, which suggest a minimum of 10 respondents per indicator, with 499 respondents being deemed adequate for testing the model's complexity and achieving sufficient statistical power (Hair et al., 2021).

Instruments

Data were collected using a structured questionnaire designed with a five-point Likert scale, ranging from 1 ('strongly disagree') to 5 ('strongly agree'). The questionnaire measures five latent variables: LSCP, GSCP, ASCP, SCR, and GCA. The development of the questionnaire was based on established scales from previous research to ensure content validity and reliability.

Lean Supply Chain Practices (LSCP): Based on the work of Bottani et al. (2022), the questionnaire includes indicators such as collaboration among employees, planned equipment maintenance, statistical techniques for process variance reduction, low equipment setup time, and pull production systems.

Green Supply Chain Practices (GSCP): The GSCP section includes indicators derived from the research by Huang et al. (2024) and Alsuraihi et al. (2022), focusing on practices such as internal environmental management, green purchasing, collaboration with customers on environmental issues, and eco-design.

Agile Supply Chain Practices (ASCP): This section assesses flexibility and responsiveness to market changes, drawing on measures from studies by Sonar et al. (2022) and Tarafdar & Qrunfleh (2017), such as the ability to handle custom orders, adapt to cost changes, and introduce product variations rapidly.

Supply Chain Responsiveness (SCR): SCR is measured by the ability to quickly adapt to customer demand and market changes, using indicators from Alfarajat (2023) and Namasivayam & Mattila (2007), such as the ability to handle non-standard orders and meet specific customer specifications.

Green Competitive Advantage (GCA): The GCA section assesses a firm's competitive position based on its green supply chain practices, using measures from Huang

et al. (2024) and Cantele et al. (2023), including indicators like cost leadership through green practices, superior green product quality, and better environmental management than competitors.

Procedure

The data collection process involved the distribution of the structured questionnaires to 499 SME managers via both online and offline methods. Prior to the main survey, a pilot test was conducted with a smaller sample to ensure the clarity and reliability of the questionnaire. Following feedback, necessary revisions were made to improve the questionnaire's validity.

The data were analyzed using PLS-SEM, a statistical method that is particularly effective for testing complex models with multiple constructs and mediating variables (Hair et al., 2017). WarpPLS software was used for the analysis, which included running algorithms for validity and reliability checks, followed by bootstrapping to assess the significance of the hypotheses. PLS-SEM allows for the evaluation of both direct and indirect effects, making it ideal for understanding the role of SCR as a mediating variable in the relationships between supply chain practices and GCA.

Data Analysis

The PLS-SEM analysis included two key components:

Measurement Model: Evaluating the reliability and validity of the constructs using indicators such as Cronbach's alpha, composite reliability, and Average Variance Extracted (AVE).

Structural Model: Testing the relationships between the constructs (LSCP, GSCP, ASCP, SCR, and GCA) using path coefficients, t-values, and bootstrapping for significance testing.

The bootstrapping technique was employed to test both the direct and indirect relationships among variables and to determine the significance of SCR as a mediating variable (Hair et al., 2021). The study's quantitative approach ensures that the findings are statistically robust and provide valid insights into the impact of Lean, Green, and Agile practices on SMEs' green competitive advantage.

Ethical Considerations

Ethical approval for the study was obtained from the relevant institutional review board. Participation was voluntary, and respondents were informed of the study's objectives, with assurances of confidentiality and the use of data solely for academic purposes. Consent was obtained from all participants prior to the survey.

RESULTS AND DISCUSSION

Sample Characteristics

The study included 499 SME managers from the Bangkalan and Sampang districts in Indonesia. The sample comprises diverse demographic groups, ensuring a broad representation of the SME sector in these regions. Respondents' gender distribution shows a higher proportion of male managers (340) compared to female managers (100). The age distribution is as follows: 50 respondents aged <30 years, 110 aged 31-40 years, 200 aged 41-50 years, and 80 aged >50 years. Regarding education levels, 99 respondents have a Senior High School education, 191 have a Diploma, and 150 have a Postgraduate degree. In terms of job tenure, 70 respondents have <10 years, 190 have 11-20 years, and 180 have >21

years of experience. This demographic diversity helps ensure the generalizability of the study findings (Wilson et al., 2024).

