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Implementation of Sustainable Business Models: A Literature Review

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Abstract

This paper explores the implementation of sustainable business models through a systematic literature review, highlighting advances in the field. Based on a bibliometric analysis using the SciMAT software, this study investigated thematic research trends and patterns between 1996 and 2024, utilizing 3,917 documents from the Scopus database. The importance of this study lies in the growing relevance of sustainable practices as a response to environmental, social, and economic crises, reinforced by the United Nations' (UN) Sustainable Development Goals (SDGs) and the global changes brought about by the COVID-19 pandemic. Sustainable business models differ from conventional ones in that they integrate sustainability objectives into business strategies, aiming to align economic growth, social justice, and environmental preservation. The analysis reveals a significant increase in publications starting in 2015, highlighting themes such as circular economy, business model innovation, life cycle assessment, and Industry 4.0 technologies. The thematic evolution indicates a shift from conceptual approaches to practical applications, emphasizing tools for measuring environmental impact and strategies based on environmental, social, and governance (ESG) criteria. The strategic diagrams employed in the study identify the maturity and centrality of research themes, showing the consolidation of integrated perspectives. This study offers a comprehensive overview of the literature, providing a foundation for researchers, policymakers, and business leaders. It suggests pathways to foster innovation, cross-sector collaboration, and sustainability in the development of more resilient and responsible business models.

Keywords
Sustainable Business Model, Sustainable Development, Sustainable Development Goals, and Systematic Review.

1. Introduction
Sustainable development was consolidated at the UN Conference in Stockholm (1972) and evolved into the Sustainable Development Goals (SDGs) at Rio+20 in 2015, establishing 17 global targets to guide public policies until 2030 (Abad-Segura and González-Zamar, 2021). However, less than 20% of these targets are progressing adequately (United Nations Brazil, 2024). Furthermore, the linear economic model of extraction, production, and disposal continues to harm the environment and human well-being (Constanza et al., 1997; Kwilinski et al., 2023). This model has had severe impacts, including the "sixth mass extinction" and the degradation of biodiversity (Ceballos et al., 2017), as well as exceeding the planet's regeneration limits (Steffen et al., 2015).

Sustainable business models emerge as a response to these challenges, balancing economic growth, environmental preservation, and social justice. Unlike traditional models, they integrate sustainability into business strategy, promoting resilience and mitigating long-term risks. In addition, they prioritize revenue diversification and restrict unlimited growth to ensure operations within the limits of natural resources (Brozovic, 2020).
Despite their importance, implementing these models faces significant barriers, including organizational resistance, a lack of strategic alignment, and high initial costs. Many innovations fail due to these challenges, negatively impacting companies (Chesbrough, 2007). Therefore, overcoming these difficulties requires joint efforts to drive a sustainable transition and minimize environmental and social impacts.

1.1 Objectives

This study analyzes the evolution of sustainable business models, highlighting conceptual changes and emerging and declining themes over time. In addition, it investigates how global factors, such as the Sustainable Development Goals (SDGs) and the COVID-19 pandemic, have impacted these topics in the academic literature.

The research is organized into five sections. Section 2 presents the theoretical framework, discussing fundamental concepts and barriers to implementing sustainable models. Section 3 describes the methods used, highlighting the bibliometric analysis with SciMAT on the business model thematic. Section 4 analyzes the results, highlighting the evolution of the themes and the impacts of the SDGs and the pandemic. Finally, Section 5 summarizes the conclusions, addressing practical and theoretical implications and suggesting directions for future research.

2. Literature Review

2.1 Business Model Definition

The business model describes how an organization creates, delivers, and captures value, connecting strategy and operations (Osterwalder et al., 2005). Initially used to communicate ideas in e-commerce (Zott et al., 2011), it has become an essential strategic tool (Doleski, 2015).

Osterwalder and Pigneur (2010) defined key elements, such as value proposition, target audiences, channels, customer interactions, operations, resources, strategic allies, costs, and revenues, in the Business Model Canvas (BMC). These elements are interdependent, and changes in the value proposition impact the entire structure (Richardson, 2008).

Furthermore, the business model encompasses internal strategies and processes, which are crucial for innovation, especially in Industry 4.0 (Osterwalder et al., 2019). It combines tangible and intangible aspects as a strategic resource for differentiation and long-term success (Teece, 2010).

2.2 Definition of Sustainable Business Model

Sustainable business models have evolved from conventional ones by integrating sustainability into their structures, balancing economic value with social and ecological impacts. This transformation promotes a more responsible financial system aligned with global challenges (Rashid et al., 2013). In this scenario, technological advances have already reduced energy consumption by up to 40% (Evans, 2009). However, there is a rebound effect, where increased efficiency generates greater demand and, consequently, environmental impacts, requiring systemic approaches (Gillingham et al. 2015).

In this context, the ESG (Environmental, Social, and Governance) concept integrates environmental, social, and governance factors. The environmental pillar focuses on reducing ecological impacts, the social pillar addresses human rights and working conditions, and governance encompasses ethics and transparency (Jain and Tripathi, 2023). Companies with rigorous ESG practices attract sustainable investors, strengthening their reputation and market resilience. Therefore, sustainable business models also offer a competitive advantage by aligning economic, social, and environmental interests (Lüdeke-Freud, 2010; Stubbs et al., 2008).

