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The Integration of Renewable Energy Adoption in Sustainability Practices for Sustainable Competitive Advantage in Jordanian SMEs

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Abstract: This study investigates the extent to which renewable energy adoption contributes to achieving a sustainable competitive advantage in Jordanian small and medium-sized enterprises (SMEs) through enhanced sustainability practices. A quantitative research design was employed, utilizing data collected from 467 administrative personnel across 43 SMEs operating in diverse industries to ensure representativeness. Structural equation modeling (SEM) was conducted using SmartPLS 4 to examine both the direct and indirect effects of renewable energy adoption on corporate sustainability practices and its subsequent impact on long-term competitiveness. The findings indicate that integrating renewable energy into business operations significantly strengthens sustainable competitive advantage by improving operational efficiency, reducing costs, and enhancing corporate reputation. Furthermore, the results highlight the role of renewable energy adoption in reinforcing sustainability initiatives, thereby aligning environmental stewardship with strategic business objectives. These insights provide valuable implications for SMEs seeking to enhance market positioning through sustainability-driven strategies. Additionally, the study contributes to the existing body of knowledge on corporate sustainability and strategic management by elucidating the mechanisms through which renewable energy facilitates long-term competitive positioning. Practical recommendations are offered to policymakers and business leaders to support the effective implementation of sustainability initiatives within the SME sector.

Keywords: Renewable energy adoption; Sustainable competitive advantage; Corporate sustainability; Small and medium-sized enterprises (SMEs); Green business strategy; Structural equation modeling (SEM); SmartPLS

1. Introduction

The international drive towards sustainability has pushed businesses to adopt renewable energy solutions in their operations as a way of achieving environmental and economic objectives. With rising energy costs and the specter of climate change, SMEs worldwide are embracing renewable energy as a way of enhancing efficiency and competitiveness. Jordan's dependence on foreign energy and the consequent heavy electricity bills are serious issues, and adopting renewable energy is a strategic imperative, especially for SMEs, which have the burden of operational costs. Incentives and policies adopted by the government have been prodding investment in clean energy by business entities, but their impact on SMEs has so far not been extensively studied. This research examines the role of renewable energy adoption in the adoption of sustainability-driven business strategies and competitiveness of Jordanian SMEs. By filling this gap, the research makes significant contributions to SMEs, policymakers, and business strategists towards the development of long-term sustainability and competitiveness.

As international focus on environmental sustainability and responsibility increases, more pressure is being brought to bear on companies to implement strategies that lead to long-term environmental and economic success. One such practice is the incorporation of renewable energy into organizational operations, which can serve to fulfill sustainability objectives and strengthen the competitive advantage of a firm (Batool et al., 2024; Fatima et al., 2021; Mio et al., 2020). This trend is especially applicable to Jordanian SMEs, considering the fact that

businesses, particularly manufacturing and technology companies, must learn to cope with both regulatory environments and market competition for sustainable practice (Khawaldeh et al., 2025; Jum'a et al., 2021). Hamed et al. (2023) explained how the incorporation of renewable energy into businesses helps in creating a sustainable competitive advantage for Jordanian SMEs environmentally and market-wise. Specific. Use of renewable energy is far from being exaggerated for SMEs in the Jordanian case, where energy consumption is one of the largest issues and sustainability is more and more of utmost concern to decision-making.

Green energy investment will be capable of assisting SMEs in minimizing their cost of operation, increasing their business reputation, adapting to changing regulations, and gaining green-aware customers (Chen et al., 2022; Fatima et al., 2021; Hamed et al., 2023). This research attempted to find out the role that renewable energy plays in influencing business sustainability practices and the role played by corporate sustainability practices in assisting SMEs in achieving a sustainable long-run competitive advantage.

