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Sustainable Business Models Innovation and Design Thinking: A Bibliometric Analysis and Systematic Review of Literature

Juliana Kurek [1,*], Luciana Londero Brandli [1], Marcos Antonio Leite Frandoloso [1], Amanda Lange Salvia [1] and Janaina Mazutti [1,2]

[1] Graduate Program in Civil and Environmental Engineering, University of Passo Fundo, Campus I—BR 285, Passo Fundo 99052-900, RS, Brazil
[2] Research and Transfer Centre "Sustainable Development and Climate Change Management", Hamburg University of Applied Sciences, Ulmenliet 20, 21033 Hamburg, Germany
* Correspondence: jkurek@upf.br

Abstract: The process of integrating sustainability into businesses and processes is still recent, both in startups, small and medium-sized companies and even multinationals. Sustainable business models became a phenomenon of global interest and Design Thinking has been increasingly used as a strategy to support this process. In this context, the aim of this article is to improve the understanding of how Design Thinking (DT) and its set of tools and methods contribute to the creation and innovation of sustainable business models (SBM). The analysis of frameworks indicates that the main methodologies linking Design Thinking and Sustainable Business Models are Workshops, Brainstorming, Co-creation and Prototyping. Also, approaches such as Circular Economy, Business Models and Product-Service System models are emerging as a means of enabling the collaborative consumption of products and services and with positive results for sustainable business. The analysis of the articles reveals that user-oriented innovation and analysis of stakeholder needs is present in practically all evaluated frames, but prototyping and experimentation represent a gap that should be better explored in the frameworks.

Keywords: sustainability; innovation; innovative sustainable business models; design thinking; framework

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1. Introduction

Technological advances have been changing the world, raising humanity to new standards of living and increasing the consumption of goods and services, leading to the increased generating of waste and pollution. Correspondingly, the number of scientific publications on the subject has also increased significantly, especially covering the sustainability approach to innovation in business models, which had been ignored in traditional models that focus exclusively on economic issues [1]. Currently, sustainability is recognized as a central issue, as well as an opportunity for businesses. It is applied not only in product and/or process changes but also to new combinations of products and services and business models [2]. Achieving better organizational performance is directly related to management decisions on innovation in production processes and business models.

Some research in the format of systematic literature review (SLR) [3–5] seeks to understand the principles and role of the process of business models in the transition to sustainability, in addition to outlining trends in this field of research. However, several gaps are identified to advance in a design for SBM. Recent studies have evaluated the evolution of the innovation process of sustainable business models under the lens of design [6,7]. These authors analyzed existing sustainability assessment frameworks and tools for business models and related them to design principles.

Design Thinking presents user-centric problem-solving approach and has recently attracted research interest as a possible approach to solving complex socioecological

problems [8–12]. Conceptually, DT aims to translate observations into insights, and insights into products and services that can improve lives [13]. The DT process is interactive and consists of steps that do not follow a linear order, but a rather complex one [14]. However, changing from a product-centric perspective to a solution-oriented perspective is a challenge [15].

Carlgren and colleagues [16] discuss similarities and discrepancies in the way the concept is generally portrayed. The study based on empirical interviews led to the development of a framework to identify five themes that characterize DT: User Focus, Problem Framing, Visualization, Experimentation and Diversity. According to the authors, there is a need to address production processes, products and service provision, while designing consumption patterns and lifestyles for the transformation into sustainable social processes [16,17]. O DT can be at the center of the discussion, contributing to the construction of a systemic methodology to generate new sustainable business models (SBMs) [18].

The purpose of DT is to develop creative and user-relevant ideas to find a solution that could have a positive impact on the future [11]. In this way, the integration of DT into the innovation process in SBMs helps to create additional forms of value and includes stakeholders previously lacking in the value proposition. Thus, the sustainable value ideation process helps companies improve their performance while becoming more sustainable.

Recently, Pan and colleagues [18] indicate that the development of research in SBM is positive and that greater collaboration between institutions and authors is needed to explore the internal drivers and design SBM, since the topic is emerging, but is affected by a high failure rate due to the lack of reliable and efficient methods. In this way, the need to apply DT to SBMI is highlighted. However, the localized articles are not enough to specify the DT implementation and present the main practical points for the survival of the construction and application of a method for the SBM design [11].

The scope of this review encompasses existing frameworks and tools that address the assessment and monitoring of the sustainability of business models, as well as the understanding of how DT and its set of tools and methods contribute to business creation and innovation de SBM. A literature review and a systematic literature review are useful for locating existing studies and assessing their contributions to past research and directing future research. To formulate the review question, an initial review of the most relevant literature was carried out, including reviews on sustainable business models and archetypes [19], innovation of sustainable business models, tools to support the benchmark study on sustainable business models, sustainable business circular business [2,20], and guiding principles and sustainability assessment criteria for Innovation in sustainable business models SBMI [21–23].

In this context, this study aims to improve the understanding of how Design Thinking (DT) and its set of tools and methods contribute to the creation and innovation of sustainable business models (SBM). Three research questions guide the development of this paper:

RQ1. Which are the academic sources and articles that have been influencing research on innovative SBMs?

RQ2. Which are the trending research topics in the area of innovative business models?

RQ3. Why is DT guiding and contributing to the use of innovation in SBMs?

While responding to these research questions, this study presents an analysis of models, methods, processes and tools to support the ideation and construction of SBMs from the perspective of DT and presents the main practical points for the construction and application of a method to o design SBM.

2. Sustainable Business Models and Design Thinking for Innovation and Sustainability

2.1. Sustainable Business Models

There are several definitions for the business model process and a variety of descriptions about what the components are, how they are interconnected and how they create value in a proposal [19–22]. The Business Model Canvas [21] is the most used conceptual tool and contains a set of objects, concepts and relationships to express the business

logic of a company or company network. It also indicates how the company delivers and exchanges value.

The notion of SBMs derives from the qualification of business models with concepts from theories of corporate sustainability [23]. It includes theories on stakeholder management [24] and sustainable value creation [25]. Consequently, a SBM incorporates multiple stakeholders, the creation of value (monetary and non-monetary) for a wide range of stakeholders, and a long-term perspective.

Assessing the influence and relationship of stakeholders in the sustainable innovation process, [26] note the need for organizations and institutions not only to satisfy the diverse expectations of stakeholders, but also to meet the growing need for innovations focused on sustainability.

Tyl and colleagues [27] highlight, however, that the thought of creating local value can be a great perception for designers to develop more eco-innovative concepts, through the design of new products and new business models. In this direction, they include resources that are needed for local project operation processes.

Innovation in SBMs is defined as the process of redefining the core objective and how the company delivers sustainability across economic, social and environmental aspects [25]. Design, as a creative activity, proposes to develop products and services based on human needs in which multidisciplinary teams adopt an orientation to find relevant solutions to complex problems as an approach to the development of innovative solutions to the challenges of sustainability [16]. Poldner and colleagues [28] highlight that translating a message of innovation and sustainability into a tangible product involves preserving support for techniques of transformation and addition of novelties.

2.2. Design Thinking for Innovation and Sustainability

The DT process comprises value ideation, value opportunity selection, and value proposition and includes previously underserved stakeholders in the value proposition. Therefore, the ideation of sustainable value can be contemplated in the process and support companies to improve their performance [12].

Despite the diversity in the DT approach, several universities have introduced DT programs centered on frameworks that present a set of tools and that emphasize a human-centered approach, as well as interdisciplinary teams [18].

Brown [13] organizes the Design Thinking process into three spaces or stages: (i) inspiration, (ii) ideation and (iii) implementation. The inspiration stage is characterized by the problem or opportunity that motivates the search for solutions, obtained through observation, empathy and immersion in the context. Ideation is the process of generating, developing and testing ideas, identifying patterns, defining opportunities and creating solutions. Implementation is the last step, corresponding to the path that takes the innovation to the market.

