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Original Research

Rise and Evolution of Design Thinking Research for Business Innovation

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Abstract: As organizations are increasingly demanding faster and more successful innovations in the markets, design thinking (DT) has established itself as a generative approach or methodology for solving complex problems and as a driver for the development of products and services that offer superior value to users. To understand this phenomenon, this exhaustive review has been carried out through a scientometric analysis of DT for innovation, examining annual scientific production, country-specific contributions, journal publications, and collaboration networks between authors. The results allow us to identify a growing interdisciplinary interest in the applicability of DT for business innovation. The United States is the country that stands out in academic production, while Germany and Italy concentrate the most important academic networks. Using the Tree of Science (ToS) metaphor, three subtopics were identified as current trends in the field: DT for innovation activities within the business sector, applicability and contributions of DT in other sectors, and DT as a learning and innovation methodology. This study provides a framework for understanding the evolution and current state of design thinking and thus for projecting future research and new applications of design thinking as an approach to innovation in increasingly diverse fields.

Keywords: *Design Thinking, Innovation, Review, Scientometrics, Tree of Science*

Introduction

Design thinking (DT) has become an authentic phenomenon with the boom caused by IDEO in the 1990s, derived from a process of analysis and reflection on the way designers think and do, an evolution that during the last three decades has expanded the use of design to transdisciplinary fields (Bender-Salazar 2023). In this evolutionary process, DT has been considered an iterative methodology that enables radical innovations through the generation and validation of solutions oriented to the needs and values of users (Brown 2009; Verganti 2009), creating business value and competitive advantages (Martin 2009). In this sense, Liedtka (2020) considers DT as a social technology that enables organizations to build dynamic capabilities essential for strategic adaptation. The emphasis on prototyping and conducting small experiments that allow testing the idea in action facilitates better decision-making by reducing cognitive biases (Liedtka 2011).

The rise in popularity of DT can be attributed to its customized applications and the increasing demand for learning and training. This trend is particularly evident in the business sector, where DT is emerging as a strategic component in personnel training programs to foster creative problem-solving (Bertão et al. 2023). In education, DT is being effectively used to incorporate design challenges. This allows students to accurately identify stakeholder needs and test assumptions, thereby improving the quality of the proposed solutions while developing higher-order thinking skills (Assen et al. 2023; Bender-Salazar 2023).

At the intersection of design and management, DT emerges as both a problem-solving methodology and a theoretical discipline, with a pronounced emphasis on fostering innovation, particularly within the business domain. According to Martin (2010, 38), "design-thinking firms stand apart in their willingness to engage in the task of continuously redesigning their business." This article explores the relationship between DT and "business innovation," as defined by the Oslo Manual (OECD/Eurostat 2018, 46) as "a new or improved product or business process (or combination thereof) that significantly differs from the firm's prior offerings and has been introduced to the market or adopted by the firm."

DT has been extensively studied, with numerous systematic and bibliometric reviews available. For instance, Dragičević, Vladova, and Ullrich (2023) conducted a bibliometric review of DT in the context of the digital world, while Lyu et al. (2023) focused on virtual reality in their literature review, and Li and Zhan (2022) undertook a systematic review in the context of K-12 education. Consequently, this article presents a unique perspective by concentrating on publications that explore the intersection of DT and business innovation.

Based on the literature reviewed in the study period, this is the first bibliometric review of DT with a focus on business innovation. We use scientometric analysis to explore the scientific production, research development, collaboration network, and key themes and trends in this domain. The study aims to advance the theory of DT in business innovation, reveal current tendencies, and suggest new research directions in a rapidly evolving field.

Methodology

Recent scholarly literature advocates for the integration of the Web of Science (WoS) and Scopus databases to conduct more comprehensive scientometric analyses (Grisales Aguirre, Robledo, and Zuluaga 2023; Aguirre and Cuervo 2023). This study aligns with this proposition, employing the "bibliometrix" and "tosr" packages (Aria and Cuccurullo 2017) to consolidate the primary registers with their corresponding references. The search parameters incorporated the terms "design thinking" and "innovation business" across both databases (Table 1). The yield was significantly higher in Scopus, constituting 58.86 percent of the total, thereby highlighting the prominence of the topic within this database. However, upon merging the two databases and eliminating duplicate entries, the final tally amounted to 568 documents. Consequently, 125 documents (22.0%) were exclusively found in WoS and

not in Scopus, underscoring the necessity of utilizing both databases in scientometric analyses to ensure comprehensive coverage.

Table 1: Parameters Used in SCM and AI

Parameters	*Web of Science*	*Scopus*
Range	2000–2023	
Date	July 9, 2023	
Document types	Papers, books, chapters, and conference proceedings	
Search field	Title, abstract, and keywords	
Words	"Design thinking" AND "innovation business"	
Results	202	491
Total (Wos + Scopus)	568	

