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Bibliometric Analysis of Sustainable Product Innovation as a Competitive Advantage

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ABSTRACT

This study conducts a comprehensive bibliometric analysis to map the intellectual structure and research evolution of sustainable product innovation as a source of competitive advantage. Using Scopus-indexed publications and VOSviewer visualization techniques, the analysis examines affiliation networks, author collaborations, country co-authorship patterns, keyword co-occurrence structures, density maps, and temporal overlay trends. The results reveal that the field is dominated by strong institutional clusters, global research collaborations, and a dense thematic focus on innovation, sustainable development, competitive advantage, and product development. High-impact literature highlights the role of green innovation performance, dynamic capabilities, big data analytics, and knowledge-based perspectives in strengthening organizational competitiveness. The density and overlay visualizations show a shift from general innovation management toward sustainability-driven strategies, circular economy practices, and technology-enabled green innovation. Overall, the study demonstrates that sustainable product innovation has become a central strategic pillar in enhancing firm competitiveness, supported by interdisciplinary contributions and increasing global academic engagement. These insights provide a foundation for future research directions and practical implications for organizations aiming to integrate sustainability into their innovation processes.

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1. INTRODUCTION

Sustainable product innovation has increasingly become a strategic priority for firms operating in competitive and environmentally conscious markets. As global industries face rising pressure from stakeholders—consumers, regulators, and investors—to adopt sustainability-oriented practices, innovations that minimize ecological impact while enhancing product value have emerged as a critical source of advantage [1], [2]. Across manufacturing, technology, and service sectors, companies are aligning their innovation processes with sustainability principles not only to meet regulatory demands but also to differentiate themselves in crowded markets and cultivate long-term performance advantages [3], [4].

Existing research shows that sustainable product innovation contributes substantially to organizational competitiveness. Highly cited studies such as [5]–[7] emphasize the strong relationship between green innovation performance and corporate strategic advantage, demonstrating that firms that invest in environmentally friendly technologies can create distinctive differentiation in the marketplace. Similarly, [8], [9] highlight how big data and management capabilities strengthen the impact of green innovation on overall firm outcomes. These scholarly contributions position sustainable innovation as both a technological and managerial imperative for modern organizations, reinforcing its role as a core driver of sustainable competitive advantage.

In addition to environmental considerations, sustainable product innovation is tightly connected to organizational knowledge, technological capabilities, and strategic decision-making. Works such as [8], [10] underscore that knowledge-based advantages—particularly technological know-how, knowledge integration, and cross-firm collaboration—directly influence innovation performance and competitive outcomes. This suggests that sustainability-driven innovation is not a single initiative but an integrated strategic process involving dynamic capabilities, continuous learning, and resource orchestration.

Recent developments in technology, especially artificial intelligence (AI), data analytics, and additive manufacturing, have further accelerated sustainable innovation practices. For example, [9], [11] demonstrate how green dynamic capabilities shape firms' ability to innovate sustainably in manufacturing settings, while [10], [12] discuss how 3D printing and advanced production technologies support eco-efficient product development. Similarly, [13]–[17] highlight the emerging challenges of algorithmic bias in data-driven innovation, signaling the need for responsible technological use when implementing AI-supported innovation strategies. These themes indicate that sustainable product innovation is evolving within a technologically advanced ecosystem that offers both opportunities and complexities.

Despite the rapid growth of the literature, the intellectual structure and research evolution of sustainable product innovation as a source of competitive advantage remain fragmented, as studies span multiple domains—including strategic management, environmental science, operations, and information systems—making it difficult to fully understand the field's overarching development. A systematic bibliometric mapping is therefore essential to clarify how key concepts, influential authors, and thematic clusters have shaped the research landscape. By employing a comprehensive bibliometric analysis of Scopus-indexed publications, this study visualizes the structure of the research domain, identifies the most impactful literature, explores knowledge networks, and uncovers thematic patterns characterizing the field. Through network visualization, overlay mapping, density analysis, and citation analysis, the findings provide a clearer picture of how sustainable product innovation has evolved as a strategic mechanism for achieving competitive advantage, offering valuable insights to guide future research and inform practitioners in designing more effective, sustainability-oriented innovation strategies.

