https://doi.org/10.3311/PPso.37773

Periodica Polytechnica Social and Management Sciences, 34(1), pp. 77–93, 2026

Exploring the Universe of Lean Startup

A Four-dimensional Review

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Received: 25 June 2024, Accepted: 02 January 2025, Published online: 20 March 2025

Abstract

The lean startup (LS) methodology has become a widely used tool by entrepreneurs around the world. Despite its popularity, there are doubts about its scientific validity, particularly from an academic perspective. This article presents a literature review of the LS methodology. A search was conducted in the Scopus database, and 57 scientific articles were selected for analysis. The results are classified into four main categories: literature review, theoretical development and conceptual framework, measurement and effectiveness testing, and practical application. The findings indicate that while the methodology is still in a developmental phase, it is effective in promoting innovation and adaptability in various business contexts. Future research should focus on quantitative studies and longitudinal research to provide solid empirical evidence of its effectiveness, as well as explore its adaptation to different cultural, industrial, and geographical contexts.

Keywords

lean startup, innovation, business model validation, lean startup approaches

1 Introduction

The lean startup (LS) methodology has emerged as one of the most significant advancements in entrepreneurship applied in recent years. Currently, many entrepreneurs worldwide employ this methodology, highlighting its relevance and applicability. However, doubts persist about its scientific validity, especially from an academic perspective. Critics point out the vagueness and lack of specificity of certain postulates, particularly those related to hypothesis validation experiments and the concept of pivoting. The LS methodology was developed by Eric Ries in 2011 (Ries, 2011), drawing on principles from customer development (CD) and lean manufacturing (LM) (Shepherd and Gruber, 2020). In fact, due to their affinity, both CD and LS are known as LS approaches (LSA) (Ghezzi, 2019). The concept of CD was introduced by Steve Blank (2007) as an approach where entrepreneurs should go to the market and directly engage with potential customers to develop a product or service that will later be launched to the market. On the other hand, LM is an operational management methodology developed by Toyota, aimed at maximising production process efficiency while minimising waste (Tuz and Sertyeşilışık, 2022).

The LS methodology proposes a logic for business development that seeks to find a repeatable and scalable business model while minimising waste. This involves reducing risk through an experimental approach that places less emphasis on exhaustive planning of complex business models (BMs) and more on validating assumptions outside the office, directly in the market. That is, instead of spending a lot of time developing detailed business plans based on numerous assumptions, it suggests creating a flexible and improvable business plan, continually validated through customer interaction.

According to Ries (2011), much of the inherent risk in traditional BMs stems from reliance on assumptions whose validity is unknown. This learning process is based on the feedback loop known as build-measure-learn (BML) and on principles such as creating a minimum viable product (MVP), experimentation, and decisions about perseverance or pivoting (Felin et al., 2020; Ries, 2011). The BML

Cite this article as: Fernández Rosas, A. A., Blanco-Mesa, F., Silva Rodríguez, J. D. (2026) "Exploring the Universe of Lean Startup: A Four-dimensional Review", Periodica Polytechnica Social and Management Sciences, 34(1), pp. 77–93. https://doi.org/10.3311/PPso.37773

cycle allows the entrepreneur to quickly move through a learning process, where mistakes are seen as opportunities for learning. Through this cycle, it can be determined whether the approach taken is effective, which may involve continuing with adjustments or even pivoting, which involves making significant changes that require restarting the process with a new and different business model.

Ries (2011) proposes that assumptions critical to the success of the business model should be seen as hypotheses requiring validation through testing with real customers in the market, rather than accepted as factual truths. This is where the concept of MVP comes into play, as the simplest and most cost-effective version of a product. The MVP allows the entrepreneur to maximise validated learning, as it is based on experiments and direct customer feedback (Ries, 2011). This knowledge is considered validated because it comes from real market interactions and data, providing a solid foundation for product development. Establishing indicators and accounting for innovation allows measuring progress through various stages: setting a starting point, fine-tuning the engine, and pivoting or persevering. From LS, different types of pivots are also proposed to facilitate understanding of the process of significant change: zoom-in, zoom-out, customer segment, customer need, business architecture, value capture, growth engine, channel, and technology.

The LS approach uses the business model canvas (BMC) as a tool to quickly identify and map key market, customer, and value proposition concepts. This approach allows for a better representation of the underlying business process concepts. Recent contributions have provided greater clarity for LS implementation. Osterwalder et al. (2014) describe in detail the process of designing the organisational value proposition, which includes seeking three types of fit: problem-solution, product-market, and business model. This process is based on the initial definition of the customer profile and value proposition, followed by a continuous cycle of design, testing, and adjustments involving prototyping and rapid testing and improvement.

Furthermore, Bland and Osterwalder (2019) defined 44 specific experiments for discovering and validating business plan hypotheses, categorising them based on cost, time required, implementation, and strength of evidence. The selection of the appropriate experiment depends on the type of hypothesis, the level of uncertainty, and the urgency to obtain evidence. These experiments facilitate business model validation and encourage data analysis, followed by actions such as further experimentation, perseverance, or pivoting (Bocken and Snihur, 2020). Despite the experimental popularity of the LS methodology, many of its postulates have not been scientifically validated. In other words, much of the claims about its effectiveness are based more on anecdotal experiences than on rigorous research (Frederiksen and Brem, 2017). This study aims to conduct a comprehensive literature review on the LS methodology and the validation of its postulates. The document is divided into six sections: the second describes the methodology, the third presents the results obtained, the fourth discusses these results, and the fifth provides the study's conclusions.

2 Methodology

A review of the extant literature was conducted by searching a recognised database using a set of keywords that establish a logical pattern with different stages (see Fig. 1). The database used was Scopus, which provides an extensive collection of literature, its strict journal selection criteria, and its ability to offer impact metrics that provide a measure of the importance and influence of indexed publications (Elsevier, 2024). Additionally, it facilitates the expeditious identification of pertinent and authoritative research, the identification of experts, and access to reliable data, metrics, and analytical tools (Blanco-Mesa et al., 2017; 2019; 2023). As with WoS, a substantial number of publications are

