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CRITICAL SUCCESS FACTORS OF LEAN SIX SIGMA IN SMES: A STRUCTURED REVIEW

Erick Anantha Haryo Purnomo[1*], Suharnomo[2], Amie Kusumawardani[3], and Purnawan Adi Wicaksono[4]

[1]Doctoral Program in Management, Faculty of Economics and Business, Universitas Diponegoro, Indonesia
[2-4]Faculty of Economics and Business, Universitas Diponegoro, Indonesia

*Email corresponding author: Naramasi.anantha@gmail.com

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Abstract

This study aims to identify and synthesize the Critical Success Factors (CSFs) influencing Lean Six Sigma (LSS) implementation in Small and Medium Enterprises (SMEs). A Systematic Literature Review (SLR) was conducted using the PRISMA framework to identify, screen, and evaluate relevant studies retrieved from the Scopus database. From an initial pool of 164 articles, 31 studies met the inclusion criteria and were selected for detailed analysis. Descriptive, bibliometric, and thematic analyses were employed to examine publication trends, industrial sectors, research methodologies, and dominant implementation factors. The findings indicate that Lean Six Sigma research remains highly concentrated in the manufacturing sector, while studies focusing specifically on SMEs remain relatively limited. The review identified several dominant Critical Success Factors, including top management commitment, employee involvement, training and education, customer focus, organizational culture, strategic alignment, continuous improvement orientation, resource allocation, and technology readiness. The findings suggest that successful Lean Six Sigma implementation in SMEs depends not only on technical tools and methodologies but also on organizational readiness and managerial capability. This study contributes to the literature by providing an updated mapping of Lean Six Sigma research within SME contexts and offers practical guidance for SME practitioners seeking to implement continuous improvement initiatives effectively.

Keywords: Lean Six Sigma, Critical Success Factors, SMEs, Systematic Literature Review, Continuous Improvement

INTRODUCTION

In the current business environment, organizations operate under increasingly dynamic and competitive conditions that require continuous improvement in quality, operational efficiency, productivity and customer satisfaction. Rapid changes in market structures, increasing customer expectations and pressure to reduce operational costs have encouraged organizations to adopt management approaches capable of delivering systematic and sustainable process improvement (Antony et al., 2017; Albliwi et al., 2015). Consequently, organizations increasingly seek integrated improvement methodologies that simultaneously enhance operational performance and

organizational competitiveness.

Among various improvement approaches, Lean Six Sigma (LSS) has emerged as one of the most widely adopted business strategies due to its ability to integrate process efficiency and quality improvement within a unified framework (Snee, 2010; Pepper & Spedding, 2010). Lean Six Sigma combines the strengths of Lean philosophy and Six Sigma methodology to create a comprehensive approach toward operational excellence. Lean primarily focuses on eliminating waste and removing non-value-added activities to improve process flow and responsiveness (Womack & Jones, 2003), whereas Six Sigma emphasizes reducing process variation and improving quality performance through statistical analysis and data-driven decision making (Antony et al., 2008; Chakravorty, 2009). The integration of both approaches enables organizations not only to accelerate operational processes but also to increase consistency, reliability and customer value (George, 2002).

Historically, Lean and Six Sigma developed independently and demonstrated substantial success across industrial applications. Lean originated from the Toyota Production System (TPS), emphasizing customer value creation through continuous waste elimination and flow improvement (Womack et al., 2007). Six Sigma emerged as a structured quality management methodology designed to minimize process variability and reduce defects using analytical and statistical tools (Naslund, 2008). The convergence of these philosophies resulted in Lean Six Sigma, which is increasingly recognized as an effective strategy for achieving operational excellence and sustainable business performance (Thomas et al., 2008; Snee, 2010).

Initially, Lean Six Sigma was predominantly implemented in manufacturing industries due to more structured operational environments, established process standards and stronger organizational resources (Drohomeretski et al., 2014). Over time, LSS applications expanded into healthcare, education, financial services, public administration and digital transformation initiatives (Antony et al., 2018; Sony et al., 2020). Nevertheless, the distribution of Lean Six Sigma literature remains uneven, with manufacturing continuing to dominate both implementation and academic discussion.

The literature mapping conducted in this study shows that among the selected studies, approximately 32.3 percent of Lean Six Sigma research remains concentrated in manufacturing sectors, while studies specifically addressing Small and Medium Enterprises (SMEs) account for only 6.5 percent of the literature reviewed. This imbalance indicates that knowledge development regarding Lean Six Sigma implementation in SMEs remains relatively limited despite the strategic contribution of SMEs to employment generation, innovation and economic development (OECD, 2023).

