Future of Work and Digital Management Journal

Article type:
Original Research

Article history:
Received 22 February 2025
Revised 13 May 2025
Accepted 20 May 2025
Published online 28 June 2025

Identifying the Factors Affecting the Creation of Sustainable Green Competitive Advantage in a Big Data Environment: A Case Study of Small and Medium-Sized Enterprises in Isfahan Province

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How to cite this article:
Mohammadi Fesharaki, M., Karimi, F., & Ghorbani Dinani, H. (2025). Identifying the Factors Affecting the Creation of Sustainable Green Competitive Advantage in a Big Data Environment: A Case Study of Small and Medium-Sized Enterprises in Isfahan Province. *Future of Work and Digital Management Journal, 3*(2), 1-12. https://doi.org/10.61838/fwdmj.3.2.16

ABSTRACT

Big data is a powerful tool for creating and maintaining sustainable green competitive advantage in today's business world. Organizations that can effectively use data to analyze customer behavior, optimize operations, and drive innovation will hold a stronger position in the market. In fact, big data, by empowering green marketing capabilities, enables companies to achieve sustainable advantages in competitive environments. This relationship highlights the importance of integrating data-driven technologies with green strategies to achieve long-term sustainability. The purpose of this study is to identify the factors influencing the creation of sustainable green competitive advantage in a big data environment in small and medium-sized enterprises (SMEs) of Isfahan Province. To select the sample, using available random sampling and based on Cochran's formula, 384 employees of SMEs in Isfahan Province were chosen for model fitting. Data were collected within the framework of 8 components and 45 questions during the period from January to February 2025. The research hypotheses were tested using SmartPLS software. The results indicated that the model, based on the components of organizational learning, green marketing capabilities, green innovation strategies (green product innovation and green process innovation), competitive market, sustainable green competitive advantage, and big data capabilities, is valid, and the relationships among the variables were significant.

Keywords: Big data capabilities, big data environment, innovation strategies, sustainable green competitive advantage.

Introduction

In the rapidly evolving landscape of global business, the pursuit of sustainable competitive advantage has become one of the most pressing priorities for organizations. The emergence of big data technologies, green innovation practices, and digital transformation strategies has fundamentally altered how firms develop, sustain, and expand their market positions. With increasing environmental concerns, social pressures, and regulatory mandates, companies—particularly small and medium-sized enterprises (SMEs)—are compelled to integrate green strategies into their core operations while leveraging advanced technological capabilities. This integration not only enhances organizational performance but also contributes to broader societal and environmental objectives [1-3].

The role of big data in sustaining competitive advantage has gained considerable scholarly attention. Big data analytics capabilities enable firms to transform raw information into actionable insights, thereby facilitating smarter decision-making, process optimization, and innovation [4, 5]. By empowering organizations with tools to anticipate customer needs, optimize resource utilization, and predict market trends, big data serves as a critical enabler of competitive differentiation. In

particular, the application of data-driven strategies has been linked to green practices, helping firms align profitability with sustainability objectives [6, 7]. Research suggests that in industries ranging from banking to pharmaceuticals, the adoption of big data-driven approaches strengthens firms' ability to innovate while meeting environmental obligations [8, 9].

Green innovation strategies are equally pivotal for organizations striving to achieve sustainability. Enterprises that adopt eco-innovation practices—including green product and process innovation—develop unique advantages that are difficult for competitors to replicate [10, 11]. By embedding environmental responsibility within their innovation processes, firms can foster stronger relationships with stakeholders, respond to regulatory requirements, and align with shifting consumer preferences [12, 13]. The mediating role of green innovation in linking organizational learning, marketing capabilities, and competitive advantage has been underscored in several studies [14, 15].

Organizational learning and knowledge-based resources further strengthen the capacity of firms to exploit technological and environmental opportunities. SMEs, in particular, benefit from developing ambidextrous innovation strategies that balance exploitative and exploratory approaches [5]. Through organizational learning, companies can adapt to turbulent environments, generate innovative ideas, and translate them into sustainable practices [2]. For instance, integrating green creativity with corporate social responsibility has been shown to enhance brand performance and long-term competitiveness [13]. Moreover, the interplay of organizational knowledge with big data analytics has been found to significantly improve firm performance across industries [16].