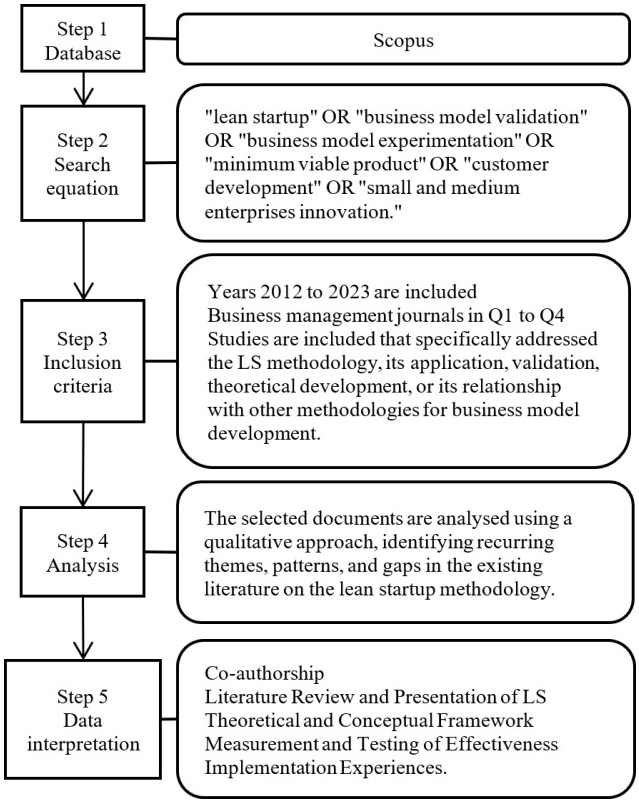

Fig. 1 Stages in this study review (Own elaboration)

included; however, Scopus exhibits a more expansive coverage of publications and journals, characterised by a notable absence of significant citation impact and a national orientation (Waltman, 2016; Blanco-Mesa et al., 2023).

The keywords considered to construct the search equation were LS, business model validation, business model experimentation, MVP, CD, small and medium enterprises innovation. The keywords were selected through a four-step process. First, LS was chosen as the central concept of analysis. Second, the fundamental components of the methodology ('business model validation', 'business model experimentation', 'minimum viable product', 'customer development') were identified based on Ries (2011). Third, following the recommendations of Tranfield et al. (2003) regarding the importance of including contextual concepts in systematic reviews, the component 'small and medium enterprises innovation' was added. Finally, the validity of the terms was verified through preliminary searches in the Scopus database, which demonstrated their frequent use and their ability to fully capture the subject of analysis. With the keywords defined, the search equation was established as follows: "lean startup" OR "business model validation" OR "business model experimentation" OR "minimum viable product" OR "customer development" OR "small and medium enterprises innovation". All types of documents from the years 2012 to 2023 were included. Documents from the year 2024 were excluded because it is currently in progress and consolidated results are not yet available.

A total of 357 scientific documents were obtained, focused on business management journals in quartiles 1, 2, 3, and 4. These were analysed and selected taking into consideration an evaluation of titles, abstracts, and keywords. Studies are included that specifically addressed the LS methodology, its application, validation, theoretical development, or its relationship with other methodologies for business model development.

As a result, 57 documents that met the established criteria are selected. The complete list of documents is included in the Appendix A. The selected documents were analysed using a qualitative approach, identifying recurring themes, patterns, and gaps in the existing literature on the LS methodology. A co-authorship analysis was performed using VOSviewer (van Eck and Waltman, online), and additional analysis was based on Blanco-Mesa et al. (2023) and van Eck et al. (2006). The studies were categorised according to the type of evidence presented and their contribution to knowledge on the subject.

3 Results

The first analysis performed on the selected documents was an analysis of the 10 authors with the most publications on the topic. As shown in Fig. 2, Ghezzi A. and Cavallo A. are the most prominent authors with ten and five published documents, respectively. This indicates a considerable difference compared to the other authors, who do not exceed two publications. These results may suggest that the topic is underdeveloped, which could be due to its relative novelty or limited academic interest.

Additionally, a co-authorship analysis of the selected documents was conducted using VOSviewer, and the results are presented in Fig. 3. As evidenced, Ghezzi A. is a central author in the field of LS study, with multiple publications and a broad co-authorship network, particularly between Ghezzi A. and Cavallo A., as well as with other authors who form a core group of frequent co-authors.

Fig. 4 shows the number of publications on LS during the period under analysis. An increase in academic interest in LS can be observed, especially from 2017 onwards, with a notable peak in 2023. After conducting a comprehensive analysis of the selected literature, the obtained information was classified into four essential categories:

1. literature review,
2. theoretical development and conceptual framework,
3. measurement and testing of effectiveness,
4. implementation experiences.

The results obtained in each category are detailed below.

3.1 Literature review and presentation of LS

This category includes documents whose purpose is to review previous related works, present and analyse the LS

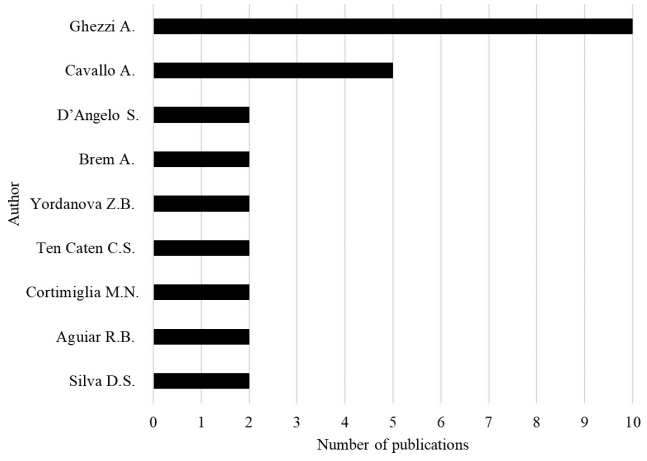

Fig. 2 Number of publications per author (Own elaboration)

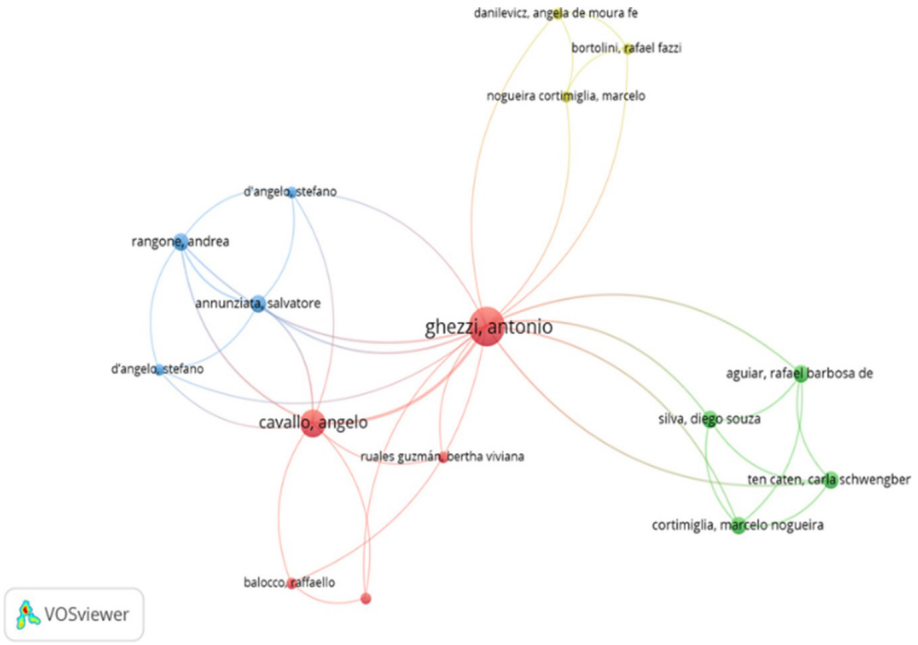

Fig. 3 Co-authorship analysis (Own elaboration)