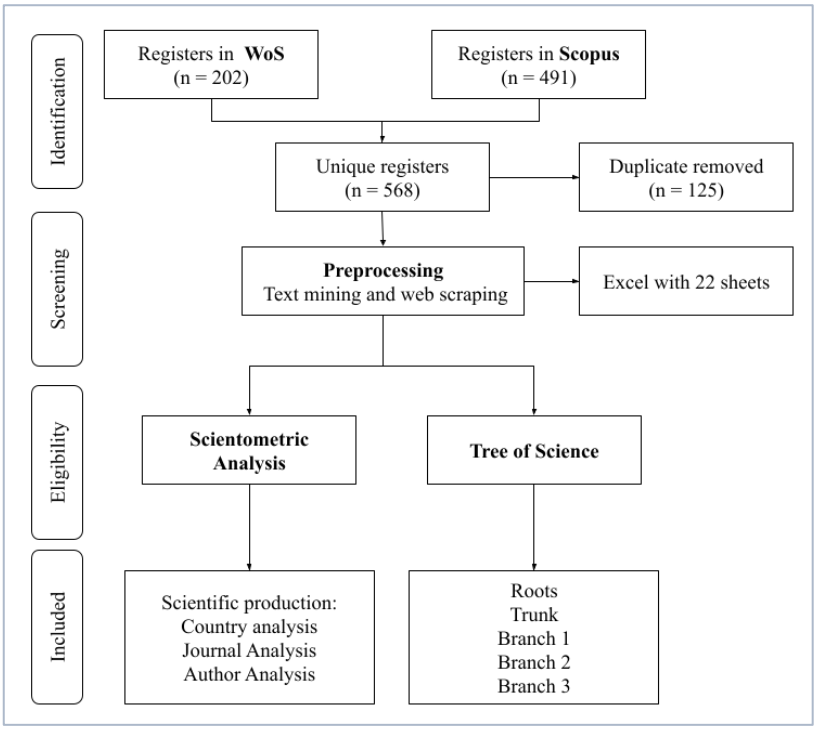

Figure 1: PRISMA Diagram for Preprocessing Data

PRISMA is a well-established methodology to track the preprocessing data in the literature review (Page et al. 2021). Figure 1 shows the process from the search in WoS and Scopus until the selection of final papers in the scientometrics and ToS sections. The files

downloaded from WoS were in text format, while those from Scopus were in bib format. To create a more readable format, it was necessary to use the bibliometrix package. However, these files are reached in unstructured data; for example, references to have authors, years, journal names, and titles. Working with this type of data expands the scientometric analysis of a research topic; however, more complex processes are needed to disaggregate this type of data (Robledo, Duque, and Aguirre 2023). We performed text mining and web scraping to enrich the data from WoS and Scopus. The output is an Excel file with twenty-two sheets with detailed information on each main and reference paper.

Scientometric Mapping

This study subdivides the scientometric mapping into four distinct segments: scientific production, country-specific contributions, journal collaboration, and author collaboration analysis. This approach enables researchers to gain a comprehensive overview of DT in business innovations from a scholarly perspective. Additionally, we adhere to the recently proposed methodologies of Hurtado-Marín et al. (2021), which advocate for the utilization of authors' references to construct a more structured social network. This allows for a deeper understanding of the networking processes among researchers (Robledo, Vasquez, et al. 2022).

Tree of Science

The ToS methodology recommends scholarly articles and organizes them in a dendritic structure (tree). For instance, seminal articles are situated at the root, articles that provide foundational support for the topic are placed in the trunk, and papers that address sub-areas of DT in business innovation are placed in the branches. The overarching process for constructing the ToS of a scientific domain is to generate a citation network from the WoS and Scopus files. The SAP algorithm is then used to identify the articles in the root, trunk, and branches (Zuluaga et al. 2022; Robledo, Zuluaga, et al. 2022). This process facilitates a rapid, comprehensive understanding of a research topic, bypassing the need for an extensive screening process. The ToS methodology has been implemented in several disciplines, including social sciences (Hoyos et al. 2023; Erazo-Muñoz, Escobar-Ospina, and Alexis-Pineda 2022), engineering (Benavides-Sánchez, Castro-Ruíz, and Narváez 2023) and health (Marín-Rodríguez, González-Ruiz, and Botero 2023; Rabelo Florez 2023). A thorough review of the initial diffusion process can be found in Eggers et al. (2022).

Scientometric Analysis

Scientific Production

Figure 2 illustrates the scientific production of articles on DT and innovation published in the WOS and SCOPUS databases from 2002 to 2022. However, no publications on this topic

were found between 2003 and 2006. Consequently, the period from 2007 to 2022 was considered, during which a total of 539 documents were published. The publication pattern exhibited repetitive cycles or movements, allowing for the identification of three distinct periods with unique characteristics, which are described in what follows.

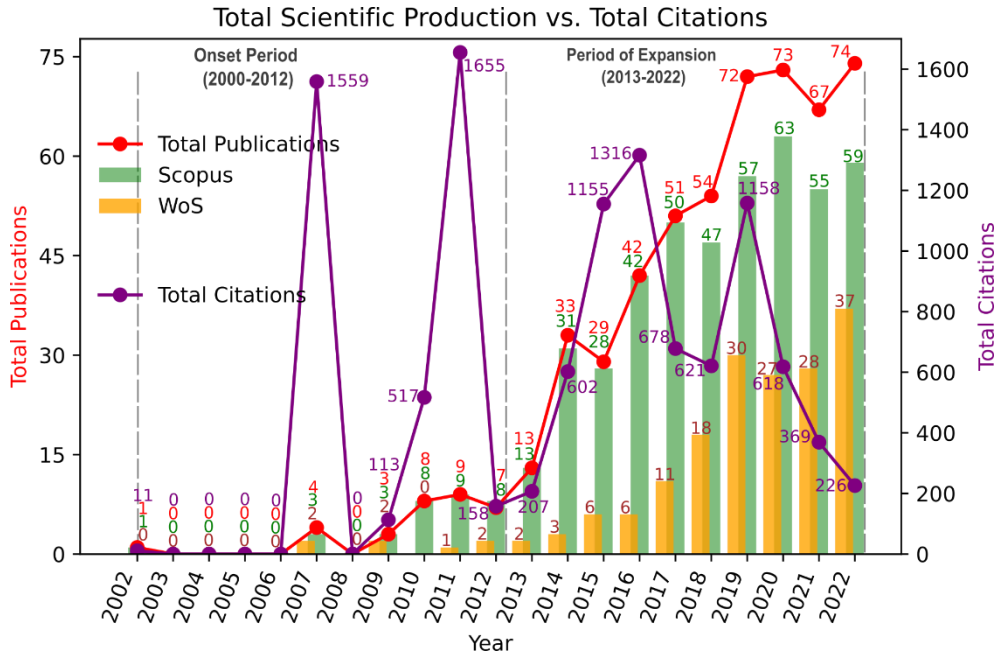

Figure 2: Annual Scientific Production of DT for Innovation in Scopus and WoS

Initiation (2007–2012)

This stage exhibits low productivity, with a total of thirty-one published articles, accounting for 5.8 percent of the overall scientific production. The growth rate stands at 11.8 percent, indicating the nascent birth and development of the topic. In contrast to the low production rate, the highest "peaks" in total citations are observed specifically in 2007 and 2011.