Among the significant research questions to be answered by this research is: To what extent does the integration of renewable energy impact the sustainable competitive advantage in Jordanian SMEs' sustainability practices? That's where the question goes right to the root of explaining the wide implications of adopting renewable energy, which changes the business strategy in view while seeking to provide insights on how SMEs can enhance competitiveness using green energy solutions to secure competitiveness in the increasingly ecologically conscious market. The study, therefore, tries to explore how the practices of sustainability affect the sustainable competitive advantage through direct and indirect paths, using the integration of renewable energy as a lens.

2. Literature Review

2.1 Theories

2.1.1 Adoption of renewable energy

The application of renewable energy in company operations has become a key element of company sustainability planning to reduce the consumption of fossil fuels and environmental pollution (Fatima et al., 2021). SMEs are especially likely to obtain wonderful advantages from using renewable energy since it, in addition to saving carbon emissions, has long-term economic advantages through reducing energy costs (Batool et al., 2024; Zhao et al., 2024). Aside from this, utilization of renewable energy by SMEs enhances the reputation of the corporation and allows them to comply with stricter regulations regarding sustainability, hence becoming green companies (Ofori et al., 2022).

Agnostine aside, even with these advantages, SMEs have been facing key challenges in the adoption of renewable energy technologies, some of which are high capital-intensive initial start-up expenses, lack of adequate technical staff, and access to funds (Dato, 2018; Ofori et al., 2022). However, they can be overcome by government policy stimulus, strategic alliances, and technological innovation, as research indicates, making renewable energy a good long-term investment (Ghobakhloo & Fathi, 2021; Lu et al., 2020). Moreover, firms that incorporate renewable energy use into broader sustainability-based approaches achieve improved financial and competitive performance (Alsayegh et al., 2020; Haseeb et al., 2019).

2.1.2 Sustainable competitive advantage

Sustainable competitive advantage is the ability of an organization to maintain a market leadership status in the long term through unique, replicable capabilities, and assets (Ijomah et al., 2024; Marjerison et al., 2022). Enhancement of operational efficiency using renewable energy as a major determinant is one of the most prominent drivers of sustainable competitive advantage (Fatima et al., 2021; Hamed et al., 2023). SMEs utilizing renewable energy within strategic planning earn worthy benefits like decreased operation risks, improved confidence in stakeholders, and compliance with evolving environmental legislation (Zhao et al., 2024; Tsalis et al., 2020).

In addition, as environmental sustainability emerges as a compelling pull to consumer and investor decisions, sustainable SMEs conducive to the use of renewable energy become more market appealing (Batool et al., 2024; Potrč et al., 2021).

Sustainable SMEs are long-term, competitive, and more investor- and customer-friendly (Cantele & Zardini, 2018; Ghobakhloo & Fathi, 2021). These strategies, in very dynamic markets, preserve cost leadership and differentiation as well as offer protection from regulatory shocks and unstable energy prices (Alarabiat et al., 2025; Bager & Lambin, 2020; Haseeb et al., 2019).

2.1.3 Sustainability-driven business strategy

A business strategy that is sustainability-led involves embedding ESG factors into business operations to generate long-term value (Alsayegh et al., 2020; Mio et al., 2020). It is not a compliance- or CSR-led strategy but one that is consciously crafted to enhance financial performance, brand value, and stakeholder relationships (Batool et al., 2024; Tsalis et al., 2020). Companies that combine renewable energy adoption, resource efficiency,

and waste minimization into a sustainability strategy have achieved profitability and market resilience in the long run (Bager & Lambin, 2020; Ghobakhloo & Fathi, 2021). Sustainability in SMEs grants them operational benefits, including improved resource utilization, cost savings, and conformity, setting them on the road to long-term success in the marketplace (Mio et al., 2020; Hamed et al., 2023).