The DT process based on the experiences of various projects and which has been used at the Hasso-Plattner Institute and Stanford University presents the process in five iterative steps [29]: (i) empathy that is the basis of human-centered design development; (ii) the definition of insights and the scope of a significant challenge of the problem from the user's point of view; (iii) ideation, which is the moment to explore a wide space of solutions and a wide diversity of ideas; (iv) the prototype with low cost and low resolution features to learn and quickly explore new possibilities; (v) and, finally, testing—that it is the stage of gathering feedback, redefining solutions and continuing to learn about its users [30].

When approaching design management at its operational level, [31] recommend considering the implications that each design activity will have on the environment, which highlights the need to have a more comprehensive view, not only of the productive process, but also of the consequences of process. The discipline that focuses on the environmental dimension of sustainability allied to the design process is usually called product life cycle design, or even Eco-design and Design for Environment [32]. The focus of this approach is

intervention at the origin (i.e., design of the product or service) in order to minimize its impact on the environment [31].

2.3. Methods and Tools for Developing Sustainable Business Models

The Business Model Canvas [21] and its wide use to model businesses for small businesses or large corporations, as well as create new businesses, indicates that it is an important and recognized tool for understanding and communicating an organization's business model [33]. However, for organizations that pursue sustainability-oriented innovation, new creative tools are needed to design a balance between the pillars of sustainability (economic, social and environmental) [9,33–35].

To assist companies in setting up or transitioning to SBMs, researchers and practitioners have developed tools and processes to facilitate their design; for example, the Design of Flourishing Enterprises approach [36], the Triple-Layered Business Model Canvas [33] and the Value Mapping Tool [25,37]

The Triple Layer Business Model Canvas [33] is a tool to support this creative exploration of SBMs and sustainability-driven innovation more broadly. It integrates the original business model canvas concept and integrates new layers that explore the creation of environmental and social value, in addition to the economic [21].

Using a Canvas for SBMs designed for the linear economy as a starting point certainly carries the risk of falling back into old and linear design patterns of business models. Therefore, an approach for circular models has been developed and addressed by several authors [38–40].

Recently, archetypes distributed by environmental, social and economic categories with the main types of innovation derived from the concepts of sustainable development and the TBL approach [33] are supporting and composing the proposals for innovation of SBMs [41–43].

To operationalize observations, field notes, evaluation forms and user discussions, interviews and co-creation sessions, brainstorming and value mapping, workshops are widely used by several authors in their proposals [1,35,38,44–46].

The business model innovation process aims to ensure the sustainable development of an organization. And it can be a completely new [21] or improved [19] business model, or a multifaceted and integrated business model [12]. Geissdoerfer and colleagues [47] distinguished four generic configurations of business model innovation: start-ups, business model transformation, business model diversification, and business model acquisition.

3. Methodology

This paper applies a two-approach methodology to respond to its research questions: bibliometric analysis and systematic review of the literature. In doing so, models and variables involved in the process of innovation in business models were identified, and the contribution of DT has been discussed.

As for the sampling and screening process a Table 1 presents the applied criteria. A search string was used in two databases (Web of Science and Scopus) to maximize the number of results for analysis, without limitation for the publication year and covering all languages. Using this set of criteria, 371 articles were found (already excluding duplicates and early access papers). This set of articles (n = 371) was investigated by means of bibliometric analysis (responding to RQ1). A second assessment consisted of selecting articles that focused exclusively on frameworks, conceptual models, methods or tools which were associated with DT practices (n = 33). This set was investigated through systematic review (responding RQ2 and RQ3).

After searching the Web of Science and Scopus databases using bibliometric tools, the following are presented: (i) Evolution of publications on the topic; (ii) Places where the topic is published and discussed; (iii) Most cited reference articles; (iv) Geography of scientific publication.

Table 1. Sampling criteria for the selection of articles in scientific databases.

Phases	Description
Formulation of the review question	RQ1. Which are the academic sources and articles that have been influencing re-search on innovative SBMs? RQ2. Which are the trending research topics in the area of innovative business models? RQ3. Why is DT guiding and contributing to the use of innovation in SBMs?
Location of studies	Databases: Web of Science and Scopus Period: Not specified (all papers between 1900–2022) Language: All languages
Selection of studies for review	Search String: ("Sustainable Business Model*" OR "Sustainable Business Model* Innovation") AND ("Design Thinking" OR "Design") (TOPIC i.e., title, abstract and keywords)
Analysis of these studies and synthesis of the findings	Bibliometric analysis and Systematic review literature

The systematic review process considered as follows [48]: (1) formulation of the review question, (2) location of studies, (3) selection of studies for review and (4) analysis of these studies and synthesis of findings in a set of design principles. It was also based on the guidelines for the preparation of the Preferred Reporting for Systematic Reviews (PRISMA 2020) [49] which indicates, among several guidelines, that we should indicate the conduct of the systematic review process through a flowchart containing the form of selection, inclusion and exclusions of review also specific the number of jobs generated by the database.

In conducting and synthesizing the data, content analysis was used, which consists of a set of techniques for analyzing texts in a systematic way [50], which can be applied qualitatively and quantitatively to assess structural (descriptive) aspects and of content [51]. The research from [50,52] suggests four steps for conducting a content analysis: (i) material selection, (ii) descriptive analysis, (iii) category selection and (iv) material evaluation, [53].

This process resulted in thirty-three (33) relevant articles listed in Appendix A. The articles were identified by adherence to the theme involving innovation in sustainable business models with studies addressing **models, framework, methods or tools** that were associated with DT practices. The epistemological definition of these concepts can generate a wide discussion; therefore, the research was based on current definitions with a focus on the construction of artifacts generated by research in design science. Thus, for Dresch and collaborators [54] "**models** can be understood as a set of propositions or statements that express relationships. They are considered representations of reality that present both the variables of a given system and their relationships". March and Smith [55] state that "in design, models represent situations as statements of problems and solutions", and the authors present **method** as "a set of steps necessary to carry out a certain task, intended/desired results. (. . .) Methods can be linked to models and method steps can use parts of the model". Lacerda and colleagues [56] complement and reinforce that the methods are typical research creations in design science. Thus, the method can be understood as the way in which an objective is achieved through the implementation of predetermined procedures (such as frameworks, for example). Caixeta and Fabricio [57] state that, in general, a **framework** is designed to visualize and solve a problem and consists of a skeleton that serves to aggregate processes, methods and techniques. It fundamentally has assumptions, concepts, values and practices that guide execution. The **tool**, in turn, is a resource that can be used to achieve a certain result and can be inserted into a method. Caixeta and Fabricio [57] define tools as "a device or instrument to perform a specific function". In the context of this research, the declaration of the authors of the articles under study was also taken into account regarding the conceptualization of their proposals. That is, if the article proposes/presents a model, framework, method and tool.

The reference identification process by the selection of articles for the SLR is based on the conceptual references of several authors about the Design Thinking process; therefore,

similarities between the proposals for defining the steps, by different authors, can be observed [14,29,30,58–60].

Carlgren and colleagues [16] perform the analysis of the DT discourse from the managerial point of view, allowing for an investigation of the concept and its application in practice. The authors reveal five main characteristics: (i) focus on the user; (ii) problem framing; (iii) visualization; (iv) experimentation and (v) diversity.

Similar to DT, the Lean Startup methodology [61] also brings an iterative and user-centered approach based on a three-step customer feedback loop: (i) build, (ii) measure, (iii) learn [61]. As a result, it involves creating a Minimum Viable Product (MVP) that is the simplest possible prototype that must be tested with customers.

Design Thinking uses creativity in the pursuit of innovation and experimentation. Solutions are developed iteratively based on knowledge of the needs of users, customers and stakeholders, generating solutions that capture, create and deliver value. Furthermore, testing solutions from inception to problem resolution validate business viability and customer desire [61–63].

