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A Systematic Bibliometric Review and Visualization of the Intersection between Lean Start-ups and Sustainability

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Abstract

In an uncertain business landscape, success as a start-up requires more than just innovation and entrepreneurship. It also demands a commitment to continuous improvement, experimentation, and sustainability while meeting the genuine needs of customers. This bibliometric review aims to systematically explore the path to sustainable entrepreneurship for start-ups adopting the lean method by mapping the critical literature and research directions. The review employs a quantitative approach to synthesize Scopus-listed research resources, applying novel visualization techniques such as Co-Coupling Network and Co-Occurrence Network analyses. The analysis covers lean start-up queries between 2008 and 2023. A total of 934 research articles were reviewed until the end of December 2023 (31/12/2023), highlighting how the selected issue has evolved. The results identify eight clusters that reflect different research topics and their associated keywords to offer a niche perspective on the evolution of the lean start-up methodology, emphasizing continuous experimentation and user-centered design for business model innovation. The results offer valuable insights for academic researchers and practicing lean professionals and provide a roadmap for start-ups seeking success. Moreover, this review is a benchmark for economic policymakers and start-up entrepreneurs seeking to make well-prepared decisions and adopt agile development methodologies.

Keywords: bibliometric review; innovative SMEs; lean start-ups; spin-offs, sustainable entrepreneurship

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1. Introduction

Lean Start-up term is a revolutionary management concept for developing a business or product to reduce the risk of failure most efficiently. Lean Start-up (LS) philosophy has since been extended to any individual, team or company looking to bring new products or services to market. Today, its popularity has grown significantly outside its birthplace in Silicon Valley and has spread almost worldwide [1]. LS is an approach to launching start-ups and new products that treat every product and business idea that needs to be validated through rapid experimentation in the marketplace. The purpose of experimentation is to test primary business hypotheses, such as assumptions about value and growth, and to help entrepreneurs start the learning process as quickly as possible.

The approach relies on scientific and continuous experimentation, iterative product launches and constant customer feedback to identify their real needs and ensure a proper learning process. Like the principles of Lean Management, the LS philosophy seeks to eliminate wasteful practices and increase value-creating in the product development phase to give startups a better chance of success. It is important to note that the LS approach is not a panacea for business failure. Over-expenditure of time and money can lead to business failure. Nevertheless, the Lean philosophy facilitates identifying and eliminating unsound ideas lacking market support, thus reducing uncertainty in developing new products [2].

The Lean Startup methodology is not an entirely new and untested concept. It is partly based on the Toyota Product System (TPS), which emphasizes minimizing wasteful resource utilization and shares some critical points. Nonetheless, there needs to be more literature on how and in what form the Lean Startup methodology contributes most to the development and success of businesses [3]. The field still needs comprehensive, holistic theories that can be used to guide future development [4]. Consequently, our knowledge about the most critical steps in different stages of the startup process is limited and inconsistent, let alone how, why, and in what context these factors are connected [5].

We have reviewed the development of different aspects of research to understand how start-ups can be successful. In order to attain this objective, we have taken into account the elements that are conducive to the success of start-ups and the implementation of lean methodologies for the purpose of sustainable advancement. Previous literature reviews have conducted a comprehensive mapping of lean start-up models published in the 2000s, considering existing review guidelines [6]. Additionally, they have addressed agile software development, customer-oriented design, and lean start-up concepts [7]. However, the current literature is much less informed and lacks a holistic review of the successful and future sustainable functioning of start-ups and the combined role of lean.

The aim of this bibliometric analysis is to help startup researchers and practitioners review the development of various research perspectives and consider the broader theories related to the lean startup concept. We will examine a variety of research methods and research areas to nuance the findings and provide startup researchers with valuable theories and methods used in business creation and development, new product introduction and experimentation, user-centered design, and business model innovation. By drawing on experts from different fields and adopting a diverse professional perspective, this analysis also calls for further evidence and using the latest methodologies to better understand the broader socio-economic impacts of sustainable development.