The digital transformation of SMEs has emerged as a critical driver of sustainable growth. Digitalization of business processes, customer interactions, and operational strategies enhances the capacity of firms to innovate and remain competitive in dynamic markets [17, 18]. However, digitalization requires not only technological adoption but also resource orchestration and strategic vision to ensure successful implementation [18, 19]. Studies reveal that digital transformation can catalyze green innovation and open innovation processes, especially when organizations develop ambidextrous capabilities that bridge short-term efficiency with long-term exploration [19]. Furthermore, digital customer service initiatives in SMEs have been identified as major enablers of organizational improvement and competitive advantage [17].

Green marketing capabilities also play an indispensable role in creating sustainable competitive advantage. By aligning marketing activities with environmental values, firms are better positioned to attract environmentally conscious consumers and differentiate themselves in competitive markets [20, 21]. Empirical evidence suggests that green marketing orientation significantly contributes to firm performance, particularly in SMEs, where resource constraints make innovation-driven differentiation essential [11, 21]. The integration of big data analytics into green marketing has further enhanced firms' capacity to design effective strategies that resonate with consumers and stakeholders alike [22, 23].

The interaction between big data, innovation, and marketing is further complicated by the pressures of globalization, Industry 4.0, and shifting consumer behaviors. In this regard, lean practices and advanced technologies such as Industry 4.0 solutions have been found to strengthen firms' dynamic capabilities, enabling them to adapt swiftly to market disruptions and environmental demands [24]. Similarly, predictive modeling tools and customer analytics enhance the ability of firms to assess customer lifetime value, thereby ensuring that marketing and innovation investments are effectively targeted [25]. This emphasis on predictive insights reflects a broader trend toward data-driven decision-making in pursuit of long-term sustainability.

The COVID-19 pandemic further accelerated the adoption of digital and green practices across industries. With shifts in consumer purchasing patterns and supply chain disruptions, firms were compelled to embrace digital platforms and green innovations to maintain resilience [26]. Evidence indicates that such turbulence prompted organizations to reassess their strategies, integrating sustainability into core functions as a mechanism for crisis management and future preparedness [9]. The growing emphasis on resilience through green innovation highlights the need for firms to balance immediate competitive priorities with long-term ecological sustainability [10].

The relationship between finance, innovation, and sustainability also deserves attention. Green finance mechanisms have been shown to influence enterprises' capacity for green technology innovation, underscoring the financial dimension of sustainable competitive advantage [27]. By providing the necessary resources and incentives, financial institutions enable firms to pursue ambitious sustainability agendas, including energy-efficient retrofits and eco-innovation strategies [28]. These financial and technological enablers, when combined with organizational learning and marketing capabilities, contribute to holistic sustainability-oriented business models [29].

Despite the promise of these practices, challenges remain. Research has shown that SMEs often face barriers to adopting big data and green strategies, including limited financial resources, lack of technical expertise, and resistance to organizational change [3, 29]. Moreover, cultural and regional contexts can shape the extent to which these practices are successfully implemented. For example, studies in Iran have emphasized the importance of big data capabilities in industries such as banking and marketing, illustrating context-specific pathways toward competitive advantage [7, 23, 30]. Similarly, case studies from Egypt and North Africa reveal how digital transformation and lean industry practices contribute to self-sustainability and resilience in resource-constrained contexts [8, 24].

Taken together, the literature highlights a clear trend: sustainable competitive advantage in the modern business environment is increasingly dependent on the integration of big data analytics, green innovation strategies, digital transformation, and green marketing capabilities. These elements are not isolated but interact synergistically to enhance organizational resilience, responsiveness, and long-term success [12, 19, 22]. By leveraging data-driven insights, fostering organizational learning, and aligning marketing with sustainability values, firms can navigate turbulent environments and secure durable advantages in competitive markets [2, 4].

The present study contributes to this growing body of knowledge by examining the factors that drive the creation of sustainable green competitive advantage in a big data environment, focusing on small and medium-sized enterprises in Isfahan Province. Building upon insights from global research while contextualizing findings within the regional industrial landscape, this study aims to bridge theoretical perspectives with practical applications. In doing so, it provides both academic and managerial implications for organizations seeking to thrive in an increasingly data-driven and sustainability-oriented global economy.

