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Enhancing Operational Efficiency: A Study on Lean Manufacturing Implementation in Small and Medium-sized Enterprises

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Abstract

The purpose of this paper is to provide small and medium-sized enterprises (SMEs) with a comprehensive guide that can be used to implement Lean Manufacturing (LM). Small businesses face challenges when implementing LM, but its benefits are also highlighted in the introduction. LM implementation guide and effectiveness assessment are the objectives. The literature review assesses LM frameworks, adoption, models, and success. In order to develop the research methodology, relevant studies on LM implementation in manufacturing SMEs were reviewed. The results discuss models and approaches for adopting LM and also measuring its success. A lack of standardized models and the importance of real case studies are highlighted in the conclusion. Specifically, it calls for further research on LM implementation in SMEs in the United States. As well as providing practical guidance for organizations seeking to implement LM effectively, this paper contributes to the understanding of LM implementation in SMEs.

Keywords

SMEs, Lean Manufacturing, and LM.

1. Introduction

The Lean Manufacturing (LM) philosophy has become increasingly popular in recent years due to its potential to improve efficiency, reduce waste, and increase profitability in companies' supply chain. A supply chain is made up of the facilities, functions, and activities involved in producing and delivering products and services from suppliers to customers (Soltani et al. 2023).

After World War II, Toyota's Taiichi Ohno and Eiji Toyoda developed LM in response to the country's limited resources and need for efficient production. Through standardized work, just-in-time production, and continuous improvement, the Toyota Production System eliminated waste and enhanced quality. LM principles have evolved and expanded beyond the manufacturing industry (Womack & Jones, 2003) to include healthcare and services. Lean implementation, however, is not a simple process. It can affect an organization's resources as well as its employees. As a result of implementing Lean, an organization needs to develop a collaborative and cross-functional mindset, rather than a traditional siloed approach (AlManei et al., 2017a).

Many SMEs face challenges when implementing LM, despite its potential benefits. Even though Lean is popular among large manufacturing companies, it may not apply equally to small and medium-sized enterprises. SMEs often lack resources, expertise, and an understanding of Lean principles. Therefore, while SMEs are eager to adopt Lean practices, they may find it difficult to stay competitive in highly competitive markets (Sahoo & Yadav, 2018a; de Oliveira & Junior, 2019a).

In order to guide organizations toward successful implementation of Lean, various roadmaps and frameworks have been developed. In most cases, these frameworks involve integrating Lean principles into an organization's strategy, culture, and operations. In some frameworks, training and development of employees are also emphasized, as well as the involvement of external experts or consultants (AlManei et al., 2017b).

Because small and medium-sized businesses do not understand how to apply Lean principles to their specific business context, they encounter significant challenges when adopting Lean Management (Sahoo & Yadav, 2017). It is often difficult for SMEs to identify waste and improve processes systematically due to a lack of resources and expertise. In addition, they may find Lean tools and techniques too complex or resource-intensive for their operations (Sahoo & Yadav, 2018b). As a result, SMEs may need to modify Lean principles to suit their business context and operational constraints.

Small and medium-sized businesses play an important role in the global economy. The definition of a small business varies by country, but generally, it refers to businesses with fewer than a certain number of employees and a certain revenue. As an example, an SME in the United States is typically defined as a business with fewer than 500 employees, but this definition may vary by industry and sector (U.S. Small Business Administration (SBA) and National Institute of Standards and Technology (NIST), n.d.). SMEs play an important role in the development and growth of developing countries. SMEs are the backbone of many economies, providing jobs and contributing to GDP. It is important to note, however, that SMEs face unique challenges that are not shared by larger companies. The lack of financial and human resources is one of the biggest challenges for SMEs. The leadership of SMEs lacks long-term commitment and limited resources when it comes to implementing new processes and technologies (AlManei et al., 2017c). Furthermore, the highly competitive industrial environment has dictated the development of this sector, making the companies very vulnerable and highly dependent on the global market. Especially pertinent to small and medium-sized businesses, which are increasingly adopting lean solutions to improve their operational value chain and management approach to a more systemic approach.

