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Decarbonization: How does it impact the sustainable development of small and medium enterprises?

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ABSTRACT

In pursuit of Vietnam's net-zero emissions target by 2050, decarbonization has become vital to the sustainable development of small and medium enterprises (SMEs). Despite their economic significance, many Vietnamese SMEs face persistent challenges such as limited access to green finance, technological constraints, and insufficient policy and institutional support. This study adopts a quantitative approach utilizing Partial Least Squares Structural Equation Modeling (PLS-SEM) to assess the effects of decarbonization on SMEs' sustainable development across economic, environmental, and social dimensions. Data were collected from 430 respondents across diverse sectors and regions in Vietnam, with analysis conducted using SmartPLS software. The findings indicate that decarbonization plays a crucial role in improving overall business performance and exerts an even more pronounced direct effect on sustainable development. In addition, business performance serves as a mediating factor linking decarbonization initiatives to sustainability outcomes. Although the research has not addressed different decarbonization strategies, its findings underscore the pivotal impacts of emission reduction in supporting SME sustainability and offer valuable implications. The insights are particularly relevant not only for Vietnam but also for other countries in the region in the process of moving towards a net-zero emission target, where SMEs also play an important role in economic development but still face many similar barriers.

Contribution/ Originality: The study provides empirical evidence regarding the critical role of SMEs' decarbonization in enhancing business performance and promoting sustainable development. It employs quantitative analysis and highlights policy implications for Vietnam and other regional countries on the pathway to achieving net-zero emissions.

1. INTRODUCTION

Climate change is widely acknowledged as one of the most pressing and multifaceted global issues of the 21st century. The rapid acceleration of global warming, largely attributed to human-induced greenhouse gas (GHG) emissions, has elevated decarbonization understood as the reduction of carbon dioxide (CO_2) emissions through energy transition and the application of clean technologies to the forefront of international economic and policy agendas. In alignment with this global call to action, Vietnam has pledged to achieve net-zero emissions by 2050, a commitment officially announced during the 26th United Nations Climate Change Conference (COP26). Reaching this ambitious objective necessitates profound structural transformations at the institutional and macroeconomic

levels, alongside active participation from all industries, with particular emphasis on small and medium-sized enterprises (SMEs), which are considered the backbone of the Vietnamese economy.

SMEs constitute nearly 98% of registered firms in Vietnam, contribute over 45% to the national GDP, and generate around 60% of total employment (ADB, 2024). Their significance in fostering job creation, driving innovation, and strengthening regional economies underscores their central role in advancing sustainable and inclusive growth. Nevertheless, compared with larger corporations that possess greater financial resources and organizational capacity to adapt to environmental requirements, SMEs often encounter obstacles in terms of capital access, technological upgrading, and managerial expertise (OECD, 2021). This reality positions SMEs as both indispensable contributors and particularly vulnerable participants in the country's transition toward a low-carbon economy.

The paradigm of sustainable development, commonly framed around the interdependent pillars of economic prosperity, environmental stewardship, and social equity, provides a critical foundation for assessing long-term corporate performance in the context of decarbonization. Seminal contributions such as Elkington's "triple bottom line" concept (Elkington, 1998) and the framework proposed by Dyllick and Hockerts (2002) highlight the importance of embedding these dimensions into strategic management, particularly for firms operating under conditions of volatility and limited resources. Previous scholarship has explored diverse drivers of sustainable business practices, including stakeholder engagement (Freeman, 1984), the development of resource-based capabilities (Barney, 1991), and the influence of institutional or regulatory pressures (Scott, 2001). However, relatively few studies have contextualized these theoretical perspectives within the lived experiences of Vietnamese SMEs. Existing studies in Vietnam and other developing economies are often limited to macro-level policy analyses or conceptual discussions, leaving a significant gap in understanding the micro-level mechanisms through which SMEs engage in low-carbon transitions. Key questions persist: do decarbonization strategies genuinely strengthen firm performance, or do they merely generate additional compliance costs? Furthermore, the precise pathways through which carbon reduction initiatives shape environmental, economic, and social outcomes in the SME sector have yet to be fully explored and substantiated through empirical research.