Measurement Model

The measurement model was tested for reliability and validity. The composite reliability scores for all constructs were above the threshold of 0.70, ranging from 0.91 to 0.94, confirming that the constructs are reliable (Hair et al., 2017). The average variance extracted (AVE) values for all constructs were greater than 0.50, indicating good convergent validity. These results suggest that the indicators used to measure the constructs are valid and appropriate for further analysis (Kunaifi & Syam, 2021).

Model Fit

The model fit indices indicated an acceptable fit. The SRMR value was 0.07, which is below the recommended threshold of 0.08, suggesting that the model fits the data well (Hair et al., 2017). Additionally, the NFI value of 0.91 exceeds the threshold of 0.90, further supporting the model's adequacy. The Chi-Square value of 3.57, which is below the threshold of 5, also confirms the model's good fit.

Hypothesis Testing

The path coefficients and corresponding p-values for each hypothesis are summarized in Table 1. Hypothesis testing revealed several significant results, with Lean Supply Chain Practices (LSCP), Green Supply Chain Practices (GSCP), and Agile Supply Chain Practices (ASCP) all having significant effects on Supply Chain Responsiveness (SCRes) and Green Competitive Advantage (GCA).

1. Lean Supply Chain Practices (LSCP) → SCRes: LSCP has a positive and significant effect on SCRes ($\beta = 0.332$, $p < 0.001$). This suggests that effective implementation of lean practices enhances the responsiveness of supply chains to market changes, which in turn strengthens competitiveness.
2. Green Supply Chain Practices (GSCP) → SCRes: GSCP also has a positive and significant impact on SCRes ($\beta = 0.349$, $p < 0.001$). This finding indicates that the integration of green practices enhances the supply chain's ability to respond efficiently to market changes, reinforcing the need for sustainability-focused practices.
3. Agile Supply Chain Practices (ASCP) → SCRes: ASCP's impact on SCRes is positive and significant ($\beta = 0.341$, $p < 0.001$). This shows that agile practices increase responsiveness by allowing firms to adapt quickly to market demands, which is crucial for maintaining competitiveness.
4. LSCP → GCA: The relationship between LSCP and GCA is significant ($\beta = 0.249$, $p < 0.001$), confirming that lean practices contribute positively to achieving a green competitive advantage. These practices help improve sustainability performance, which is a competitive differentiator in today's market.
5. GSCP → GCA: GSCP has a significant positive effect on GCA ($\beta = 0.216$, $p < 0.001$), suggesting that adopting green practices directly enhances an organization's ability to build and maintain a green competitive advantage.
6. ASCP → GCA: The path coefficient for ASCP to GCA is 0.073 ($p = 0.051$), which is close to being significant but does not meet the conventional threshold of $p < 0.05$. This suggests that while ASCP may contribute to GCA, the relationship is not strong enough to be conclusive in this study.
7. SCRes → GCA: SCRes significantly influences GCA with a path coefficient of 0.336 ($p < 0.001$). This indicates that supply chain responsiveness plays a critical role in

enhancing green competitive advantage, especially in adapting to environmental and market changes.

The results emphasize the importance of integrating Lean, Green, and Agile Supply Chain Practices to enhance Supply Chain Responsiveness and Green Competitive Advantage. Lean practices contribute to operational efficiency and environmental sustainability, while Green practices strengthen a company's environmental performance and its competitive position in the market. Agile practices enhance responsiveness, enabling companies to remain competitive in dynamic markets.