Based on these references, four (4) categories were established that were considered relevant for the evaluation of the selected articles: (A) User focus and stakeholder need analysis; (B) Co-creation and interdisciplinary; (C) Capture, create and deliver value; and (D) Prototyping and Testing.

This process is summarized in Figure 1-PRISMA flow diagram for systematic reviews.

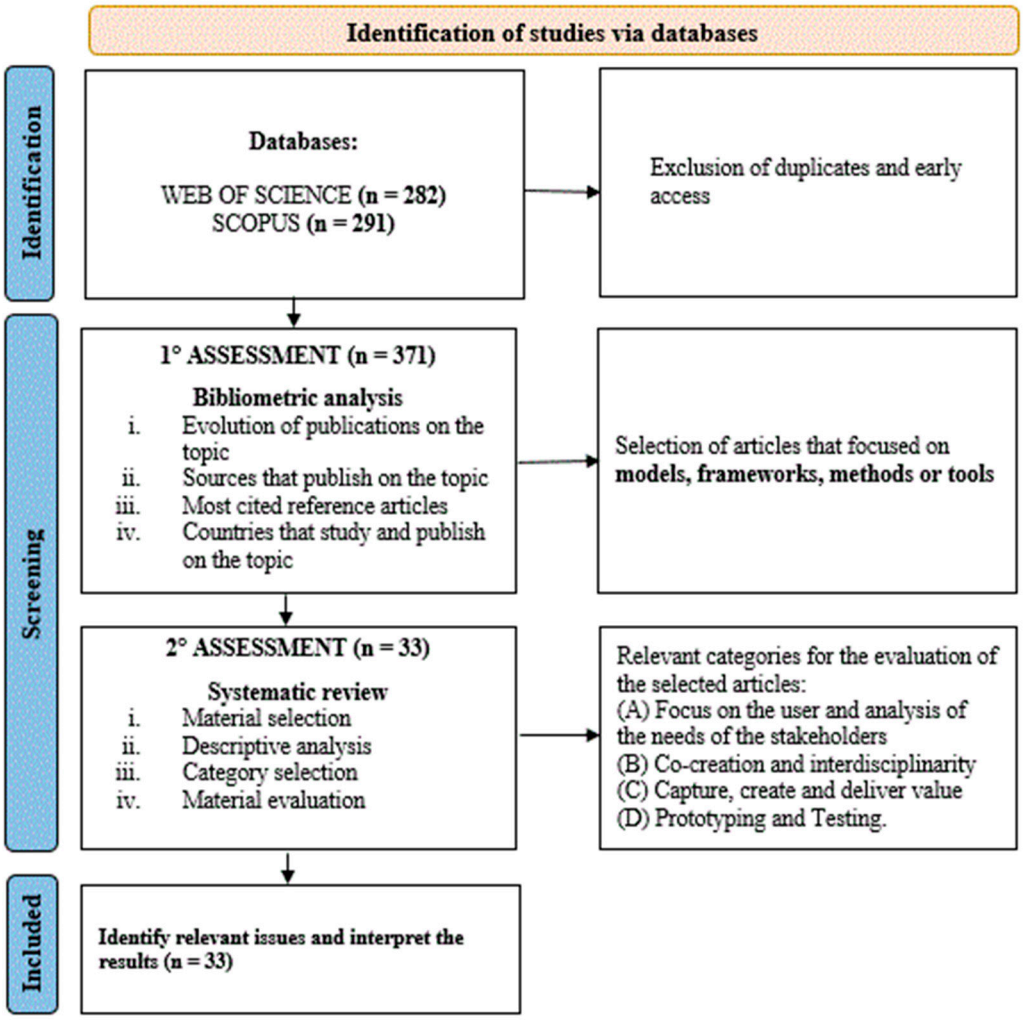

Figure 1. PRISMA flow diagram for systematic reviews.

4. Results

4.1. Research on Innovative Sustainable Business Model

The presentation of the study results starts with the bibliometric analysis and the state-of-the-art using the search strings related to Sustainable Business Model, Innovation and Design Thinking.

Figure 2 provides an overall picture of the number of articles published per year. The analysis of this bibliometric analysis shows an increase in the number of publications, particularly between 2012 and 2020. Furthermore, the last four years (2018–2021) comprise 60% of all publications within the analyzed period, which confirms the increasing importance and interest in the topic of SBMs, innovation and DT.

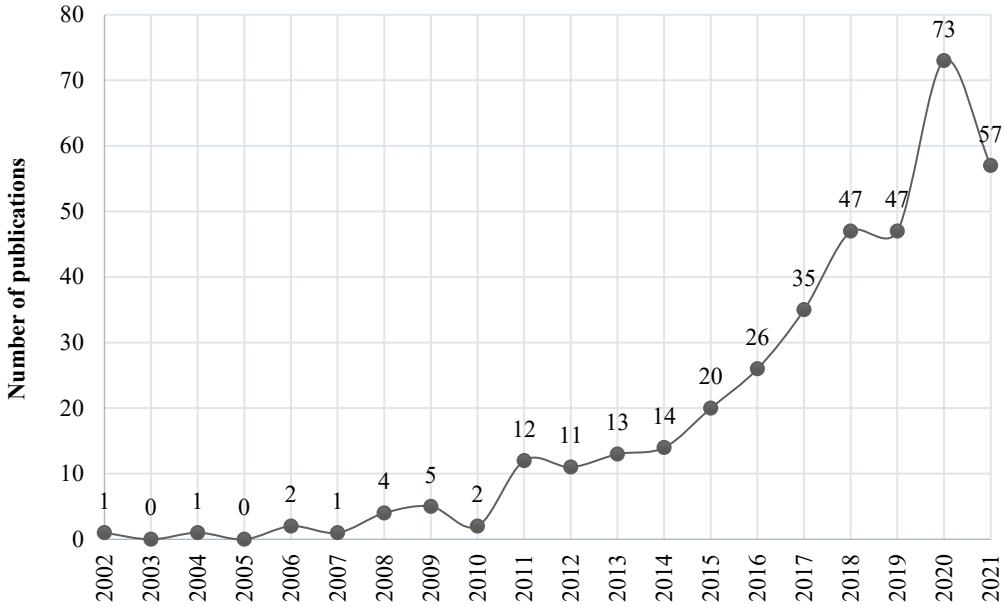

Figure 2. Scientific production on the topic.

Additionally, the analysis has shown that 66% of the published documents are articles, followed by 20% classified as proceedings or conference papers. Reviews and book chapters are represented by 8% and 3% of the sample, respectively.

The analyzed articles were published in 200 different sources. Almost 40% of all publications are concentrated in 10 main sources, as shown in Figure 3. The other sources represent less than 1% in terms of articles published. The top 2 sources are the Journal of Cleaner Production, with 57 published documents (15%) and Journal Sustainability, with 42 articles (11%). The impact factors of these journals are 9.297 and 3.251, respectively.

Regarding the number of citations per analyzed article, Table 2 summarizes the top 10 most cited publications. In total, the set of 371 analyzed articles had 6432 citations to date.

The most cited study is "Designing the Business Models for Circular Economy-Towards the Conceptual Framework" from [64], published as an article in Sustainability. It has 452 citations to date and uses literature review to analyze circular economy based on a business model structure. The author redefines the business model canvas and identifies new components (the take-back system and adoption factors).

The second most cited study is "The triple layered business model canvas: A tool to design more sustainable business models", from [33], with 313 citations. The findings also lead to the creation of two new dynamics for analysis (horizontal coherence and vertical coherence), but in the context of a case study and the provision of a design tool to integrate sustainability in business model innovation.

Completing the top 3 most cited studies is the paper "Business Model Innovation for Sustainability: Towards a Unified Perspective for Creation of Sustainable Business Models" published in 2017 by [65]. With 291 citations in total, it also uses literature review to analyze

business model innovation and finalizes with five propositions to support innovation in the contexts of SBMs, with especial attention given to the role of stakeholders.