A bibliometric review and visualization analyses can summarize research trends, identify existing research gaps, and provide insights for future research. The remaining chapters of this study will review and evaluate the published literature on Lean Startups, including empirical, case studies, and overviews. The visualization analysis will identify different patterns, trends, and gaps in the literature, providing a clear and comprehensive picture of the research field. Combining a bibliometric review and visualization highlights the importance of the diversity of start-ups and lean methodology.

2. Data and Methods

The analysis was conducted using the Scopus database for international literature research. Scopus is recommended for separating publications by authors with the same name due to its filtering and indexing techniques [8]. We chose Scopus over similar databases, such as Web of Science and PubMed, because it has a broader content coverage [9]. It also offers individual profiles for authors and institutions and free access to author and source information, including metrics. Finally, the size and diversity of its publications make it an ideal choice for bibliographic analysis [10].

We used a Systematic Literature Network Analysis (SLNA) to select and evaluate relevant literature. The data were collated until the end of December 2023 (31/12/2023). The initial year of the search interval was identified as 2008, which marks the year in which the concept of the Lean Startup was first employed. This approach involves a bibliometric review (see Figure 1), where appropriate search terms are selected based on the research questions, and irrelevant articles and duplicates are excluded from the literature. The first stage involves a bibliometric review, where we prioritize transparency, explanatory, and heuristic features [11]. We carefully select search terms based on research questions and exclude irrelevant articles or duplicates to ensure an objective and scientifically sound evaluation of our search results. It also helps prevent potential biases from influencing our findings [13]. Finally, we will leverage bibliographic network analysis and visualization techniques to identify current and emerging research topics using methods, e.g., Co-Coupling Network and Co-Occurrence Network. These methods allow us to stay up-to-date and informed on the latest advancements in the field. The utilization of research methodologies enables an inclusive account of qualitative aspects that effectively reinforce the bibliometric analysis. By evaluating the titles, abstracts, and keywords of studies, content analysis via search technique minimizes potential bias and enhances the accuracy and consistency of pre-determined inquiries.

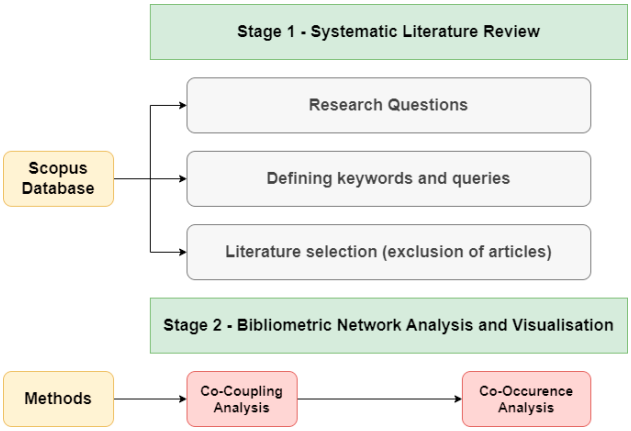

Fig. 1. Framework of Systematic Literature Network Analysis (SLNA).

The open-access software package VOSviewer (1.6.20) provides unlimited analysis capabilities for bibliometric mapping and visualization of data downloaded from Scopus and used for systematic analysis. The Visualization of Similarities (VOS) algorithm allows the visualization of direct and indirect relationships between elements and the proximity of entities in the network map. The proximity of network nodes means that in some groups, they occur together more often than in others. In addition, an element always appears in the center of the map. In this case, it can be assumed to belong to more extensive and diverse groups of other elements and the most prominent clusters, color-coded in the view constructed accordingly [12]. This overview allows us to identify the most prolific and cited authors and the influential research areas (clusters) to provide a comprehensive picture of the structure of the literature and its evolution over time.