Methodology

The present research is applied in terms of purpose and descriptive–correlational in terms of data collection method, and it is based on structural equation modeling (SEM). The statistical population included all managers of small and medium-sized enterprises (SMEs) in Isfahan Province. According to Cochran's formula and considering the infinity of the population, 384 individuals were selected as the sample. Data were collected using a questionnaire consisting of 8 categories, including

organizational learning, green marketing capabilities, green innovation strategies (green product innovation, green process innovation), competitive market, sustainable green competitive advantage, and big data capabilities. The relationships among the variables were tested using SmartPLS software.

Findings and Results

To measure the variables, a standardized questionnaire was used. The indicators were translated, and the necessary modifications were made based on expert opinions. Factor loadings, which indicate the strength of the relationship between a latent variable and its observed variables, were examined. The factor loadings of the variables were greater than 0.5, indicating an acceptable correlation between observed variables and their respective latent variables. In addition, the results of the measurement model showed that the bootstrapping (t) values in all cases were greater than the critical value of 1.96, indicating the significance of the correlations between the observed and latent variables. Accordingly, each latent variable was correctly measured by its respective observed variables.

The reliability of the research variables was tested using Cronbach's alpha (above 0.7), composite reliability (CR) (above 0.7), and average variance extracted (AVE) (above 0.5), with the aid of SmartPLS software. The results showed that the research variables possessed both reliability and convergent validity (Cronbach, 1951; Fornell & Larcker, 1981). In summary, this study used quantitative methods and a questionnaire tool to examine the relationships among relevant variables and confirmed the validity and reliability of the measurement instrument. Table (1) shows that the research variables possess reliability and convergent validity.

Table 1

Reliability and Convergent Validity of the Research Model Variables

Variables	Cronbach's Alpha	Composite Reliability (CR)	AVE
Organizational Learning	0.844	0.888	0.615
Green Marketing Capabilities	0.877	0.905	0.577
Green Innovation Strategies	0.812	0.876	0.639
Green Product Innovation	0.852	0.894	0.628
Green Process Innovation	0.857	0.894	0.628
Competitive Market	0.871	0.907	0.661
Sustainable Green Advantage	0.880	0.912	0.675
Big Data Capabilities	0.897	0.916	0.549

The Cronbach's alpha values for all variables were greater than 0.7; therefore, in terms of reliability, all variables were confirmed. The values of the average variance extracted (AVE) were also higher than 0.5 in all cases; therefore, convergent validity was also confirmed.

In discriminant validity analysis, the differences between the indicators of one construct and those of other constructs in the model are examined. This analysis is carried out by comparing the square root of AVE for each construct with the correlation coefficients between the constructs. To this end, a matrix is formed in which the main diagonal values represent the square roots of AVE for each construct, and the upper and lower diagonal values represent the correlation coefficients among the constructs.

Table 2

Comparison Matrix of AVE Square Roots and Construct Correlations

Variables	Green Innovation Strategies	Competitive Market	Green Marketing Capabilities	Green Process Innovation	Green Product Innovation	Sustainable Green Advantage	Big Data Capabilities	Organizational Learning
Green Innovation Strategies	0.799							
Competitive Market	0.572	0.813						
Green Marketing Capabilities	0.725	0.658	0.759					
Green Process Innovation	0.776	0.575	0.728	0.798				
Green Product Innovation	0.753	0.538	0.731	0.782	0.793			
Sustainable Green Advantage	0.598	0.564	0.673	0.615	0.583	0.822		
Big Data Capabilities	0.714	0.697	0.702	0.754	0.714	0.734	0.741	
Organizational Learning	0.715	0.581	0.708	0.715	0.771	0.613	0.737	0.784

As shown in the matrix, the square root of AVE for each construct is greater than the correlation coefficients of that construct with other constructs, which indicates the acceptability of discriminant validity for the constructs.

To evaluate the quality or validity of the model, indices of communality and redundancy were used. Communality assesses the quality of the measurement model for each block.