The most significant work in terms of citation count in 2007 is Bill Buxton's book, which addresses the intersection of DT, innovation, and business within the framework of user experience sketching as a tool in the design process (2007). Another highly relevant article is by Beckman and Barry (2007), proposing an integration between the innovation process and learning models with implications for the structuring, leadership, and learning of innovation teams in organizations. In 2011, Dorst stands out in terms of citations, serving as a significant reference in the study field. It presents the central axis of DT and proposes design practice frameworks for solving complex problems in organizations.

Growth (2013–2018)

This stage witnessed exponential growth in productivity. The number of publications increased to 222 documents, accounting for 41 percent of the total publications conducted. A rising trend with an annual growth rate of 32.95 percent is observed, highlighting the significant interest that DT and innovation have garnered in recent years. The most significant research (Liedtka 2015) identified how DT could enhance positive innovation outcomes by reducing cognitive biases in idea generation, user inputs, and testing.

In 2016, notable works emerged, such as the development of a workshop for the value mapping process as a means through which DT can enhance sustainable business modeling (Geissdoerfer, Bocken, and Hultink 2016), and the development of a DT framework for building management and innovation capabilities in health-care systems (Roberts et al. 2016).

Seasonality (2019–2022)

This stage is characterized by the highest volume of publications in the study, exhibiting periodic patterns in behavior and sustained upward or downward changes, with a ceiling of over sixty-seven publications per year. Over these 4 years, the total number of publications amounted to 286 documents, representing 53 percent of the scientific production in the field. The year 2019 recorded the highest number of publications, indicating that the topic remains novel and of significant interest to the scientific community. The prominently cited article examines the review and comparison of Circular Economy–oriented and Sustainability–oriented approaches in Business Model Innovation (Pieroni, McAloone, and Pigosso 2019).

Country Analysis

Table 2 presents three variables related to the production, impact, and quality of academic output in the top 10 countries within the analyzed thematic area. Production indicates the quantity of scientific documents generated by each country. Impact is measured by the cumulative citations of all the articles generated. Lastly, quality is assessed based on the Scimago ranking, where Quartile 1 (Q1) represents the highest ranking and Quartile 4 (Q4) represents the lowest ranking.

In this regard, the US leads the list of the top 10 countries with the highest productivity, in contrast to Ireland, which occupies the last position. The US, with a total of 101 documents and 18 percent, leads in terms of publication volume, followed by Germany, with 8.7 percent. In descending order, the list includes the United Kingdom, Australia, Brazil, Italy, China, India, Canada, and Ireland. Regarding citations, the US and Canada are the countries with the highest referencing, accounting for 24.5 and 14.1 percent, respectively, surpassing countries like Germany, the United Kingdom, and Australia, which, despite having a higher number of publications, do not exhibit significant citation rates.

Table 2: Top 10 Most Productive Countries

Country	*Production*		*Citation*		*Q1*	*Q2*	*Q3*	*Q4*
USA	101	18.04%	2,092	24.58%	23	18	14	6
Germany	49	8.75%	505	5.93%	10	5	0	3
UK	40	7.14%	725	8.52%	14	3	3	1
Australia	37	6.61%	412	4.84%	13	6	1	1
Brazil	27	4.82%	125	1.47%	4	2	4	0
Italy	25	4.46%	277	3.25%	8	3	0	2
China	19	3.39%	238	2.8%	3	5	2	2
India	19	3.39%	106	1.25%	3	2	6	1
Canada	18	3.21%	1,200	14.1%	4	3	5	1
Ireland	15	2.68%	168	1.97%	1	1	0	0

Regarding quality, the publication quartiles for articles on DT and innovation are Q1 (eighty-three publications), Q2 (forty-eight publications), Q3 (thirty-five publications), and Q4 (seventeen publications). Seventy-one percent of the categorized publications are found in Q1 and Q2, indicating that a high proportion of publications in this field are of high quality.

On the other hand, Figure 3 depicts a network of the main country groups identified. The first group is led by Germany, engaging in scientific collaborations with countries such as Colombia and Finland. The collaborative study with Colombia presents the best practices of DT for designing academic innovation programs, based on an analysis of eleven university training programs from different countries (Wiesche et al. 2018). Similarly, the study with researchers from Finland proposes a curriculum structure with DT methods and theoretical aspects for the development of courses and workshops (Lugmayr et al. 2014).

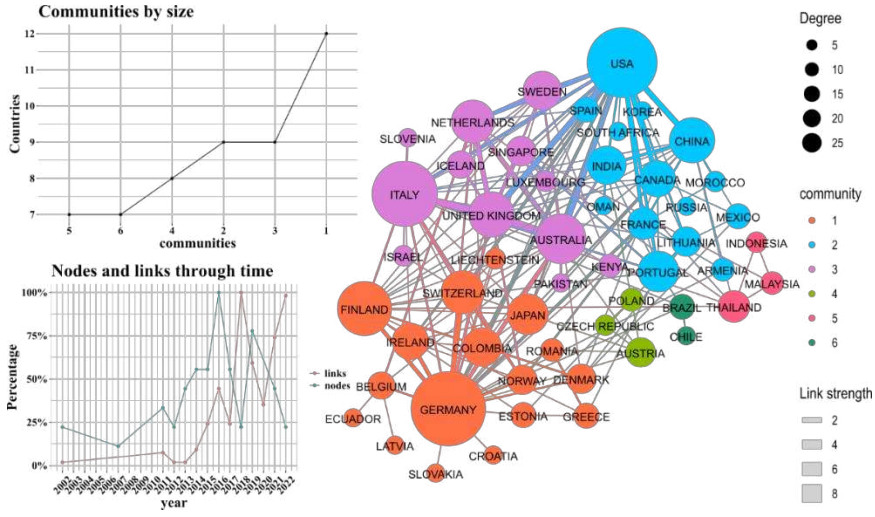

Figure 3: Country Collaboration Network

On the left side of the graph, the number of groups (communities) is displayed according to their size. Group 1 comprises a total of twelve countries, significantly larger than groups 2 and 3, which consist of nine countries each. The second figure from the left illustrates the number of nodes and links generated over time. The graph demonstrates a consolidation of the scientific community, starting in 2017, characterized by a growth in connections exceeding the number of countries entering this academic community.