3. Results of the Bibliometric Review and Visualization

We thoroughly reviewed the literature in the Scopus database and identified the relevant terms, synonyms, and abbreviations related to lean and startup. Using the query command TITLE-ABS-KEY, we searched the publications' titles, abstracts, and keywords, considering those above, e.g., lean, startup (and synonym) phrases (Equation 1). The keywords were "lean," "start-up," and a combination of the terms "spin-off" and "spin-out," which were used to describe start-ups in the university ecosystems.

$$TITLE - ABS - KEY\ (lean\ AND\ (startup*\ OR\ start-up*\ OR\ spinout*\ OR\ spin-off*))) \quad (1)$$

A total of 934 research articles were reviewed until the end of December 2023 (31/12/2023). For further analysis, we included only articles, conference papers, book chapters, books, reviews, conference publications and reviews,

short surveys, and notes, including those published in the press. In terms of search results and distribution of documents (%), conference publications (44.6%) were the most popular source, followed by articles (38.8%) and book chapters (7.6%). The distributions (%) of subject areas were as follows. Most sources were derived from the following subject areas, in order: Business (22.5%), Computer Science (19.2%), Engineering (16.1%), Economics (7.4%), Decision Sciences (7.2%), Social Sciences (7.0%), Mathematics (5.8%), Energy (3.9%), Environmental Sciences (1.6%), Earth Sciences (1.4%) and other (7.8%).

2008 was selected as the initial year of the search interval when *Eric Ries* first used Lean Startup. The query thus generated 829 hits in the period examined, from 2008 to 2023. Finally, we cleaned the data of duplicates, i.e., second or multiple copies published by the same author(s) with duplicate titles but in different sources (preprint, conference proceedings). The remaining number of sources was 806.

Most sources are published in the United States, Italy and Germany when considering geographical locations and countries. The United Kingdom, Finland, Brazil, Norway, China, Canada and India are also in the top ten. The distribution of research across nations may suggest that the topic is globally significant. Following an initial period between 2008 and 2014, academic interest in lean-based start-ups increased. The number of publications rose to 47 in 2015 and doubled in 2018 (92). Although the number of publications has stayed the same between 2018 and 2023, on average, around 90 papers per year are published on the research topic.

3.1. Co-Coupling Network (CCN) Analysis

The CCN analysis can be used to identify studies of pioneering importance. The CCN map represents the total citations received for a given publication in the entire database, regardless of whether the publication is part of the linked citation network [13]. The strength of association classifies papers based on their normalized citation scores since acceptance in Scopus. This analysis identifies the top works of current interest to the scientific community (Figure 2). It also identifies promising new articles that have appeared since the first publications.

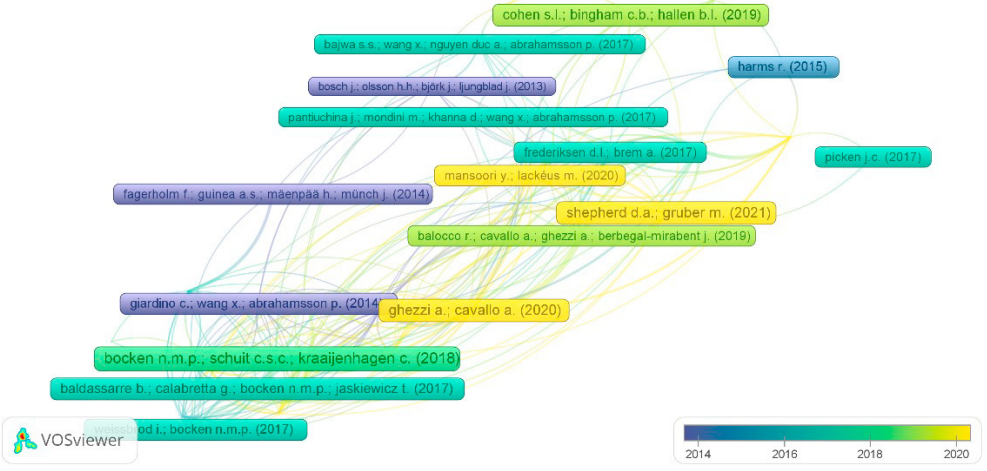

Fig. 2. Network Map of Top Cited Articles (chronological).