Against this backdrop, this study addresses this critical gap by empirically investigating the relationship between decarbonization and sustainable development among Vietnamese SMEs. It specifically examines how initiatives such as clean energy adoption, carbon management practices, and green innovation shape business performance and, in turn, contribute to sustainability objectives. The study also incorporates the mediating role of operational efficiency and assesses barriers, including resource constraints, awareness levels, and institutional support. Using PLS-SEM and a robust dataset of 430 SMEs across diverse sectors and regions, the research generates novel evidence to deepen scholarly understanding of sustainability transitions in emerging markets.

The study makes three major contributions. First, it enriches the theoretical discourse by demonstrating how decarbonization directly and indirectly drives sustainable development in SMEs, thereby addressing a neglected dimension of the sustainability literature in developing contexts. Second, it provides practical insights for managers and policymakers by highlighting the barriers SMEs face in their low-carbon transition and proposing targeted policy interventions that can mobilize green finance, promote low-carbon innovation, and enhance institutional support. Third, beyond Vietnam, the findings offer broader policy relevance for Asian economies where SMEs similarly dominate the business landscape and face comparable challenges, thereby contributing a regional perspective to the global sustainability debate.

The remainder of the paper is structured as follows: Section 2 presents a literature review, Section 3 details the research methodology, including model construction, data collection, and analysis techniques. Section 4 presents the empirical findings and comprehensively discusses the results. Finally, Section 5 summarizes the key conclusions, policy implications, and limitations of the study and offers directions for future research.

2. LITERATURE REVIEW

Sustainable development and decarbonization are two closely related concepts in the modern context, especially under the pressure of global climate change and international commitments such as the Paris Agreement and COP26. Sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987). The "Triple Bottom Line" model (Elkington, 1998) is one of the prominent approaches emphasizes that sustainable development should be measured based on three aspects: economic, social, and environmental.

Decarbonization is understood as the process of reducing greenhouse gas emissions, mainly CO_2, through measures such as renewable energy conversion, optimizing energy efficiency, technological innovation, and improving product manufacturing processes (Grubert & Hastings-Simon, 2022; Myskiv & Yaroslavovych, 2024). SMEs are increasingly incorporating sustainability considerations into their business strategies. Decarbonization can be pursued via managerial practices or technological initiatives such as renewable energy adoption, cleaner production equipment, or waste heat recovery systems. Triana, Suk, and Ota (2024) explore SMEs in Nagasaki Prefecture in their early stages of decarbonization and confirm that the manager's willingness is the main factor determining the firm's level of carbon management. According to Miller, Neubauer, Varma, and Williams (2011), 40–50% of SMEs with relatively large environmental footprints are the most likely to invest in environmental tools and solutions. This process is not only a technical necessity but also an opportunity for SMEs to enhance internal capacity, strengthen brand reputation, and access preferential finance (Khanra, Kaur, Joseph, Malik, & Dhir, 2022). However, it entails substantial upfront costs, which require stakeholder engagement and policy support.

Empirical evidence confirms the strong link between decarbonization and firm performance. Busch, Bassen, Lewandowski, and Sump (2020) found that higher carbon emissions are negatively associated with both short- and long-term financial performance, while França, López-Manuel, Sartal, and Vázquez (2023) using panel data from 1,264 firms between 2005 and 2019, demonstrated that carbon abatement significantly improves ROA, ROE, and Tobin's Q. Similarly, Busch and Lewandowski (2018) showed that SMEs adopting clean production technologies could reduce energy costs by 15–30%, thereby improving profit margins and competitiveness. Beyond financial gains, decarbonization also opens access to climate finance, green investment funds, and international sustainability programs (Bakhtiari, Breunig, Magnani, & Zhang, 2020).

Within Asia, comparative studies suggest similar opportunities and constraints. The Asian Development Bank highlights that SMEs in ASEAN contribute over 97% of enterprises and 69% of the labor force, yet face significant financing and technological barriers to decarbonization. In Vietnam, SMEs account for 97% of enterprises and contribute nearly 45% of GDP, but remain heavily dependent on fossil fuel-intensive processes and lack systematic access to green finance (ADB, 2024). Toan, Duc, and Anh (2025) analyze the relationship between management practices and the sustainability performance of SMEs in Thailand, Malaysia, and Vietnam, and confirm that while SMEs in Thailand and Malaysia have advanced in renewable adoption due to stronger state support, Vietnamese SMEs are lagging in both awareness and technology diffusion. Lau (2022) investigates the decarbonization pathway for countries in ASEAN and shows that fossil fuels still play an important part in energy-using strategies in these countries, and emphasizes the need for countries to use technologies to reduce CO2 emissions from fossil power and industrial plants. These comparative insights reinforce the need for policy mechanisms such as regional green credit guarantees, tax incentives, and technology transfer platforms to level the playing field across ASEAN economies.