2.3 Innovation in Sustainable Business Models

Innovation in sustainable business models restructures the creation, delivery and capture of value, generating positive social and environmental impacts (Amit et al., 2012). It goes beyond products and services, transforming operating systems and value networks to maximize these benefits (Bocken et al., 2013). To address unsustainability at its root,

it is necessary to modify business logic and integrate long-term considerations. Schaltegger et al. (2012) classify innovations from defensive strategies (incremental adjustments) to proactive strategies, which redesign the business logic for comprehensive sustainable development.
Implementing these innovations can occur through sustainable startups, transformation of existing models or diversification into new approaches (Bocken et al., 2016). Examples include circular economy, energy transition, and offering functionality instead of ownership, as in the Product-Service-System (PSS) (Tukker, 2004). Despite initial challenges, environmental regulations and emerging technologies favor these innovations. Hybrid cars, for example, initially rejected, became viable with regulatory support and market changes. Thus, innovation in sustainable models is not limited to incremental adjustments but promotes profound transformations in value creation.

3. Methods

This paper conducts a bibliometric mapping with the primary objective of mapping the thematic landscape of implementing sustainable business models. The research adopts a qualitative-quantitative approach (Silva et al., 2020), combining the quantification of relevant variables with exploring and understanding the main topics related to the theme. The Science Mapping Analysis Tool (SciMAT) software was utilized due to its ability to integrate methods, algorithms, and measures across all stages of processing, in accordance with the methodological framework proposed by Cobo et al. (2011), as detailed in this chapter and briefly explained in Figure 1.

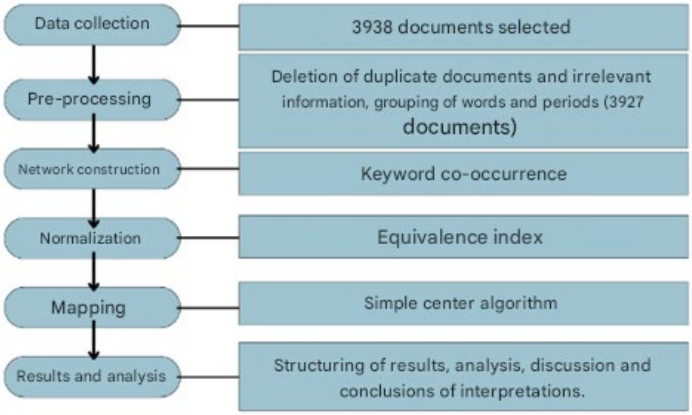


Figure 1. Framework for research mapping (developed based on Cobo et al., 2012).

3.1 Systematic literature search

To begin the analysis, it was first necessary to determine which database the research would be structured in. Scopus was chosen because it is a very popular and reputable database that surpasses other databases, containing almost twice as many peer-reviewed scientific publications. This enables a comprehensive search that yields complete results, facilitating an accurate analysis of this field (Gomez-Jauregui et al., 2014).

The second step was to determine the keywords to search for articles related to the research object. To provide a more comprehensive approach to the topic, only combinations of more generic words were selected. Thus, we searched using “sustainable business model” OR sustainable AND “business model” OR sustainability AND “business model.” As a result, 11,151 documents were obtained.

The filters available in the Scopus database were used to obtain only documents relevant to the study in question. Thus, the filtering began with the research areas, selecting only documents related to engineering and business (Engineering AND Business, Management, and Accounting). Regarding the type of document, only articles and reviews (Article AND review) were selected, as these are materials that feature well-developed studies. Additionally, only articles written in English were selected to facilitate understanding. Finally, there were no filters related to the publication period, as the goal was to understand how the research evolved over the years. Thus, 3,938 documents were obtained for analysis.

3.2 Analysis of documents

A total of 3,938 documents were exported to SciMAT software, containing author, source, abstract, keywords, institution, and citations, but due to duplications and incomplete information, 3,917 documents remained after preprocessing. The total number of keywords in these documents was reduced from 14,962 to 13,347 by grouping variations and synonyms without excluding any relevant information. The documents were organized into five periods: 1996–2009, 2010–2014, 2015–2019, 2020–2022, and 2023–2024. This categorization considers the increase in publication volume following the 2015 SDGs and the COVID-19 pandemic, which profoundly influenced research on sustainable business models.

Keywords were analyzed based on co-occurrence, i.e., the frequency with which they appeared together in the documents (Cobo et al., 2011). Data reduction applied minimum frequency and edge value thresholds to prioritize relevant connections. The equivalence index was used to measure the strength of links between clusters and normalize co-occurrence frequencies (Cobo et al., 2011; Callon et al., 1991). The simple center algorithm, widely used in co-word studies, was adopted for clustering, highlighting the connections between clusters (Bailón-Moreno et al., 2005). Core mapping (Core Mapper) identified the most relevant documents, while the h-index assessed the impact and influence of clusters in the analyzed set (Alonso et al., 2009). These steps revealed thematic evolution and advances in studies on sustainable business models.

Once all processing for scientific mapping has been completed in SciMAT, strategic diagrams, also known as Callon diagrams, are obtained, as illustrated in Figure 2. These diagrams refer to the analysis for each group of previously delimited periods.