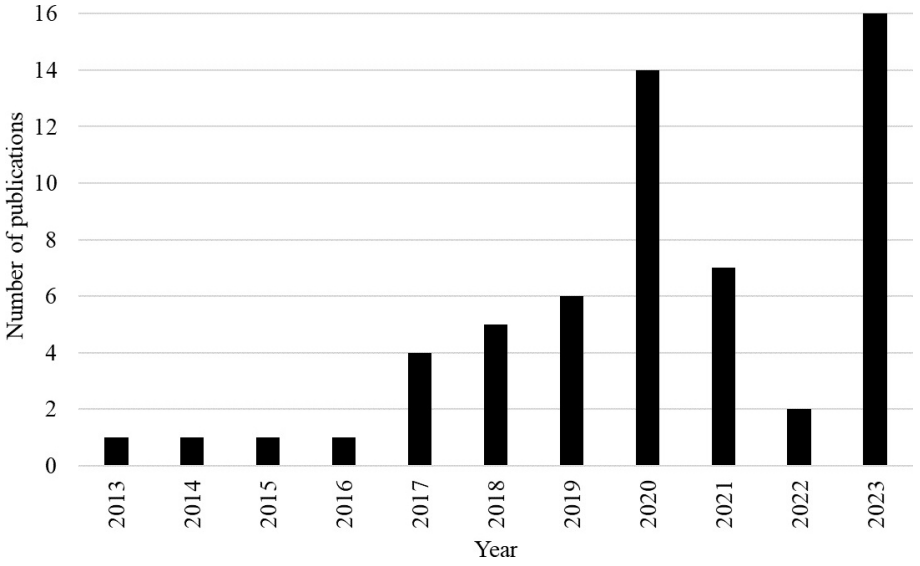

Fig. 4 Number of publications per year (Own elaboration)

methodology, and offer well-founded critiques. The selected studies include critiques by Felin et al. (2020) and Bocken and Snihur (2020), literature reviews by Bortolini et al. (2021), Peralta et al. (2020), Silva et al. (2020), Lizarelli et al. (2021), Sanasi (2023), Frederiksen and Brem (2017), and Galli (2019), as well as analyses by Soegoto et al. (2023), Boni (2016), York and Danes (2014), Shepherd and Gruber (2020), and McGrath (2023).

Felin et al. (2020) present a critique of the LS methodology, highlighting that it promotes incremental experiments that generate value gradually, relies on easily perceptible customer feedback, and on validated learning. In the view of these authors, this approach underestimates the task of creating new theories and hypotheses. Additionally, it lacks the specificity needed to guide startups in the creation and testing of hypotheses, as well as in conducting experiments to test them.

In contrast, Bocken and Snihur (2020) argue that LS is not (nor should be) associated with incrementalism, as it can generate both incremental and radical innovation, promotes iterative experimentation that reduces uncertainty, and fosters learning and novelty at a low cost. The authors also argue that LS is not designed for ideation but for experimental design and testing during the innovation process.

The analysis of literature reviews allows gaining insight into various aspects of LS. Bortolini et al. (2021) explore

the connection between LS and previous theories, demonstrating its compatibility with the strategy learning school and the effectuation and bricolage schools in entrepreneurship. The authors have identified some approaches that could enhance LS, such as milestones or checkpoints (McGrath and MacMillan, 1995) and tools for product creation (Blank, 2007). Peralta et al. (2020) propose LS as an innovation methodology that addresses practical customer issues. Silva et al. (2020) meanwhile identify the lack of clear guidelines in the LS literature to assist entrepreneurs and learners in its application. The authors highlight the possibility of integrating LS with other methodologies, the successful implementation of LS in various types of companies such as digital startups, large manufacturers, and software companies, and identify the crucial elements of success, including early customer interaction, feedback seeking, experimentation, and the development of the MVP.

Lizarelli et al. (2021) find that LS is conceived as a tactic to acquire knowledge and adjust products or services in an agile manner through a step-by-step development, as opposed to conventional methods. The authors find more advantages than disadvantages associated with the execution of LS. It is also noted that the most frequent implementation challenges are related to the correct application of the tools and methods themselves, as well as their application in established companies. Some key success factors are the support of top management, the correct identification of customers, the effective use of their feedback, the proper application of the method, and the ability to manage pivots.

Sanasi (2023) argues that, although the literature focuses on the validation process, its understanding has largely centred on individual experiences and decision-making, neglecting the internal organisation of startups. Furthermore, they find that pivoting is highly valued for the flexibility and adaptation it offers in the face of environmental uncertainty. Boni (2016) supports the LS approach for being grounded in the scientific method and hypothesis-driven discovery. Additionally, he proposes the need to develop more innovative BMs through the application of LS.

Frederiksen and Brem (2017) evaluated the merits of LS and find substantial support in the scientific literature. The general effectiveness of areas such as user involvement, iterative product development, experimental product development, MVP, and entrepreneurial thinking is highlighted. They emphasise the need for more scientific research to support areas such as experimental design in LS, which Ries mainly supports with anecdotal evidence. Galli (2019) suggests that LS is adapting innovative processes within organisations. Their findings suggest that the LS methodology is more precise and faster for conducting experiments than traditional BMs. Several barriers to implementation are identified, such as structural and cultural rigidity, lack of autonomy, and difficulties in integrating LS with conventional methods of strategic planning.

Regarding the relationship and comparison of LS with other methodologies, Shepherd and Gruber (2020) provide a more comprehensive framework that includes five main blocks: navigating market opportunities, business model, validated learning/CD, MVP, and perseverance or pivoting. Soegoto et al. (2023) conclude that LS stands out among all methodologies for its more efficient phases. They find LS to be an effective strategy for obtaining direct feedback from consumers and for improving business operations by adjusting them according to consumer preferences. McGrath (2023) compares LS and Discovery-Driven Growth (DDG) approaches from the perspective of Resource-Based View (RBV). It is emphasised that the LS approach assumes an organisation that does not yet exist and seeks to identify a repeatable and scalable business model, whereas DDG starts with the premise that a company has already built a reliable and sustainable business model. Their results suggest that both approaches provide a fast track to innovation, reducing costs and risks.