2. METHODS

2.1 Design

This study employs a bibliometric analysis approach to systematically map the scientific development of sustainable product innovation and its role in competitive advantage. Bibliometric analysis is widely used to identify publication patterns, influential authors, intellectual structures, thematic clusters, and research evolution within a specific domain. By combining quantitative metrics with network-based visualizations, this method enables

researchers to uncover relationships among keywords, authors, countries, and citations that shape the academic discourse surrounding sustainable innovation.

2.2 Data Source and Selection Process

All bibliographic data for this study were collected from the Scopus database, which was selected for its comprehensive coverage of peer-reviewed publications in management, environmental studies, technology, and innovation, as well as its strong indexing standards, robust citation network, and widespread use in bibliometric research. The search process employed keywords related to "sustainable product innovation," "green innovation," "competitive advantage," and "sustainability-driven innovation," using Boolean operators such as AND, OR, and TITLE-ABS-KEY to ensure accuracy and relevance. To maintain methodological consistency and ensure the inclusion of high-quality scientific work, the search was limited to journal articles written in English, after which duplicate records were removed and the remaining dataset was manually screened to confirm its relevance to sustainable product innovation and competitive advantage.

2.3 Data Cleaning and Preparation

Before running the bibliometric analysis, a rigorous data cleaning process was performed to enhance the accuracy and reliability of the results. This included standardizing author names to correct spelling variations, harmonizing keywords with similar meanings (e.g., "green innovation" vs. "green product innovation"), and consolidating institutional affiliations that appeared under different abbreviations. Additionally, metadata such as publication year, citation counts, country of origin, and source title were verified to ensure completeness. This process ensured that network visualizations, overlay maps, and citation metrics accurately reflected the underlying knowledge structure of the field.

2.4 Analytical Techniques and Visualization Tools

The cleaned data were analyzed using VOSviewer, a widely used software tool for constructing and visualizing bibliometric networks. Several visualization techniques were applied to deepen the understanding of the research landscape. Network visualization was used to map relationships among keywords, authors, and sources, enabling the identification of dominant themes and collaboration patterns, as reflected in Figures 1, 4, and 5. Overlay visualization highlighted the temporal evolution of research themes by distinguishing newer topics with lighter colors and older themes with darker tones, as shown in Figure 2, revealing emerging areas such as algorithmic innovation, AI-supported sustainability practices, and green dynamic capabilities. Density visualization (Figure 3) illustrated the intensity of keyword co-occurrence, where brighter regions indicated central concepts like green product innovation, competitive advantage, and technological capability. In addition, citation analysis examined the most influential articles based on citation counts, with foundational contributions from Chen et al. (2006), El-Kassar & Singh (2019), and Dangelico (2016), allowing researchers to trace conceptual development and methodological trends across the field.

The research procedure followed four systematic phases to ensure methodological rigor. The first phase involved data collection, where Scopus-indexed publications were retrieved using predefined keywords and search strategies. This was followed by data screening, including the removal of duplicates, language filtering, and relevance assessment. The third phase focused on data processing through standardization, metadata verification, and preparation for visualization. Finally, the analysis and visualization phase generated network, overlay, density, authorship, and country maps using VOSviewer, which were subsequently interpreted descriptively to uncover thematic patterns, collaboration

structures, and conceptual evolution within the domain of sustainable product innovation and competitive advantage.

2.5 Ethical Considerations

This study uses publicly accessible bibliographic metadata and does not involve human subjects or sensitive information. All data processing and reporting adhere to ethical research standards, ensuring transparency, reproducibility, and integrity.