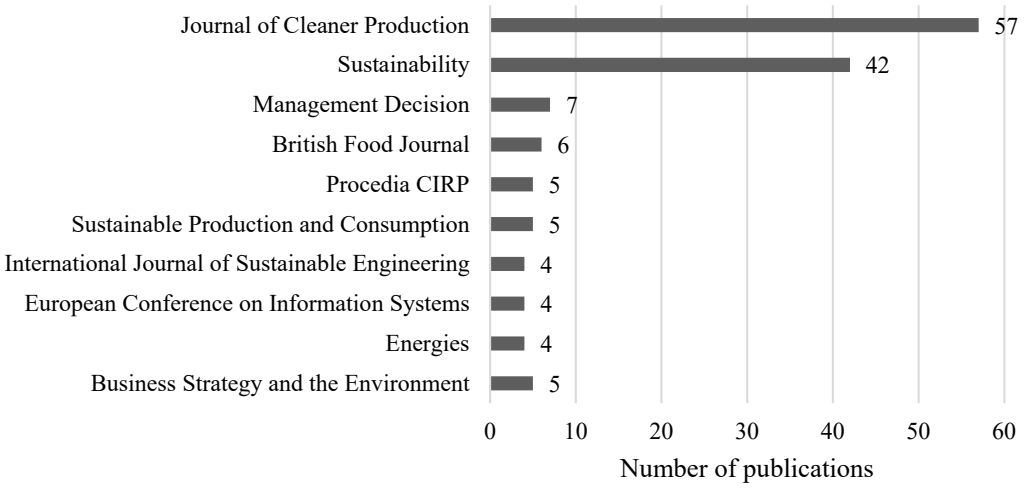

Figure 3. Journals with the highest scientific production.

Table 2. Most cited articles.

Title	Reference	Cited
Designing the Business Models for Circular Economy-Towards the Conceptual Framework	[64]	452
The triple layered business model canvas: A tool to design more sustainable business models	[33]	313
Business Model Innovation for Sustainability: Towards a Unified Perspective for Creation of Sustainable Business Models	[65]	291
Business models and supply chains for the circular economy	[47]	234
Sustainable consumption and production for Asia: sustainability through green design and practice	[66]	211
An Ontology for Strongly Sustainable Business Models: Defining an Enterprise Framework Compatible With Natural and Social Science	[36]	196
Two life cycle assessment (LCA) based methods to analyse and design complex (regional) circular economy systems. Case: making water tourism more sustainable	[67]	148
Design thinking to enhance the sustainable business modelling process—A workshop based on a value mapping process	[12]	147
Value mapping for sustainable business thinking	[35]	147
Bridging sustainable business model innovation and user-driven innovation: A process for sustainable value proposition design	[49]	126

Figure 4 combines authors and affiliations with the highest scientific production on the topic of SBMs and DT. NMP Bocken is the most active author, and its studies focus mostly on mapping and modelling sustainable businesses. In terms of affiliations, Netherlands and UK occupy the first positions with Delft University of Technology, University of Cambridge and University of Manchester. In terms of geographical, scientific production, UK, Germany and Italy comprise the countries with the highest number of publications (n = 40, 34 and 31, respectively) (Figure 5). Europe has 7 out of the 10 most active countries, representing 45% of all publications. North America is represented by the United States, and Asia is represented by India and China.

After analyzing the content of the articles found, taking into account the adherence of the article as a whole to the research question, a systematic literature review was carried out focusing on the research questions (RQ2 and RQ3): What are the research topics in high in the area of innovative business models? How can DT guide innovation in SBM? Among the 371 articles that address business model, sustainability and innovation, 33 (thirty-three) articles were selected for analysis that presented models, methods, processes and/or tools for modeling sustainable business using DT.

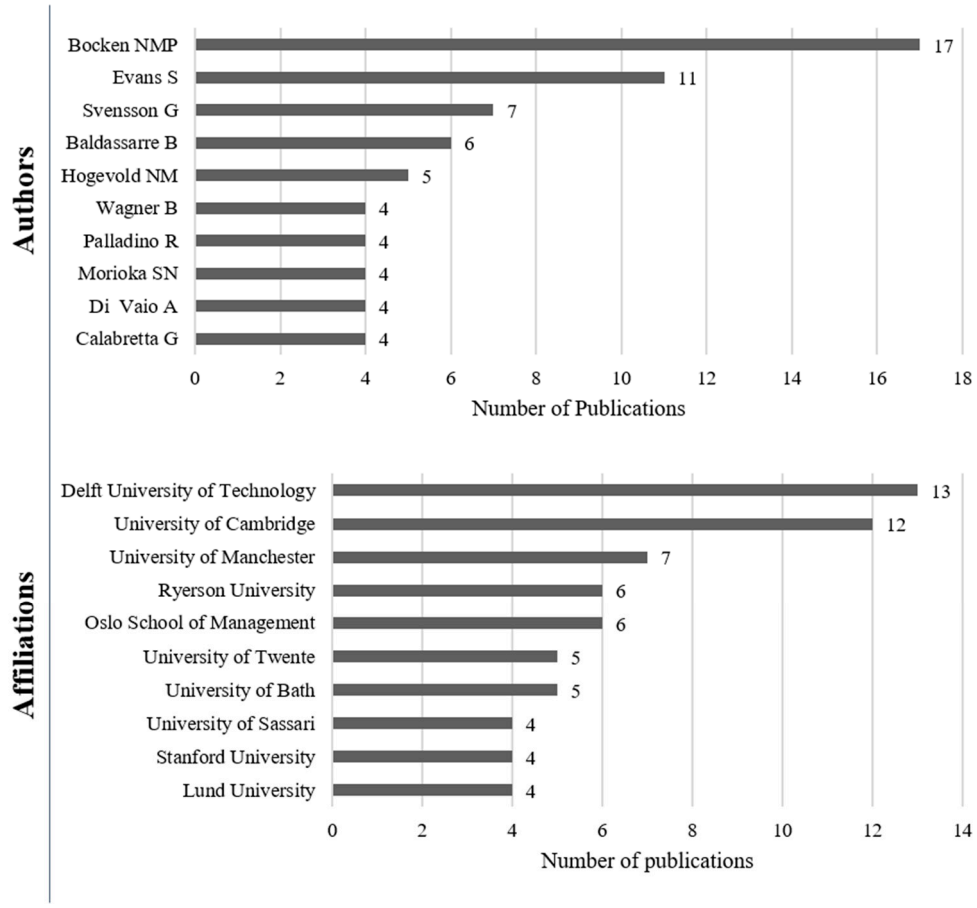

Figure 4. Authors and affiliations with the highest scientific production on the topic.

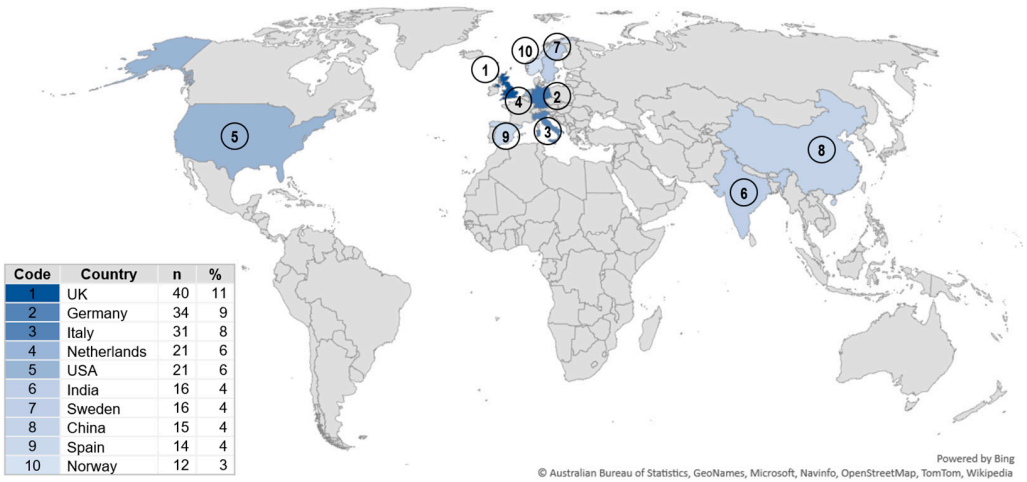

Figure 5. Geographical scientific production in terms number (n) and percentage (%) of publications.