Journal Analysis

Table 3 presents the academic productivity and impact (measured by impact factor and h-index) published in WoS and Scopus, as well as the quality measured in quartiles, of the top journals in the field of DT and innovation. In general, there is a high productivity of journals with a high impact according to the quartiles specified in the Table 3, as 70 percent of them fall within Q4, Q3, Q2, or Q1 journals.

Table 3: Top 10 Most Productive Journals

Journal	*WoS*	*Scopus*	*Impact Factor*	*h-Index*	*Quantile*
Journal of Cleaner Production	16	8	1.98	268	Q1
Design Journal	13	8	0.4	25	Q2
Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	0	11	0.32	446	Q3
Communications in Computer and Information Science	0	10	0.19	62	Q4
Proceedings of the European Conference on Innovation and Entrepreneurship, ECIE	0	9	0	7	–
Lecture Notes in Business Information Processing	0	7	0.35	56	Q2
Technology Innovation Management Review	6	0	0.56	15	Q2
Advances in Intelligent Systems and Computing	0	6	0	58	–
Smart Innovation, Systems and Technologies	0	6	0.17	31	Q4
ASEE Annual Conference and Exposition, Conference Proceedings	0	5	0	39	–

Two journals stand out in terms of academic productivity. The first one is the *Journal of Cleaner Production*, published by Elsevier and based in the UK. It is classified in Q1 and focuses on topics related to clean technologies and practices, renewable energy, the environment, and sustainability. This journal is relevant to the present study as it has published articles connecting innovation and DT to sustainability (Geissdoerfer, Bocken, and Hultink 2016; Pieroni, McAloone, and Pigosso 2019).

The second journal in terms of productivity is *Design Journal*, published by Taylor & Francis and also based in the UK. It is classified in Q2 and covers the broad field of design, including novel perspectives such as the integration of DT in business education curricula (Çeviker-Çınar, Mura, and Demirbağ-Kaplan 2017) or the understanding of how DT is relevant in the entrepreneurship process, specifically in opportunity identification, generation of innovative solutions, and development of innovation capabilities in organizations (Carella et al. 2023).

Author Collaboration Network

At an individual level in the review of DT and innovation, the most relevant researchers, their different collaborative networks, and affiliations were identified. Table 4 presents the top 10 authors based on productivity and impact.

Table 4: Production by Author

No.	*Researcher*	*Total Articles*	*Scopus h-Index*	*Affiliation*
1	C. Wrigley	8	18	The University of Queensland, Brisbane, Australia
2	V. Taratukhin	6	0	Silicon Valley/Us West, US
3	F. Uebernickel	5	17	Hasso-Plattner-Institut Für Softwaresystemtechnik, Potsdam, Germany
4	K. Cormican	4	14	Hasso-Plattner-Institut Für Softwaresystemtechnik, Potsdam, Germany
5	D. de Paula	4	6	Hasso-Plattner-Institut Für Softwaresystemtechnik, Potsdam, Germany
6	C. Dell'era	4	24	Politecnico di Milano, Milan, Italy
7	I. Hawryszkiewycz	4	11	University of Technology Sydney, Sydney, Australia
8	J. Liedtka	4	22	Treehouse Innovation, US
9	S. Magistretti	4	14	Politecnico di Milano, Milan, Italy
10	C. Baughn	3	13	Boise State University, Boise, US

The author with the highest productivity is Cara Wrigley. Her research focuses on the application of design to foster innovation processes in organizations and design education, proposing the creation of a DT training program. She stands out for her proposal of an educational innovation matrix based on the design as a working prototype and methodological framework for teaching DT (Wright and Wrigley 2019). In terms of the highest number of citations, Claudio Dell'Era leads the list of authors with the highest h-index. His most significant work (Magistretti, Pham, and Dell'Era 2021) proposes five dynamic capabilities of DT necessary for identifying opportunities for a more human-centric digital transformation.

The second most cited researcher is Jeanne Liedtka, whose research has focused on studying the link between DT and innovation. Her most recent work (Jaskyte and Liedtka 2022) analyzes DT practices (in a sample that includes business, government, and nonprofit sectors) and their effectiveness in generating innovation in organizations, revealing that the benefits are not only directed at users and innovation teams but can have a systemic reach.

As shown in Figure 4, the network of scientific collaboration among authors consists of seven communities. The two largest communities are formed by researchers from the Hasso Plattner Institute (Germany) and the Politecnico Di Milano (Italy), respectively. These communities reflect both thematic and geographic proximity, which enable effective collaboration among peers.

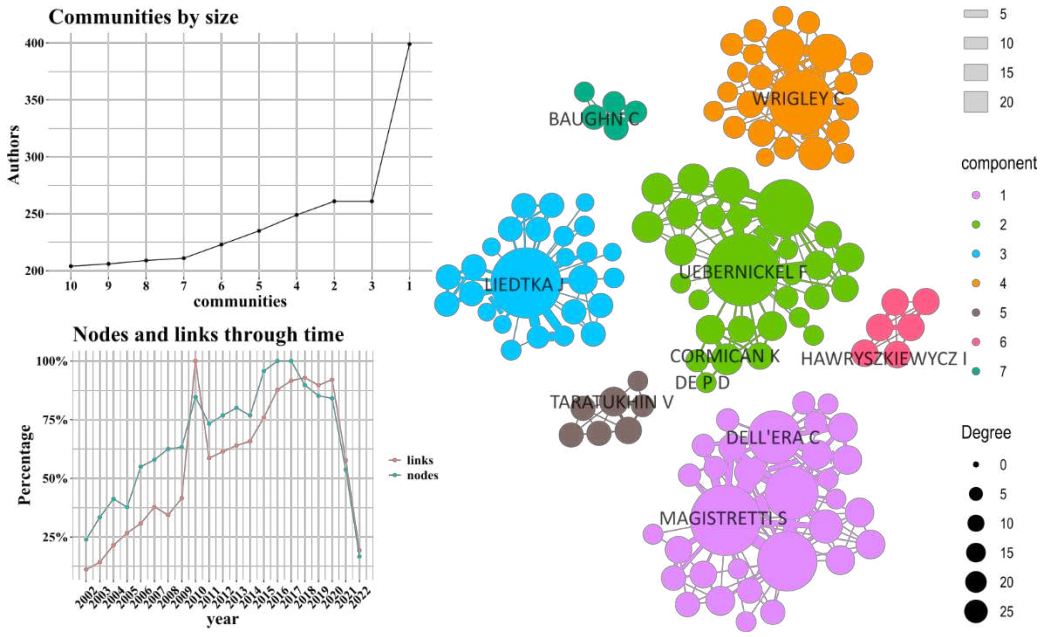

Figure 4: The Collaboration Network Is Built from the Top Researchers' Ego Network

The School of Management at Politecnico di Milano hosts the most representative cluster, led by Stefano Magistretti and Claudio Dell'Era, who study the relationship between DT and innovation. They found that DT projects can pursue solution innovation (new products and services), strategic transformation, or neither of the two (Magistretti et al. 2022).