3. RESULTS AND DISCUSSION

3.1 Affiliation Network Structure

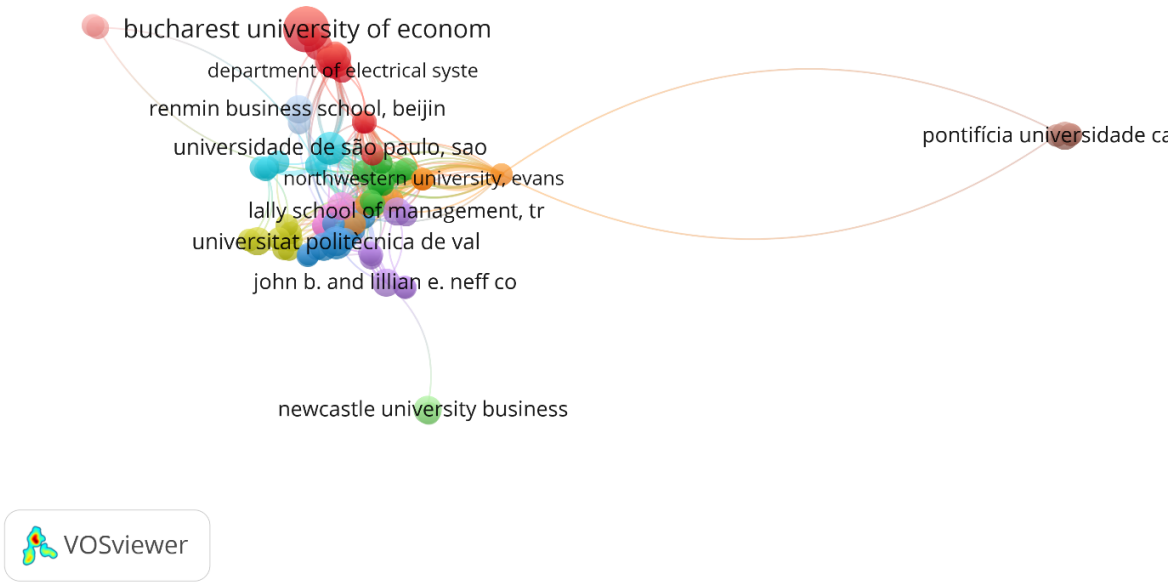

Figure 1. Affiliation
Source: Data Analysis Result, 2025

The affiliation network (Figure 1) reveals that research on sustainable product innovation is dominated by several key institutions forming dense and interconnected clusters, with the Bucharest University of Economic Studies emerging as the largest node due to its strong research output, frequent collaborations, and central role in the field. Other active affiliations—including Renmin Business School (Beijing), Universidade de São Paulo, Northwestern University, Universitat Politècnica de València, and the Lally School of Management—also cluster closely, reflecting repeated co-authorship and shared theoretical orientations in innovation management, sustainability governance, and technology-driven competitiveness. In contrast, Pontifícia Universidade Católica appears more isolated, indicating limited but regionally focused collaboration patterns, while Newcastle University Business School occupies a smaller peripheral position, signaling an emerging yet developing contribution to the domain. Collectively, these institutional linkages highlight a robust European–Asian collaboration landscape, complemented by North and South American participation, underscoring the global relevance of sustainable product innovation in addressing competitive and environmental challenges.

3.2 Author Collaboration Network

Figure 2. Author Visualization
Source: Data Analysis Result, 2025

The author network (Figure 2) shows a diverse pattern of collaboration structured into several distinct clusters, with a prominent group led by authors such as Kaur, Sati Renjit, Al Halbusi, Hussam, Lin, Han, Mady, Khalid, and Hong, Paul C., reflecting a multidisciplinary approach that spans innovation strategy, sustainability, competitiveness, and organizational performance, often supported by cross-country and cross-institutional collaborations typical of research on technological innovation and sustainability. Another major node, represented by Corso, Mariano, forms a smaller yet cohesive cluster indicative of specialized work in managerial innovation, product development, or sustainability adoption frameworks, while Hacklin, Fredrik appears as an isolated but influential node, suggesting contributions through high-impact conceptual or theoretical publications with fewer co-authorship ties. Overall, the collaboration patterns reveal an interdisciplinary and multi-regional research environment that integrates perspectives from innovation management, environmental sciences, and organizational studies, demonstrating a balanced combination of conceptual and empirical inquiry aimed at understanding the link between innovation and competitive advantage.