Despite these challenges, SMEs must implement modern manufacturing techniques to stay competitive in the global market. LM is a manufacturing approach that is particularly suited to SMEs as it allows them to produce more with fewer resources and at higher quality levels. Implementing LM techniques can help SMEs increase their productivity, reduce waste, and improve their sustainability (León-Guizado et al., 2021a). However, the implementation of LM in SMEs poses even more challenges than in large organizations. Before committing to LM adoption, SMEs need to know the costs and benefits of implementation (AlManei et al., 2017d).

Studies show that SMEs implement lean principles mostly at the manufacturing level, and this type of enterprises often chooses to select techniques that carry less investment effort (León-Guizado et al., 2021b). In SMEs, manufacturing is usually the main focus, so implementing lean philosophy may help develop better production practices and to create a more conducive environment for continuous improvement.. Nevertheless, lean implementation processes often fail to produce significant results in the long run when companies achieve significant short-term results. It is impossible to manage lean without measuring its performance. For this reason, it is crucial to identify and understand the reasons for high failure rates when embarking on the lean journey so that proper implementation can be planned. (Sahoo & Yadav, 2018c).

In addition to obvious and well-advertised benefits such as increasing market share, improving customer satisfaction, and increasing the company's sustainability, the drivers also have to do with improving the company's internal performance, such as increasing flexibility, introducing realistic and meaningful key performance indicators, desire (AlManei et al., 2017e). Study participants in some more mature companies simply sought to apply best practices. However, management, lack of resources, resistance to change and other factors can hinder the implementation of LM. Management can be a driver and a barrier to lean implementation. It is also important to have the resources they need, and their lack is a noticeable obstacle. While LM has historically been associated with large corporations, the benefits of implementing lean practices in SMEs have become increasingly recognized. However, SMEs face unique challenges when implementing LM, including limited resources and resistance to change.

Due to their limited resources, León-Guizado et al. (2021c) suggest that sophisticated lean techniques like Six Sigma, Failure Model Evaluation Analysis, and Total Quality Management may not be suitable for SMEs. For implementing Overall Equipment Effectiveness and understanding Single Minute Exchange Dies, the authors suggest using more elementary tools such as 5S and visual management. As a central strategy to overcome these challenges, new technologies should also be incorporated.

According to AlManei et al. (2017f), management can both hinder and facilitate lean implementation in SMEs. SME implementation of Lean can also be hampered by a lack of resources and resistance to change, as well as the method of introducing lean (internally or through a consultant).

While SMEs face challenges, they can greatly benefit from implementing LM practices. Although the exact proportion of SMEs varies by industry and sector, Sahoo and Yadav (2018d) emphasize SMEs' importance in the US economy. Therefore, to remain competitive and sustainable in today's dynamic business environment, SMEs must adopt LM practices.

In general, introducing LM to small and medium-sized enterprises requires taking into consideration their difficulties and restrictions. With the right tools and methods, SMEs can overcome these obstacles and enjoy the advantages of LM, such as enhanced productivity, reduced waste, and higher quality.

1.1. Literature Review

Through a literature review, this paper identifies and addresses frameworks for implementing LM in SMEs. The study criteria were selected from 2013 to present the most current research in the field. In order to formulate research questions and develop a source for implementing LM in SMEs, various articles were examined. Through a structured literature review, all relevant papers related to LM implementation in SMEs were collected and analyzed. Starting with a brief explanation of LM and its adoption and application in SMEs, the paper presents various focused topics. Then the models for implementing LM practices in small- and medium-sized manufacturing enterprises and methods for assessing their success are discussed. MavScholar, a Minnesota State University, Mankato library, served as the primary source of this research.