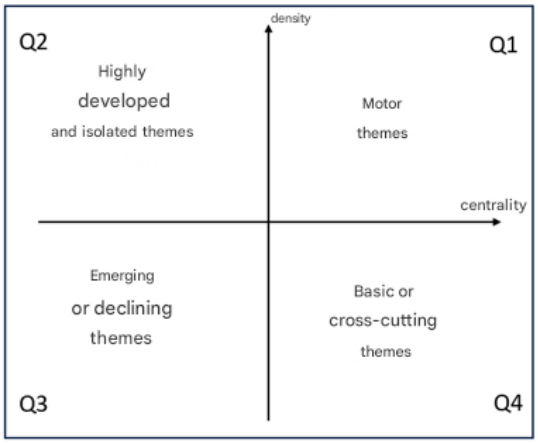


Figure 2. Strategic diagram (Cobo et al., 2011).

The diagrams used are two-dimensional, organized into four quadrants based on density (y-axis), which measures the strength of internal connections, and centrality (x-axis), which assesses the connection of a cluster with others. The first quadrant (Q1) brings together driving and central themes, the second (Q2) highlights developed but isolated themes, the third (Q3) covers emerging or declining themes, and the fourth (Q4) addresses basic and underdeveloped themes (Cobo et al., 2011).

4. Results and discussions

4.1 Temporal analysis

The research's temporal analysis aims to understand how the topic of sustainable business model implementation has evolved over the years from 1996 to 2024. This evolution is directly related to external factors, such as global initiatives and significant events, including the adoption of the Sustainable Development Goals (SDGs) and the impact of the COVID-19 pandemic. The graph presented in Figure 3 and the data tabulated in Table 1 provide a detailed view of the increase in the number of publications and the keywords used over the years.

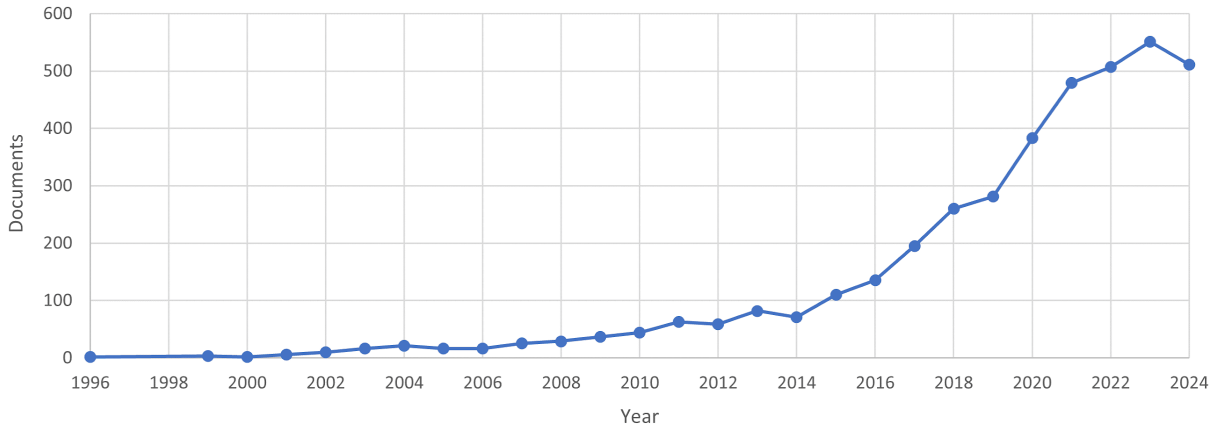


Figure 3. Graph of the temporal development of the theme (Authors, 2024).

The graph demonstrates an exponential growth in scientific production on the topic, especially from 2015 onwards, coinciding with adoption the Sustainable Development Goals (SDGs) and the increasing global awareness of corporate sustainability. The period from 2020 to 2023 witnessed a rapid increase in the number of publications, likely driven by the impact of the COVID-19 pandemic, which underscored the need for resilient and sustainable business models. In 2024, a slight decline in publication volume is observed, which may indicate the maturation of the field and a transition towards more specific and applied studies.

Table 1. Number of documents and keywords by period.

Periods	Documents	Keywords
1996-2009	183	982
2010-2014	321	1817
2015-2019	983	4388
2020-2022	1373	6348
2023-2024	1067	4908

4.2 Development of research topics

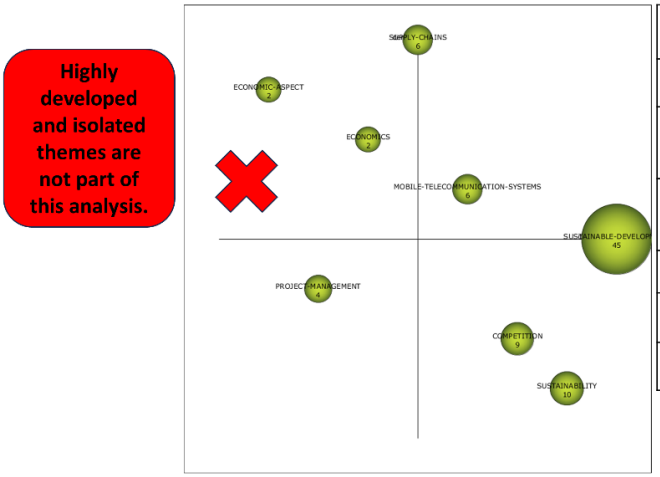
The analysis of the following five strategic diagrams enables us to understand the thematic evolution of the research field on sustainable business models, considering the number of documents and the h-index of each thematic cluster. In this way, the classification of the themes in the quadrants of the diagrams reflects their centrality and density, which are fundamental aspects for determining the degree of development, impact, and relevance of each topic in the field. In this analysis, the themes in the second quadrant, which present high density and low centrality, were excluded because they are isolated and specialized topics with little connection to the main structure of the field.