Decarbonization also creates wider social and environmental benefits. According to the ILO (2018), the global green transition could generate 24 million new jobs by 2030, though it risks displacing workers in carbon-intensive sectors. This highlights the importance of retraining and upskilling programs across ASEAN. Moreover, the World Health Organization (2021) estimates that air pollution from fossil fuels contributes to over 8 million premature deaths annually, underscoring the health co-benefits of clean technology adoption. In addition, there is a growing trend of green consumption, where customers increasingly prioritize using environmentally friendly products and

services. NielsenIQ (2024) reports that 66% of global consumers are willing to pay more for sustainable products, a trend increasingly evident in Asian markets such as Vietnam, Thailand, and Indonesia. This creates pressure but also opens up opportunities for SMEs to build green strategies to achieve customer loyalty and ensure sustainable development.

Based on the literature, three hypotheses are proposed:

H_1: Decarbonization strategies have a positive effect on the performance of enterprises.

H_2: Corporate performance has a positive impact on sustainable development.

H_3: Decarbonization strategies have a direct positive impact on sustainable development.

3. METHODOLOGY

3.1. Research Design

The primary objective of this study is to investigate the extent to which decarbonization initiatives affect the sustainability of SMEs in Vietnam, while also analyzing the intermediary role played by operational efficiency. Based on the Resource-Based View (RBV) (Barney, 1991), Triple Bottom Line theory Elkington (1998), and Institutional Theory Scott (2001) the research develops a structural equation model that links three key latent constructs: decarbonization strategies (CO_2), operational efficiency (HQHD), and sustainable development (PTBV). The model is evaluated using Partial Least Squares Structural Equation Modeling (PLS-SEM), implemented via SmartPLS version.

Figure 1. The conceptual model of the study.

Figure 1 illustrates the conceptual framework that shows how decarbonization strategies are hypothesized to influence the sustainable development of SMEs, both directly and indirectly through the mediating role of corporate operational efficiency. This model confirms the mechanism by which firms' efforts to reduce CO_2 emissions can improve operational efficiency and finally enhance long-term sustainability.

3.2. Development of Questionnaires and Research Scale Selection

The study employed a quantitative research design using survey data collected from SMEs operating across various sectors and regions in Vietnam. A structured questionnaire was designed based on an extensive literature review and validated measurement scales adapted to the Vietnamese SME context. The questionnaire was administered between January and March 2025, both in Google Forms (via business associations and professional networks) and online via secure survey platforms. All respondents were informed of the voluntary nature of the survey and were assured of the anonymity and confidentiality of their responses.

There are three main sections in the survey form:

1. Demographic information: firm size, industry, years in operation, region, and ownership structure.
2. Perceptions and practices related to decarbonization: extent of energy transition, use of green technologies, awareness of carbon emissions, environmental audits, and stakeholder pressure.
3. Outcomes related to operational performance and sustainable development: measured across economic, environmental, and social dimensions. Operational performance is measured by four items assessing productivity improvement, cost optimization, resource efficiency, and internal process innovation. Sustainable development is captured using nine items across the triple bottom line: economic performance

(revenue growth, cost reduction), environmental performance (emissions reduction, energy efficiency), and social performance (labor welfare, community engagement, compliance with standards).

All items were measured using a 5-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree. A total of 430 valid responses were obtained, representing SMEs in manufacturing, services, trade, and agriculture.

4. RESULTS AND DISCUSSION

4.1. Model Results

Table 1 summarizes the demographic profile of the 430 SMEs surveyed across Vietnam. The sample reflects a diverse sectoral distribution, with firms engaged in services (43.5%), trade (24.5%), industrial production (25.0%), and other activities (7.0%). In terms of size, medium enterprises dominate the sample (60.5%), while small enterprises account for 39.5%, broadly consistent with the overall enterprise structure in Vietnam. Regarding operational longevity, almost half of the surveyed firms have been in business for 5–10 years (48.5%), and one-third have operated for more than a decade (33.5%), suggesting that the sample largely consists of established enterprises. Awareness of sustainability and decarbonization remains uneven: only 8.0% of firms report very high awareness, while 35.5% indicate an average level, and 24.5% report low awareness. This variation underscores both the heterogeneity of the SME sector and the need for more targeted education and outreach to enhance firms' understanding of sustainability and low-carbon practices.