In general, LS is positively evaluated by the authors. Its effectiveness compared to other methodologies, its importance for generating radical innovations, and its ability to address uncertainty at a low cost are highlighted. In this sense, the importance of iterative experimentation, validated learning, and MVP development is emphasised. Additionally, there is a debate about its limitations, including an emphasis on incrementalism and the lack of specific guidelines for creating and validating hypotheses. Some key success factors and barriers to its implementation are identified.

3.2 Theoretical and conceptual framework

This category includes research focused on the development of theoretical concepts of LS. It comprises a large number of current studies characterised by the use of qualitative methodology. This field presents a variety of concepts and approaches addressing challenges and opportunities in LS. Most of these studies challenge, improve, and expand the foundations of LS, significantly contributing to its evolution (Meagher et al., 2020). The diversity of approaches and the variety of contexts in which these studies are developed suggest that the various ways in which LS can be adapted to different scenarios are still being

explored. In line with the observations in the previous category, and despite the multiple advances and practical application of LS, there is evidence of numerous perspectives and areas yet to be defined in its theoretical development.

For example, York and Danes (2014) criticise the lack of rigour in the "hypothesis testing" of Blank's CD model associated with LS. They identify selection, representativeness, acquiescence, confirmation, overconfidence, and optimism biases. The concept of System 1 thinking (intuitive) and System 2 thinking (systematic, reasoned) from Stanovich and West (2000) is used to suggest methods that could be integrated into the process to mitigate bias risks. These methods also include validation in pairs through structured and ongoing interviews. These interviews should focus on current practices and real issues, avoiding simplistic responses and inappropriate linear models. On the other hand, Ghezzi and Cavallo (2020) establishes an integrated framework that includes innovation in BMs, LSA, and agile development (AD). Their results suggest that LSA enhances innovation in digital projects by incorporating key elements such as operational and strategic agility.

D. A. Reis et al. (2021) propose a framework with three phases (idea generation, conversion, and diffusion) that integrates LS with design thinking (DT) and BMC to describe the process through which entrepreneurs apply new business methodologies to create new businesses, for the generation and refinement of ideas, as well as for the structuring of their initial operations. Blank and Eckhardt (2023) linked LS with several academic theories of entrepreneurship, demonstrating its compatibility with various theoretical frameworks such as organisational learning theory, entrepreneurship theory, and corporate innovation literature. The researchers suggested that incorporating bricolage theory into LS methodology can provide a more structured way to integrate the resources that entrepreneurs possess at the outset of the process.

van Vliet (2020) provides a model of the behaviour of companies in complex product systems engineering under LS, validating the effectiveness of MVP in reducing risks through iterative learning. Yli-Huumo et al. (2015) obtain results suggesting that rigorous experimentation can reduce technical debt in software companies. The researchers found that if experimental testing is rigorously conducted by qualified teams, intentional technical debt can be reduced and unintentional debt prevented. Brecht et al. (2021), based on a literature analysis, formulate an experimentation framework for B2B startups that validates business desirability.

Khanna et al. (2018) found that learning in startups is complex, nonlinear, and that the relationship between hypotheses and MVP is dynamic. Contrary to what LS proposes, the authors found that developing an MVP does not have to be tied to a pre-established hypothesis. Sala et al. (2022) obtained results that validated Ries's (2011) 14 pivots and identified two new ones: the business ecosystem pivot and the brand pivot. The presence of the domino effect phenomenon in pivoting is corroborated, indicating that a strategic change can trigger multiple adjustments for the startup. Axelson and Bjurström (2019) studied the concept of time embedded in LS within the process of a technology spinoff. LS involves a traditional and sequential approach to timing and coordination. The authors argue that optimal evolutionary speed not only involves velocity but also the opportune moment. In adverse economic conditions, it is better to be patient and allow for the natural development of market relationships.

Ghezzi (2020) shows that the analysed companies use their BMs as cognitive lenses to make sense of the LS approach and to create heuristics in their entrepreneurial process. These heuristics enhance the sense of opportunity, help concretise opportunities through hypothewsis formulation and experiment planning, act as a mental framework for filtering, selecting, and organising limited and unstructured data, and simplify the process of reviewing and adjusting the model based on customer feedback. On the other hand, Björklund et al. (2020) argue that experimentation not only accelerates decision-making in uncertainty but also embodies effectual logic, which involves controlling uncertain events rather than predicting them. They establish that even incremental experimentation can fortuitously trigger radical innovations. Münch et al. (2013) identify the strengths and weaknesses of a co-creation case of an MVP between industry and academia. They highlight the communicative advantage of small teams and the effectiveness of milestone setting, focusing on tangible achievements and allowing for product owner feedback.

Seppänen et al. (2017) identified ten idea validation practices in a multiple-case study of established companies. These practices included close cooperation with the customer, the MVP, copying existing products, market research, prototyping, technological feasibility study, pivoting, support from the parent company, support from educational institutions, and expert support. Close cooperation with the customer was particularly common in products aimed at the mass market. Through a case study, Dennehy et al. (2019) developed a process map for

the MVP. This map advocates an iterative process that begins with gathering information from current or potential customers, moving through the design and construction of technology to pilot evaluation, allowing the relative value of the MVP to be judged. This iterative cycle continues until the MVP approaches the Final Minimum Product (FMP). Upon reaching the FMP, evaluation concludes, and product launch is planned.

Ganguly and Euchner (2018) present a case of experimentation for validation within a physical goods manufacturing company. They highlight four essential attributes for the correct execution of an experiment: focusing on a few factors, measuring results against a hypothesis, simplicity and economy, and design oriented to obtaining answers quickly. They provide specific examples of experiments in various categories, addressing aspects such as value creation, willingness to pay, supply chain, operational costs, channel efficacy/efficiency, partners, technology in use, and human behaviour.

Burnell et al. (2023) suggest that startup founders are often reluctant to change their value propositions, especially through pivoting. They also establish that those with more entrepreneurial experience, more frequent interaction with mentors, and larger teams tend to be more likely to adjust their value propositions in response to negative feedback during the experimentation process. Sadeghiani et al. (2024) contrast the concept of pivot in SMEs with that of the LS methodology, demonstrating how they differ. It is found that the literature discusses specific aspects of the pivot but does not fully address the broader picture associated with the concept. The authors address different factors that trigger the pivot and conceptualise the different types of pivots in SMEs, such as last-resort pivot, opportunistic pivot, relief/updating pivot, and seasonal pivot. They discuss the different outcomes of the pivot, noting that success is defined differently in various contexts. In this same vein, Sadeghiani and Anderson (2023) observe that the concept of pivot lacks clarity in the literature, and through an abductive evaluation that contrasts existing definitions with analysed practical cases, they present a clear definition characterising the pivot as "substitution". They also present strategies to improve the concept, such as eliminating ambiguous qualifiers.