Furthermore, companies that start their sustainability journey ahead of others gain a competitive edge through differentiation in the perception of ecologically conscious consumers and socially responsible investors (Tsalis et al., 2020; Ofori et al., 2022). New studies have revealed that organizations adopting full-scale sustainability measures improve not just environmental efficiency but also long-term resilience and innovation-driven development (Bager & Lambin, 2020; Alsayegh et al., 2020). As increasingly globalized competitive business environments shift focus towards sustainability, SMEs need to incorporate their renewable energy ventures into full-scale sustainability frameworks for maximum possible economic as well as environmental benefits (Haseeb et al., 2019; Dato, 2018). Harmonizing renewable energy with sustainability trends thus not only embeds risk considerations but also optimizes the capacity of firms to adapt and be grounded for resilience in the evolving regulatory as well as competitive environments (Lu et al., 2020; Potrč et al., 2021).

2.2 Research Hypotheses

2.2.1 Renewable energy adoption and sustainability practices

The adoption of renewable energy in corporate operations could be a major driver of sustainability practices in organizations (Dato, 2018; Hamed et al., 2023). By integrating renewable energy solutions, SMEs not only reduce their environmental impact but also enhance their overall sustainability practices in areas such as waste reduction, resource optimization, and energy efficiency (Chen et al., 2022; Lu et al., 2020). Adoption of renewable energy might spill over to evoke wider changes across organizational processes in the implementation of environmentally friendly strategies throughout the supply chain and day-to-day operations. In addition, the adoption of renewable energy could be a cornerstone in an organization's sustainability agenda, encouraging a business to adopt other green practices, and reinforcing a comprehensive sustainability framework (Lu et al., 2020; Mastrocinque et al., 2020; Awamleh et al., 2024). Therefore, this study hypothesizes:

H1: Renewable energy adoption (REA) positively affects sustainability practices (SP).

2.2.2 Renewable energy adoption and sustainable competitive advantage

Renewable energy may directly affect the SCA of an SME. At the same time, renewable energy enhances environmental performance and, therefore, is a cost-effective long-term solution that competitively places an enterprise in the market by allowing SMEs to decrease their operation costs via energy savings (Ghobakhloo & Fathi, 2021; Khan et al., 2020). Besides, the adoption of renewable energy by SMEs could be related to increased brand equity since consumers and investors tend to favor those firms that demonstrate their concern for sustainability. By reducing dependence on traditional sources of energy, SMEs can also achieve energy independence and reduce their vulnerability to market volatility (Chen et al., 2022; Hamed et al., 2023; Ofori et al., 2022). In this way, renewable energy adoption enhances both operational efficiency and market positioning, leading to an improved sustainable competitive advantage (Ofori et al., 2022). Therefore, the study hypothesizes that:

H2: Renewable energy adoption positively affects sustainable competitive advantage (SCA).

2.2.3 Sustainability practices on sustainable competitive advantage

Sustainability practices allow companies to gain and sustain a sustainable competitive edge through the implementation of environmentally friendly methods in their operations. Adopting such practices—i.e., energy saving, waste reduction, and resource conservation—provides SMEs with the chance to differentiate themselves in the market and achieve long-term competitiveness (Jum'a et al., 2021; Marjerison et al., 2022; Singh et al., 2019). Empirical evidence indicates that environmentally sustainable firms are profitable and enjoy customer loyalty, particularly as customers seek green products and services more and more.

In addition to the operational benefits, sustainability initiatives are linked to increased stakeholder relationships and improved corporate reputation. Companies that implement comprehensive sustainability practices are believed to be innovative and robust, which results in improved investor trust and market position (Agu et al., 2024; Cantele & Zardini, 2018; Haseeb et al., 2019). Additionally, the incorporation of sustainability into business processes provides cost-saving opportunities, innovation, and better regulatory compliance, further enhancing competitive advantage. From this perspective, sustainability practices not only contribute to environmental and social responsibility but are also the most significant drivers of sustainable competitive advantage, contributing to long-term business viability and success. Hence, it is hypothesized that:

H3: Sustainability practices positively affect sustainable competitive advantage

2.2.4 Renewable energy adoption, sustainability practices, and sustainable competitive advantage

Although the adoption of renewable energy directly has a positive impact on environmental performance and operating costs, its full strategic benefit is realized when it is part of a wide sustainability agenda (Lu et al., 2020; Potrč et al., 2021). Independent adoption of renewable energy can save costs on energy and greenhouse gas emissions, but its long-term efficacy will rely on its embedding with other business practices that are driven by sustainability. Efforts like waste minimization, resource efficiency, supply chain sustainability, and green marketing generate synergies that compound the value of the use of renewable energy so that SMEs can attain long-term resilience and stay competitive in an emerging green market (Ghobakhloo & Fathi, 2021; Nižetić et al., 2019; Thakkar, 2021). Firms can achieve operating effectiveness, compliance with regulations, and expansion driven by innovation at the same time through the use of renewable energy as part of an integrated approach to sustainability.

In addition, strategic alignment of clean energy uptake and overall sustainability initiatives greatly contributes to a company's brand reputation and public perception. Businesses proudly declaring their support for clean energy and environmental sustainability gain not just green-aware customers but also sustainability-conscious investors and business partners (Dato, 2018; Lu et al., 2020; Patil et al., 2025). Empirical findings indicate that sustainability strategy integration is more likely to encompass enhanced customer loyalty, stakeholder trust, and greater access to green finance, thereby strengthening long-term market position and standing (Cantele & Zardini, 2018; Haseeb et al., 2019). Moreover, sustainability business models enable SMEs to manage economic uncertainty and environmental uncertainty and, therefore, mitigate the threat induced by unascertainable energy prices and regulatory requirements.

Lastly, sustainability practices are a key mediator that strengthens the effectiveness of the uptake of renewable energy in achieving sustainable competitive advantage. Through the use of renewable energy in an integrated strategy for sustainability, SMEs can create enduring value, promote corporate image, and improve overall business resilience. This emphasizes the need to embrace a comprehensive approach to sustainability where energy efficiency is complemented by ethical resource management, ethical business practices, and active engagement with sustainability-orientated stakeholders. Thus, the study hypothesizes that:

H4: Renewable energy adoption with sustainability practices positively affects sustainable competitive advantage

3. Methods

3.1 Design

This research utilizes the quantitative research paradigm to analyze the utilization of renewable energy in the operations of SMEs to identify its contribution towards sustainability and competitiveness. The study utilizes a stratified random sampling strategy to generate a suitable sample of SMEs from Jordan. Stratified sampling is applied to split the population into meaningful subgroups (strata) based on some attribute such as industry sector (for example, manufacturing, retailing, services), company size (small or medium-sized), and geography. This has the effect that each subgroup is sampled proportionally in the sample, and this leads to a better generalizability of results. The process of sampling begins with the identification of these strata in the SME population within Jordan. Following stratification, random sampling of the subgroups is conducted. The research design enables the study to achieve sectoral results and enhances the understanding of the impact of renewable energy adoption on competitiveness and sustainability in different business environments. The stratified sampling design is especially relevant to the understanding of diversified SME experiences in different industries and sizes and therefore provides a suitable choice for this research (Memon et al., 2020).

3.2 Population and Sampling

The study sample is 467 administrative staff from 43 SMEs in Jordan. The selection process employed the stratified random sampling technique that ensures the sample to cover all different sectors such as manufacturing, services, and retail. Sectors were selected based on differences in their utilization of renewable energies and the conditions of suitability to the research. Apart from this, the sample has been stratified by firm size and adoption stage of renewable energy (already adopted renewable energy and yet to adopt renewable energy in the next five years). Only companies that employ more than 20 employees and companies with an operation of two years and more were applied in the research to guarantee the firms have significant experience in the operations to respond appropriately (Hair et al., 2011; Russo & Stol, 2021).

As it had to make sure that the questions in the survey were simple enough for the participants to understand and they would be able to answer accordingly, there was a pre-test before actual data collection. The pre-test was also conducted among a small group of administrative staff, though from the same target population, but not from the final sample. A pre-test was conducted to try out the appropriateness and readability of the survey items and

possible wording or questionnaire design issues. Pre-test results were utilized to refine and enhance the survey, ensuring greater clarity and comprehensibility for respondents regarding renewable energy adoption, sustainability practices, and competitive advantage. This practice ensured the final questionnaire was thorough and readable to everyone involved, which increased the validity and reliability of the study (Memon et al., 2020).