Table 3

Communality and Redundancy Indices

Variable	Communality (CV Com)	Redundancy (CV Red)
Green Innovation Strategies	0.310	0.217
Competitive Market	0.299	0.279
Green Marketing Capabilities	0.473	0.273
Green Process Innovation	0.411	0.312
Green Product Innovation	0.319	0.211
Sustainable Green Advantage	0.380	0.243
Big Data Capabilities	0.386	0.287
Organizational Learning	0.313	0.221

Furthermore, Tenenhaus et al. (2005) introduced the Goodness of Fit (GOF) index to assess model fit. The overall goodness of fit can be calculated by computing the geometric mean of the average communality and the average R^2 values. For this index, the values of 0.01, 0.25, and 0.36 are described as weak, moderate, and strong, respectively.

$$GOF = \sqrt{(\text{Average Communality} \times \text{Average } R^2)}$$

Table 4

Communality and R^2 Values

Variable	Communality Values	R^2
Green Innovation Strategies	0.580	0.694
Competitive Market	0.651	–
Green Marketing Capabilities	0.576	0.432
Green Process Innovation	0.575	0.602
Green Product Innovation	0.623	0.566
Sustainable Green Advantage	0.612	0.358
Big Data Capabilities	0.523	–
Organizational Learning	0.663	–

As shown in the table, only the endogenous variables have R^2 values. After calculations, the GOF index was obtained as 0.564, which is a strong value and indicates the high overall quality of the model.

The relationships among the studied variables in each of the research hypotheses were tested using causal structure and the partial least squares (PLS) technique. In the overall research model, presented in Figure (1), the measurement model (showing the relationship between each observed variable and its latent construct) and the path model (explaining the relationships among the latent constructs) were calculated. To assess the significance of the relationships, t-statistics were calculated using the bootstrapping technique, the results of which are presented in Figure (2).

Table 5

Path Coefficients

Path Direction	Effect	t-statistic
Competitive Marketing → Green Marketing	0.658	17.275
Green Marketing → Innovation Strategies	0.730	11.154
Organizational Learning → Innovation Strategies	0.584	18.815
Big Data Capabilities → Innovation Strategies	0.861	13.265
Innovation Strategies → Sustainable Advantage	0.598	14.265

The test of the first hypothesis showed that the effect of competitive marketing on green marketing was 0.658, and the corresponding t-statistic was 17.275, which is greater than the critical t-value of 1.96 at the 5% error level, indicating that the observed effect is significant. Therefore, with 95% confidence, competitive marketing has a positive and significant effect on green marketing.

Regarding the second hypothesis, the effect of green marketing on innovation strategies was 0.730, and the corresponding t-statistic was 11.154, which is greater than the critical t-value of 1.96 at the 5% error level, indicating that the observed effect is significant. Therefore, with 95% confidence, green marketing has a positive and significant effect on innovation strategies.

According to the test of the third hypothesis, the effect of organizational learning on innovation strategies was 0.584, and the corresponding t-statistic was 18.815, which is greater than the critical t-value of 1.96 at the 5% error level, indicating that the observed effect is significant. Therefore, with 95% confidence, organizational learning has a positive and significant effect on innovation strategies.

The test of the fourth hypothesis showed that the effect of big data capabilities on innovation strategies was 0.861, and the corresponding t-statistic was 13.265, which is greater than the critical t-value of 1.96 at the 5% error level, indicating that the observed effect is significant. Therefore, with 95% confidence, big data capabilities have a positive and significant effect on innovation strategies.

Finally, the test of the fifth hypothesis showed that the effect of innovation strategies on sustainable green competitive advantage was 0.598, and the corresponding t-statistic was 14.265, which is greater than the critical t-value of 1.96 at the 5% error level, indicating that the observed effect is significant. Therefore, with 95% confidence, innovation strategies have a positive and significant effect on sustainable green competitive advantage.