Table 1. Sample size demographics.

Demographic variables	Classify	Rate (%)
Profession	Service	43.5%
	Trade	24.5%
	Industrial production	25.0%
	Other industries	7.0%
Business size	Small business	39.5%
	Medium enterprises	60.5%
Years of operation	Less than 5 years	18.0%
	5–10 years	48.5%
	Over 10 years	33.5%
Level of awareness about sustainability and decarbonization	Very low	7.0%
	Low	24.5%
	Average	35.5%
	High	25.0%
	Very high	8.0%

Source: Self-synthesized data from survey

The internal consistency and convergent validity of the constructs were assessed using Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE), as summarized in Table 2. All factor loadings were above the recommended threshold of 0.70, confirming strong indicator reliability. Cronbach's alpha values ranged from 0.815 for HQHD to 0.998 for CO_2, while CR values spanned from 0.874 to 0.999, both well above the minimum benchmark of 0.70, thereby demonstrating excellent internal consistency.

Similarly, AVE values ranged between 0.635 (HQHD) and 0.986 (CO_2), establishing robust convergent validity. Of particular note, the CO_2 construct displayed exceptionally high CR and AVE values, underscoring its strong measurement quality and reliable convergence as a latent variable.

Table 2. Description of Cronbach's alpha, composite reliability, and AVE.

Variables	Cronbach's alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	AVE
CO_2	0.998	0.998	0.999	0.986
HQHD	0.815	0.881	0.874	0.635
PTBV	0.964	0.987	0.967	0.769

The HTMT (Heterotrait-Monotrait) ratios reported in Table 3 provide evidence for assessing discriminant validity among the constructs CO_2, HQHD, and PTBV. Conventionally, HTMT values below 0.90 indicate satisfactory discriminant validity (Henseler, Ringle, & Sarstedt, 2015). In this study, the ratios between CO_2 and HQHD (0.751) and HQHD and PTBV (0.775) fall within the acceptable range, confirming adequate discriminant validity for these relationships. Nonetheless, the HTMT value between CO_2 and PTBV (0.929) slightly exceeds the conservative threshold, signaling a possible overlap between these constructs. This finding suggests the need for further diagnostic checks, such as examining cross-loadings or considering model refinement, to ensure the robustness of the measurement model.

Table 3. Distinguishing value (HTMT).

Variables	CO_2	HQHD	PTBV
CO_2			
HQHD	0.751		
PTBV	0.929	0.775	

Table 4 presents the Variance Inflation Factor (VIF) coefficients used to evaluate potential multicollinearity within the structural model. The reported values $CO_2 \rightarrow$ HQHD = 1.000, $CO_2 \rightarrow$ PTBV = 2.147, and HQHD $\rightarrow$ PTBV = 2.147 are all substantially below the conservative threshold of 3.0. This outcome suggests that multicollinearity is not a concern in the model, thereby supporting the reliability, stability, and interpretability of the regression estimates (Hair, Hult, Ringle, & Sarstedt, 2022; Kock & Lynn, 2012).

Table 4. VIF coefficient.

Path relationships	VIF
CO_2 reduction (CO_2) $\rightarrow$ Operational efficiency (HQHD)	1.000
CO_2 reduction (CO_2) $\rightarrow$ Sustainable development (PTBV)	2.147
Performance (HQHD) $\rightarrow$ Sustainable development (PTBV)	2.147

Table 5 reports the R^2 coefficients indicate the proportion of variance in the dependent variables explained by the predictors. The R^2 value for HQHD is 0.534 (adjusted R^2 = 0.533), reflecting a moderate level of explanatory power. In contrast, the R^2 for PTBV is substantially higher at 0.921 (adjusted R^2 = 0.920), demonstrating an exceptionally strong explanatory capacity. In practical terms, this means that the model accounts for more than 92% of the variation in SMEs' sustainable development outcomes. Such a result highlights the critical influence of decarbonization initiatives and operational efficiency as key determinants of sustainability performance, reinforcing their strategic importance for both theory and practice.