4.2. Trending Research Topics in the Area of Innovative Business Models and Design Thinking

Figure 6 presents the main topics related to Sustainable Business Models, Innovation and Design Thinking based on the bibliometric results from Web of Science and Scopus databases. The results were merged in a Research Information Systems Document (.ris) format and analyzed in the VOS Viewer software. As for the software parameters, the minimum number of occurrences of a keyword was defined as 5, resulting in 39 selected keywords and 4 clusters. The minimum number of keywords per cluster was kept as the default value 3 and the clustering resolution as 1.

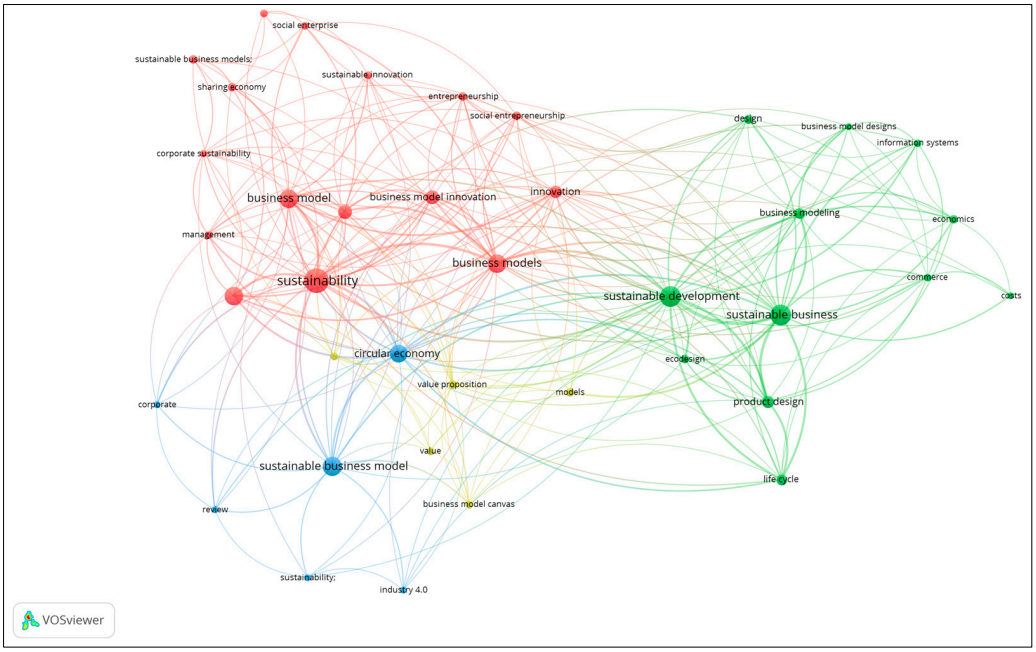

Figure 6. Co-occurrence analysis.

In the co-occurrence analysis, 4 main clusters are identified.

As shown in Figure 6, the co-occurrence analysis indicated the key terms that are more discussed in the literature (bigger nodes in the figure): sustainability, business model(s) and sustainable development. These are, on the one hand, reflection of the search string used for collecting articles in the databases. On the other hand, they also reflect trending research areas. The connections these terms hold with other keywords present interesting results on the use of design thinking: with uses in product design, industry and commerce and entrepreneurship.

The analysis identified 4 main clusters. The red cluster is related to sustainability and integrates the topics of sustainable business models and business model innovation. Analyzing the conceptual references of the articles, it is observed that there is a tendency to bring together the Business Model Innovation (BMI) and SBM approaches to an analysis of Sustainable Business Model Innovation (SBMI) [10,45,68,69]. The green cluster shows the connection between sustainable development, business models and sustainable business, but directs the approach to commercial aspects of the business area, with terms as commerce, costs, product design and lifecycle. Also, business model patterns are an emerging tool for recognizing trends among existing business models. In this way, Product-Service Systems (PSS) models are emerging as a means of enabling the collaborative consumption of products and services and with positive results for sustainable business. Also noteworthy are business models based on the Sharing Economy Business Models (SEBMs) that can be an example of a user-oriented PSS, which facilitates the sharing, renting or pooling of resources to provide the required service in a more sustainable way [38,43,70].

The blue cluster connects to corporate sustainability and is centered on sustainable business model and includes Industry 4.0 and circular economy as keywords. The approach to sustainability in business emerges as the Circular Economy and Business Models for a circular economy are treated in the articles as an alternative to the linear economy, as well as to develop products having in mind reuse that keeps the materials in the productive cycle. In this way, thinking for circular economy and circular-economy oriented startups are highlighted by the authors analyzed as an important alternative to developing innovative SBMs [9,38,39]. Finally, the yellow cluster is focused on value proposition and integrates topics such as business model design and business model canvas. These strategies are connected in the context of value creation as researchers seek and propose ways and tools to create, develop and deliver sustainable value in businesses [1,33,35,41,42,71].

When it comes to an analysis over time, Figure 7 presents the research topics in focus of recent studies. Terms in darker colors (purple to green) include topics published between 2016 and 2018. The terms in yellow are linked to the most recent publications, which indicate trends in current research. While the economic approach of business models was already consolidated in the initial years of analysis, most recent topics for research are sustainable business models, sharing economy, circular economy. Related terms which represent hot topics for research include concepts of sharing economy, corporate sustainability, social entrepreneurship, Industry 4.0 and innovation. These aspects combine priority areas within the study of business models, especially the connection between social aspects and technology, and their innovative combination with the principles of sustainable development. The Industry 4.0 is considered an industry model that further integrates innovation into its processes, a factor for which it is also known for its approach to sustainability within the organization [72,73] so it is clear the focus of sustainable business models to incorporate the approach to Industry 4.0 in its framework. The other highlight identified in the most recent research is focused on social entrepreneurship, which brings together the sharing economy and circular economy themes, showing how the new business models are seeking sustainability as a business strategy [70,74].

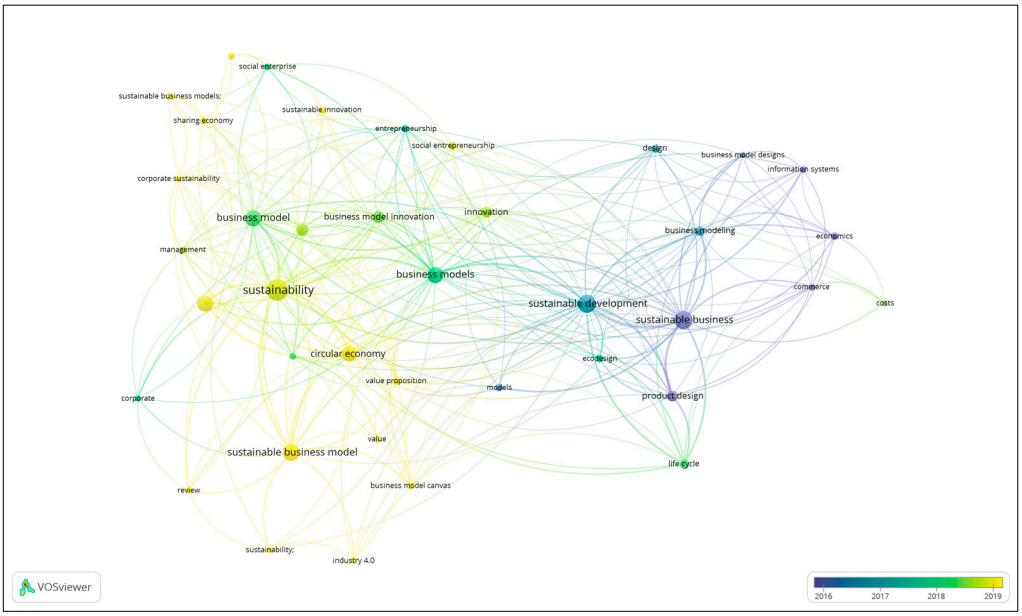

Figure 7. Co-occurrence analysis considering a time frame.