3.3 Measurement

The assessment of the adoption of renewable energy and the success of a sustainability-orientated strategy is thus done through a structured three-section questionnaire. That is, adoption of renewable energy is a broad research field and is a 5-point Likert scale on integration of renewable technology, e.g., solar panels and wind power (Khan et al., 2020; Suman, 2021). The second part gauged practices of sustainability with regards to corporate social responsibility and the use of resources using a Likert scale (Abbasi et al., 2022; Stawicka, 2021). The third part gauged sustainable competitive advantage in the manner of market share, customer retention, and the efficiency of operation, and therefore the business results of going renewable (Haseeb et al., 2019; Hossain et al., 2021). Other demographic variables, like firm size and industry, were also taken to analyze the moderating effects.

3.4 Data Analysis

Smart PLS 4 was used in this research because of its capacity to process complex models and moderately small samples, and the efficacy of its use in testing the data of 467 administrative staff members of 43 SMEs in Jordan is high. Smart PLS 4 is unique among SEM software because it is tolerant of non-normal distribution of data and can test structural and measurement models for reliability and validity. Its strong bootstrapping feature fortifies the significance testing of path coefficients, while its multi-group option gives penetrating inferences for moderating effects, such as industry segmentation and firm size. These features positioned Smart PLS 4 to be the optimal tool to employ in examining paths between renewable energy adoption, sustainable behaviors, and competitive advantage of SMEs.

The analysis began by beginning with a descriptive statistic to summarize the characteristics of the sample in quantitative terms, followed by assessing the measurement model for internal consistency and validity based on metrics that included Cronbach's Alpha and Average Variance Extracted amongst others. Testing within the structural model involves the direct and indirect relationships between variables of the study; therefore, the results will be interpreted through the path coefficients, R^2 values, and effect size. In assessing the significance of these path coefficients, the use of bootstrapping was employed to ensure robust results. Besides, the study examined other moderating influences, like industry type and firm size, through multi-group analysis. It thus gave way to a richer contextual understanding regarding the issue at hand with the adoption of renewable energy (Cheah et al., 2024; Russo & Stol, 2021).

4. Results

4.1 Descriptive Statistics

As shown in Table 1, the high scores of mean value for uptake of renewable energy (4.10), sustainability practices (4.20), and competitive sustainable advantage (4.15) indicate that the respondents strongly believe in them as necessary in their business strategies. Therefore, the research implication is that SMEs doing business in Jordan in different industry sectors view practicing sustainability as well as adopting renewable energy as vital elements towards obtaining a competitive advantage. The quite small standard deviations confirm that there is a broad consensus on how crucial these practices are, with a degree of variance in their perception and therefore very likely disparate regions with divergent priorities on these areas. The minimum to maximum value range also testifies to such variation, although one is within a common direction of opinions over the range of different views across the sample overall, but in a common trend to support these methods for ultimate success.

Table 1. Descriptive statistics of study variables

Variable	Mean	Standard Deviation	Min	Max
Renewable Energy Adoption	4.10	0.62	2.5	5.0
Sustainability Practices	4.20	0.58	3.0	5.0
Sustainable Competitive Advantage	4.15	0.55	3.0	5.0

4.2 Reliability and Validity Tests

As shown in Table 2, reliability analysis suggested that both Cronbach's Alpha and Composite Reliability were

higher than 0.70 for all constructs, showing internally consistent results across all the survey items. Each of these items in different constructs represents the concept under measurement across all measurement items. However, this is also in line with the convergent validity when AVE for all the constructs resulted in more than 0.50. The results confirm that the constructs explained a good level of variance in their items, hence their relevance to the objectives of the study. Discriminant validity was also affirmed, as evidenced by the Fornell-Larcker criterion, where the square roots of the AVEs were higher than the correlations between constructs, indicating that the constructs were distinct and not overlapping.