Overall, the findings suggest that SMEs in the targeted regions can benefit significantly from adopting these integrated practices to improve their sustainability and competitiveness. However, the limited effect of ASCP on GCA indicates that further research is needed to explore the relationship between agility and sustainability in supply chain practices, particularly in the context of SMEs.

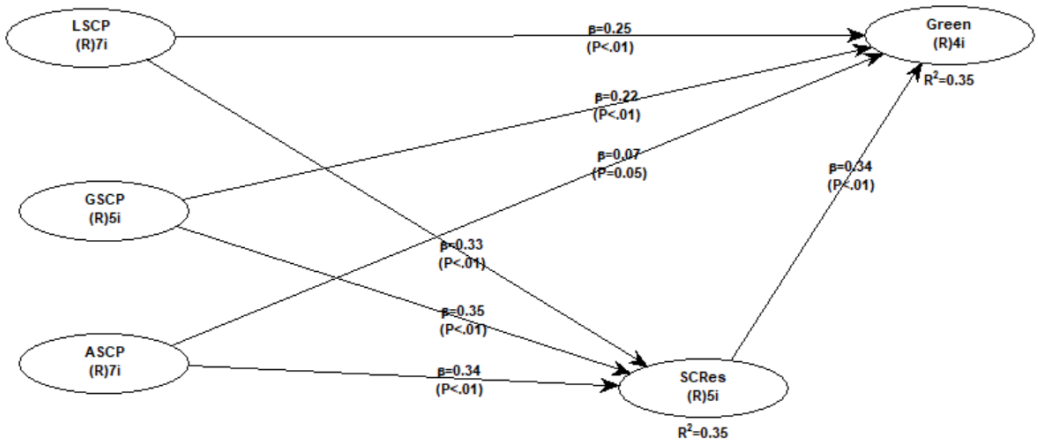

Figure 1.
Path Analysis

Discussion of Main Results

This study provides significant insights into the role of Lean, Green, and Agile Supply Chain Practices (LSCP, GSCP, ASCP) in enhancing Green Competitive Advantage (GCA) in SMEs in Bangkalan and Sampang districts. The results confirm that these practices play a crucial role in fostering sustainable competitiveness, with Supply Chain Responsiveness (SCR) acting as a key mediator. The integration of Lean, Green, and Agile practices, combined with SCR, contributes to the adaptive capabilities of SMEs, enabling them to thrive in dynamic market conditions (Rahman, & Kunaifi, 2022).

Impact of Lean Supply Chain Practices (LSCP) on Green Competitive Advantage (GCA)

The direct effect of LSCP on GCA is found to be significant ($\beta = 0.249$, $p < 0.001$), confirming that lean practices contribute positively to green competitiveness. This aligns with previous studies, suggesting that reducing waste, improving process efficiency, and enhancing operational capabilities through lean practices not only reduce costs but also foster environmental sustainability, which in turn strengthens the competitive position of firms (Mathiyazhagan et al., 2021). Lean practices, by focusing on waste reduction and operational efficiency, help SMEs better utilize resources, improving both economic and environmental performance (Teece et al., 1997).

Impact of Green Supply Chain Practices (GSCP) on Green Competitive Advantage (GCA)

GSCP significantly influences GCA ($\beta = 0.216$, $p < 0.001$), highlighting the role of sustainability-focused practices in building a competitive advantage. These practices include green purchasing, eco-design, and investments in sustainable technologies, which not only improve environmental performance but also help businesses align with increasing consumer demand for environmentally friendly products (Saisridhar et al., 2024). The finding is consistent with earlier research, which stresses the importance of green practices in enhancing a firm's market position and meeting regulatory requirements (Li et al., 2024).

Impact of Agile Supply Chain Practices (ASCP) on Green Competitive Advantage (GCA)

The relationship between ASCP and GCA was found to be weaker but still positive ($\beta = 0.073$, $p = 0.051$), suggesting that while agility enhances a firm's ability to respond to market changes, its direct impact on green competitiveness may be less pronounced than LSCP or GSCP. This result aligns with prior research, which suggests that agility, while critical in improving responsiveness and flexibility, does not always directly translate into environmental performance unless it is coupled with other sustainable practices (Mohaghegh & Größler, 2024).