The second most representative cluster is headed by Falk Uebernickel, who collaborates with Danielly de Paula, both from the Design Thinking and Innovation Research at the Hasso Plattner Institute. They also have ties with other prominent researchers, such as Kathryn Cormican, from the School of Engineering at the University of Galway (Ireland). For example, these researchers have proposed a managerial mental model that uses DT to foster a culture of innovation in organizations seeking digital transformation (de Paula et al. 2023).

Tree of Science in Design Thinking for Business Innovation

Utilizing the algorithmic results, we identified works that contribute to shaping the "tree of science" in our research focus on "design thinking and business innovation." Figure 5 visually represents this tree, showcasing key articles in each category. The roots represent foundational articles, offering theoretical underpinnings to the topic. The trunk encompasses articles providing structure, facilitating the consolidation and growth of the subject. In the branches, one finds the most recent works revealing perspectives shaping the future of the subject. Collectively, the "tree of science" for DT in business innovation allows a chronological visualization of the academic production's evolution.

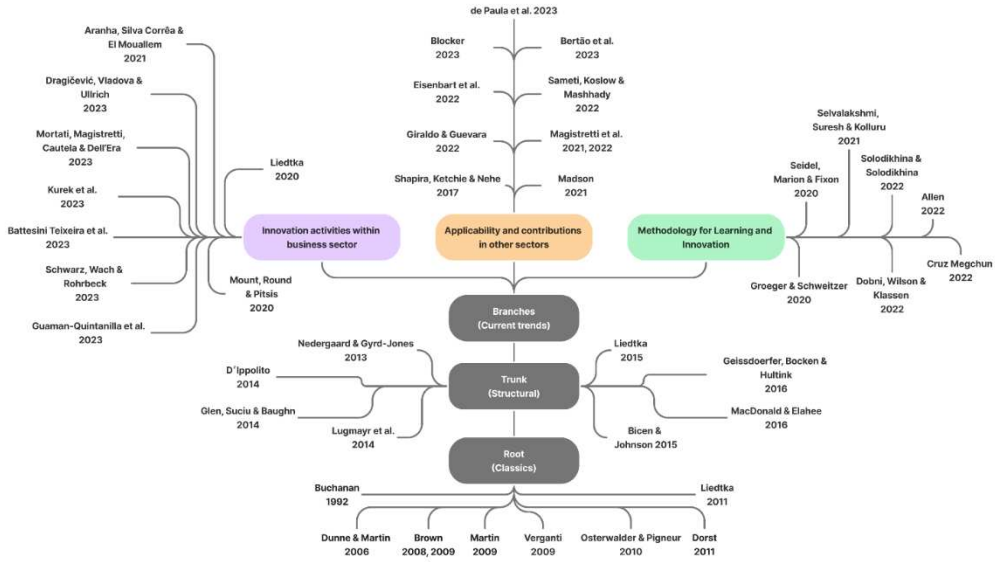

Figure 5: Tree of Science in Design Thinking for Business Innovation

Based on the identification of the articles, a review of the most important aspects of DT for the business innovation is carried out in order to present a general overview of the topic.

Roots (Classic or Foundational Works)

In the tree metaphor, the roots represent the works that underpin the field of study. In our case, the work by Buchanan (1992) serves as a cornerstone that lays the foundations of DT, as it infers that the designer can deliberately shape design problems by managing different interests and developing invention as a working hypothesis for exploration and development. In the same vein, Dorst (2011) explains that the central challenge of design, the complex problems of organizations, requires a type of abductive reasoning that involves generating both the "what" and the "how" that lead to a desired value.

The link between design and innovation is rooted here with perspectives from management or design that seek to take a perspective beyond the product and into the organizational realm. In this regard, we find industrial designer Tim Brown, a figure popularized for promoting DT as a "discipline," a methodology, a culture, and a form of leadership that leverages the sensitivity and methods of designers (thinking and doing) to create solutions oriented toward people's needs, which can be developed with available technology and can generate profitability for companies (Brown 2008, 2009).

From a management perspective, Roger Martin makes a distinction between DT as the way in which a designer "thinks"—the cognitive processes used to design products, services, and systems—and design as the "end result"—aesthetic and functional products and services (Dunne and Martin 2006). He proposes that through DT, companies can achieve a balance between exploration and exploitation of knowledge, thereby creating value and competitive advantages (Martin 2009). On the other hand, Verganti (2009) suggests, in addition to technological and market innovation, a third pathway: innovation of meanings, which aims to create products and services that fundamentally change the sense and purpose for users.

Lastly, we encounter scholarly works focused on the tools applicable in DT. Liedtka (2011) concludes that DT facilitates the generation and validation of more effective and less risky ideas by employing tools such as journey mapping, assumption testing, rapid prototyping, and customer co-creation. Furthermore, Osterwalder and Pigneur (2010) propose the utilization of the "Business Model Canvas" as a visual tool for the design, redefinition, and implementation of business models. In this respect, we can consider this work a seminal contribution to the field of business design.

Trunk (Structural Works)

Following the metaphor of the tree of science, the trunk represents works that provide essential structure and support for the development of the topic. Within this core, three

distinct thematic lines emerge: DT for innovation activities, DT for sustainability, and DT in the context of entrepreneurial and business education.