3.3 Country Collaboration Network

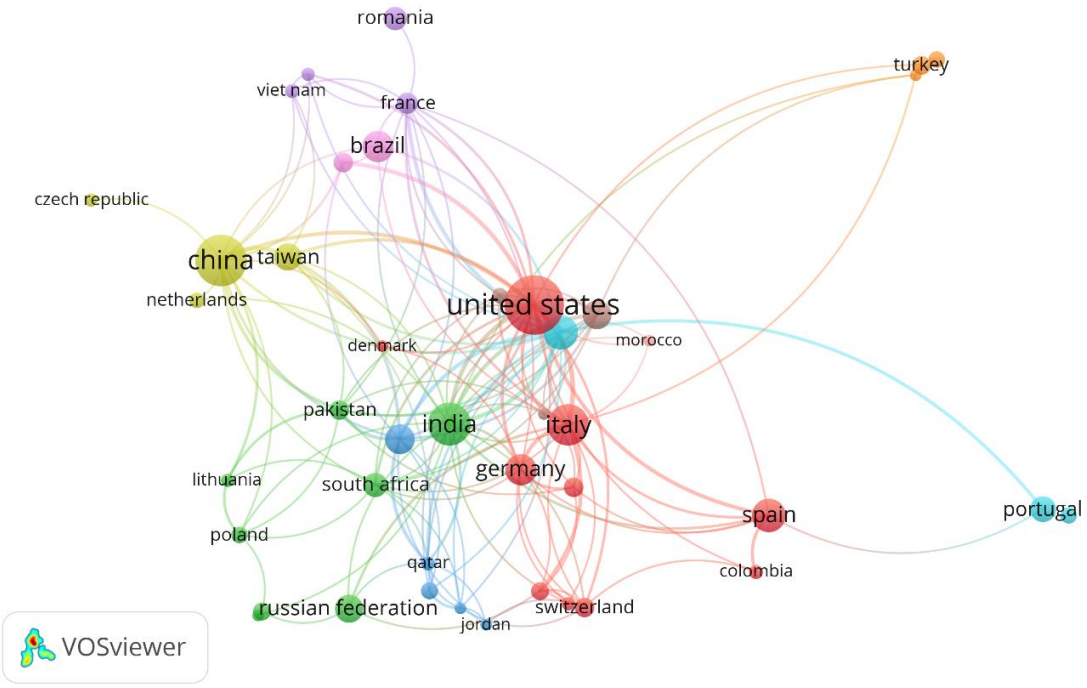

Figure 3. Country Visualization
Source: Data Analysis Result, 2025

The country co-authorship network (Figure 3) demonstrates strong global collaboration patterns, with the United States, China, India, Germany, Italy, and Spain emerging as central hubs due to their high publication volumes and dense international linkages. The United States appears as the dominant node, reflecting its major contributions to innovation studies, sustainability transitions, and competitive strategy research, while China and India follow closely, supported by rapid academic growth and strong interest in green manufacturing, eco-innovation, and technological capability development. European countries—including Italy, Spain, Germany, France, the Netherlands, and Switzerland—form a tightly connected cluster, underscoring Europe's long-standing leadership in sustainability policy, environmental regulation, and circular economy innovation. Additionally, emerging contributors such as Brazil, Morocco, Vietnam, Lithuania, Pakistan, and Qatar highlight the expanding global engagement with sustainability-driven innovation research, collectively indicating that sustainable product innovation has become a worldwide academic endeavor shaped by shared environmental challenges and competitive pressures across regions.