Four top publications with the highest normalized citation scores are closely associated with Business Model Innovation (BMI). BMI is a widely-used concept in the field of practical entrepreneurship. It is built on five critical components for launching a newfound business, e.g., business model, customer development through validated learning, minimum viable product, persistence or pivoting, and navigating market opportunities [14]. The LS method is centered around the idea that entrepreneurs should consistently explore, experiment, and cyclically investigate their customers during product development. Business experimentation aims to enhance BMI activities through ongoing, collaborative learning with stakeholders, all while managing risks and resources [15]. In essence, this LS toolkit enables rapid experimentation and iteration (even stopping and restarting) of business models, facilitating learning

and considering the needs of value owners (customers) and the tasks to be performed. As the business model is launched on day zero, the same tools can be used initially to search for business models. Subsequently, an unending cycle of pursuing a business innovation strategy can commence when the models reach the execution phase. At this juncture, the LS toolkit will be supplanted by conventional business execution tools [16].

In the early stages of their development, digital startups often undergo innovation in their value architecture and business model [17]. Accordingly, the theoretical strengths of effectuation can inform the development of other entrepreneurial methods. At the same time, the strengths of alternative entrepreneurial methods can be used to address the potential weaknesses of effectuation, such as its limited behavioral tactics and applicability to later stages of venture development [18].

3.2. Co-Occurrence Network (CON) of Keywords Analysis

In order to analyze author keywords, we utilize co-occurrence network maps and cluster analysis. In the network representation, items are depicted by their labels and either a circle or square shape [19]. Their size is determined by their weight, representing their importance. The network nodes signify the selected keywords, while their size reflects their significance [20]. Some labels may be excluded to avoid overlapping.

VOSviewer generated a total of 60 nodes, which were sorted into 8 clusters. As there is no overlap between the clustering of the nodes, a given keyword can only belong to one cluster. In total there were 442 connections in the co-occurrence network. The higher the number, the more important the keyword is in the network and the more often it appears together with other terms. The relationship between two items indicates term co-occurrence, with a numerical value indicating the strength of the relationship. The CON analysis network maps reveal publications where two terms co-occur. Visualizing these maps can provide insights into the current LS research.

An example of the Lean Start-up keyword network visualisation is shown in Figure 3. The distance between two keywords in the visualisation partially indicates relatedness in terms of co-occurrence relationships. In general, the closer the two keywords are, the stronger their relationship. The strongest keyword relationships are indicated by lines in different colours, indicating the clusters to which each item belongs.

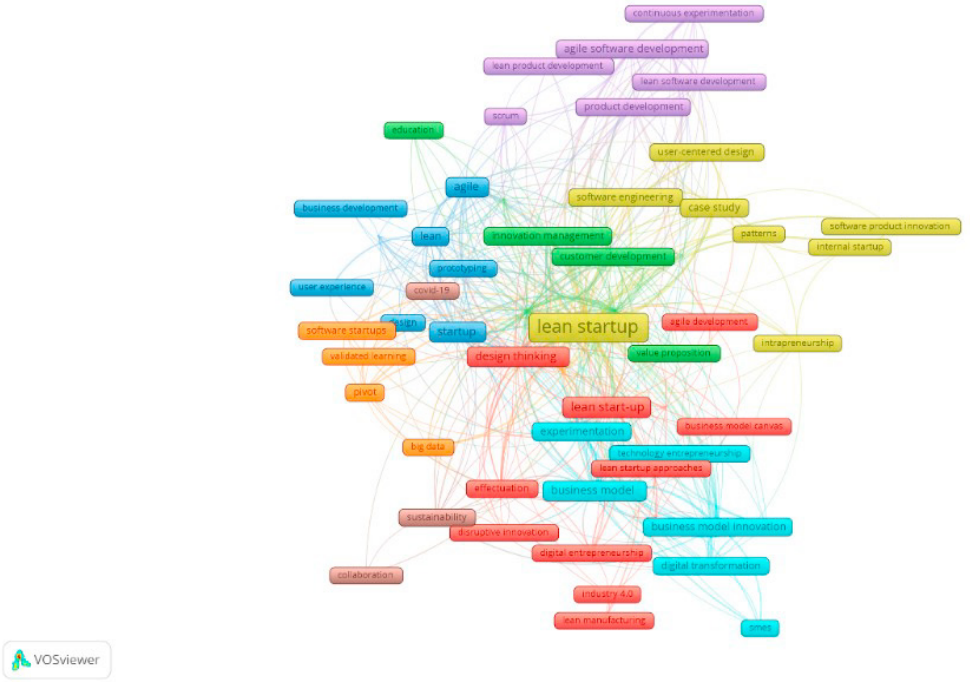

Fig. 3. Keywords Network Map (clusters).