2. Objectives

The objective of this research paper is to explore an effective source for implementing LM in SMEs by addressing key questions related to its implementation and assessing its success or failure. In the past two decades, several lean implementation frameworks have been presented as roadmaps for guiding organizations on the sequence of lean tools to be introduced, and success criteria. However, the assessment of LM implementation and its success or failure remains an important issue that needs to be addressed. Therefore, this paper aims to address these issues and provide a comprehensive guide for LM implementation in SMEs.

3. Methods

An analysis of the existing literature regarding LM implementation in SMEs and its effect on their strategic and operational objectives will be conducted in this study. Specifically, this study addresses two research questions:
What are some of the models and frameworks used to implement LM in SMEs?
Q2: What measures can be used to assess the success of a LM initiative?
In order to accomplish these objectives, a thorough review approach will be employed. In the review process, relevant studies on LM implementation in SMEs are searched, selected, and synthesized from a variety of academic databases, such as MavScholar and Google Scholar.

The focus of this research is primarily on papers published after 2017, in order to ensure that the most recent approaches and insights are included. Focusing on recent literature, this study seeks to capture the latest advancements and emerging trends in applying LM to SMEs.

The review includes studies that meet two main inclusion criteria. To provide valuable insights and practical implications, studies must focus specifically on LM implementation in manufacturing SMEs. Secondly, studies that present theoretical frameworks and models for LM implementation in SMEs will also be included. To enhance the validity and applicability of the findings, this comprehensive approach gathers a variety of perspectives and experiences.
After identifying and selecting relevant studies, a careful analysis and synthesis of the approaches was conducted. This process involves extracting key themes, models, and frameworks used in LM implementation in SMEs from the selected literature. Moreover, the qualitative and quantitative methods used to measure the success of LM implementation in SMEs will be reviewed and evaluated.

As shown in Figure 1., this study employs a systematic approach to conduct a comprehensive literature review on Small and Medium-sized Enterprises (SMEs) implementing Lean Manufacturing (LM) and its impact on their strategic and operational goals. This diagram illustrates the sequential steps involved in the research process, from searching for relevant articles to reviewing selected studies. It aids in understanding the systematic review process done in this research by providing a visual representation of the methodology.