3.4 Keyword Co-Occurrence Network

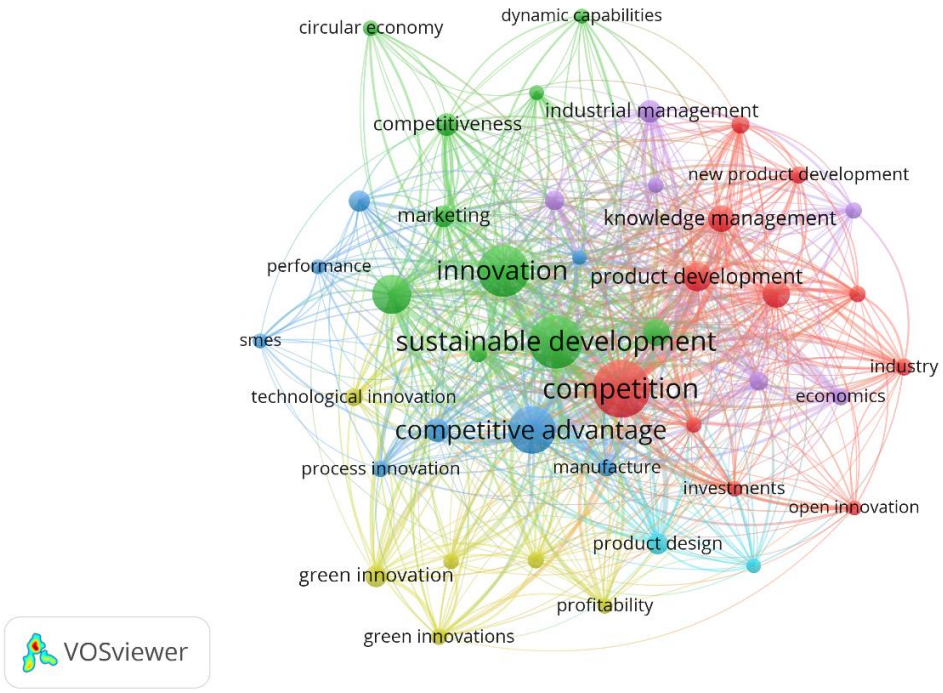

Figure 4. Network Visualization
Source: Data Analysis Result, 2025

Figure 4 presents the keyword co-occurrence network generated through VOSviewer, illustrating the conceptual structure of research on sustainable product innovation and competitive advantage. The central nodes—"innovation," "sustainable development," "competition," and "competitive advantage"—form the core of scholarly attention, showing that innovation serves as the unifying construct linking environmental sustainability with market competition. Surrounding this core, several thematic clusters emerge. The green cluster highlights environmental and technological concepts such as circular economy, competitiveness, technological innovation, and process innovation, indicating the integration of eco-efficiency into product development strategies. Meanwhile, the red cluster emphasizes managerial and organizational themes including knowledge management, industrial management, and new product development, underscoring the role of internal capabilities and knowledge processes in enabling successful sustainable innovation.

Additional clusters complement the framework. The blue–turquoise cluster reflects performance-oriented themes such as profitability, investments, manufacturing, and open innovation, connecting environmental innovation with financial outcomes and strategic differentiation. The yellow cluster shows a growing emphasis on green innovation and SMEs, suggesting that sustainability-driven innovation is increasingly essential not only for large firms but also for smaller enterprises adapting to regulatory and market pressures. Collectively, the network demonstrates a densely interconnected scientific landscape, where sustainability, innovation capability, competitive strategy, and organizational management are deeply interrelated. This indicates a mature and conceptually integrated research domain, with future research likely to explore the dynamic interplay among environmental innovation,

managerial capabilities, technological change, and global competitive pressures.