The overlay content mirrors the network display, except for the elements' colours, which remain detached from the clusters. Each item corresponds to the score, ranging from blue (lowest score) to yellow (highest score) by default. Figure 4 exhibits the most recent and yellow (significant) keywords and topics in the chronological (overlapping) network map, e.g., sustainability, pandemic (COVID-19), digital transformation, and Business Model Innovation.

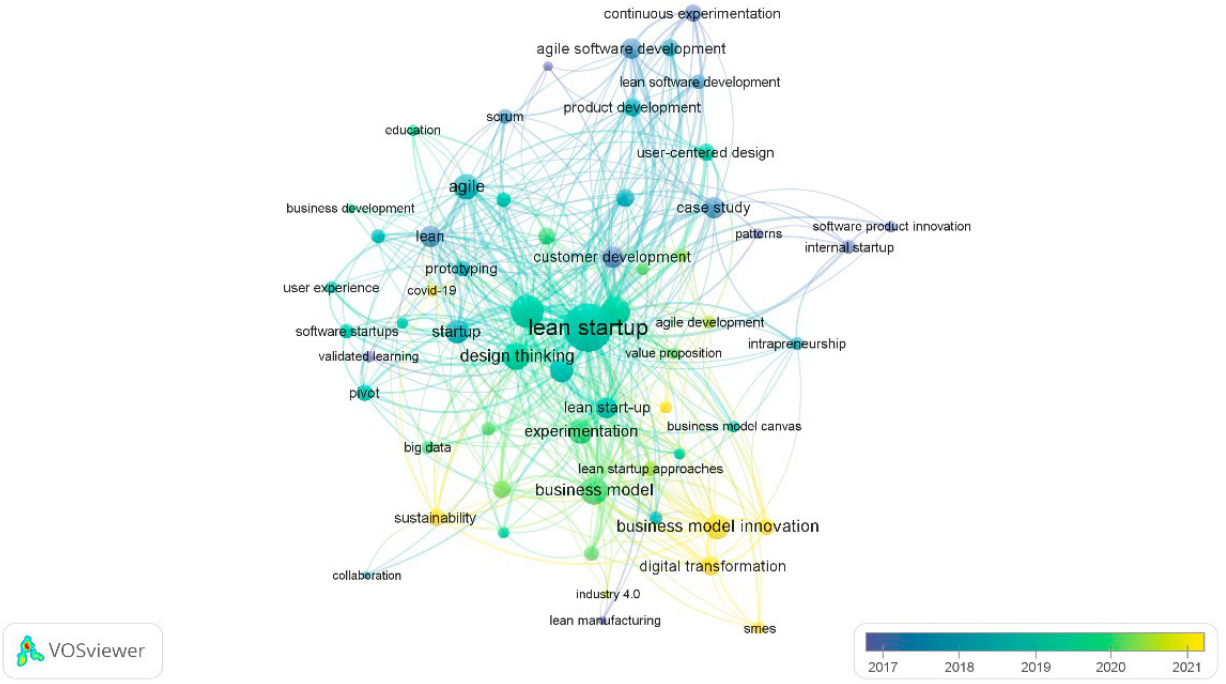

Fig. 4. Keywords Network Map (chronological).

CON related cluster analysis can uncover patterns and trends in the field based on frequently used terms [21]. Table 1 provides a more comprehensive breakdown of the keywords and clusters generated by the CON method. By default, the software clusters elements based on their association strength, which is normalized [22]. It is worth noting that clusters in VOSviewer do not overlap, meaning each element can only belong to one cluster. While clusters do not necessarily encompass all aspects of the map, there may be some elements that do not belong to any cluster at all. The previously identified clusters, depicted in Figure 3, are represented by colours corresponding to the clusters in column one. The cluster analysis yielded eight distinct research themes (topics), ordered by the total link strength (TOP 3) of keywords in the dataset.