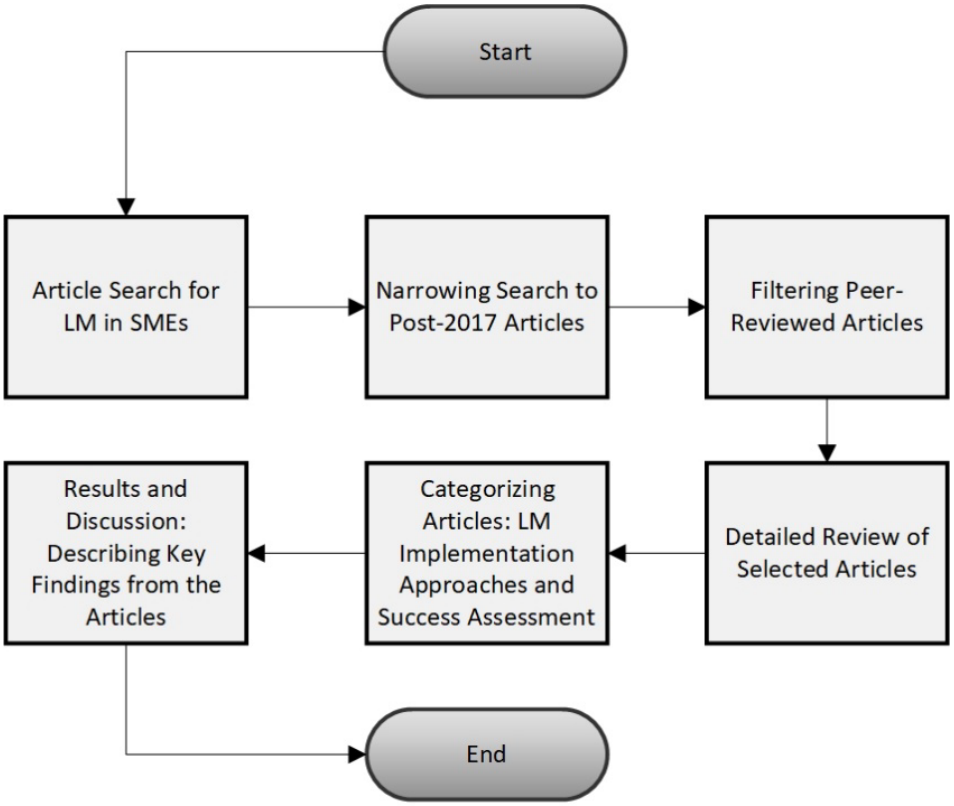

Figure 1. Flowchart of Systematic Review Methodology for LM Implementation in SMEs

4. Results and Discussion

This section presents and discusses recent models for implementing LM in SMEs, as well as approaches for measuring LM's success. In order to implement LM in small and medium-sized businesses, a range of models that are representative of different approaches have been selected, and these models have been cited extensively in the literature. Some of the models are based on real case studies, while others are theoretical models developed by researchers. Approaches for measuring the success of LM in SMEs, which include both qualitative and quantitative measures, are also presented. The strengths and weaknesses of each approach are discussed, and recommendations are provided for SMEs looking to implement LM and measure its success. The aim of this section is to provide a comprehensive understanding of how SMEs can implement LM effectively and measure its impact on their operations by combining these models and approaches.

The model presented by León-Guizado et al. (2021d) is structured in three blocks, following the Planning, Doing, Checking (or studying), and acting (PDCA) cycle. The upper block comprises variables under the plan, while the central block shows the process flow for production management. Check/act actions constitute the third block. These include measures to monitor and assess production management against objectives and plans, as well as corrective and preventive measures. A change awareness stage is also included in the model to prevent any implementation issues with lean tools. Symbolizing the beginning and end of production management, the customer is displayed both on the right and left sides of the chart (as shown in the Figure 2.). In addition to planning the supply of demand, the model emphasizes the importance of customer requirements for product design and development. There are various formulas for performance analysis included in the model, including commitment compliance percentages, on-time delivery percentages, and efficiency percentages. A three-phase implementation process involves reorganizing job descriptions, organizing sequential activities and balancing production, standardizing work methods, and conducting initial awareness and training.