4.2.1 Period 1996-2009

Between 1996 and 2009, the field of sustainable business models began to consolidate itself in the academic literature, with 183 documents and 982 keywords identified (Table 1). During this period, publications focused on conceptual formulation and differentiation between traditional and sustainable models, seeking to align economic performance, reduction of environmental impacts, and social demands. A landmark of this period was the work of Stubbs and Cocklin (2008), who proposed a theoretical model to conceptualize "sustainable business models" as an alternative to traditional profit-based paradigms.

Despite this conceptual advance, the practical adoption of these models was limited by the lack of global awareness of challenges such as climate change and environmental degradation, resulting in a relatively low number of publications. The strategic analysis of this period (Figure 4) shows the predominance of quadrant Q1 (driving themes), with "sustainable development" leading as the central topic (45 documents, h-index of 15). This theme was essential to structure the field, establishing theoretical bases for integrating sustainability into business (Pieroni et al., 2019).

a)



b)

Cluster	Number of documents	h-index
Suply chain (Q1/Q2)	6	2
Mobile Telecommunication Systems (Q1)	6	3
Sustainable development (Q1/Q4)	45	15
Competition (Q4)	6	9
Sustainability (Q4)	10	9
Project management (Q3)	4	3

Figure 4. a) Strategic diagram for 1996-2009 obtained from the SciMAT software; b) Expository table of the data found (Authors, 2024).

In quadrant Q3 (emerging themes), topics such as "competition" and "project management" began to explore the relationship between sustainability, competitiveness, and organizational management, but still with little connection to the core research. Quadrant Q4 (marginal themes) included "sustainability" (10 documents, h-index of 9), highlighting sustainability as a competitive differentiator but without great centrality or density. Quadrant Q2 (highly developed and isolated themes) presented "economics" and "supply chains", well-developed topics but disconnected from the central research core.

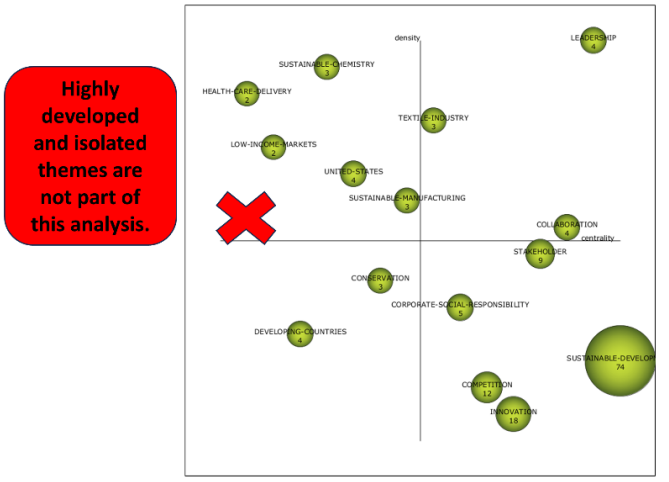
These results demonstrate that, in the initial period, the field was in a structuring phase, emphasizing fundamental concepts and little practical application. The topic's evolution in the following years was driven by the maturation of academic discussions and the increase in social and political pressure for more sustainable business practices.

4.2.2 Period 2010-2014

Between 2010 and 2014, the number of publications on sustainable business models increased to 321 documents, with a significant increase in the use of keywords, which reached 1,817 (Table 1). This increase reflects a broader recognition of the strategic role of sustainability in companies, driven by public policies and greater social awareness about the limits of economic growth based on excessive consumption. In this context, eco-efficiency has become a central approach to align operational efficiency and reduction of environmental impacts (Bocken et al., 2013), while the circular economy and product-service systems have been highlighted as promising models for transforming business.

The theme "sustainable development" was further consolidated during this period, with 74 documents and an h-index of 33 (Figure 5), strengthening the theoretical basis of the field and encouraging its application in specific sectors. At the same time, innovation began to play a central role, with "innovation" reaching 18 documents and an h-index of 14, demonstrating a growing interest in practical strategies for implementing sustainability in business (Santa-Maria et al., 2022).

a)



b)

Cluster	Number of documents	h-index
Leadership (Q1)	4	3
Textile industry (Q1)	3	2
Collaboration (Q1)	4	3
Stakeholder (Q4)	9	8
Corporate social responsability (Q4)	5	3
Sustainable development (Q4)	74	33
Competition (Q4)	12	9
Innovation (Q4)	18	14
Conservation (Q3)	3	2
Development countries (Q3)	4	4

Figure 5. a) Strategic diagram for 2010-2014 obtained from the SciMAT software; b) Expository table of the data found (Authors, 2024).

In quadrant Q3, emerging themes such as “developing countries” and “conservation” emerged, reflecting an initial interest in sustainability applied to specific contexts, such as developing countries and environmental preservation. In quadrant Q4, “corporate social responsibility” (CSR) appeared with 5 documents and an h-index of 3, suggesting social responsibility integration into sustainable business practices. In addition, topics such as “collaboration,” “competition,” and “stakeholder” began to connect business operations to sustainability, influencing both driving and emerging themes. Of note was “competition,” which addressed strategies to reconcile sustainability and competitiveness, anticipating more practical trends and preparing the ground for the Sustainable Development Goals (SDGs) launched in 2015.