Impact of Supply Chain Responsiveness (SCR) on Green Competitive Advantage (GCA)

SCR was found to have a strong positive effect on GCA ($\beta = 0.336$, $p < 0.001$), underlining its critical role in enhancing green competitiveness. This result is consistent with the literature, which emphasizes that an agile and responsive supply chain is essential for businesses to adapt to rapidly changing market conditions, including shifts in environmental regulations and consumer preferences for sustainable products (Qrunfleh & Tarafdar, 2017). SCR enables SMEs to better align their operations with sustainability goals, which in turn enhances their competitive edge (Kunaifi et al., 2024).

Mediating Role of SCR

The mediation analysis reveals that SCR significantly mediates the relationships between LSCP, GSCP, and ASCP and GCA. These findings confirm that SCR not only strengthens the direct impacts of these supply chain practices on GCA but also plays a pivotal role in translating these practices into improved competitive advantage. Previous studies have pointed to SCR as a crucial factor that facilitates the implementation of lean, green, and agile practices by enabling faster adaptation to market dynamics and enhancing operational flexibility (Almugren et al., 2024).

CONCLUSION

This study provides strong evidence on the significant impact of Lean, Green, and Agile Supply Chain Practices (LSCP, GSCP, and ASCP) on Green Competitive Advantage (GCA) in Small and Medium Enterprises (SMEs) in the Bangkalan and Sampang districts of Indonesia. The findings show that all three practices positively contribute to enhancing GCA, although their impacts vary. Lean practices (LSCP) significantly improve operational efficiency and reduce waste, which not only supports environmental sustainability but also strengthens the firm’s competitive position. Green practices (GSCP) play a critical role in helping SMEs align their operations with sustainability goals and consumer preferences, thus improving their market position. Meanwhile, Agile practices (ASCP), although contributing

to supply chain responsiveness, showed a weaker direct impact on GCA, indicating that its benefits on competitiveness may require integration with other practices for maximum effect.

Furthermore, this study highlights the crucial role of Supply Chain Responsiveness (SCR) as a mediator in enhancing GCA. SCR was found to be a significant mediator, reinforcing the relationships between supply chain practices and the firms' ability to achieve sustainable competitive advantage. This emphasizes the importance of adaptability and flexibility in the modern business environment, where rapid responses to market and environmental changes are essential.

Based on these findings, several strategic recommendations can be made for SMEs aiming to enhance their green competitive advantage. First, SMEs are encouraged to adopt an integrated approach that combines Lean, Green, and Agile supply chain practices in their operations. This approach allows for simultaneous improvements in efficiency, sustainability, and responsiveness, providing a significant competitive edge. Second, SMEs should prioritize increasing their SCR by improving operational flexibility, adopting technology for better demand forecasting, and strengthening relationships with customers and suppliers.

Third, given the growing demand for sustainable products, SMEs should focus on adopting Green Supply Chain Practices (GSCP) to meet consumer expectations and regulatory requirements. Additionally, digitalization should be considered as a factor that can enhance supply chain responsiveness. Future research should explore the role of digital transformation in improving supply chain practices, particularly in enhancing SCR. Finally, future research should expand this model to include other mediating or moderating factors, such as organizational culture or digital transformation, that may further strengthen the relationships between supply chain practices and GCA.

Acknowledgment

The entire author team would like to express their gratitude to all parties who have supported this research, especially the funders: Directorate of Research, Technology, and Community Service, Ministry of Education, Culture, Research and Technology. According to the Research Program Implementation Contract. Number: Based on the Decree No. 0070/C3/AL.04/2025 and the agreement/contract numbers 128/C3/DT.05.00/PL/2025; 036/LL7/DT.05.00/PL/2025; 156/E.02/UNIRA-LPPM/VI/2025.

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