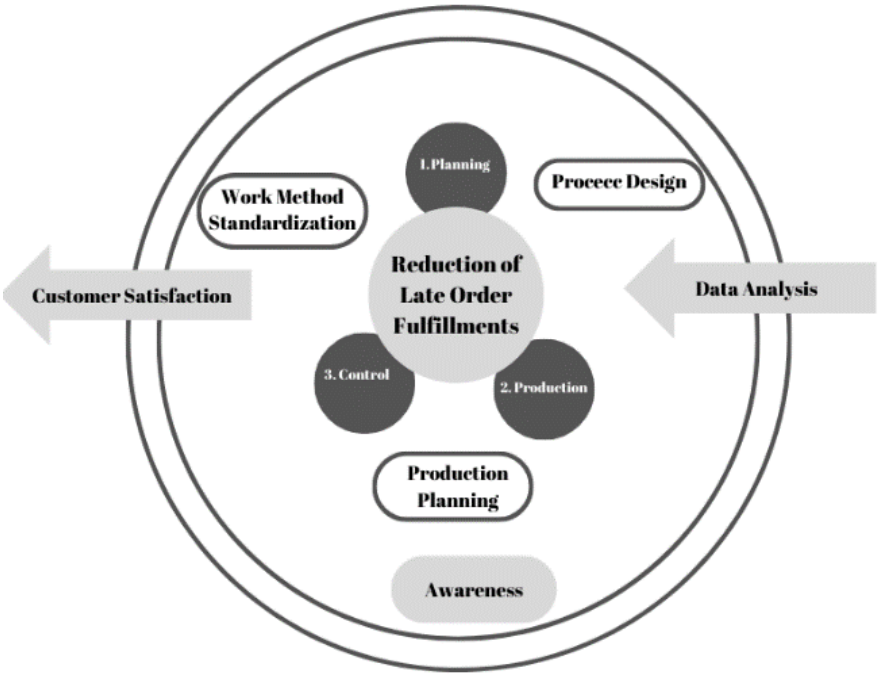

Figure 2**.** The three-block model

In Romana (2020) The authors of the paper discuss the importance of understanding SMEs and their definition, which varies from place to place. They apply a methodology to a Portuguese traditional company to support their study in practical terms. The paper suggests that implementing lean principles in SMEs should be done step by step due to a lack of resources. The "Lean Staircase" plan proposed in literature consists of an investment phase and an improvement phase. The investment phase involves adopting lean principles and applying some basic lean tools, while the improvement phase involves the application of more complex lean tools and other supporting initiatives. The implementation plan suggests that the company should continuously reset its goals and review them with time for continuous improvement. Other implementation plans suggest starting with defining milestones for the company's goals and simultaneously conducting the Value Stream Map and diagnosis of the full production system. The diagnosis stage is common in all plans and can be done with a lean assessment tool (LAT) or by performing an in-place diagnosis on the shop floor. However, the usage of LAT has some limitations, such as the unavailability of accurate statistical data.

In (de Oliveira & Junior, 2019b) writers proposed the use of the Lean Furniture Framework (LFF) for their case study in the Brazilian furniture sector. As shown in the Table1., in the assessment stage of the implementation, the authors suggested monitoring results at the end of project implementation every six-month cycles (activity 5.1), and re-evaluating the company's level of adherence to LM through the reapplication of the LM diagnostic form by the process improvement committee (activity 5.2). Based on the new diagnosis and critical evaluation of the implementation, it is recommended to re-evaluate the LM implementation scope (activity 2.3) and resume the LM implementation cycle towards the Toyota Way.

Table 1. Detailed phases, steps, and activities of the LFF model

Phases	Steps	Activities	Practices/tools	Suggested participants
Preparation	1. Lean manufacturing assessment	1.1. Determine how well the furniture industry adheres to LM	- Lean manufacturing assessment form	- An outsider is preferred.
	2. LM implementation planning	2.1. Outline the LM approach. 2.2. Determine the scope of the LM implementation (limit of action); 2.3. Establish the implementation objectives. 2.4. Determine the performance indicators. 2.5. Establish a process improvement committee and an implementation team. 2.6. Determine what training participants will need. 2.7. Analyze the current state of the value stream mapping (VSM), identify opportunities for improvement, and elaborate the changes to be made VSM of the future state for the implementation scope.	- Teamwork. - Workshops. - Value stream mapping. - Elaborate a 'senior management commitment contract with LM implementation to ensure support and resource availability. - Evaluate hiring a consultant.	- Project implementation manager. - Representative from organization's board of directors. - Managers (or representatives) of the areas affected by the implementation.
Execution	3. Pilot project execution and follow-up	3.1. Establish the project's scope. 3.2. Gather and analyze detailed data about the process that needs to be improved. 3.3. Plan the necessary resources (physically, financially, humanly, administratively); 3.4. Formulate an action plan (schedule) for improvement. 3.5. Manage kaizen projects to ensure improvement. 3.6. Using Gemba to monitor activities (a 'go-and-see' approach); 3.7. Determine what was planned versus what was accomplished. 3.8. Process evaluation.	- Teamwork. - Workshops. - Value stream mapping. - LM tools (as needed); - Project management approach to implementation. - Audits.	- Implementation team. - Employees directly involved in the activities. - Process improvement committee. - Project manager. - Management representative.
	4. Lean Manufacturing Deployment	4.1. Establish a new pilot project scope. 4.2. Repetition of activities 3.2 to 3.7 (three-month cycle	- Teamwork. - Workshops. - Value stream mapping. - LM tools (as needed); - Project management approach to Implementation. - Audits.	- Implementation team. - Employees directly involved in the activities. - Process improvement committee. - Project manager. - Management representative.
Continuous improvement	5. Assessment of the implementations	5.1. Evaluate results after six months of implementation. 5.2. Conduct a reevaluation of the furniture industry's adherence to LM.	- Teamwork. - Workshops. - Audits. - Lean manufacturing diagnostic form.	- Process improvement committee. - Implementation team. - Project manager. - Management representative.