3.5 Density Visualization

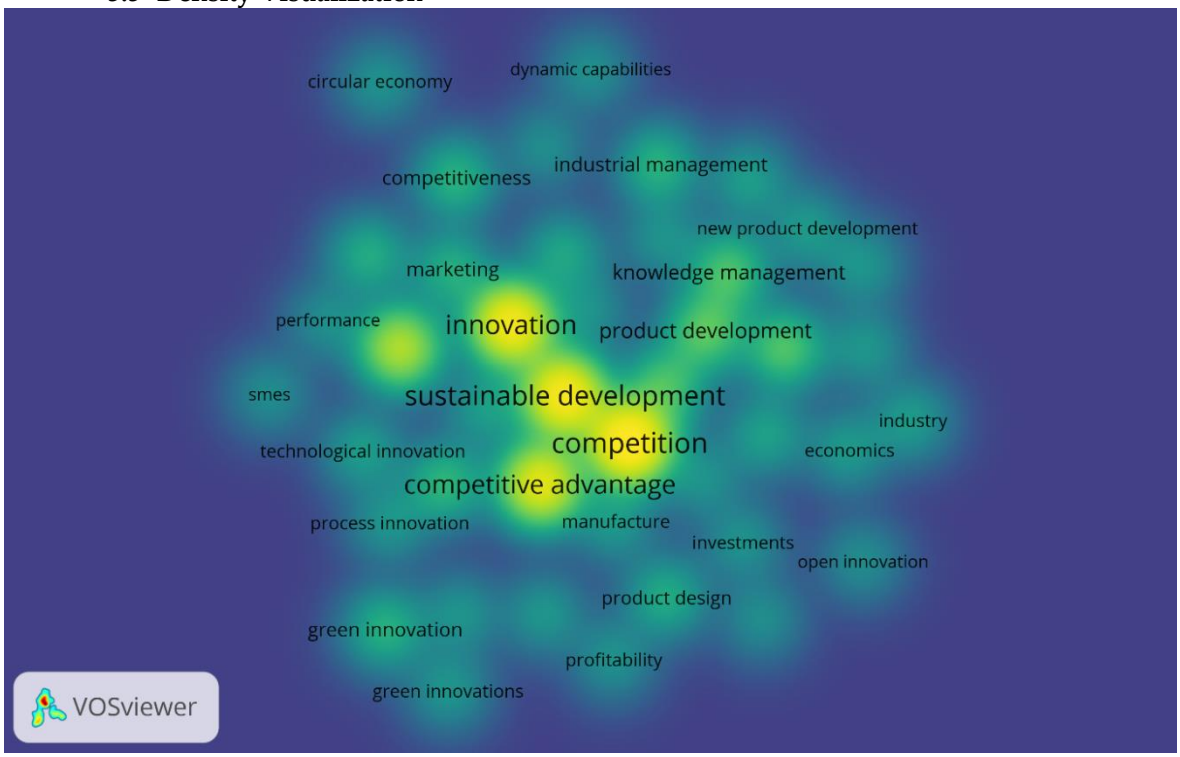

Figure 5. Density Visualization
Source: Data Analysis Result, 2025

The density map (Figure 5) confirms the centrality of key themes such as innovation, sustainable development, competition, and competitive advantage, which appear as bright "hotspots" indicating high keyword co-occurrence and strong thematic dominance. Surrounding these core areas, medium-density regions—comprising knowledge management, industrial management, new product development, technological innovation, and circular economy—reflect active yet somewhat secondary research attention, while lower-density peripheral themes such as SMEs, economics, open innovation, and profitability represent emerging but still developing areas of inquiry. Collectively, the density visualization illustrates a convergent knowledge structure in which innovation and sustainability form the intellectual core, supported by managerial, economic, and technological perspectives that enrich and extend the broader understanding of sustainable product innovation.