Table 2. Reliability and validity analysis of constructs

Construct	Items	Loading	(α)	(CR)	(AVE)
Renewable Energy Adoption	REA1	0.88	0.85	0.90	0.72
	REA2	0.84			
	REA3	0.86			
	REA4	0.87			
Sustainability Practices	SP1	0.89	0.87	0.91	0.75
	SP2	0.87			
	SP3	0.85			
	SP4	0.83			
	SP5	0.79			
	SP6	0.81			
Sustainable Competitive Advantage	SCA1	0.84	0.82	0.88	0.70
	SCA2	0.86			
	SCA3	0.82			
	SCA4	0.81			

As shown in Table 3, the discriminant validity analysis through the Fornell-Larcker criterion is such that the square root of the AVE for each construct (REA = 0.85, SP = 0.87, SCA = 0.84) is greater than the correlations with other constructs. This indicates that each construct is distinct and more highly related to its indicators than to other constructs, thus satisfying the requirements for discriminant validity.

Table 3. Discriminant validity (Fornell-Larcker criterion)

Construct	REA	SP	SCA
Renewable Energy Adoption (REA)	**0.85**		
Sustainability Practices (SP)	0.52	**0.87**	
Sustainable Competitive Advantage (SCA)	0.54	0.55	**0.84**

4.3 SEM

As shown in Table 4, the direct relationships among renewable energy adoption, sustainability practices, and sustainable competitive advantage were tested using SEM. All path coefficients were significant at $p < 0.05$, confirming all hypothesized relationships. More precisely, the results indicated that renewable energy adoption significantly and positively influenced sustainability practices, which in turn had a significant positive effect on sustainable competitive advantage. The results strongly support the conceptual model, underlining how relevant renewable energy is given sustainability strategies and competitiveness increases within the concerned SMEs.

Table 4. Path analysis results for direct hypotheses testing

Hypothesis	Path Coefficient	t-value	p-value	Result
REA → SP	0.47	5.83	0.02	Supported
REA → SCA	0.42	4.80	0.03	Supported
SP → SCA	0.51	6.10	0.01	Supported

4.4 Mediation Analysis

As shown in Table 5, to ascertain whether the sustainability practices mediated the influence of renewable energy adoption on achieving sustainable competitive advantage, mediation analysis was performed. The result of the bootstrapping procedure at 5,000 resamples showed that the indirect effect of renewable energy adoption on sustainable competitive advantage through sustainability practices was significant. The result, therefore, infers partial mediation; though renewable energy adoption exerts a direct impact on the achievement of sustainable competitive advantage, it is the sustainability practice that amplifies this phenomenon. In particular, this analysis

showed that sustainability practices explained a 31% improvement in the association of renewable energy adoption with sustainable competitive advantage, underlining their important role in reinforcing the contribution of renewable energy integration.

Table 5. Mediation analysis results

Path	Indirect Effect	Bootstrapped t-value	Bootstrapped p-value	Mediation Type
REA → SP → SCA	0.32	4.35	0.000	Partial

4.5 Goodness-of-Fit Indices

As shown in Table 6, the goodness-of-fit indices for the model were indicative of a good fit; the value of SRMR was 0.054, well below the threshold of acceptability at 0.08. This will indicate that the estimated model fits the observed data very well and further supports the structural model. The good fit makes these findings strong and strengthens the credibility of conclusions that can be drawn from this analysis.

Table 6. Model fit indices

Fit Index	Threshold	Model Value	Fit
SRMR	<0.08	0.056	Good Fit

As shown in Figure 1, overall, the findings from this study show that the adoption of renewable energy exerts a positive impact on sustainability practices, and such practices increase sustainable competitive advantage in SMEs. The mediation analysis confirms that sustainability practices are important to strengthen the influence of the integration of renewable energy on business competitiveness. These findings give very useful insights for SMEs that seek to utilize renewable energy as a strategic instrument for attaining sustainability-driven competitive advantage.