The first thematic line explores the application of DT in innovation activities, with a specific focus on customers, online services, product development, processes, strategies, and competition. D'Ippolito (2014) conducted a literature review on DT and its influence on achieving competitiveness in companies from a multidisciplinary and multivariate perspective. It describes various aspects and dimensions of DT that influence the performance and competitive advantage of companies, such as product design, services, processes, organization, and strategy.

Liedtka (2015) proposes a theoretical framework to link DT with innovation outcomes. The objective is to reduce information processing biases that individuals may have, which directly impact decision-making. The article identifies the main cognitive biases that hinder the innovation process, such as overconfidence, failure to verify information, fear of resource loss, and beliefs.

In their work, MacDonald and Elahee (2016) analyze the integration of DT with co-creation, addressing the challenges commonly faced by project managers in collaborative efforts with clients. The study advocates the application of network theories and consumer behavior to better assess and manage the contributions of customers belonging to an online community, taking into account four aspects: the nature of the problem, the type of community, motivation, and compensation for participation. It analyzes and compares two case studies, the InnoveCentive platform and OpenIDEO, emphasizing their strengths and weaknesses.

Moving to the realm of circular economy, sustainability, and innovation, Nedergaard and Gyrd-Jones (2013) explore, through case analysis, how innovation serves as a crucial factor for brand growth from a sustainability perspective. The study establishes three key management elements: directing innovation investments toward the brand, customer knowledge orientation, and allocation of resources to maintain competitive advantages.

Bicen and Johnson (2015) explore how organizations can innovate by breaking paradigms with limited resources and in environments characterized by abrupt and unpredictable changes, which have been less studied at the time of publication. Similar to the previous article, it describes the innovation capacity methodology called Lean, which adds the ability to experiment to the DT process of companies by combining available resources with agile prototypes to address new challenges and opportunities.

Geissdoerfer, Bocken, and Hultink (2016) suggest combining DT and innovation to develop sustainable business models. This approach aims to enhance the creative process and overall business modeling, resulting in truly sustainable value propositions. The study presents a new working framework based on value mapping, which was developed through an analysis of existing literature, expert interviews, and workshops. As a result, it generated alternative forms of value: economic, social, and environmental, aligning with the interests of current and potential stakeholders.

Finally, several articles on DT applied in the context of business education are identified. Lugmayr et al. (2014) address the application of DT in media management education, drawing from the experience of developing such courses in different universities. In the same vein, Glen, Suciu, and Baughn (2014) invite business schools to explore non-traditional pedagogical approaches by combining analytical reasoning with DT. Both articles illustrate how DT enables students to tackle complex and uncertain problems that require disruptive thinking, providing guidance for developing similar courses and programs across various educational contexts.

It is important to note that some documents cover overlapping topics, reflecting the diverse applications that DT has had and continues to have in its evolution.

Branches (Current Trends in DT for Business Innovation)

This section elucidates the primary clusters that constitute the subtopics within the overarching theme, as identified through the Tree of Science (ToS) methodology. Figure 6 presents a citation network accompanied by a word cloud analysis for each cluster. In line with the metaphor of the ToS, these subtopics can be envisioned as branches, representing "current trends" on the topic of DT for business innovation.

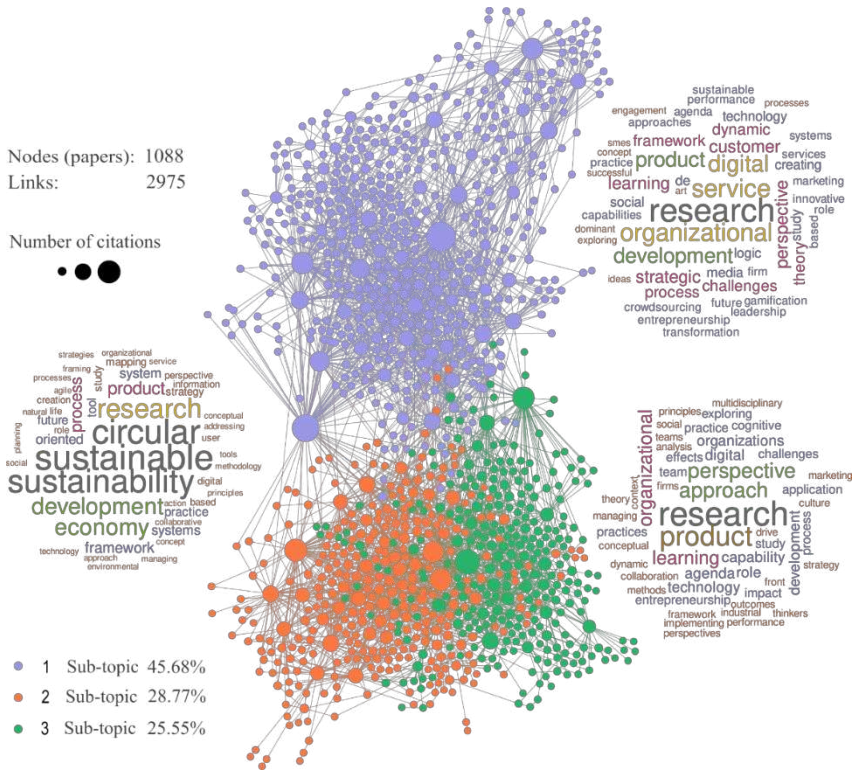

Figure 6: DT Citation Network with the Three Biggest Clusters

By leveraging this co-citation network, we can map the most recent works in the field, pinpointing key areas where research is developing. Three main branches emerge: DT for innovation activities within the business sector, applicability and contributions of DT in other sectors, and DT as a methodology for learning and innovation. Notably, the first branch is distinct from the other two, signifying a well-defined thematic focus, albeit with some nodes intertwined with the others. Meanwhile, the latter two branches are intertwined, suggesting they are still evolving and share common thematic approaches.

Branch 1—Design Thinking for Innovation Activities within the Business Sector

The first branch encompasses a variety of studies focusing on the theoretical aspects that underpin the framework, development, and perspective of DT in the innovation activities in business and organizations. These studies primarily analyze the applicability of DT across all levels of the firm, with a particular emphasis on its connection to innovation in products, services, customers, and organizational support activities. Through a case study, Aranha, Corrêa, and El Mouallem (2021) demonstrate how a company applies DT to identify market opportunities and foster innovation.