4.3. Contribution of Design Thinking to the Use of Innovation in Sustainable Business Models

At this stage, we present the analysis of the selected articles, as well as identify whether the stages of design thinking are part of or permeate the methodological and referential proposals. Table 3 provides this detailed analysis. This classification is based on four (4) categories that were considered relevant for the evaluation of the selected articles: (A) focus on the user and analysis of the needs of the stakeholders (B) Co-creation and interdisciplinary (C) Capture, create and deliver value (D) Prototyping and Testing.

4.3.1. User Focus and Stakeholder Needs Analysis (A)

User-oriented innovation identifies business opportunities and develops new concepts involving different groups of customers and/or potential users and, in this sense, DT is gaining popularity as an approach to enable innovation [49]. Joyce and Paquin [33] reinforce the importance of design as a process to reach sustainable products and services and that a design approach should also pave the way for the development of new SBMs. A broad and proactive stakeholder approach and a long-term perspective to complement short-term ones are also crucial factors for sustainable business success [47].

Table 3. Categories considered relevant for the evaluation of the selected articles.

Categories	Description
(A) focus on the user and analysis of the needs of the stakeholders	Through different means of immersion (interviews, field visits, etc.).
(B) Co-creation and interdisciplinary	Which allows that in the discovery phase, the team can diverge, while in the interpretation phase, the team converges on significant insights, clarifying aspects of the problem and value for the user.
(C) Capture, create and deliver value	To, the team must approach the problem by converging to select one or a few ideas that must be submitted
(D) Prototyping and Testing	To experiment with refinement, through prototyping and sharing with the relevant audience, finally, the design team develops and improves the final solution.

Kurucz and colleagues [75] suggest that the main challenge of leadership for sustainability can be understood as the integration and continuous alignment of the intention and action of multiple stakeholders and that meeting this challenge requires an ongoing process of reflective practice and construction of collective meaning among relevant stakeholders. Yet, these complex problems can only be tackled through collective, multisectoral (involving governments, business and civil society), multilevel (local to global) and multidisciplinary (bringing all relevant academic, social and scientific knowledge to the definition and solution of the problem) efforts.

To respond to these persistent challenges, the United Nations (UN) introduced the 2030 Agenda for Sustainable Development, including its 17 Sustainable Development Goals (SDGs) and 169 targets to eliminate poverty and achieve global sustainable development by 2030 [76,77]. According to the World Economic Forum, there has never been "a more pressing need for a collaborative, multi-stakeholder approach to shared global problems" [78].

Furthermore, it is observed that many companies are moving towards an extensive application of technologies in their business processes. Industry 4.0 consists of the application of some complementary technologies called Cyber-Physical Systems capable of connecting people, machines and objects to better manage and control the value creation process and supply chain [68,69,79].

Integrating DT into the innovation process helps create additional forms of value and includes previously underserved stakeholders in the value proposition. Thus, the "Value Ideation" process helps companies improve their performance and, at the same time, become more sustainable. Elements of DT stimulate the ideation process and help harmonize the often-conflicting interests of stakeholders [12,37,44].

The main challenge of leadership for sustainability can be understood as the integration and continuous alignment of the intention and action of multiple stakeholders. The analysis of the articles reveals that user-oriented innovation and analysis of stakeholder needs are present in practically all evaluated frames.

It is understood that to address sustainability challenges that require different types of knowledge, perspectives and collective efforts, workshops are used quite frequently to enhance stakeholder relationships, build trust and co-produce viable solutions.

4.3.2. Co-Creation and Interdisciplinary (B)

Co-creation depends on engaging relevant project stakeholders to ensure that their different and divergent needs are taken into account and met [45]. In this way, offering collaborative methods and tools are fundamental to achieve this goal [31].

Pieroni and colleagues [40] highlight that collaborative ideation to model and co-create value beyond customers and to incorporate broader stakeholders such as the environment or society is still a weakness of methods and processes for new business models.

Several researchers have begun to bring together DT to support collaborative ideation within highly uncertain innovation processes [11,12,49]. The expansion of the DT dimension

increases the complexity of the innovation process and places higher requirements on the organization's collaborative and co-creation capacity to integrate its partners [10,11].

Regarding co-creation and multidisciplinary, the analyzed articles present, in general, frameworks based on the use of workshop and brainstorming, which allow co-creation work in the process of mapping, ideation and selection of valuable opportunities. However, these complex problems can only be addressed through collective, multisector, multilevel and multidisciplinary approaches.

Collaboration between various stakeholders through workshop and brainstorming methodologies can contribute to the repeatability of these actions in pursuit of improving business models aligned with sustainability. This research recognizes workshops that adopt DT and business models as valuable platforms for sustainability advances.

4.3.3. Capturing, Creating and Delivering Value (C)

Sustainable value creation encompasses diverse items such as resource conservation, reduced emissions, healthy rates of profit reinvestment, secure employment and social equity [12].

The capture, creation and delivery of value is the logic of a business model and for the design of a sustainable value proposition in SBM it is necessary to map and understand the stakeholders in a broad sense, identifying their needs and interests and, progressively, combining them into a value proposition that assesses new opportunities from the perspective of these various stakeholders [35,42,45]. Various analytical frameworks represent this inclusion [35]. Also supporting this process are the archetypes of sustainable innovation that provide solutions to challenges related to the environment and society [35,42]. The three-layer business model canvas, on the other hand, contributes to the visualization of the economic, sociocultural and environmental dimensions of sustainability through the integration of various business components [33].

More and more attention has been paid to value in the field of business because of its economic and social implications. Companies play an important role in the transition to more sustainable economic systems [12] and represent entities capable of producing shared value and not just short-term profitability [71].

When it comes to capturing, creating and delivering value, the studies are making use of visual tools, design probes, service blueprints, appreciative inquiry, contextual, actor maps, personas, road mapping, and three-layer business model canvas interviews. These strategies are important to visualize the economic, sociocultural, and environmental dimensions of the models' sustainability, and play an important role capable of producing shared value and not just short-term profitability.

Sustainable business model frameworks utilize workshops due to their visual power, flexibility and usability with the aim of promoting creative innovation and collaboration, for example, participants can use sticky notes to map the relationships between activities to show the value opportunities created, destroyed and lost and reflect on present and future business activities [12–35] Such value mapping can facilitate collaboration because it encourages workshop participants to consider various types of outcomes from their activities and to assess possible partnerships in terms of sustainability [35].

4.3.4. Prototyping and Testing (D)

Prototypes are an essential feature of DT. The logic is to idealize, test variations, validate learning through experimentation and pivot if necessary [12,49]. Iterations are performed to address these strengths and weaknesses, refine aspects of the design, and ensure that the desired value is reflected. Practices that enable this activity include defining assumptions, testing features, and evaluating results. For example, generating a product/service MVP makes it more effective to understand the intended value across the stakeholder network, as well as minimizing costs with short iteration cycles [11,12,45,46,49].