Richter and Wrobel (2023) studied the prototyping process in successful digital startups. Their results suggest that entrepreneurs intuitively adopt the LS approach, using tools like the BMC to summarise hypotheses and focus on value creation. For the authors, the networks of entrepreneurs, both existing and emerging, are essential elements for the prototyping process. The continuous expansion of networks, especially connecting with a specific network of potential customers, is emphasised. Interaction with the existing network significantly impacts the evolution of the business model. Fernandes et al. (2023) found that the use of LS contributes to reducing uncertainties in the development of technological projects. The uncertainties most mitigated are associated with products and resources. Within this latter category, the components of knowledge and team profile, process quality, and resource acquisition, as well as marketing strategy and pilot production, are highlighted. Uncertainties related to products were less mitigated.

D'Angelo et al. (2023) created a conceptual model on experimentation in established organisations. They highlighted three possible organisational designs for experimentation: diffuse, concentrated, and separate. The first two are more suitable for incremental innovations, while the separate model is more associated with generating radical ideas. Bruton et al. (2023) examined how institutional differences and resource constraints in impoverished non-Western environments can affect the effectiveness of LS. The authors analysed the impact on opportunity search, business model, validated learning, MVP, and the decision to persevere or pivot in each environment. Additionally, they proposed several optimal LS characteristics that can be used to maximise benefits in such situations.

Puutio (2023) proposed a portfolio of 'agile intellectual property' comprising trade secrets, copyrights, and trademarks, which integrate properly with the agility and efficiency of LS. These assets play a fundamental role in various stages of the MVP creation process, from conceptualisation and testing to decision-making on whether to persevere or pivot. Patil et al. (2023) identify and classify accelerating factors in Internet of Things (IoT) technology projects. The authors find that the LS approach and ecosystem agility introduce an agile culture that fosters team cohesion and accelerates the achievement of organisational goals. Balocco et al. (2019) proposed a framework based on the LM tool known as single-minute exchange of dies (SMED). The approach was established to optimise changeover time in digital startup BMs. The framework guides entrepreneurs to identify, group, prioritise, test, and execute business model changes efficiently. Raneri et al. (2023) designed a predictive model powered by artificial intelligence that provides entrepreneurs with a digital platform to conduct automated testing. Their algorithm anticipates the desirability level of product design

decisions (PDD) in digital environments. It could also anticipate less relevant PDDs, facilitating a quick evaluation of the impact of new decisions.

In general, some criticisms regarding the methodological rigour of LS are evident, particularly concerning hypothesis testing. The concept of "pivot" and the MVP process map are developed, and the inclusion of methods to reduce bias risks in experimentation is suggested. Furthermore, an agile IP portfolio associated with LS is developed, and its integration with other approaches such as DT and BMC is explored. Finally, LS is linked to some academic theories, and adaptations are proposed to enhance its effective application in non-Western contexts.

3.3 Measurement and testing of effectiveness

This category includes studies that aim to establish the validity and effectiveness of the LS method or its components. Unlike its predecessors, authors in this category primarily use quantitative methodology, although there are some studies that use qualitative approaches. For example, Harms and Schwery (2020) establish a model to measure the effectiveness of LS in startups. The model compared the extent to which startups used LS with project performance and found a moderately strong relationship. The authors established the construct 'LS capability' (LSC) through factors such as customer orientation, hypothesis testing, iterative experimentation, validation, and learning. Project performance was defined as the timely and within-budget creation of a high-quality solution. Although the psychometric properties were good, issues with discriminant validity were identified, especially in hypothesis testing.

Leatherbee and Katila (2020) tested the effectiveness of formulating various hypotheses about the business idea, the positive relationship between hypothesis probing and inspiration to formulate new hypotheses, and the positive relationship between probing and convergence on a business idea. Confirmation of the main LS assumptions was obtained, except for the role of hypothesis formulation. Their results suggest that teams that generate more hypotheses tend to investigate them less, and that teams with formal business training show greater resistance to hypothesis formulation. Their results suggest that the emphasis on learning through thinking in MBA programs might restrict the appreciation of action-based methods like LS. On the other hand, Tohanean and Weiss (2019) analyse a case study and find the importance of LS, especially the iterative approach and the creation of MVPs for green business model innovation, using the BML cycle to better understand target group requirements and reduce costs.

Newbert et al. (2020) analyse the advantages and disadvantages of early customer involvement in the LS approach. Their results indicate that, while this feature facilitates the creation of products that customers are willing to buy and thus helps achieve initial sales, it can also cause costly delays in product launches. These effects intensify with high levels of innovation. Scheuenstuhl et al. (2021) experimentally investigated whether the LS approach can improve innovation processes in established companies. The overall performance resulting from the application of the LS methodology, measured by the average of three individual categories, led to the creation of more effective BMs. In a separate analysis, only willingness to pay stood out as statistically significant. The initial inclusion of customers also improves the innovation process.

Ghezzi (2019) examines the implementation of LSA in a sample of startups, finding that the vast majority of participants have adopted the LS methodology, experiencing various benefits from its application. Entrepreneurs adopt 'effectual' or 'bricolage' approaches to navigate environments with limited resources and high uncertainty. Although LS has gained followers worldwide, it faces challenges in strengthening its theoretical foundations and some issues with its operationalisation, especially in traditionalist cultures that seek conventional results through more creative approaches. L. P. Reis et al. (2021) study how lean product development (LPD) and LS influence the performance of Brazilian startups. The findings suggest that LS has a significantly positive effect, particularly on teamwork and MVP development.

Yordanova (2017) investigates the viability, utility, and knowledge transfer of various LS tools and techniques to innovation project management. The results suggest that all LS tools and techniques examined are extensively used in innovation projects. Among the most used and with positive effects are tests and experiments, measurements, continuous deployment, split testing, and validation learning. Yordanova (2018) conducts a critical analysis of LS to see if it compromises the development of radical innovations. Although the research does not provide conclusive evidence, the results from various methods used indicate that user participation and indiscriminate application of LS can negatively affect organisations' innovative capacity and the development of disruptive innovations. The authors argue that LS is not a universal solution and should be implemented by the company after an adequate analysis of its suitability.