Figure 1

Model with Beta Coefficients

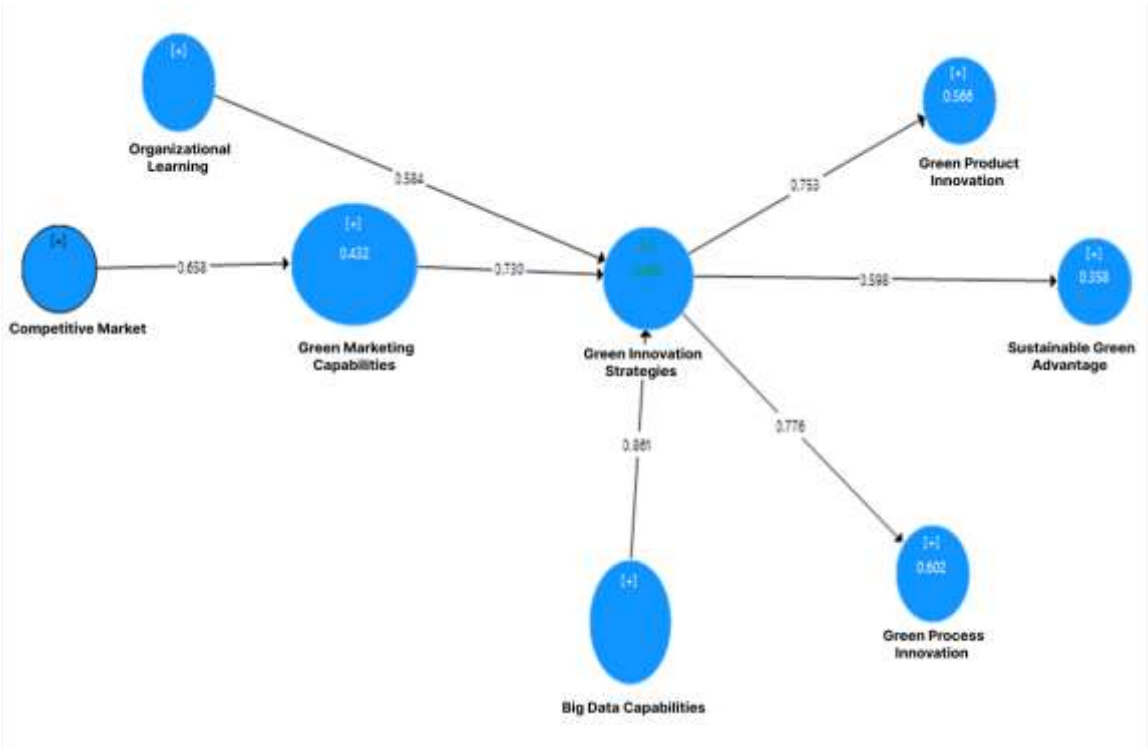
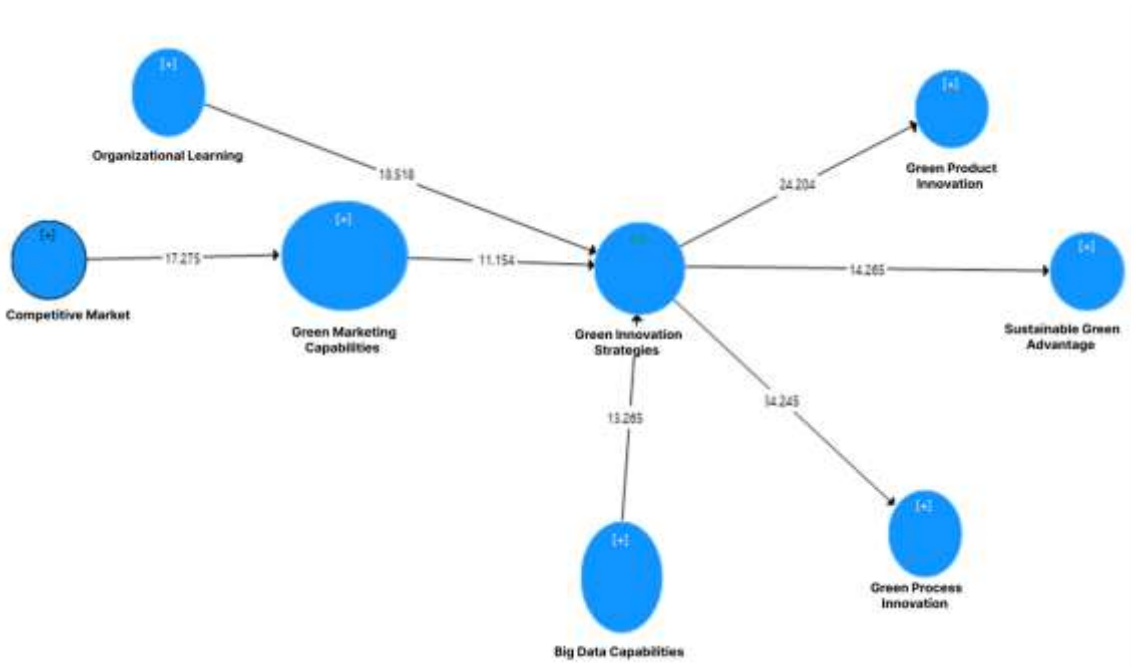