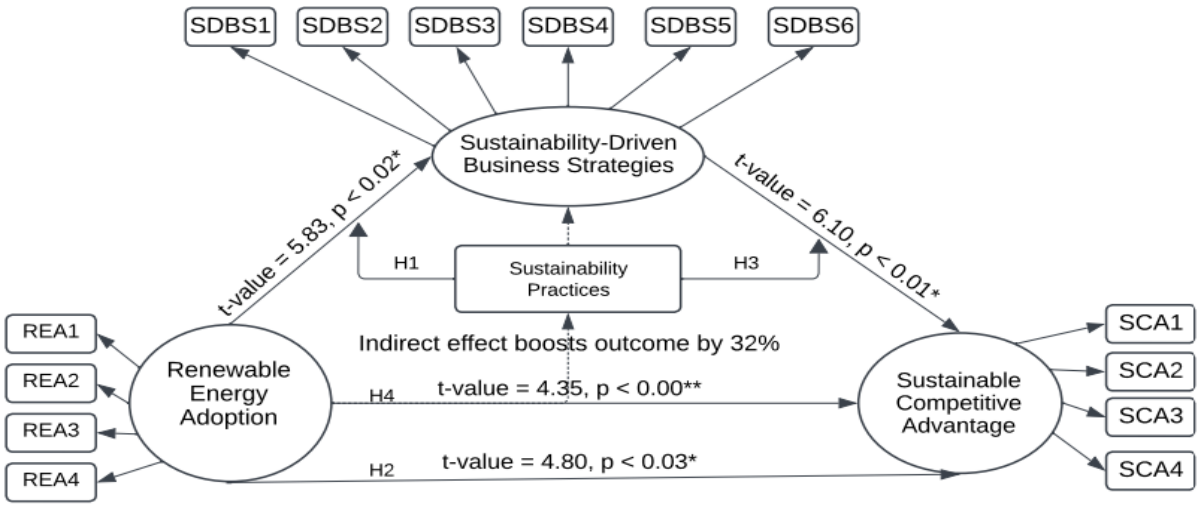

Figure 1. Structural model

5. Discussion

The first hypothesis, which is linked to the effect of REA on SP, shows that the REA significantly affects SP because the path coefficient is 0.47 at $p < 0.05$, thus supporting the literature about the facilitation of sustainability practices through renewable energy (Lu et al., 2020; J & Majid, 2020). This finding confirms the work of Khan et al. (2020), who indicated that the adoption of renewable energy is important in improving sustainability practices among organizations. However, other researchers, such as Ostergaard et al. (2022), have argued that the effectiveness of renewable energy adoption on sustainability may differ across industries or particular practices and requires further research to consider these contextual factors.

The second hypothesis deals with how SCA is related to renewable energy adoption. Indeed, the result verified the hypothesis for positive influence (0.42; p-value < 0.05), supporting the possibility that the firm can explore opportunities to benefit in the form of a competitive advantage as regards improved sustainability performance arising out of renewable energy adoption. It follows earlier findings from Khan et al. (2020), which have identified

a relationship between adopting renewable energy and building a strategic advantage in competitiveness. Another approach includes research by Zahedi et al. (2022), which advises the link between competitiveness from renewable energy adoption being especially applicable to industries where sustainability issues create key market differentiation.

The third hypothesis is about sustainability practices affecting sustainable competitive advantage, with the path coefficient coming to 0.51, showing a positive significant impact ($p < 0.05$). This evidence supports the assertion by Kwarteng et al. (2016), that sustainable practices are essential for long-term competitiveness, as sustainability practice improves a company's reputation, reduces operational costs, and attracts environmental consumers. However, all sustainability practices are not transformed into competitive advantages, as the successful implementation of such practices requires correct application and must be matched with the strategic objectives of the company (Saputra et al., 2023).