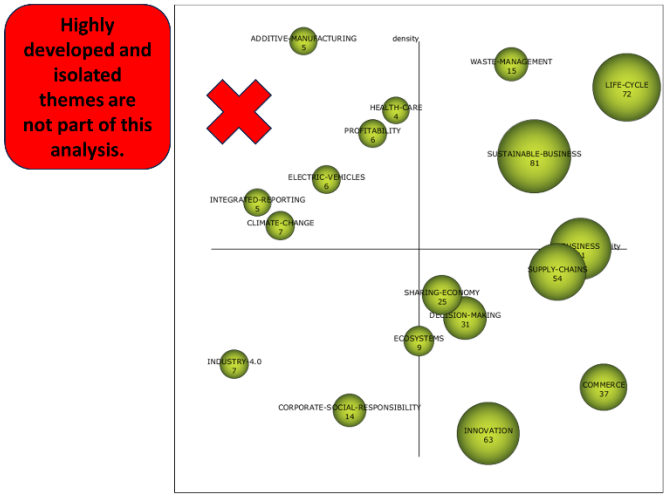
Although this period marked significant progress, growth was not yet exponential. However, the increasing adoption of sustainable practices and strengthening discussions on innovation indicated that the field was poised for accelerated evolution in the following years.

4.2.3 Period 2015-2019

The period 2015–2019 marked a turning point in the research field, with the number of publications increasing to 983 documents and keywords reaching 4,388 (Table 1). This growth coincided with adopting the Sustainable Development Goals (SDGs) during the Rio+20 Conference in 2015, driving the integration of environmental, social, and economic goals into corporate and academic agendas. The SDGs have come to guide the global sustainability agenda, directly influencing research into sustainable business models (Geissdoerfer et al., 2018).

The change in focus was also reflected in the literature, as can be seen in Figure 6, with "sustainable development" giving way to "sustainable business," which led as the central theme, with 81 documents and an h-index of 56. Life cycle assessment (Q1) emerged as a strategic tool for measuring and mitigating environmental impacts throughout the production chain, aligned with SDG 12, enabling the adoption of sustainable standards from production to the disposal of products and services.

a)



b)

Cluster	Number of documents	h-index
Life cycle (Q1)	72	43
Sustainable business (Q1)	81	56
Waste management (Q1)	15	14
Business (Q1/Q4)	61	34
Suply chain (Q4)	54	39
Sharing economy (Q4)	25	23
Decision making (Q4)	31	23
Commerce (Q4)	37	23
Innovation (Q4)	63	28
Coporate social responsability (Q3)	14	10
Industry 4.0 (Q3)	7	7

Figure 6. a) Strategic diagram for the period 2015-2019 obtained from the SciMAT software; b) Expository table of the data found (Authors, 2024).

In quadrant Q3, Industry 4.0 emerged as an emerging theme, driven by technologies such as the Internet of Things (IoT), artificial intelligence, and blockchain, increasing industrial efficiency and resilience in line with SDG 9 (Industry, Innovation and Infrastructure). In quadrant Q4, the Sharing Economy stood out as an alternative to linear consumption, promoting the sharing of goods and services and contributing to SDGs 12 and 13 by reducing waste and emissions. Also, in this quadrant, sustainable supply chain management gained strength, exploring the integration of environmental and social criteria from acquiring raw materials to delivering products, aligning with SDGs 12 and 9. Furthermore, practices such as the circular economy and ESG (Environmental, Social, and Governance) have established themselves as key strategies for transforming business models. This period marked a significant evolution in research, evidencing a transition from conceptual approaches to practical applications aimed at meeting global sustainability goals.

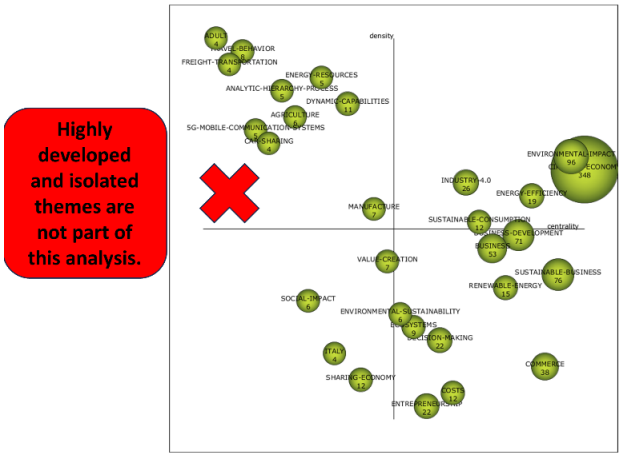
4.2.4 Period 2020-2022

Between 2020 and 2022, the COVID-19 pandemic accelerated digitalization and the adoption of green technologies, enabling companies to implement more sustainable practices in a rapidly changing business landscape (Geissdoerfer et al., 2023). The number of publications in the period reached 1,373 papers and 6,348 keywords (Table 1), driven by two main factors: reduced pollution during lockdowns (Shehzad et al., 2020) and increased academic productivity due to researchers' extra time (Furstenau et al., 2021).