Shah et al. (2019) presents a model for implementing LM in small and medium-sized engineering organizations (SMEOs), called LEMSEO (Lean Manufacturing in Small-sized Engineering Organizations). The authors note that previous attempts to implement LM in SME organizations using models designed for larger organizations have often been unsuccessful. The LEMSEO model proposes that LM implementation in SMEOs should occur in three phases. The first phase involves implementing a micro-project that requires no funding to create awareness about LM. In the confidence building phase, a mini-project is implemented to develop confidence in the management and employees. Finally, the lean culture inculcation phase involves implementing a major project using value stream mapping (VSM) and continuously monitoring the benefits accrued while making efforts for the sustainable development of lean culture. This model is intended to overcome the challenges of implementing LM in SMEs and promote continuous improvement through waste elimination.

Sahoo & Yadav, (2018e) present a study that aims to investigate the effects of lean production practices on the performance of SMEs in India. The authors employed a Structural Equation Modelling (SEM) approach to examine the strength of the relationship between lean production strategy and plant performance. It was found that lean production strategy positively correlated with plant performance. In the calculations, lean production practices are associated with positive effects on the performance of SMEs. Also, the authors found that the process improvement (PI) approach had the greatest impact on operational performance, followed by the waste reduction (WR) approach

and the material flow management (FM) approach. LM in the Indian manufacturing sector is described in this paper with an emphasis on critical success factors as well as barriers.

In (Elkhairi et al., 2022), four phases are described, each of which comprises a set of steps (as shown in Figure 3.), the preparation phase, the diagnostic phase, the identification of problems, and the subsequent resolution of them, as well as looking for ways to improve. For Lean to be successful, authors recommend following a step-by-step implementation guide or model. Various models, including the "model of commitment to lean production", the "Lean operational model", the "Lean production model," and the "extended model of design process of lean.". An algorithm is proposed to determine the best route for lean implementation. There are four main phases in the proposed algorithm: preparations, diagnostics, problem solving, and continuous improvement. Steps are taken to complete each stage.