Baldassarre and colleagues [45] highlight prototyping elements that can create and deliver sustainable value: (i) User journey: which is the sequence of actions that end users

need to perform to obtain and use the product/service prototype; (ii) Costs to create and deliver the product/service prototype and how these costs are shared among stakeholders; (iii) Revenue streams generated and how these revenues are shared among stakeholders. A new wave of business strategies can also be highlighted, which may include some lean innovation tools that can more efficiently DT activities [11] such as Lean Startup [80].

The final category covered prototyping and experimentation. These seem to represent a gap that should be better explored in the frameworks. The ways of testing the product/service and collecting feedback are essential features of Design Thinking and help recognize the strengths and weaknesses of the product and/or service. In this sense, a new wave of business strategies can be highlighted and may include some lean innovation tools allied to design thinking such as Lean Startup, which proposes the development of a minimum viable product.

5. Conclusions

This study aimed to improve understanding of how Design Thinking and its set of tools and methods contribute to the creation and innovation of sustainable business models. The article shows the main sources and articles that have influenced research on innovative SBMs, compiles several studies and frameworks in which researchers propose useful connections for the innovation process in sustainable business models in the light of DT.

The first research question focused on the academic sources and articles that have been influencing research on innovative sustainable business models and design thinking. The bibliometric analysis has confirmed the exponential growth in publications on this topic. Two journals contain over 25% of all published documents: The Journal of Cleaner Production and Sustainability. The authors of the most cited studies [33,64,65], covering different models and contributions to innovative business models and circular economy. Additionally, N.M.P. Bocken and S. Evans are the authors with the highest scientific production on the topic, and the most active affiliations are Delft University of Technology (Netherlands), and University of Cambridge and University of Manchester (UK).

The second research question was dedicated to identifying trending research topics in the area of innovative business models. Analyzing the conceptual references of the articles selected for the systematic review, it is possible to observe the tendency to bringing together Business Model Innovation and Sustainable Business Model approaches to an analysis of Sustainable Business Model Innovation. In other words, researchers seek and propose ways and tools to create, develop and deliver sustainable value in their businesses in an innovative way. Also, approaches such as Circular Economy and Business Models are treated in the articles as an alternative to the linear economy. In this way, design thinking for circular economy-oriented startups is highlighted by the authors as an important alternative to developing innovative and sustainable business models.

Finally, through the third research question, this study analyzed the selected articles in relation to the contribution of DT and why its principles are present in proposals for innovation in sustainable business models. DT elements stimulate the process and help reconcile the often-conflicting interests of stakeholders. The analyzed articles showed that DT is enabling and guiding the use of innovation in SBMs, according to these four categories (A) Focus on the user and analysis of the needs of the stakeholders (B) Co-creation and interdisciplinary (C) Capture, create and deliver value (D) Prototyping and Testing.

Given the above, it is considered that this research confers an innovative character when evaluating the framework proposals selected in the literature aimed at innovation in sustainable business models and the integration of the DT methodology. The gap between sustainable design theory and its implementation in practice had been noted and discussed in the literature. The categorization proposal to evaluate the models is relatively new, despite the DT being widely explored and used in several aspects. Thus, this article contributed to the expansion of studies that enable progress in the area of innovation in sustainable business models. Future research could explore the following

questions: How can a universal framework be designed to develop SBM in practice? How can design thinking be combined with technological tools to contribute to SBM? How can the value efficiency of the SBM framework be measured through prototyping and hands-on experimentation?

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Appendix A

Table A1. Select articles that focused exclusively on, conceptual models, frameworks, methods or tools.

No	Authors	Title	Conceptual Reference	Criteria for Selection
1	[46]	Transformative service research, service design, and social entrepreneurship. An interdisciplinary framework advancing wellbeing and social impact	SBM, Service Design, Social impact.	Propose an interdisciplinary framework
2	[49]	Bridging sustainable business model innovation and user-driven innovation: A process for sustainable value proposition design	SBMI, User-driven Innovation.	Propose a method for sustainable value proposition design
3	[45]	Addressing the design-implementation gap of sustainable business models by prototyping: A tool for planning and executing small-scale pilots	SBM, SBMI.	Use a tool for planning and executing small-scale pilots
4	[44]	Workshop methodology design: Innovation-oriented participatory processes for sustainability	Workshop methodologies, DT, SBMI.	Propose a method for Workshop
5	[37]	A value mapping tool for sustainable business modelling	Sustainable Value Mapping and Innovation	Propose a method for Workshop
6	[35]	Value mapping for sustainable business thinking	SBMI, Sustainable Value Mapping.	Presents a model for modelling business sustainable
7	[2]	Sustainable business model experimentation by understanding ecologies of business models	SBMI, Ecology of Business Model.	A framework for value mapping
8	[1]	A framework to explore the functioning and sustainability of business models	BMI, Value creation and Value proposition, Corporate Sustainability, Innovation,	A framework for workshop
9	[9]	A tool for collaborative circular proposition design	CE, DT, Collaborative Innovation	A tool for collaborative

Table A1. *Cont.*

No	Authors	Title	Conceptual Reference	Criteria for Selection
10	[34]	Sustainable Business Models Canvas for Sustainability, Evaluation Method, and Their Application to Additive Manufacturing in Aircraft Maintenance	Business Model Canvas, Additive Manufacturing	Method and application for BMCS
11	[81]	Dynamic business modeling for sustainability: Exploring a system dynamics perspective to develop sustainable business models	SBM, Sustainability, System Dynamics Modeling.	Presents a model for business modeling for sustainability
12	[70]	Sharing economy business models for sustainability	Sharing Economy Business Models (SEBMs)	A tool for Modeling SEBMs
13	[12]	Design thinking to enhance the sustainable business modelling process—A workshop based on a value mapping process	SBMI, BMIP—Business Model Innovation Process, DT,	Method and application a workshop
14	[82]	The Cambridge Business Model Innovation Process	ISBM, SBM, DT, Sustainable Value, BMIP	Framework for implementation SBMI
15	[11]	Sustainable business modeling: The need for innovative design thinking	SBM, IBM, DT	Framework for modeling SBM
16	[38]	Developing and implementing circular economy business models in service-oriented technology companies	Back casting, CE, Eco-design, Service, SBM	Framework and application
17	[83]	Co-creation and Design Thinking to Envision More Sustainable Business Models: A Foresight Design Approach for Organizational Sustainability of SME Manufacturers	SBM, Co-creation, DT.	Method for Workshop at DT
18	[33]	The triple layered business model canvas: A tool to design more sustainable business models	SBM, Sustainable Value Creation.	A tool to SBM
19	[10]	The Redesign canvas: Fashion design as a tool for sustainability	SBM, Sustainable Fashion Design.	A tool for SBM
20	[75]	Relational leadership for strategic sustainability: practices and capabilities to advance the design and assessment of sustainable business models	Strategic Sustainability, SBM.	Model of the leadership for strategic sustainability
21	[79]	The perspective of capability providers in creating a sustainable I4.0 environment	Industry 4.0, SBM.	Framework to guide decision in SBM
22	[58]	The Circular Business Framework for Building, Developing and Steering Businesses in the Circular Economy	CE, circular-economy oriented startups.	Conceptual Blocks for Framework
23	[80]	Towards Sustainable Innovative Business Models	SBM, BMI.	Method for application the triple-layered canvas
24	[42]	The sustainable business model pattern taxonomy-45 patterns to support sustainability-oriented business model innovation	SBM, Sustainable Value Creation.	Model for SBM patterns, can serve as a basis for more unified and comparable studies of SBMs