Ibba et al. (2018) find, through three case studies, that the use of LS is useful for addressing critical aspects of financing with Initial Coin Offerings (ICOs). The repetition of the LS process and the active participation of all involved parties enhance the success of the original idea, especially in the ICO realm. Zhuge et al. (2023) investigate the connection between LS, the iterative process of organisational learning, and the sustainable growth of new companies. The results suggest that LS fosters sustainable improvement by enhancing recurring learning. Market development enhanced the positive effect of iterative learning on sustainable development, while technological development moderated this positive effect.

Silva et al. (2021) analysed the adoption of LS by Brazilian technology companies and its suitability to their emerging economic environment. The authors emphasise the importance of LS for the rapid development, adaptation, and continuous validation of technological startup BMs. Their findings also acknowledge that the context poses limitations affecting the use of LS, particularly regulatory requirements, technological and legal uncertainties, lengthy product development cycles, and high manufacturing and development costs.

Studies suggest that the application of LS has a positive impact on generating effective BMs and on the sustainable growth of startups. These results have been consistent in established companies. LS is particularly useful in emerging markets, especially in technology startups. Its advantages include iterative learning, teamwork, MVP creation, and, in general, its potential for managing innovative projects. However, some issues with its application in traditionalist cultures that prioritise established practices and conventional results are evident. It is also suggested that the indiscriminate application of LS may lead to costly delays, especially for radical innovations. Its application must be cautious, as its success depends on the organisational context.

3.4 Implementation experiences

This category includes research describing the practical implementation of LS and its components, predominantly using qualitative approaches, especially case studies. Chen et al. (2017) present a case study on the creation of an ice cream machine using LS and the 40 principles of systematic innovation. The team received feedback from customers after the experiment and repeatedly modified the machine design to meet the requirements of the Taiwanese market, as well as the demands of Industry 4.0 globally. The outcome was a vending machine that reduced labour costs and created more business opportunities.

Čalopa et al. (2020) examine the level of knowledge and implementation of LS in a sample of Croatian SMEs. Although nearly half of the companies do not follow the LS methodology, most incorporate some of its principles selectively to adapt to market changes, revealing extensive but unsystematic application of LS. Very few companies demonstrate knowledge and awareness of the importance of networks under the LS approach. Cavallo et al. (2020) present a successful case of a small agricultural company innovating its business model to internationalise using LS. The entrepreneur adopted a gradual approach, assessing the product's viability before expanding the business. Internationalisation included testing and experimentation, enhancing customer experience through mobile applications and other associated services.

Meanwhile, Philippi et al. (2023) examine to what extent the concepts of "effectuation" and LS were applied by the 25 finalist entrepreneurs of the Swiss Innovation Challenge in its 2022 edition. Their results indicate that 96% applied effectuation and 60% used LS as an approach to decision-making. Most of these startups prefer effective communication with their customers from the outset, although they made little use of feedback, with only 32% of startups iteratively validating hypotheses.

In general, the results highlight the versatility of LS in different contexts and its ability to adjust BMs through constant iterations in the market. However, challenges are identified in its systematic application, as in some cases, not all its stages are fully implemented.

4 Discussion

The literature review shows that studies using a qualitative approach predominate over quantitative ones. This characteristic suggests that LS is still in a phase of development and refinement, and that currently, authors focus their analyses more on exploration and deployment rather than exhaustive evaluation. Similarly, it is found that there is little quantitative evidence to support or refute many of the hypotheses developed from qualitative research. This scenario tends to restrict the generalisability of findings and the evaluation of LS's impact on performance and innovation. Therefore, a greater quantitative research focus is required to consolidate LS as a robust methodology.

The analysis and classification of the literature on LS into four categories offer a comprehensive view of the advancements, debates, and challenges for its development and implementation. The results of the analysis reveal that, although LS is subject to some criticisms, the vast majority of studies show positive signs of its effectiveness.

These findings suggest that LS is effective in fostering innovation and adaptability but requires careful and contextualised implementation. The first analysis deals with literature reviews. Within this category, the critical voices include Felin et al. (2020), who take issue with the focus on incremental experiments and the lack of specificity to guide startups; York and Danes (2014), who disapprove of the lack of rigour in hypothesis testing and identify several biases but suggest methods to mitigate them; Silva et al. (2020), who point out the lack of clear guidelines in the LS literature to assist entrepreneurs; Yordanova (2018), who warns that the indiscriminate application of LS can negatively affect innovative capacity and the development of disruptive innovations; and Newbert et al. (2020), who suggest that involving customers early in the innovation process can cause costly delays in product launches, especially in high-innovation applications.

On the other hand, other authors, such as Peralta et al. (2020), Silva et al. (2020), Lizarelli et al. (2021), Boni (2016), Soegoto et al. (2023), and McGrath (2023), highlight the benefits of LS for innovation and its ability to adjust products or services in an agile manner, finding more advantages than disadvantages in its implementation. Bortolini et al. (2021) and Frederiksen and Brem (2017) find significant support for LS in the scientific literature. Bocken and Snihur (2020) and Björklund et al. (2020) highlight LS's potential to foster both incremental and radical innovations. Ghezzi (2020), D. A. Reis et al. (2021), Blank and Eckhardt (2023), and Shepherd and Gruber (2020) present frameworks that integrate LS with other methodologies such as market opportunity navigation, DT, and AD. This more holistic perspective does not present LS as an isolated methodology but as an approach that can significantly benefit from integration with other methodologies.

The large number of works classified in the theoretical development and conceptual framework category suggests an effort to expand and improve the foundations of LS through qualitative research. For example, Khanna et al. (2018) explore the non-linear learning path in startups, Axelson and Bjurström (2019) analyse the conception of time in LS, and Seppänen et al. (2017) identify idea validation practices in established companies. Fernandes et al. (2023) address uncertainty mitigation in technological project development, and Richter and Wrobel (2023) emphasise the importance of entrepreneurs' networks for LS. Balocco et al. (2019) propose an SMED-based framework to optimise time in digital startups, and Patil et al. (2023) identify business agility factors in IoT technology projects. Bruton et al. (2023) suggest specific adaptations to maintain LS effectiveness in impoverished non-Western environments.

The MVP has also been the subject of several improvements. Dennehy et al. (2019) developed a process map for using an MVP, and Puutio (2023) proposes an agile intellectual property portfolio. Regarding the experimentation process, Ganguly and Euchner (2018) highlight essential attributes for its correct execution, Brecht et al. (2021) design an experimentation framework for B2B startups, D'Angelo et al. (2023) explore possible organisational designs for experimentation in established organisations, and Yli-Huumo et al. (2015) investigate reducing technical debt in software companies through rigorous experimentation. Where pivots are concerned, research has refined several aspects: Sadeghiani et al. (2024) and Sadeghiani and Anderson (2023) address the definition and clarity of the pivot concept, Sala et al. (2022) identify new types of pivots, and Burnell et al. (2023) point out the negative tendency of startup founders to change their value propositions through pivots.