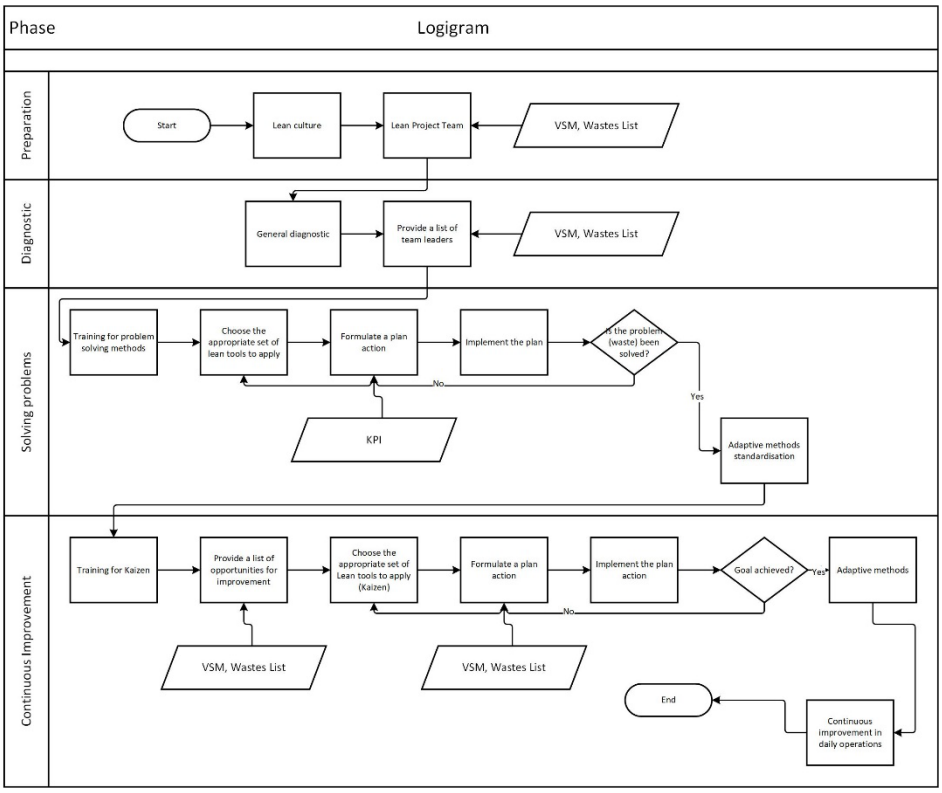

Figure 3. Proposed algorithm for four phases model

During the preparation phase, all members of the company must be enthusiastic, confident, and eager to actively participate in the change project. This phase is mainly psychological. Additionally, everyone should understand the objectives of the lean Culture Basics. Diagnostics is the second phase. This phase involves a deep diagnostic to determine how the firm is doing and what issues it has. As part of this process, the team will be trained on methods and techniques for solving problems related to Lean in order to choose the ones most appropriate for the company. Following the selection of the most appropriate lean methods and techniques for the company's context, a work program will be developed specifying the time required for each process and the key performance indicators (KPIs). Lastly, there is the "Continuous improvement" phase. Having resolved the company's major issues, the search for standardization and perfection begins by continually developing and improving the firm's processes.

Faisal, (2018) states that SMEs are implementing LM to improve their competitiveness. However, future-state Value Stream Mapping (VSM) of LM could not be implemented at the shop floor level. Therefore, the paper proposes using predictive simulation analytics as a tool for the implementation of VSM in SMEs. In this study, predictive simulation analytics is used to analyze the future-state mapping of VSM for the implementation of LM. This paper explains how to implement VSM and develop a simulation model using Arena software. Several types of goods are manufactured

by Company A, a small company. For improving competitiveness in SMEs, predictive simulation analytics of VSM are an appropriate analytical tool for implementing LM. Based on the paper's conclusions, the framework of LM should be designed for SMEs with predictive simulation analytics of VSM.

Caldera et al. (2019) developed a 3P model for lean and green strategy that presents four steps for SMEs to engage in sustainable business practices. The authors conducted case studies with potential SMEs in Queensland and found that the model, which includes a 3P matrix, can guide SMEs to use the best tools and processes based on their circumstances and aspirations. The four steps include exploring, prioritizing, investing, and monitoring and evaluating. The model can be used iteratively, and senior decision makers in the case studies emphasized that it should be inspired by the PDCA cycle. The authors conclude that their model provides a useful guide for SMEs to engage in sustainable business practices and to address strategic work areas through systematic trialing and integration of tools.

Table 2. highlights the key models, frameworks, and approaches discussed in this article regarding the implementation of LM in SMEs. Each model or framework is accompanied by a brief description, implementation phases or steps, and the approach used to measure the success of LM implementation. Lean Staircase, Lean Furniture Framework, LEMSEO, Lean Production Practices, Predictive Simulation Analytics of VSM, and the 3P Model for Lean and Green Strategy are all highlighted in the findings. SMEs seeking to implement LM effectively and measure its impact on their operations can benefit from this table's summary and clarification of research findings.