Figure 2

Model with T-Values



Discussion and Conclusion

The findings of this study demonstrate that competitive marketing exerts a significant and positive influence on green marketing, green marketing in turn strongly affects innovation strategies, organizational learning enhances innovation capacity, big data capabilities serve as powerful enablers of green innovation, and finally, innovation strategies positively contribute to sustainable green competitive advantage. Collectively, these results provide empirical evidence that organizational performance and sustainability outcomes are intricately tied to the integration of technological, marketing, and learning-oriented factors. These findings also resonate with the broader literature on sustainability, big data, and green innovation, while adding valuable contextual insights from SMEs operating in Isfahan Province.

The first hypothesis of the study, which confirmed that competitive marketing has a direct and significant impact on green marketing, is consistent with research highlighting the role of market competition in shaping sustainable strategies. Market dynamics push firms to align with consumer expectations for environmentally responsible practices, reinforcing the link between competitive intensity and the development of green marketing capabilities [20, 21]. This alignment echoes prior studies that identified how eco-conscious consumers favor organizations that position sustainability as part of their value proposition, thereby forcing firms to embed green elements into their marketing mix [10, 11]. Our findings extend these insights by demonstrating that in the context of SMEs, competitive market pressures act not only as constraints but also as enablers that accelerate the diffusion of green marketing practices.

The second major finding relates to the significant role of green marketing in influencing innovation strategies. The path coefficient indicated a robust positive relationship, suggesting that firms which prioritize environmental marketing initiatives are more likely to adopt eco-innovation practices. This result is aligned with the literature emphasizing the mediating role of marketing capabilities in translating environmental orientation into tangible innovation outcomes [15, 22]. For instance, research has shown that green marketing strategies not only build brand equity but also create internal momentum for the development of sustainable products and processes [10, 13]. Our findings also support the argument that green marketing fosters organizational legitimacy, thereby strengthening managerial commitment to eco-innovation [9, 26]. In this way, marketing serves as a bridge between external pressures and internal innovation processes.

The third result concerns the positive effect of organizational learning on innovation strategies. This outcome is consistent with studies that recognize learning as a dynamic capability critical to green transformation [2, 16]. Organizational learning enhances the absorptive capacity of firms, enabling them to acquire, assimilate, and apply new knowledge in the pursuit of eco-innovations [29]. In highly dynamic environments, learning-driven adaptability ensures that firms not only adopt sustainable practices but also develop resilience in the face of technological turbulence [12, 19]. These results emphasize the significance of cultivating a culture of continuous improvement and knowledge exchange to promote innovation in SMEs.

The fourth hypothesis highlighted the critical role of big data capabilities in shaping innovation strategies. The strong path coefficient revealed that firms equipped with advanced analytics are more capable of implementing green innovation strategies. This finding reinforces prior evidence on the value of data-driven decision-making in sustaining competitive advantage [4, 5]. Big data enables firms to capture real-time insights, understand evolving customer preferences, and optimize resource allocation, thereby fostering eco-innovative solutions [6, 28]. In the context of SMEs, big data offers particular value by compensating for resource limitations through better forecasting, predictive modeling, and process efficiency [7, 25]. Moreover, studies in industries such as banking, dairy, and pharmaceuticals demonstrate that data-driven

strategies amplify environmental and financial performance simultaneously [8, 30]. Our results underscore the notion that big data serves not just as an operational tool but as a strategic capability for driving sustainable innovation.

The final hypothesis confirmed that innovation strategies significantly contribute to achieving sustainable green competitive advantage. This is consistent with prior studies indicating that eco-innovation serves as a critical pathway through which organizations create enduring differentiation [14, 15]. Innovation strategies, encompassing both product and process dimensions, allow firms to simultaneously address ecological challenges and competitive pressures [10, 11]. For example, the integration of eco-design in products or the optimization of energy efficiency in processes not only reduces environmental impact but also enhances reputation, customer loyalty, and long-term profitability [3, 13]. The present study thus reinforces the argument that green innovation is not merely a compliance requirement but a source of strategic advantage [1].