The research field has seen a thematic reconfiguration, with the term "sustainable development" being replaced by more specialized approaches, such as "circular economy" (348 documents, h-index of 72) and "environmental impact" (96 documents, h-index of 40). This reflects the segmentation of sustainability studies, focusing on strategies such as waste reduction and environmental impact measurement, aligned with SDGs 12 and 13.

In the quadrant analysis (Figure 7), the circular economy stood out in quadrant Q1, while "energy efficiency" and "Industry 4.0" emerged in Q3, with a focus on renewable energy and industrial digitalization. The "sharing economy" declined in Q4, reflecting the decrease in collaborative services during the pandemic. In addition, themes such as "sustainable business" and "business development" migrate to a strategic role, supporting emerging areas, such as the circular economy and environmental impacts, from the perspective of ESG criteria.

a)



b)

Cluster	Number of documents	h-index
Environmental impact (Q1)	96	40
Industry 4.0 (Q1)	26	20
Energy eficiency (Q1)	19	11
Circular Economy (Q1)	348	72
Sustainable Cosumption (Q1)	12	11
Business development (Q4)	71	35
Business (Q4)	53	26
Sustainable business (Q4)	76	37
Renewable energy (Q4)	15	9
Decision making (Q4)	22	13
Commerce (Q4)	38	19
Entrepreneurship (Q4)	22	7
Social impact (Q3)	6	4
Sharing economy (Q3)	12	10
Value creation (Q3)	7	5

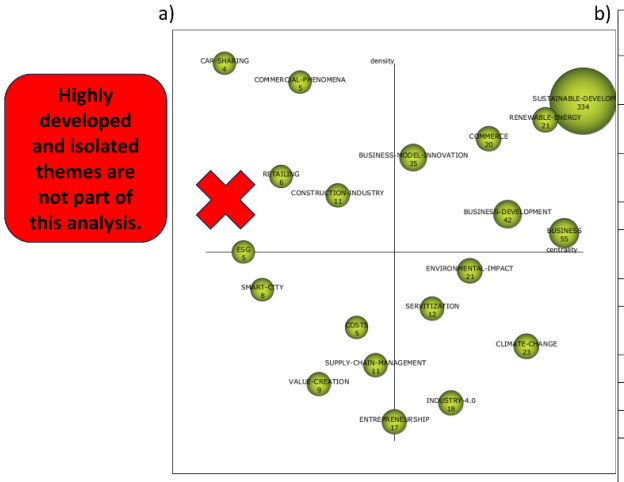
Figure 7. a) Strategic diagram for 2020-2022 obtained from the SciMAT software; b) Expository table of the data found (Authors, 2024).

4.2.5 Period 2023-2024

Between 2023 and 2024, research on sustainable business models stabilized, with 1,067 publications and 4,908 keywords (Table 1). This reflects the maturation of the field and a greater focus on qualitative studies and empirical analyses (Uvarova et al., 2023). The exploratory approach gave way to a more practical application of sustainable business models.

In the first quadrant, as shown in Figure 8, the theme "sustainable development" was once again dominant, bringing together sub themes such as "circular economy", "environmental impact," and "life cycle", reflecting a more integrated approach to the SDGs and the urgency of their global goals (Raman et al., 2023). The "business model innovation" concept stood out, aligned with SDGs 9 and 12, promoting technological innovation to increase sustainability and competitiveness (De Simone et al., 2023).

a)



b)

Cluster	Number of documents	h-index
Sustainable development (Q1)	334	29
Renewable energy (Q1)	21	7
Business model innovation (Q1)	35	10
Commerce (Q1)	20	7
Business development (Q1)	42	13
Business (Q1)	55	13
Environmental impact (Q4)	21	8
Servitization (Q4)	12	4
Climate change (Q4)	23	7
Industry 4.0 (Q4)	18	8
Entrepreneurship (Q4)	17	2
Smart city (Q3)	8	4
Suply chain management (Q3)	11	6
value creation (Q3)	9	4
costs (Q3)	5	3

Figure 8. a) Strategic diagram for 2023-2024 obtained from the SciMAT software; b) Expository table of the data found Aauthors, 2024).

In the third quadrant, the concept of a "smart city" emerged, highlighting the application of technologies for sustainable cities, which aligns with SDG 11. "Value creation" also became an important theme, emphasizing the role of stakeholders in generating sustainable value (Raman et al., 2023).

In the fourth quadrant, "servitization" and "sharing economy" indicate the transition to models based on services and regenerative practices aligned with SDG 12. "Environmental impact" and "Industry 4.0" were repositioned, reflecting a more complementary role, focusing on digitalization and blockchain as facilitators of circular and regenerative chains (Sreenivasan et al., 2023).

5. Conclusion

This study provides a comprehensive analysis of the evolution of sustainable business models by applying bibliometric techniques to a systematic literature review spanning the period from 1996 to 2024. Through the use of the Science Mapping Analysis Tool (SciMAT), the research mapped key thematic trends, conceptual developments, and the consolidation of research domains related to sustainability-oriented business practices. The results demonstrate a progressive shift from foundational theoretical discussions toward more applied, innovation-driven approaches, reflecting the growing maturity and strategic relevance of the field.