Table 2. Models and Frameworks for LM Implementation in SMEs

Model/Framework Name	**Authors/Year**	**Description/Summary**	**Implementation Phases/Steps**	**Success Measurement Approach**
Lean Manufacturing	León-Guizado et al. (2021d)	PDCA cycle-based model with three blocks for planning, process flow, and check/act actions	1. Plan: Variables under the plan phase 2. Process Flow: Production management flow 3. Check/Act: Monitoring, assessing, and taking corrective/preventive measures	Formulas for performance analysis: commitment compliance percentages, on-time delivery percentages, efficiency percentages
Lean Staircase	Romana (2020)	Step-by-step implementation plan with investment and improvement phases	1. Investment Phase: Adopting lean principles and applying basic lean tools 2. Improvement Phase: Applying more complex lean tools and supporting initiatives	Continuous goal resetting and reviewing, Value Stream Map, diagnosis of the production system
Lean Furniture Framework	De Oliveira & Junior (2019b)	Assessment and cyclic re-evaluation of LM implementation using diagnostic form	Monitoring results every six-month cycles Re-evaluating adherence to LM through reapplication of diagnostic form by process improvement committee	Toyota Way implementation, cyclic re-evaluation of LM implementation
LEMSEO	Shah et al. (2019)	Three-phase model for implementing LM in small and medium-sized engineering organizations	1. Micro-project for awareness 2. Mini-project for confidence building 3. Major project with value stream mapping and continuous monitoring	Continuous monitoring of benefits, sustainable development of lean culture
Lean Production Practices	Sahoo & Yadav (2018e)	Study on the effects of lean production practices on SME performance in India	Structural Equation Modeling (SEM) approach Lean production practices positively correlated with plant performance	Process improvement (PI), waste reduction (WR), material flow management (FM) approach

Predictive Simulation Analytics of VSM	Faisal (2018)	Use of predictive simulation analytics for future-state Value Stream Mapping (VSM) implementation in SMEs	Predictive simulation analytics for analyzing future-state mapping of VSM Implementation of VSM using Arena software	Future-state mapping using predictive simulation analytics
3P Model for Lean and Green Strategy	Caldera et al. (2019)	Four-step model for SMEs to engage in sustainable business practices	1. Explore: Identifying tools and processes 2. Prioritize: Selecting the best tools based on circumstances 3. Invest: Implementing selected tools 4. Monitor and Evaluate: Systematic trialing and integration of tools	PDCA cycle inspiration, systematic trialing, and integration of tools

5. Conclusion

In conclusion, it is clear that SMEs play a critical role in the economy, and effective implementation LM can contribute significantly to their growth. Through the review of recent models for implementing LM in SMEs and approaches to measure its success, this research has shed light on the potential benefits of this methodology for SMEs. However, a gap in research exists in the form of real case studies, which can provide practical insights for SMEs in implementing LM. While some case studies have been conducted around the world, most research remains theoretical. Therefore, future research should focus on gathering real data and conducting case studies on real companies to help SMEs in implementing LM.

There is also a lack of standardized models available to assess the success of LM implementation in SMEs. Many studies have relied on survey-based methods to conclude whether LM implementation has been successful or not. To better evaluate the impact of LM on SMEs, future research should focus on developing comprehensive models that take into account various factors that contribute to operational efficiency and waste reduction. Such models can help SMEs to better evaluate their LM implementation, identify areas for improvement, and optimize their processes for maximum efficiency.

Furthermore, it is concerning that the research on LM in SMEs in the US is lacking despite SMEs making up 99 percent of the US manufacturing sector. Most of the research conducted in this area dates back to the 1990s, and the few existing studies are insufficient to address the current challenges faced by SMEs. Therefore, more research is needed in this area to provide practical insights for SMEs in the US to implement LM effectively.

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Biographies

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