Furthermore, the capabilities of DT in different business contexts are examined. In this regard, the digital world and sustainability have posed challenges for organizations. In response to these challenges, DT has gained considerable importance by offering tools for solving complex problems. Dragičević, Vladova, and Ullrich (2023) provides a theoretical review of the relationship between DT and digital capabilities in the fields of education and business, revealing the connection between DT and the necessary competencies in the digital world, such as creativity, multidisciplinary collaboration, critical thinking for solving complex problems, empathy, and practical iteration with users. Similarly, Mortati et al. (2023) discuss the practical and theoretical implications of using big data and different types of data (old and new, large and small) in the DT process. Their discussion revolves around the stages of the DT process, such as observe and learn, synthesize and frame, vision and opportunity, and solve and realize, drawing insights from the analysis of eight innovation projects in Italian consulting service companies.

In the context of sustainable business models, techniques such as workshops, brainstorming, co-creation, and prototyping are highlighted as linking DT and sustainability, with a focus on customer-oriented innovation and the study of stakeholder needs (Kurek et al. 2023). In the textile industry, a methodology based on DT proposes the incorporation of circular economy elements in the development of new innovative products based on design and consumption cycles, covering five main stages of DT: (1) empathy; (2) defining user needs and problems; (3) ideation; (4) prototyping; (5) testing, and three macro phases of new product development (planning, development, closure) (Battesini Teixeira et al. 2023).

Additionally, the positive contribution of incorporating future anticipation methods in the success of DT projects is highlighted, with scenario planning, a widely used and popular method for strategic foresight in DT, standing out as an effective approach to address future challenges (Schwarz, Wach, and Rohrbeck 2023).

Another field of application for DT is education, where the impact of DT on the higher education sector has been analyzed, revealing improvements in creativity development and problem-solving skills among university students who applied DT. These results support the need to incorporate DT programs or curricula in the training of university professionals (Guaman-Quintanilla et al. 2023). In the realm of non-designers, a model for solving complex problems is presented, based on collaboration and idea exchange, along with theoretical and practical scope (Mount, Round, and Pitsis 2020).

Branch 2–Applicability and Contributions of Design Thinking in Other Sectors

DT has gained significant popularity as a methodology for problem-solving, fostering innovation, and creating sustainable value. This second branch encompasses studies on the applicability and contributions of DT in sustainability, circular economy, and other sectors.

In the face of sustainable development challenges, Shapira, Ketchie, and Nehe (2017) propose a prototype for incorporating strategic sustainability into the DT process to contribute to achieving strategic and sustainable outcomes. This study presents the contributions and barriers of the DT process in relation to strategic sustainable development (SSD).

In technology companies, research on users, prototyping-experimentation, user-customer journey mapping, interaction with people, the use of visual tools, and co-creation with users are identified as key aspects of the successful implementation of DT to drive innovation in technical design (Eisenbart et al. 2022).

Another success factor that facilitated the adoption of DT practices was the implementation of a personalized DT-based training methodology, as evidenced in the case study of the Research and Development department at LG, where empathetic observation expanded learning possibilities, enhancing the importance and effectiveness of DT (Bertão et al. 2023). In the health-care sector, practical examples of DT application are presented, along with recommendations for its implementation in medical education (Madson 2021).

In the telecommunications sector, a managerial model is proposed by de Paula et al. (2023) to drive innovation in the realm of digital transformation, utilizing DT. This requires a mindset and organizational culture shift that fosters user-centered innovation and agile experiences. DT facilitates this change by providing a process for solving complex problems with innovative solutions. The managerial mindset model comprises dimensions of attitude, knowledge, skills, and behavior (de Paula et al. 2023).

Education is another sector that has been impacted by DT. Positive effects on interdisciplinary learning are observed as it provides university students with a broader

intellectual perspective to apply different viewpoints and solve complex problems (Blocker 2023). Similarly, in the online education market, the applicability of the design sprint or accelerated design is presented, specifically in the creation of an innovative solution that involves actions such as defining, framing, experimenting, and learning (Magistretti et al. 2022). In the same vein, Fridman, Meron, and Roberts (2022) present a study supported by three examples applied in diverse educational contexts. It examines education in DT and the responsibility it holds in combining feasibility, viability, and desirability principles with social responsibility, environmental sustainability, ethics, critical thinking, and accountability. The authors propose the conceptual and operational framework for integrating responsible design into DT education, inviting debate on its challenges and limitations in current practice.

In this context, the opinions of professional designers and marketing researchers regarding creative design contrast. Professionals perceive it as a means to solve user problems with products, while marketing researchers associate creative design with a set of product characteristics or requirements (Sameti, Koslow, and Mashhady 2022).

Lastly, Giraldo Ospina and Guevara Sánchez (2022) draw attention to the designing individual and their personality traits associated with thinking, their passive cognitive resistance to innovation, and their link to linear thinking. The authors present a model of differential equations determined by data from 342 engineering and business professionals.

Branch 3–Design Thinking as a Methodology for Learning and Innovation

This particular subtopic is focused on the application of design in learning and organizational contexts. Primarily, we identify authors who seek to study the links between DT and innovation in higher education pedagogy through a student-centered approach. To foster an innovative mindset in engineering students, they combine STEAM strategies with a symbiosis of DT and business thinking (Solodikhina and Solodikhina 2022). In postgraduate business education, especially in MBA studies, some authors aim to integrate DT into pedagogical innovation (Selvalakshmi, Suresh, and Kolluru 2021) or develop a mindset that promotes designerly ways of thinking and doing in students (Groeger and Schweitzer 2020). Others explore intersections such as DT and anthropology to teach strategic innovation and enable students to address challenges responsibly (Cruz Megchun 2022). In this subtheme, Seidel, Marion, and Fixson (2020) identify DT as one of the four methods for teaching innovation, which focuses on learning the design process and is oriented toward incremental innovation projects with high levels of uncertainty. Therefore, DT-based innovation courses tend to be both experiential and interdisciplinary.