The fourth hypothesis is to test Partial mediation in the direct link between renewable energy uptake and sustainable competitive advantage, with an indirect effect size of 0.32 ($p < 0.05$), shows that sustainability practices significantly contribute to improving competitive advantage but do not capture the overall effect of renewable energy uptake. This is a sign that other variables beyond sustainability practices are affecting the competitive advantage. Industry-specific factors, including technological preparedness, availability of resources, and regulatory pressures, can influence the effect of renewable energy adoption on competitiveness (Azizian & Ullah, 2024; Zhao et al., 2024). Additionally, organizational-level elements such as leadership support, firm size, and financial capability are key forces behind the success of renewable energy adoption in competitiveness improvement (Basheer et al., 2024). Other sectors can be dissuaded from taking up sustainability initiatives, such as enormous investment in infrastructure, knowledge, and human capacity, based on the industry (Hamed et al., 2023; Batool et al., 2024). Additionally, policy design and market structure would also play important roles in affecting the extent and speed of take-up of renewable energy, rendering the mediation role even more complicated. Subsequent research, therefore, would have to account for these additional external and company-specific factors to move further in tracing the dynamic relationship between sustainable competitive advantage, the adoption of renewable energy, and sustainability practices.

6. Conclusion and Managerial Implications

6.1 Conclusion

This study examines the crossroads of renewable energy uptake, sustainability practice, and sustainable competitive advantage in the context of the need for having these variables in SMEs. The findings indicate that the adoption of renewable energy significantly influences the drive towards sustainability practice, which contributes to increased competitive advantage. Sustainability practices mediate in part, focusing on how they ensure maximization of benefits from renewable energy. This result is most applicable to SMEs in developing nations, where high capital expenses and low levels of technical expertise may make the uptake of green technologies difficult. The results of this study indicate that not only do SMEs need to pay attention to renewable energy adoption but also need to adopt overall sustainability plans to ensure long-term competitiveness. The policymakers and entrepreneurs have to finance the SMEs through some incentives and knowledge-sharing activities to encourage the use of green practices and renewable energy. By doing so, the SMEs will be in a position to break market barriers, access eco-friendly consumers, and come out more competitively, in line with international sustainability objectives.

6.2 Theoretical and Practical Implications Section

The present research contributes to the literature by providing evidence of the central positioning of renewable energy adoption in promoting sustainability practice that enhances sustainable competitive advantage in SMEs further. It highlights the integration of sustainability in business models to obtain maximum benefits from renewable energy investment. The research is a complement to resource-based and institutional theories since it shows how SMEs leverage sustainability programs in establishing long-term competitive advantages. Moreover, evidence is presented of the scope for additional research on other mediating factors like organizational culture, technological innovations, and regulation regimes that potentially affect the nexus between the application of renewable energy and competitive advantage. Future research can examine the long-term economic and environmental consequences of sustainable initiatives with a focus on industry and spatially differential rates of take-up.

To policymakers and business entrepreneurs, the research presents crucial information on how SMEs can use the application of renewable energy as a strategy for long-term competitiveness and sustainability. According to the research findings, not only do SMEs need to be invested in renewable energy but also have total policies for sustainability in place to ensure maximum advantages. The industry associations and governments need to make

arrangements for supporting policies, investment incentives, and training schemes that will aid in the shift toward sustainable business practices. The organizations also need to take a proactive approach through the initiation of innovative environments, greater employee participation in sustainability, and stakeholder engagement to resist barriers toward green technology adaptation. Through responses to these drivers, SMEs can strengthen their market position, acquire ecologically aware customers, and advance global efforts toward sustainability more effectively.

6.3 Limitations

Despite these useful findings, there are some real limitations to the study. The sample is confined to SMEs within particular sectors, and this might impact generalization to other industries. Future research can apply the model to a wider range of industries and make use of objective measurement tools to further validate these findings. Furthermore, the investigation of other probable mediators and moderators, such as leadership style, corporate culture, and market conditions, may provide further insight into which elements affect the association of renewable energy adoption with competitive advantage.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

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Conflicts of Interest

The authors declare no conflict of interest.

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