The analysis revealed that sustainable business models have become increasingly central to academic and managerial discourse, particularly in the context of global transformations prompted by the Sustainable Development Goals of the United Nations and the socioeconomic impacts of the COVID-19 pandemic. Topics such as circular economy, life cycle assessment, Industry 4.0, and business model innovation have gained prominence, signaling a deepening integration between sustainability and organizational strategy.

By examining the density and centrality of thematic clusters, this study contributes to a clearer understanding of how research in this field has evolved, offering valuable insights for scholars, policymakers, and business leaders. The findings highlight the crucial role of sustainable business models in enabling resilience, value creation, and long-term competitiveness in increasingly complex and dynamic environments.

In conclusion, sustainable business models represent a critical pathway for aligning economic performance with social and environmental responsibility. This study reinforces the urgency of advancing integrated strategies that foster

innovation, collaboration, and systemic thinking to support the transition toward more inclusive and sustainable business ecosystems.

References

Abad-Segura, E., De La Fuente, A., González-Zamar, M. D., and Belmonte-Ureña, L. J., Effects of circular economy policies on the environment and sustainable growth: Worldwide research, *Sustainability (Switzerland)*, vol. 12, no. 14, pp. 1–27, 2020.

Abad-Segura, E. and González-Zamar, M. D., Sustainable economic development in higher education institutions: A global analysis within the SDGs framework, *Journal of Cleaner Production*, vol. 294, April 20, 2021.

Alonso, S., Cabrerizo, F. J., Herrera-Viedma, E., and Herrera, F., h-Index: A review focused in its variants, computation and standardization for different scientific fields, *Journal of Informetrics*, October 2009.

Beattie, V. and Smith, S. J., Value creation and business models: Refocusing the intellectual capital debate, *British Accounting Review*, vol. 45, no. 4, pp. 243–254, December 2013.

Bocken, N., Short, S. W., Rana, P., and Evans, S., A value mapping tool for sustainable business modelling, *Corporate Governance (Bingley)*, vol. 13, no. 5, pp. 482–497, 2013.

Bocken, N. M. P., Short, S. W., Rana, P., and Evans, S., Product design and business model strategies for a circular economy, *Journal of Industrial and Production Engineering*, vol. 33, no. 5, pp. 308–320, July 3, 2016.

Ceballos, G., Ehrlich, P. R., and Dirzo, R., Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines, *Proceedings of the National Academy of Sciences of the United States of America*, vol. 114, no. 30, pp. E6089–E6096, July 25, 2017.

Chesbrough, H., Business model innovation: It's not just about technology anymore, *Strategy and Leadership*, vol. 35, no. 6, pp. 12–17, 2007.

Cobo, M. J., López-Herrera, A. G., Herrera-Viedma, E., and Herrera, F., An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the Fuzzy Sets Theory field, *Journal of Informetrics*, vol. 5, no. 1, pp. 146–166, January 2011.

Costanza, R., De Groot, R., Farber, S., Grassot, M., Hannon, B., Limburg, K., Naeem, S., Paruelo, J., Raskin, R. G., and Sutton, P., The value of the world's ecosystem services and natural capital, *Nature*, vol. 387, no. 6630, pp. 253–260, May 15, 1997.

De Simone, V., Di Pasquale, V., Nenni, M. D. and Miranda, S., Sustainable production planning and control in manufacturing contexts: a bibliometric review, *Sustainability (Switzerland)*, Multidisciplinary Digital Publishing Institute (MDPI), September 1, 2023.

Doleski, O. D.**,** Integrated Business Model: *Applying the St. Gallen Management Concept to Business Models*, Springer Fachmedien Wiesbaden, 2015. DOI: 10.1007/978-3-658-09698-4.

Evans, S., *Towards a sustainable industrial system: with recommendations for education, research, industry and policy*, University of Cambridge, 2009.

Furstenau, L. B., Rabaioli, B., Sott, M. K., Cossul, D., Bender, M. S., Farina, E. M. J. M., Filho, F. N. B., Severo, P. P., Dohan, M. S. and Bragazzi, N. L., A bibliometric network analysis of coronavirus during the first eight months of COVID-19 in 2020, *International Journal of Environmental Research and Public Health*, vol. 18, no. 3, pp. 1–24, February 1, 2021.

Geissdoerfer, M., Vladimirova, D. and Evans, S., Drivers and barriers for circular business model innovation, *Business Strategy and the Environment*, vol. 32, no. 6, pp. 3814–3832, September 1, 2023.

Geissdoerfer, M., Vladimirova, D. and Evans, S., Sustainable business model innovation: a review, *Journal of Cleaner Production*, Elsevier Ltd, October 10, 2018.

Ghisellini, P., Cialani, C. and Ulgiati, S., A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems, *Journal of Cleaner Production*, vol. 114, pp. 11–32, February 15, 2016.

Gillingham, K., Rapson, D. and Wagner, G., The rebound effect and energy efficiency policy, *Review of Environmental Economics and Policy*, vol. 10, no. 1, pp. 68-88, 2015, https://doi.org/10.1093/reep/rev017.

Gomez-Jauregui, V., Gomez-Jauregui, C., Manchado, C. and Otero, C., Information management and improvement of citation indices, *International Journal of Information Management*, vol. 34, no. 2, pp. 257–271, 2014.

Guldmann, E. and Huulgaard, R. D., Barriers to circular business model innovation: a multiple-case study, *Journal of Cleaner Production*, vol. 243, January 10, 2020.