From the perspective of DT as a methodology in organizations, Allen (2022), after a literature review of hybrid models between DT and Lean Startup, presents a novel methodology for Business Model Design that harnesses both the lean nature and user-

centeredness. On the other hand, Dobni, Wilson, and Klassen (2022), in a study with a sample of Japanese firms, found that DT is associated with innovation orientation: high-innovator companies use DT as a business practice, in contrast to low innovators.

Implications of Research

Theoretical Implications

The conducted scientometric analysis, involving the search, review, and evaluation of published literature, has provided insights into the thematic structure of DT in the realm of business innovation.

Utilizing the metaphor of the ToS, we successfully identified foundational works that laid the groundwork for the construction of the DT paradigm for innovation. The contemporary understanding of DT has evolved as a result of the intersection between design and management. It is through the application of DT that design practices seamlessly integrate with business practices. Notably, when profound transformations occur in the latter, DT becomes intricately linked to innovation, as emphasized by Dorst (2011). These transformative changes manifest in the creation of competitive advantages (Martin 2009) and dynamic capabilities (Liedtka 2011). This, in turn, empowers organizations to address wicked problems (Buchanan 1992), generate user-centered solutions (Brown 2009), or pursue less conventional innovations, such as imbuing products with meaning (Verganti 2009).

This study has delineated three primary subtopics, resembling branches of a tree, which spotlight the prevailing trends in the field: (1) DT for innovation activities within the business sector, concentrating on the applicability of DT in various organizational areas and processes to create value; (2) applicability and contributions of DT in other sectors, encompassing studies focused on its implementation in areas like sustainability, circular economy, digital transformation, and related domains; (3) DT as a methodology for learning and innovation, centering on studies that explore its integration in educational contexts (learning innovation and design processes) and business contexts (business model design and innovation processes).

These three branches exhibit certain overlaps, indicating the ongoing maturation of the thematic evolution of DT for business innovation. Our study introduces a distinct perspective on business innovation and employs a novel methodology, the ToS, in contrast to previous reviews (Dragičević, Vladova, and Ullrich 2023; Lyu et al. 2023; Li and Zhan 2022), with which it can be aligned and complemented.

Practical Implications

Bibliometric analyses provide a valuable means to explore key research areas, trace the evolution of a topic, elucidate connections between concepts and keywords, highlight areas of interest, and anticipate potential future research directions. In addition to providing

research opportunities for DT scholars, the practical significance of the trends identified in this study extends to providing guidance for professionals engaged in the integration of DT. This includes its application in innovation activities within organizations; in the education and training of work teams; or in interdisciplinary collaborations with other sectors, such as sustainability, circular economy, or digital transformation.

The presented bibliometric analysis aids not only in mapping research networks to identify partnerships and collaborative efforts but also in recognizing crucial journals for publication decisions. Moreover, it delves into citation patterns to gather relevant information on the topic and assesses the impact of publications by country, thereby helping to identify research stakes, resources, and sponsorship opportunities.

Conclusions

Utilizing citation network analysis on publications related to "design thinking" and "business innovation" through the WoS and Scopus platforms, this study constructed the ToS for this thematic area. Employing various bibliometric methods, the research aimed to illustrate the evolutionary trajectory of "design thinking for business innovation."

From 2007 to 2022, the behavior of academic publications on DT for innovation reveals that it was not a passing fashion but rather that it established itself as a disciplinary core that will continue to grow and develop. Consequently, three distinct periods of scientific production were identified: Initiation (2007–2012), Growth (2013–2018), and Seasonality (2019–2022). Positioned as a social technology (Liedtka 2020), DT has evolved through continuous research and the assimilation of new elements at various levels, be it mindset, tools, or activities. This evolution underscores that DT, as understood today, is a co-created technology that remains dynamic and has yet to reach its final version.

While the US dominates academic production on the topic, the most influential collaboration networks are centered on two academic institutions: the Hasso Plattner Institute in Germany and the Politecnico Di Milano in Italy. F. Uebernickel, leads the first cluster, while the second is spearheaded by C. Dell'era, and S. Magistretti,—dedicated professors and researchers in the field of DT and innovation. Both academic centers house specialized design schools and offer educational programs intertwining design and management, fostering numerous projects and research initiatives. This highlights that collaboration networks are shaped not only by geographic proximity but also by the establishment of comprehensive educational and research systems centered on the topic. The enduring institutional commitment in these academic clusters suggests that, if maintained and reinforced, Germany and Italy have the potential to take the lead in academic discourse and the advancement of DT for innovation in the future.

As a set of recommendations, although DT offers great potential for successful application in various areas, it is necessary to leave superficiality behind in its integration: it

requires methodological experts, appropriate environments, a collaborative and flexible organizational culture, managerial commitment, and, above all, overcoming the conceptual design phase and achieving the implementation of solutions (Eisenbart et al. 2022). In corporate contexts it is necessary to design an internal training plan that includes strategies to overcome limitations at the individual and organizational levels (Bertão et al. 2023).

The efficacy of DT in generating value for organizations has been a subject of scrutiny within research (Liedtka 2020). Existing literature reviews, such as the one conducted by Dragičević, Vladova, and Ullrich (2023), have highlighted the prevalent methodological approach, wherein most publications adopt an empirical and qualitative stance, with case studies being the dominant method. One of the more ambitious studies in this regard is that of Liedtka (2020), which examined fifty organizations, delving deeply into twenty-two of them along with their DT projects. This research follows purposive and non-probability sampling methods.

In light of these observations, we recommend that future studies on DT consider venturing into quantitative methods or adopt a hybrid approach combining both quantitative and qualitative methods. There should be a particular emphasis on longitudinal studies, allowing for the accumulation of evidence regarding the impact of DT integration over the medium and long term.

Some limitations are inherent in this study. First, the final data set and the works subjected to content analysis were selected by the authors, potentially introducing a selection bias into the analysis. However, stringent eligibility criteria were established and applied to mitigate this bias and ensure data quality.

Another limitation pertains to the evident overlap of articles concerning subtopics within the identified branches. Despite declarations of the "death" of DT dating back over a decade (Dorst 2011), this suggests that DT for innovation is still in a continuous process of evolution, incorporation, structuring, and development. Such a process may eventually lead to the consolidation of cohesive subthemes in the future.

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Conflict of Interest

The author declares that there is no conflict of interest.

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