Conversely, studies evaluating the validity and effectiveness of LS have mainly used quantitative approaches. These analyses have been applied to both startups and established companies. Among the startup studies, the work of Harms and Schwery (2020) stands out, finding a moderately strong relationship between the use of LS and performance, although identifying problems with discriminant validity, especially in hypothesis testing. Ghezzi (2019) suggests that startups that adopted LS benefited in their innovation process. L. P. Reis et al. (2021) and Silva et al. (2021) also find positive results in Brazilian startups, highlighting the positive impact of LS on teamwork, MVP development, rapid adaptation, and continuous business model validation.

Regarding established companies, the work of Scheuenstuhl et al. (2021) stands out, finding that LS improves innovation processes and allows creating more effective BMs. Zhuge et al. (2023) discovered that LS promotes sustainable development by improving iterative organisational learning. Other studies, such as Tohanean and Weiss (2019), suggest the importance of LS for green business model innovation, especially the iterative approach and MVP creation. Ibba et al. (2018) conclude that LS is useful for addressing critical funding aspects through ICOs.

However, within this category, some studies have also identified negative characteristics of LS. For example, Leatherbee and Katila (2020) confirm several key

assumptions of LS but find that teams tend to explore fewer hypotheses than generated and that formal business education, such as MBA studies, may be associated with resistance to hypothesis formulation. Ghezzi (2019) points out that LS faces challenges in terms of poor theoretical foundations and problems with its operationalisation, especially in traditionalist cultures. Yordanova (2018) warns that LS is not a universal solution and should be implemented after analysing its suitability.

Finally, other studies demonstrate how LS applies in various industries and contexts. Chen et al. (2017) and Cavallo et al. (2020) show how LS can be adapted for physical product development and the internationalisation of small businesses, respectively. These practical examples confirm that LS is versatile and can be successfully applied in different sectors, although its implementation is not always systematic and depends on the adaptability and creativity of entrepreneurs. The research by Philippi et al. (2023) highlights the combination of LS with other methodologies such as effectuation, emphasising the flexibility and complementary nature of LS.

Presented in Table 1 is a summary of the main of key findings on LS. The summary is divided into three main categories: effectiveness and strengths, theoretical advances, and challenges for implementation and weaknesses.

5 Conclusions

The comprehensive review of the literature on LS reveals a rich and diverse landscape of studies, most of which are qualitative. Although the prevalence of this type of study indicates an emphasis on understanding and development, there is a clear need to balance this approach by incorporating more research that allows for the robust validation and consolidation of the methodology.

Our analysis shows generalised results associated with the effectiveness of LS in fostering and promoting innovation. LS is found to be a versatile and effective methodology, adaptable in various business contexts. However, while LS offers a valuable approach for startup development and business innovation, its successful application requires a deep understanding of its principles, careful integration with other methodologies, and an adaptive approach that responds to the specific needs of each business context. The integration of LS with other methodologies can enhance its effectiveness, but additional research is needed to develop more robust theoretical frameworks and specific practical tools.

Nevertheless, it is essential to highlight the importance of additional research that allows for more precise validation of critical claims from qualitative studies, which include concerns about the lack of specificity in guidance for startups, lack of rigour in hypothesis testing, potential negative

Table 1 Summary of key findings on LS

Category	Findings
Effectiveness and strengths	High effectiveness for the innovation process and for agile adjustments of products or services in both startups and established companies.
	Improvement in teamwork, sustainable growth, and green BMs.
	Useful for addressing critical financing aspects through ICOs.
	LS is versatile and can be successfully applied across various sectors.
Theoretical advances	Improvement of the MVP (process map, agile intellectual property portfolio, industry-academia co-creation).
	Enhancement of the experimentation process (essential attributes for proper execution, framework for B2B startups, potential organisational designs for established companies, and reduction of technical debt in software companies through experimentation).
	Development of the pivoting process (definition and clarity of the pivot concept, identification of new pivots, negative tendencies of startup founders to change their value propositions through pivots).
	Others: frameworks to integrate LS with other methodologies as navigation of market opportunities, DT, BMC and AD. Non-linear learning path of startups. Conception of time in LS. Practices for validating business ideas. Mitigation of uncertainties. Importance of entrepreneurial networks. Optimisation of time in digital startups. Business agility factors. Specific adaptations to maintain LS effectiveness in impoverished non-Western environments.
Challenges for implementation and weaknesses	Focus on incremental experiments and lack of specificity to guide startups and entrepreneurs.
	Lack of rigour in hypothesis testing.
	Deficient theoretical foundations and issues with its application, particularly in traditionalist cultures.
	Indiscriminate application of LS can negatively affect the development of disruptive innovations. Early involvement of customers can cause costly delays in product launches.
	Teams tend to explore fewer hypotheses than they generate. Formal business education may be associated with resistance to hypothesis formulation.
	It is not a universal solution and should be implemented after an analysis of its suitability and the business context.

impacts on disruptive innovation capacity, and its relationship with possible delays in product launches. These points become opportunities for future research to verify their validity and establish potential improvement guidelines.

Opportunities for future research also include the development of specific guidelines for formulating and testing hypotheses, further analysis of its effective integration with other methodologies, providing enhanced theoretical and practical frameworks. Additionally, the adaptability of LS in different cultural, industrial, and geographical contexts needs to be investigated. Furthermore, more research is needed on the structural and cultural barriers established companies face when implementing LS. Finally, although many studies suggest that the LS approach is effective, longitudinal studies are required to evaluate its long-term impact on the growth and evolution of startups.

Acknowledgement

This research was funded by Universidad Pedagógica y Tecnológica de Colombia, grant numbers SGI 3778.