Table 5. R-squared coefficient.

Variables	R-squared	R-squared adjusted
HQHD	0.534	0.533
PTBV	0.921	0.920

Table 6 reports the standardized path coefficients derived from the structural model, indicating that all hypothesized relationships are statistically significant at the 1% level ($p < 0.001$). The most substantial direct effect

is observed between CO_2 reduction and sustainable development performance (PTBV) (β = 0.893, T = 44.320), underscoring the pivotal role of decarbonization in advancing sustainability outcomes. The pathway from CO_2 to operational efficiency (HQHD) is also pronounced (β = 0.790, T = 23.269), suggesting that low-carbon initiatives are closely associated with enhanced operational performance. In addition, operational efficiency (HQHD) exerts a smaller yet significant influence on PTBV (β = 0.089, T = 3.643), thereby confirming its partial mediating function within the structural framework.

Table 6. Path factor.

Path relationship	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (T/STDEV)	P values
CO_2 → HQHD	0.790	0.791	0.031	23.269	0.000
CO_2 → PTBV	0.893	0.892	0.020	44.320	0.000
HQHD → PTBV	0.089	0.089	0.024	3.643	0.000

Table 7 evaluates the f^2 effect size, which reflects the contribution of each exogenous variable to the R^2 of the endogenous variables. The CO_2 → HQHD path yields an f^2 of 1.147, and CO_2 → PTBV is exceptionally strong at 4.693, both indicating large effect sizes as per Cohen's guidelines (Cohen, 1988). By contrast, HQHD → PTBV has a small but meaningful effect (f^2 = 0.046), indicating that operational efficiency makes a modest but important contribution to sustainable development. These findings reinforce the conclusion that while HQHD serves as a pathway, CO_2 reduction directly drives the most substantial gains in sustainability.

Table 7. Influence scale coefficient.

	f - square
CO_2 → HQHD	1.147
CO_2 → PTBV	4.693
HQHD → PTBV	0.046

Finally, Table 8 summarizes the results of the hypothesis tests. All three hypotheses are strongly supported. H1 (CO_2 → HQHD) is accepted with high statistical significance, validating that internal decarbonization strategies improve enterprise efficiency. H2 (HQHD → PTBV) is also supported, albeit with a smaller beta, suggesting an indirect contribution of business performance to sustainability. H3 (CO_2 → PTBV) demonstrates the strongest effect, confirming that decarbonization directly facilitates sustainable development in SMEs. The consistently strong T-statistics and low p-values across all paths (p = 0.000) reinforce the robustness and reliability of the model's predictive capacity. Together, these results offer robust evidence for the dual-channel (direct and mediated) influence of CO_2 on long-term sustainability goals.

Table 8. Path coefficients and hypotheses.

Hypothesis	Relationship	Beta	T-value	P-value	f^2	Result
H1	CO_2 → HQHD	0.790	23.269	0.000	1.147	Accept H1
H2	HQHD → PTBV	0.089	3.643	0.000	0.046	Accept H2
H3	CO_2 → PTBV	0.893	44.320	0.000	4.693	Accept H3

4.2. Discussion

The results confirm a strong and significant relationship between decarbonization and SMEs' operational performance in Vietnam (β = 0.790, t = 23.269, p < 0.001), highlighting that carbon reduction efforts directly enhance enterprise efficiency. This relationship is also supported by a substantial effect size (f^2 = 1.147), emphasizing that decarbonization is not merely symbolic or regulatory but translates into measurable

improvements in how SMEs operate. This outcome corroborates the Resource-Based View (Barney, 1991), which argues that environmental innovations and internal green capabilities serve as valuable, rare, and inimitable resources that enhance firm competitiveness. Vietnamese SMEs that engage in low-carbon practices such as energy optimization, emissions tracking, and clean technology adoption tend to reduce operating costs, improve supply chain resilience, and increase productivity, thereby reinforcing the business case for environmental responsibility. In line with global findings by Hart and Dowell (2011) and Dangelico and Pujari (2010), the results suggest that green strategic behavior can act as a catalyst for operational excellence, especially in resource-constrained developing economies where efficiency gains are crucial.