Table A1. *Cont.*

No	Authors	Title	Conceptual Reference	Criteria for Selection
25	[71]	Towards a holistic framework for sustainable value analysis in business models: A tool for sustainable development	BM, SBM, Sustainable Value.	A tool for sustainable development by providing a framework to analyze sustainable value
26	[76]	From an ideal dream towards reality analysis: Proposing Sustainable Value Exchange Matrix (SVEM) from systematic literature review on sustainable business models and face validation	SBM, Corporate Sustainability, Sustainable Value Exchange Matrix (SVEM) SDGs.	Sustainable Value Exchange Matrix, a visual framework.
27	[68]	Transforming sustainability challenges into competitive advantage: Multiple case studies kaleidoscope converging into sustainable business models	SBM SBMI, SDGs.	Framework to support organizations towards more SBM.
28	[84]	Sustainable business model innovation: exploring evidence in sustainability reporting	SBM, Performance Measurement Corporate Sustainability.	Framework for identification and measurement of sustainability innovations
29	[40]	An expert system for circular economy business modelling: advising manufacturing companies in decoupling value creation from resource consumption	CE, SBMI, Thinking for circular economy.	Tool Circular Economy Business Modelling Expert System
30	[77]	Sustainable business model archetypes for the electric vehicle battery second use industry: Towards a conceptual framework	SBMI, Archetypes Sustainable Business Model.	Conceptual framework of sustainable innovation business model (SIBM) for industry
31	[41]	Green entrepreneurship and business models: Deriving green technology business model archetypes	Green Business Model, Value Creation Green.	Models for Typology and archetypes of green business model
32	[69]	A Networked Analysis and Engineering Framework for New Business Models	BMI, BM.	Framework Multi-layered analysis
33	[43]	Product-service system business model archetypes and sustainability	SBM, ISBM, PSS.	The proposed framework and provides a comprehensive analysis of the economic, environmental and social

Appendix B

Table A2. Selected articles and synthesizing the findings in DT principles.

No	Authors	Contributions	A	B	C	D
1	[46]	Purpose an interdisciplinary framework for SBM in Service Design for sustainable value proposition for social impact.	✓	✓	✓	✓
2	[49]	Combining principles from both sustainable business model innovation and user-driven innovation to develop more successful, radical and user-centered sustainable value propositions.	✓	✓	✓	✓
3	[45]	A tool that organizations to plan and execute small-scale pilots for implementing sustainable business models.	✓	✓	✓	✓

Table A2. *Cont.*

No	Authors	Contributions	A	B	C	D
4	[44]	Action research approach and designed a workshop methodology based on the main tenets and tools of the theory of change, design thinking, and sustainable business models.	✓	✓	✓	✓
5	[37]	Tool was developed to support sustainable business modelling, which introduces three forms of value (value captured, missed/destroyed or wasted, and opportunity) and four major stakeholder groups (environment, society, customer, and network actors). A tool was developed which was pilot tested through use in a workshop.	✓	✓	✓	
6	[35]	Value mapping tool was developed to assist in the design of sustainable business models, by considering different forms of value exchanges for a range of stakeholders as part of the business model.	✓	✓	✓	✓
7	[2]	Framework incorporates potential side-effects and boundary setting based on the concept of an 'ecology of business models' The Ecology of Business Models Experimentation map (EBME).	✓	✓	✓	✓
8	[1]	The business model framework addresses equity and distributional issues that are key to sustainable development but missed by current frameworks.	✓	✓	✓	✓
9	[9]	The tool integrates decision-making principles from the entrepreneurship theory of effectuation within a design thinking approach to stimulate collaborative ideation of circular propositions.	✓	✓	✓	✓
10	[34]	It establishes a procedure that supports the design and evaluation of business models with a sustainable perspective, integrating a new business model canvas for sustainability (BMCS) and an evaluation method.	✓		✓	✓
11	[81]	Conceptualize a dynamic business modeling for sustainability approach, which combines an adapted sustainable business model canvas and system dynamics modeling.	✓	✓	✓	
12	[70]	It is an approach that combines a sustainable business model canvas adapted to systems dynamics modeling. Has been applied to shared economy business models (SEBMs)	✓	✓	✓	
13	[12]	Integration of design thinking into the value mapping process in SBMI, including stakeholders, based on a workshop process.	✓	✓	✓	✓
14	[82]	The article presents the framework applied to a social start-up. It presents tools and processes for organizations to bridge the implementation gap in sustainable business model innovation.	✓	✓	✓	✓
15	[11]	It presents a design framework that consists of representation, exploration, prototype, and evaluation. The article provides guidance on the specific characteristics of implementing design thinking and presents key practical points for business survival.	✓	✓	✓	✓
16	[38]	It presents a Back casting and Eco-design framework for the Circular Economy (BECE) that is applied in an information and communication technology (ICT) company. It analyzes the potential of service-oriented companies in the ICT sector to build and implement circular economy business models.	✓	✓	✓	✓
17	[83]	It presents a workshop framework that was applied to thirteen (13) manufacturing organizations in a co-creation design process that resulted in more sustainable business model concepts for economic, environmental and social benefits.	✓	✓	✓	✓
18	[33]	Triple Layered Business Model Canvas supports sustainable business model innovation.	✓	✓	✓	
19	[10]	Introduces an original design tool, Redesign canvas, to support design entrepreneurs in developing sustainable fashion ventures.	✓	✓	✓	✓
20	[75]	It presents a conceptual model for the organization's sustainable strategic management, and which describes specific practices and capabilities to support strongly sustainable businesses.	✓	✓	✓	✓

Table A2. *Cont.*

No	Authors	Contributions	A	B	C	D
21	[79]	It integrates the literature review with the case study and proposes a comprehensive framework to guide the decision-making process of transforming a traditional business model (TBM) to a SBM and considers one of the main actors involved, the capacity of service providers.	✓	✓	✓	✓
22	[39]	Circular Business Framework (CBF) was created and tested based on CE principles.	✓	✓	✓	✓
23	[80]	The study is based on qualitative methods and data from a Spanish company in the wine sector. The findings indicate that the triple-layered canvas is applicable and useful for micro firms, although the process to design sustainable innovative business models might be even more important.	✓	✓	✓	✓
24	[42]	The authors ranked 45 SBM patterns, attributing these patterns to the resulting taxonomy that can serve as the basis for new sustainability-oriented business model tools.	✓	✓	✓	
25	[71]	The contributions of this article are, theoretically, to structure value concepts to better understand the sustainable value process in business models and, in practice, to offer a tool for sustainable development, providing a framework to analyze sustainable value in various ways.	✓	✓	✓	
26	[76]	Proposes the Sustainable Value Exchange Matrix, a visual framework to help academics and practitioners discuss sustainable business models, based on solid theory analysis and practice-oriented application. The tool proposed provokes reflections about organization's reason of existence and deployment of this purpose into the business model dimensions from a multi-stakeholder and from a value exchange perspective.	✓	✓	✓	
27	[68]	Proposes a theory and practice-based framework to support organizations towards more SBM, making explicit main elements to align business to sustainability performance goals. To support the argument that there is no unique solution to design SBM, this research performs multiple case studies in eleven organizations from diverse sectors, situated in Brazil and in the United Kingdom	✓	✓	✓	✓
28	[84]	A comprehensive and integrative performance measurement framework for SBM is proposed to support the identification of sustainability innovations. In this context, the purpose of this paper is to explore the contributions and limitations of the proposed framework.	✓	✓	✓	✓
29	[40]	The paper presents the development of the tool Circular Economy Business Modelling Expert System within manufacturing companies, intended to address these limitations	✓	✓		
30	[77]	Proposes the conceptual sustainable innovation business model (SIBM) framework for the EV B2U industry that includes such shared sustainable value creations which in turn drives forward business performance and sustainability at the same time, eventually creating the business case for sustainability within the EV industry.	✓	✓	✓	✓
31	[41]	It presents a typology of green technology business models, identifying twelve archetypes of based business models. Related aspects: the archetypes of sustainable business models and technological entrepreneurship activities.	✓	✓	✓	
32	[69]	Proposes a multi-layer framework to analyze existing business models	✓	✓	✓	
33	[43]	The proposed framework is novel and provides a comprehensive analysis of the economic, environmental and social sustainable value creation of known PSS business model archetypes.	✓	✓	✓	✓

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