Jain, K. and Tripathi, P. S., Mapping the environmental, social and governance literature: a bibliometric and content analysis, *Journal of Strategy and Management*, Emerald Publishing, August 1, 2023.

Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A. and Hekkert, M., Barriers to the circular economy: evidence from the European Union (EU), *Ecological Economics*, vol. 150, pp. 264–272, August 1, 2018.

Kwilinski, A., Lyulyov, O. and Pimonenko, T., Environmental sustainability within attaining sustainable development goals: the role of digitalization and the transport sector, *Sustainability (Switzerland)*, vol. 15, no. 14, July 1, 2023.

Lüdeke-Freund, F., Gold, S. and Bocken, N. M. P., A review and typology of circular economy business model patterns, *Journal of Industrial Ecology*, Blackwell Publishing, February 1, 2019.

Osterwalder, A., *The business model ontology: a proposition in a design science approach*, Université de Lausanne, Lausanne, 2004.

Osterwalder, A., Pigneur, Y. and Tucci, C. L., Clarifying business models: origins, present, and future of the concept, *Communications of the Association for Information Systems*, vol. 16, 2005.

Pieroni, M. P. P., McAloone, T. C. and Pigosso, D. C. A., Business model innovation for circular economy and sustainability: a review of approaches, *Journal of Cleaner Production*, Elsevier Ltd, April 1, 2019.do

Raman, R., Lathabhai, H., Mandal, S., Kumar, C. and Nedungadi, P., Contribution of business research to sustainable development goals: bibliometrics and science mapping analysis, *Sustainability (Switzerland)*, vol. 15, no. 17, September 1, 2023.

Rashid, A., Asif, F. M. A., Krajnik, P. and Nicolescu, C. M., Resource conservative manufacturing: an essential change in business and technology paradigm for sustainable manufacturing, *Journal of Cleaner Production*, vol. 57, pp. 166–177, October 15, 2013.

Richardson, J., The business model: an integrative framework for strategy execution, *Strategic Change*, vol. 17, no. 5–6, pp. 133–144, August 1, 2008.

Ritala, P., Huotari, P., Bocken, N., Albareda, L. and Puumalainen, K., Sustainable business model adoption among S&P 500 firms: a longitudinal content analysis study, *Journal of Cleaner Production*, vol. 170, pp. 216–226, January 1, 2018.

Ritzén, S. and Sandström, G. Ö., Barriers to the circular economy - integration of perspectives and domains, *Procedia CIRP*, Elsevier B.V., 2017.

Rizos, V., Behrens, A., Van der Gaast, W., Hofman, E., Ioannou, A., Kafyeke, T., Flamos, A., Rinaldi, R., Papadelis, S., Hirschnitz-Garbers, M. and Topi, C., Implementation of circular economy business models by small and medium-sized enterprises (SMEs): barriers and enablers, *Sustainability (Switzerland)*, vol. 8, no. 11, November 23, 2016.

Santa-Maria, T., Vermeulen, W. J. V. and Baumgartner, R. J., How do incumbent firms innovate their business models for the circular economy? Identifying micro-foundations of dynamic capabilities, *Business Strategy and the Environment*, vol. 31, no. 4, pp. 1308–1333, May 1, 2022.

Schaltegger, S., Lüdeke-Freund, F. and Hansen, E. G., Business cases for sustainability: the role of business model innovation for corporate sustainability, *International Journal of Innovation and Sustainable Development*, vol. 6, no. 2, pp. 95–119, 2012.

Silva, A. L. E., Moraes, J. A. R., Benitez, L. B. Kaufmann, E. A. and Furstenau, L. B.Mapping of scientific production on the use of biocomposites in 3D printing processes, *Ibero-American Journal of Environmental Sciences*, vol. 11, no. 1, pp. 236–250, January 6, 2020.

Sreenivasan, A., Ma, S., Nedungadi, P., Sreedharan, V. R. and Raman, R. R., Interpretive structural modeling: research trends, linkages to sustainable development goals, and impact of COVID-19, *Sustainability (Switzerland)*, vol. 15, no. 5, March 1, 2023.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., De Vries, W., De Wit, C. A., Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, L. M., Ramanathan, V., Reyers, B. and Sörlin, S., Planetary boundaries: guiding human development on a changing planet, *Science*, vol. 347, no. 6223, February 13, 2015.

Stubbs, W. and Cocklin, C., Conceptualizing a "sustainability business model", *Organization and Environment*, vol. 21, no. 2, pp. 103–127, June 2008.

Teece, D. J., Business models, business strategy and innovation, *Long Range Planning*, vol. 43, no. 2–3, pp. 172–194, April 2010.

Tukker, A., Eight types of product-service system: eight ways to sustainability? Experiences from suspronet, *Business Strategy and the Environment*, vol. 13, no. 4, pp. 246–260, July 2004.

Uvarova, I., The typology of 60R circular economy principles and strategic orientation of their application in business, *Journal of Cleaner Production*, vol. 409, July 10, 2023.

Zott, C. and Amit, R., Business model design: an activity system perspective, *Long Range Planning*, vol. 43, no. 2–3, pp. 216–226, April 2010.

Zott, C., Amit, R. and Massa, L., The business model: recent developments and future research, *Journal of Management*, July 2011.

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