Taken together, these results provide a holistic picture of how SMEs can develop sustainable competitive advantage by orchestrating resources across marketing, learning, big data, and innovation domains. The interplay between these elements mirrors the integrative frameworks advanced in the literature, where the convergence of digitalization, sustainability, and organizational learning drives long-term resilience [17-19]. The findings also echo perspectives on resource orchestration and dynamic capabilities, which emphasize the need for firms to configure and reconfigure resources in response to environmental changes [24, 29].

From a comparative perspective, the study's results align with evidence from diverse geographical contexts. In Europe, studies have shown that green finance mechanisms play a critical role in enabling eco-innovations [27], while in North Africa, lean management and Industry 4.0 tools were identified as enablers of sustainability and competitive advantage [24]. Similarly, in Asia, research on digital ecosystems and smart tourism confirms that big data-driven innovation facilitates user-centric and sustainable outcomes [28, 30]. The cross-contextual alignment suggests that while regional conditions shape specific pathways, the underlying mechanisms linking big data, learning, marketing, and innovation to competitive advantage are widely applicable.

Another dimension highlighted by this study is the mediating role of organizational learning and marketing in linking technology adoption with sustainability outcomes. Previous studies confirm that organizational learning serves as a mediator between big data capabilities and firm performance [16], while green marketing plays a similar role between environmental orientation and competitive advantage [22]. Our results add further support to these mediating dynamics, emphasizing that technology and resources alone are insufficient without supportive learning cultures and marketing systems.

The contribution of this study lies in its contextualization within SMEs in Isfahan Province, which represents an industrial sector facing both opportunities and constraints in adopting green and data-driven strategies. This focus enriches the broader literature by offering empirical evidence from a non-Western context, thereby responding to calls for more geographically diverse studies in management research [23, 29].

Despite its contributions, this study is not without limitations. First, the cross-sectional design limits the ability to establish causality among the variables studied. While significant relationships were found, longitudinal data would provide a deeper understanding of how these dynamics evolve over time. Second, the reliance on self-reported questionnaire data introduces the possibility of common method bias, as responses may have been influenced by social desirability or subjective perceptions. Third, the study focused exclusively on SMEs in Isfahan Province, which restricts the generalizability of the findings to other regions or industries with different institutional, cultural, and economic contexts. Finally, although the study

integrated multiple dimensions—including big data, marketing, innovation, and organizational learning—it did not incorporate external environmental variables such as regulatory frameworks, competitive intensity across industries, or cultural orientations, which may also play critical roles in shaping sustainable competitive advantage.

Future research could extend these findings by adopting longitudinal designs to examine how the relationships between big data, green marketing, organizational learning, and innovation strategies evolve over time. Comparative studies across different industries and geographical regions would also provide richer insights into the contextual factors that enable or hinder the development of sustainable green competitive advantage. Incorporating qualitative approaches such as interviews or case studies could offer a deeper understanding of the mechanisms and managerial practices that underlie the statistical relationships observed. Additionally, future studies could integrate external environmental variables, such as regulatory pressures, cultural orientations, and institutional support systems, to develop more comprehensive models of sustainability. Examining the role of green finance and policy incentives in supporting SMEs' adoption of big data and eco-innovation would further enhance the practical relevance of future work.

For practitioners, the findings highlight the importance of adopting a holistic approach to sustainability and competitiveness. SMEs should view big data not only as a technological investment but also as a strategic capability that must be integrated with organizational learning and marketing functions. Building a culture of continuous learning and knowledge sharing can enhance the absorptive capacity of firms, enabling them to adapt to turbulence and innovate sustainably. Managers should also prioritize green marketing initiatives, as these not only attract environmentally conscious customers but also serve as catalysts for innovation strategies. Finally, SMEs must recognize that achieving sustainable green competitive advantage requires coordinated efforts across multiple domains—data analytics, innovation, marketing, and organizational culture—rather than isolated initiatives.

Acknowledgments

We would like to express our appreciation and gratitude to all those who cooperated in carrying out this study.

Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Written consent was obtained from all participants in the study.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

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