Table 1. Key research topics under the CON.

Cluster	Keywords	Total Link Strength*	Co-occurrences	Topics
1	design thinking	90	39	Design Thinking in Entrepreneurship Education
	lean start-up	50	44	
	effectuation	35	14	
2	entrepreneurship	149	81	Customer-centered Innovation Management
	innovation	117	52	
	customer development	49	14	
3	agile	80	33	Lean Start-up and Agile Development
	startup	69	30	

	lean	50	24	
	case study	50	19	
4	software engineering	34	14	User-centered Design and Lean Start-up
	user-centered design	29	11	
	product development	32	15	
5	continuous experimentation	30	9	Product Development through Continuous Experimentation
	product management	30	9	
	business model	102	40	
6	business model innovation	76	28	Improving Business Models via Experimentation
	experimentation	71	25	
	minimum viable product	68	30	
7	pivot	26	12	Success with Minimum Viable Products
	software startups	20	12	
	sustainability	29	13	
8	covid-19	11	6	Impact of Sustainability Efforts
	collaboration	4	6	

* Ranked by priority.

Cluster 1 focuses on design thinking and effectuation in education. Many companies seek to increase the agility of their innovation processes in light of digital transformation and the increased usage of artificial intelligence. Contemporary Entrepreneurship Education (EE) is often built around a team-based challenge, such as creating a new business or solving a start-up problem [23]. Self-regulated Learning (SRL) is proposed as an effective learning method in entrepreneurial projects for creative solutions and psychological safety positively related to group performance [24]. Meanwhile, effectuation views the future as shaped by entrepreneurs who plan for contingencies based on the tools at their disposal rather than goals by leveraging the entrepreneurial spirit [25]. Effectuation is a mindset by which individuals and organizations can approach the Lean Start-up process to create, test, and evaluate opportunities and business models as quickly and cheaply as possible [26].

Cluster 2 represents the primary themes of Customer-centred Innovation Management in the enterprise. Value creation and customer satisfaction are the primary goals of successful and profitable companies in the global market. Because of their strategic importance, the entire business model, products, and services must be evaluated iteratively, determining how well companies meet customer needs and expectations [27].

In *cluster 3,* we find LS methodologies for agile software development. Over the last decade, agile methodologies have dramatically changed software development. In contrast to traditional ones, characterized by sequential phases and a high degree of up-front planning rather than formalized processes, agile methods manage uncertainty and change by relying on close collaboration with the customer. Agile software development methods are characterized by short development cycles, collaborative decision-making, fast feedback (loop) cycles, and continuous integration of code changes into existing products [28].

In *cluster 4*, we explored User-Centered Design (UCD) and software development as a dominant theme in LS research. Agile methodologies have many limitations in understanding the problem and finding a solution, leading to the proliferation of failed products and unnecessary inventory accumulation in organizations [29]. The combined approach of UCD and Lean Start-up promotes a problem-oriented mindset. It encourages software development teams to collaborate and engage throughout the development process, actively exploring stakeholder needs and ways to meet them [30].

The frontier of *cluster 5* is product development through continuous experimentation. The RIGHT model is based on rapid and high-frequency testing of iterative value creation. It requires the ability to release at least minimally viable products and features with appropriate tools, to design and manage experimentation plans and roadmaps, and to manage a flexible business strategy [31].

Cluster 6 spans small and medium enterprises (SMEs) development, digital transformation and critical words for business model innovation through experimentation. A growing body of LS research has recognized the role of experimentation in start-ups. However, there needs to be more literature on the role of experimentation in innovation

and entrepreneurship in established companies [32]. Start-ups often adopt entrepreneurial approaches such as Lean Startup (LS) and Business Model Innovation (BMI). LS focuses on experimentation during product development and testing, working closely with potential customers to get first-hand feedback. BMI focuses on modifying existing business models or developing new ones to enable differentiation from competitors [33]. BMI is assumed to be achieved when at least two elements are innovated together, and interdependencies within the overall business model are holistically considered beyond an isolated product or process innovation [34]

The *seventh* (7^{th}) cluster comprises software startups and minimum viable products (MVPs). Software startups are newly created companies with little operational history oriented toward producing cutting-edge products. When resources are scarce, survival and success depend primarily on the leaders and managers responsible for planning, directing and executing corporate strategies. Early detection and management of critical problems can increase the chances of success of a software start-up [35].