The second significant relationship observed is between enterprise operational performance (HQHD) and sustainable development outcomes (PTBV). Although the path coefficient ($\beta = 0.089$, $t = 3.643$, $p < 0.001$) is comparatively modest, it remains statistically significant, suggesting that internal efficiency improvements contribute to SMEs' sustainability agendas. This relationship is also found in Kuo, Kevin Huang, and Jim Wu (2010), in which the authors underscored the connection between business operational efficiency and environmental responsibility. The small effect size ($f^2 = 0.046$) implies that operational effectiveness, while important, serves more as a facilitating factor than a primary driver of sustainability. These findings are consistent with Elkington's Triple Bottom Line framework, which posits that long-term sustainability arises from the interaction between environmental, economic, and social performance (Elkington, 1998). In this context, SMEs that enhance their productivity, optimize resource use, and streamline cost structures could lay stronger foundations for sustainable practices, including responsible sourcing, waste reduction, and community engagement. While this indirect path is not the primary driver, it underscores that strong business performance is a vital prerequisite for sustainable development.

Most strikingly, the results also show that decarbonization poses a direct and dominant influence (CO_2) on sustainable development (PTBV) among SMEs. The path coefficient of $\beta = 0.893$ and the exceptionally high t-value of 44.320 ($p < 0.001$) signify a powerful and direct impact of carbon reduction activities on sustainability performance, far exceeding traditional predictors such as operational efficiency (HQHD). The extraordinary effect size ($f^2 = 4.693$) suggests that decarbonization is the most potent lever for advancing sustainable outcomes in this sector. This aligns with recent findings in emerging markets by Wang, Zhang, Wang, and Ding (2025), which emphasizes that climate-oriented practices are directly tied to long-term competitiveness and legitimacy. The finding underscores that sustainability in SMEs is no longer a byproduct of economic growth but a strategic imperative where carbon mitigation sits at the center. This centrality is further reinforced by the high R^2 value for the PTBV construct (0.921), confirming that decarbonization explains over 92% of the variance in sustainability performance.

5. CONCLUSION AND LIMITATIONS

This study explores the role of decarbonization in advancing the sustainable development of small and medium-sized enterprises (SMEs) in Vietnam, addressing the economic, environmental, and social dimensions of sustainability. Employing Partial Least Squares Structural Equation Modeling (PLS-SEM), the analysis demonstrates that decarbonization exerts both direct and indirect positive effects on sustainability outcomes, with the most substantial influence on long-term development performance ($\beta = 0.893$; $f^2 = 4.693$; $p < 0.001$). Operational efficiency is shown to mediate this relationship with moderate strength, highlighting the importance of internal process improvements in facilitating environmental transformation and enhancing organizational resilience.

The findings provide strong evidence that decarbonization is not only an environmental imperative but also a driver of business competitiveness. Economically, it lowers production costs via energy efficiency, strengthens compliance with international environmental standards, and expands access to green finance (Busch &

Lewandowski, 2018). These benefits are particularly significant in Vietnam, where export potential is increasingly contingent on mechanisms such as the EU Carbon Border Adjustment Mechanism. From an environmental standpoint, transitioning from fossil-based energy systems to renewables reduces greenhouse gas emissions, mitigates air pollution, and conserves resources. SMEs, often constrained by outdated technologies, stand to gain considerably from adopting cleaner production processes aligned with circular economy models and stricter regulatory requirements.

Nevertheless, several limitations are acknowledged. While the survey sample is extensive, it may not fully capture the heterogeneity of SMEs across Vietnam's diverse industrial and regional landscape. The cross-sectional nature of the data restricts causal inference and limits the ability to assess long-term dynamics. Moreover, the model does not distinguish between different decarbonization strategies, such as renewable energy adoption versus process innovation, and their respective impacts on distinct sustainability pillars. Future research should adopt longitudinal designs, explore strategy-specific effects, and incorporate qualitative insights to capture the complexity of SME transitions.

In conclusion, this study contributes novel empirical evidence to the discourse on sustainable development by demonstrating that decarbonization is not simply a regulatory obligation but a transformative pathway integrating economic efficiency, environmental stewardship, and social responsibility. As Vietnam advances its low-carbon transition in line with international climate commitments, empowering SMEs to adopt and scale decarbonization practices will be pivotal for fostering inclusive, resilient, and sustainable growth. The study also implies policy recommendations to policymakers in other Asian developing countries to accelerate legal and regulatory mechanisms in supporting SMEs in their sustainable development pathways.

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