3.6 Overlay Visualization (Temporal Evolution)

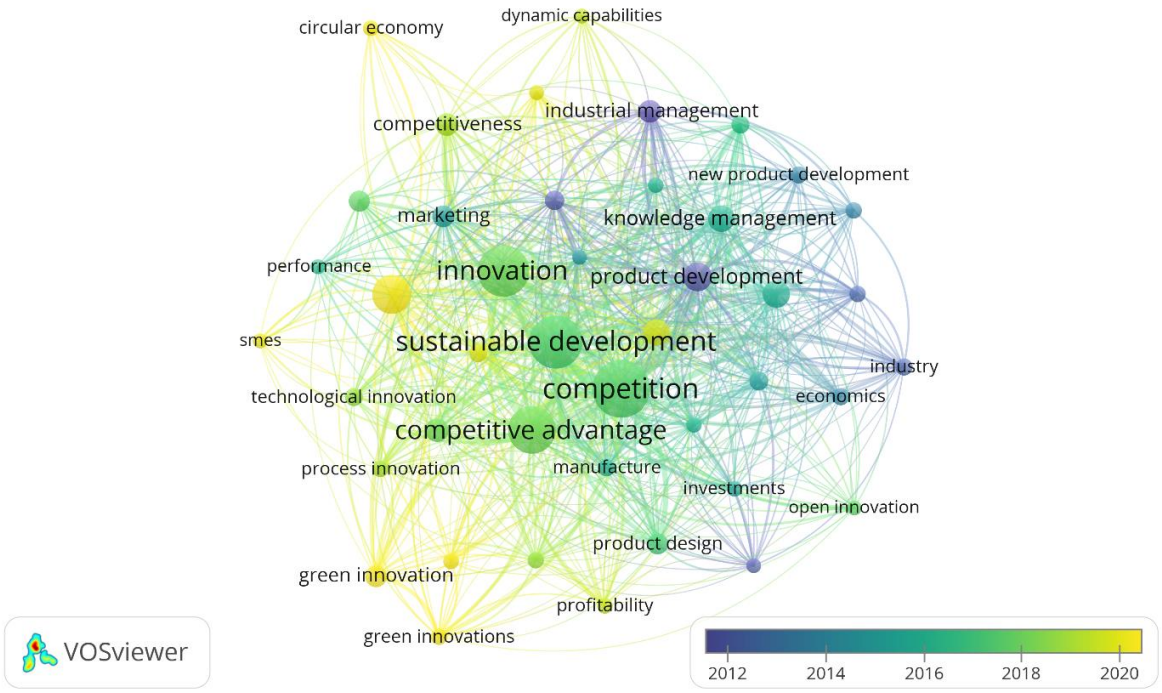

Figure 6. Overlay Visualization

Source: Data Analysis Result, 2025

The overlay visualization (Figure 6) illustrates the temporal evolution of research themes from 2012 to 2020, where earlier studies—represented by darker blue nodes—centered on product development, industrial management, knowledge management, and technology-driven innovation, reflecting foundational discussions on how firms incorporate technological advancements into product design and operational processes. In contrast, more recent studies—shown in yellow and green—emphasize dynamic capabilities, circular economy, green innovation, SMEs, and performance outcomes, signalling a growing academic focus on environmental sustainability, resource efficiency, and economic implications within the innovation process. Overall, this temporal progression indicates a clear shift from general innovation management toward sustainability-oriented competitive strategies, aligning with increasing global environmental pressures and the widespread adoption of ESG-driven organizational practices.

3.7 Citation Analysis of Influential Literature

Table 1. The Most Impactful Literatures

Citations	Authors and year	Title
1887	Chen, Y.-S., Lai, S.-B., Wen, C.-T. (2006)	The influence of green innovation performance on corporate advantage in Taiwan
988	El-Kassar, A.-N., Singh, S.K. (2019)	Green innovation and organizational performance: The influence of big data and the moderating role of management commitment and HR practices
579	McEvily, S.K., Chakravarthy, B. (2002)	The persistence of knowledge-based advantage: An empirical test for product performance and technological knowledge

Citations	Authors and year	Title
519	Dangelico, R.M. (2016)	Green Product Innovation: Where we are and Where we are Going
436	Qiu, L., Jie, X., Wang, Y., Zhao, M. (2020)	Green product innovation, green dynamic capability, and competitive advantage: Evidence from Chinese manufacturing enterprises
365	Jiménez, M., Romero, L., Domínguez, I.A., Espinosa, M.D.M., Domínguez, M. (2019)	Additive Manufacturing Technologies: An Overview about 3D Printing Methods and Future Prospects
356	Khanra, S., Kaur, P., Joseph, R.P., Malik, A., Dhir, A. (2022)	A resource-based view of green innovation as a strategic firm resource: Present status and future directions
305	Takeishi, A. (2002)	Knowledge partitioning in the interfirm division of labor: The case of automotive product development
295	Priem, R.L., Li, S., Carr, J.C. (2012)	Insights and new directions from demand-side approaches to technology innovation, entrepreneurship, and strategic management research
290	Akter, S., McCarthy, G., Sajib, S., ... D'Ambra, J., Shen, K.N. (2021)	Algorithmic bias in data-driven innovation in the age of AI