In the remaining cluster (8), sustainability is the central issue. With a growing population and increased resource consumption, the current way of living and doing business could be more sustainable. In addition to innovative technology, sustainable development based on innovative business models, a better understanding of consumer needs, and behavioral changes are fundamental [36]. BMI is sustainable if it addresses the innovation of business to create competitive advantage and higher customer value, while positively contributing to the firm, the environment and society and minimizing harm [37].

4. Conclusion and implications

The primary objective of the study was to gain insights into the factors that contribute to the success of different start-ups. We focused on identifying the issues that contribute to the long-term viability of start-ups, as well as exploring the essential and emerging lean philosophy approaches, methodologies, frameworks, and tools that are crucial for their sustainable development. Through a thorough bibliometric review, we systematically examined the factors, methodologies, and tools that drive sustainable success for start-ups embracing the lean approach. The findings offer valuable insights for academic researchers and lean practitioners by mapping the primary literature and research directions. Additionally, they can serve as a source of inspiration for new research topics and share an interest in the success of start-ups.

Previous literature reviews have systematically outlined the lean startup models published in the 2000s, considering existing review guidelines and addressing agile software development, customer-oriented design, and lean startup concepts. Nonetheless, the current literature lacks the need to include comprehensive reviews of successful and sustainable startups and the combined role of lean methodologies. Therefore, in this review, we employed innovative visualization techniques, e.g., CCN and CON analyses to map the academic development of LS research. We analyzed clusters of leading research topic networks with the highest frequency based on their co-occurrence.

Starting from the emergence of the LS term and using queries, we demonstrated how the chosen topic has evolved as scholarly interest has shifted. The findings provide a unique perspective on the evolution of LS methodology, which has shifted from a focus on continuous experimentation and user-centered design to research directions and business model innovation.

Indeed, it is essential to acknowledge its limitations. Firstly, the analyses rely solely on bibliographic data and complex queries of the Scopus database, which means that the generalizability of the findings may be limited to this specific database. Additionally, some key papers may have been omitted due to restricted access to documents, which should be considered in future research.

From this point of view, further investigation is necessary to understand how various economic and educational stakeholders collaborate to enhance the success of start-ups. The existing literature on digital competencies mainly focuses on the educational context, while the corporate aspect is less explored [38]. More concrete evidence still needs to be provided on how digital skills can influence entrepreneurship in established organizations [39]. The world of business models and technological innovation is relentless.

There is a growing interest among researchers and practitioners in management, particularly in user-centered design [40]. The principles of user-centered design emphasize the provision of appropriate LS tools to developers, enabling them to identify user needs and develop suitable solutions more effectively. The concept of the Build-Measure-Learn

(BML) cycle and pivoting, as espoused by the Lean Startup approach, offers a complementary framework for understanding problems and proposing solutions.

All organizations need to constantly learn and experiment to develop innovative products, services, and ways of working in industry and education [41]. Alongside innovative technologies, sustainable development is based on business models, understanding consumer needs, and recognizing their behavioral changes [42, 43]. Likewise, it is essential to identify sustainable business model innovations (SBMIs), strategic objectives, and technologies to enhance incubation outcomes within different start-up ecosystems. This LS toolkit allows rapid experimentation and iteration (even stopping and restarting) of business models in a circular fashion, facilitating learning and considering the needs of the value owners (customers) and the tasks to be performed. While incorporating innovative technologies is important, pursuing sustainable development through new business models, understanding genuine consumer needs, and recognizing associated behavioral changes are crucial. Future research could focus on mapping sustainable or green lean concepts.

Acknowledgments

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