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Appendix A

Table A1 List of documents included in the study

Num.	Title	Year	Journal/Publisher
1	Lean startup and the business model: Experimentation revisited	2020	Long Range Planning
2	Lean Startup and the business model: Experimenting for novelty and impact	2020	Long Range Planning
3	Customer development, innovation, and Decision-Making biases in the lean startup	2014	Journal of Small Business Strategy
4	The Lean Startup Framework: Closing the Academic–Practitioner Divide	2021	Entrepreneurship: Theory and Practice
5	Lean Startup, Agile Methodologies and Customer Development for business model innovation: A systematic review and research agenda	2020	International Journal of Entrepreneurial Behaviour and Research
6	Lean Startup: Operationalizing Lean Startup Capability and testing its performance implications	2020	Journal of Small Business Management
7	Knowledge transfer from lean startup method to project management for boosting innovation projects' performance	2017	International Journal of Technological Learning, Innovation and Development
8	A study on the lean startup development: A case of 3D ice cream machine	2017	International Journal of Systematic Innovation
9	The lean startup method: Early-stage teams and hypothesis-based probing of business ideas	2020	Strategic Entrepreneurship Journal
10	Lean startup for opportunity exploitation: adoption constraints and strategies in technology new ventures	2021	International Journal of Entrepreneurial Behaviour and Research
11	To get out of the building or not? That is the question: The benefits (and costs) of customer involvement during the startup process	2020	Journal of Business Venturing Insights
12	Lean Startup: a comprehensive historical review	2018	Management Decision
13	Theorizing 'pivot' in small and micro business	2021	Journal of Small Business and Entrepreneurship
14	The Role of Timing in the Business Model Evolution of Spinoffs: The Case of C3 Technologies	2019	Research Technology Management
15	Reflection of Literature on using Lean Innovation Models for Start-Up Ventures	2019	Journal of Modern Project Management
16	Level of knowledge and implementation of lean methodology in small and medium-sized Croatian companies	2020	TEM Journal
17	Lean business models change process in digital entrepreneurship	2019	Business Process Management Journal
18	How can the lean startup approach improve the innovation process of established companies? An experimental approach	2021	International Journal of Innovation Management
19	Digital startups and the adoption and implementation of Lean Startup Approaches: Effectuation, Bricolage and Opportunity Creation in practice	2019	Technological Forecasting and Social Change

Table A1 List of documents included in the study (continued)

Num.	Title	Year	Journal/Publisher
20	Agile Business Model Innovation in Digital Entrepreneurship: Lean Startup Approaches	2020	Journal of Business Research
21	Impact Assessment of Lean Product Development and Lean Startup Methodology on Information Technology Startups' Performance	2021	International Journal of Innovation and Technology Management
22	Toward a Recursive Stage-Based Framework for Supporting Startup Business Initiation: An Exploratory Study With Entrepreneurs	2021	IEEE Transactions on Engineering Management
23	A behavioural approach to the lean startup/minimum viable product process: The case of algorithmic financial systems	2020	International Journal of Innovation Management
24	The relationship between business model experimentation and technical debt	2015	Lecture Notes in Business Information Processing
25	Digital entrepreneurship and green business model innovation: Lean startup approaches	2019	Calitatea
26	Lean Startup Method Hampers Breakthrough Innovations and Company's Innovativeness	2018	International Journal of Innovation and Technology Management
27	ICOs overview: Should investors choose an ICO developed with the lean startup methodology?	2018	Springer, Cham
28	How do entrepreneurs think they create value? A scientific reflection of Eric Ries' Lean Startup approach	2017	International Entrepreneurship and Management Journal
29	Discovery and validation of business models: How B2B startups can use business experiments	2021	Technology Innovation Management Review
30	Critical success factors and challenges for Lean Startup: a systematic literature review	2022	The TQM Journal
31	Emerging Business Models and Strategies to Accelerate Innovation in the Biopharmaceutical Industry	2016	Journal of Commercial Biotechnology
32	Conducting Business Experiments: Validating New Business Models: Well-designed business experiments can help validate assumptions and reduce risk associated with new business models	2018	Research-Technology Management
33	Driving internationalization through business model innovation: Evidences from an AgTech company	2020	Multinational Business Review
34	From MVPs to Pivots: A Hypothesis-Driven Journey of Two Software Startups	2018	Springer, Cham
35	A qualitative research study of the tech startup journey through entrepreneurial pivoting	2022	International Journal of Entrepreneurial Behavior & Research
36	How Entrepreneurs make sense of Lean Startup Approaches: Business Models as cognitive lenses to generate fast and frugal Heuristics	2020	Technological Forecasting and Social Change
37	A competitive analysis of fail fast: Shakeout and uncertainty about consumer tastes	2020	Journal of Economic Behavior & Organization
38	Expanding entrepreneurial solution spaces in times of crisis: Business model experimentation amongst packaged food and beverage ventures	2020	Journal of Business Venturing Insights
39	Creating Minimum Viable Products in Industry-Academia Collaborations	2013	Springer, Berlin, Heidelberg
40	A framework proposition to identify customer value through lean practices	2020	Journal of Manufacturing Technology Management
41	How Are Product Ideas Validated?: The Process from Innovation to Requirements Engineering in Software Startups	2017	Springer, Cham
42	A Lean Start-up approach for developing minimum viable products in an established company	2019	Journal of Decision Systems
43	Can adopting lean startup strategy promote the sustainable development of new ventures? The mediating role of organizational iterative learning	2023	PLoS ONE
44	A review of business development methods in entrepreneurship	2023	Journal of Eastern European and Central Asian Research (JEECAR)
45	Early-stage business model experimentation and pivoting	2023	Journal of Business Venturing
46	What pivot is: Touching an elephant in the dark	2023	Digital Business

Table A1 List of documents included in the study (continued)

Num.	Title	Year	Journal/Publisher
47	Entrepreneurial experimentation in business model dynamics: Current understanding and future opportunities	2023	International Entrepreneurship and Management Journal
48	Predictions through Lean startup? Harnessing AI-based predictions under uncertainty	2023	International Journal of Entrepreneurial Behavior & Research
49	The Impact of Prototyping on the Survival Chances of Digital Early-Stage Startups: Findings and Insights from Explorative Expert Interviews	2023	European Conference on Innovation and Entrepreneurship
50	Effectuation and Lean Startup in Swiss Start-ups: An Integrative Analysis	2023	European Conference on Innovation and Entrepreneurship
51	Managing Uncertainties During the Development Process of Technological Innovation Projects: Lean Startup Contributions	2023	European Conference on Innovation and Entrepreneurship
52	Corporate Experimentation: Antitode or Oxymoron?	2023	European Conference on Innovation and Entrepreneurship
53	Who Learns Fastest, Wins: Lean Startup and Discovery Driven Growth	2023	Journal of Management
54	Lean Start-Up in Settings of Impoverishment: The Implications of the Context for Theory	2023	Journal of Management
55	Strategic Considerations and the Seed-to-Maturity Model When Establishing the Ideal IP Portfolio in the Start-up Context	2023	Springer, Cham
56	The Lean Startup as an Actionable Theory of Entrepreneurship	2023	Journal of Management
57	Business agility in technology internet of things projects	2023	Journal of Decision Systems