Source: Scopus, 2025

Table 1 highlights the most impactful publications shaping the domain, with Chen et al. (2006)—the most cited article at 1887 citations—providing early empirical evidence linking green innovation performance to corporate strategic advantage and establishing a foundational perspective that integrates environmental considerations into competitiveness. El-Kassar and Singh (2019) further demonstrate how big data and management capabilities drive green innovation adoption, revealing technology-enabled pathways to competitive outcomes, while Dangelico (2016) contributes a widely used conceptual overview of green product innovation that informs numerous subsequent empirical studies. Additional influential works include Qiu et al. (2020) and Khanra et al. (2022), which emphasize dynamic capabilities and the resource-based view, thereby expanding theoretical approaches to sustainability-oriented innovation. Technological perspectives emerge through Jiménez et al. (2019) on additive manufacturing and Akter et al. (2021) on algorithmic bias, underscoring the integration of Industry 4.0 technologies into sustainability discourse. Collectively, these citation patterns reflect strong theoretical diversity—ranging from RBV and dynamic capabilities to knowledge-based frameworks and digital technology integration—highlighting the multidimensional nature of sustainable product innovation research.

Discussion

Synthesizing all visual results, several core insights emerge: sustainable product innovation has become central to competitive advantage, as evidenced by robust empirical and theoretical contributions from influential literature; collaboration patterns across authors, institutions, and countries are globally distributed, underscoring the interdisciplinary and international nature of the field; and research themes consistently cluster around innovation capability, sustainability integration, knowledge management, and circular economy principles, reflecting a multi-layered conceptual landscape. Emerging trends such as green dynamic capabilities, AI-enabled sustainable innovation, additive manufacturing, and open innovation ecosystems further indicate the future direction of scholarly interest, while the

evolution of themes aligns with global economic and environmental shifts that increasingly position sustainability at the heart of strategic management and organizational performance. Overall, the bibliometric findings affirm that sustainable product innovation is no longer peripheral but a central strategic pillar across industries, with growing attention to how technological advancements, environmental imperatives, and organizational capabilities interact to generate long-term value.

4. CONCLUSION

The bibliometric findings of this study highlight that sustainable product innovation has evolved into a central research domain that significantly contributes to organizational competitive advantage. The analysis of institutional, author, and country networks demonstrates a globally interconnected research ecosystem, where scholars across continents collaborate to advance both theoretical and practical knowledge. Core themes—such as innovation capability, sustainable development, green innovation, product development, and competitive strategy—form the foundational structure of the field, while emerging areas including dynamic capabilities, AI-enabled innovation, additive manufacturing, and circular economy concepts signal a continued shift toward technologically advanced and sustainability-oriented research trajectories. Citation patterns from highly influential studies further reinforce the importance of integrating environmental considerations into innovation processes, showing that sustainability-oriented innovation enhances firm performance through strategic resource allocation, knowledge integration, and digital transformation.

The density and overlay visualizations reveal a clear temporal progression from traditional innovation management toward sustainability-driven models that prioritize environmental responsibility alongside competitive outcomes. Overall, this study concludes that sustainable product innovation is not merely a response to ecological challenges but a strategic mechanism for achieving and sustaining competitive advantage in an increasingly complex global environment. As industries face mounting regulatory, technological, and market pressures, the integration of sustainability principles into innovation processes will continue shaping future business models. The insights generated here provide meaningful guidance for researchers, policymakers, and practitioners seeking to strengthen innovation ecosystems and promote sustainable competitiveness within the evolving global landscape.

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