Compared with large organizations, SMEs operate under distinct organizational conditions characterized by limited financial capacity, lower technological readiness, constrained managerial capability and reduced process standardization (Hudson et al., 2001; Dora et al., 2016). These conditions create implementation challenges that differ substantially from those experienced by large enterprises. Therefore, implementation models and managerial practices proven effective in large organizations may not be directly transferable to SMEs.

Previous studies suggest that successful Lean Six Sigma implementation depends not only on technical tools and methodologies but also on organizational enablers referred to as Critical Success Factors (CSFs). Factors such as top management commitment, employee involvement, training and education, customer focus, organizational culture, strategic alignment, continuous improvement orientation, resource allocation and technology readiness have consistently been identified as determinants of implementation success (Albliwi et al., 2014; Antony et al., 2012; Laureani & Antony, 2012). However, studies addressing these factors remain fragmented across sectors and methodological approaches, resulting in limited theoretical integration and practical guidance specifically tailored to SMEs.

Therefore, a structured and systematic review is necessary to consolidate existing evidence

regarding Critical Success Factors influencing Lean Six Sigma implementation in SMEs. This study aims to identify, synthesize and classify dominant success factors while simultaneously mapping research development based on industrial sectors, research methodologies and publication trends.

The contribution of this study is threefold. First, this study contributes theoretically by providing a structured synthesis of Critical Success Factors within the SME context, which remains underexplored compared with manufacturing and large organizations. Second, the study contributes practically by offering guidance for SME practitioners and decision-makers in prioritizing implementation strategies based on dominant success factors. Third, the study contributes methodologically by demonstrating the application of Systematic Literature Review (SLR) to integrate empirical evidence and support the development of a more context-specific understanding of Lean Six Sigma implementation.

LITERATURE REVIEW

Six Sigma

The development of Six Sigma cannot be separated from the evolution of quality management philosophies that emerged during the twentieth century, particularly Total Quality Management (TQM), Deming's management philosophy, and Statistical Process Control (SPC). These approaches established the foundation for systematic quality improvement and encouraged organizations to move beyond inspection-based quality control toward process-oriented quality management.

Six Sigma was formally introduced by Motorola Corporation in 1987 as a structured methodology to improve manufacturing quality and reduce defects across organizational processes (Harry & Schroeder, 2000; Pande et al., 2000). Initially, Motorola implemented Six Sigma not only to produce defect-free products but also to transform organizational performance through a disciplined process improvement approach. The concept was developed based on Statistical Process Control (SPC), which enables organizations to monitor process capability and reduce defects to a target level of 3.4 defects per million opportunities (DPMO).

The term Sigma (σ) originates from statistical terminology and represents standard deviation, which is used to measure process variation. Within the Six Sigma philosophy, lower variation indicates greater process stability and improved capability to consistently meet customer requirements (Eckes, 2001; Rathi et al., 2016).

At the operational level, Six Sigma initially adopted the MAIC framework—Measure, Analyze, Improve, and Control—as a systematic roadmap for solving process problems. This structured approach allowed organizations to develop repeatable improvement practices without continuously redesigning solutions for each operational challenge (Snee & Hoerl, 2007). However, the methodology evolved significantly after its adoption by General Electric (GE) in the mid-1990s.

General Electric, under the leadership of Jack Welch, played an important role in transforming Six Sigma from a manufacturing quality initiative into a strategic business methodology. GE introduced the additional Define stage into MAIC and established the DMAIC (Define–Measure–Analyze–Improve–Control) framework to ensure project selection aligned with organizational objectives (Welch, 2001; Antony et al., 2012). Since then, Six Sigma expanded rapidly across multiple sectors including healthcare, finance, services and public administration (Hoerl, 2002).

The success achieved by organizations such as General Electric, Honeywell, Dow Chemical, Ford, American Express and 3M accelerated global adoption of Six Sigma as a management system capable of improving quality, reducing cost and supporting continuous organizational improvement (Creveling et al., 2003; Kumar et al., 2015).

Lean

Parallel to the development of Six Sigma, Lean emerged as another influential improvement philosophy focused primarily on eliminating waste and improving process flow. Lean originated from the Toyota Production System (TPS), which was developed in Japan during the 1930s to improve automobile manufacturing efficiency and maximize customer value (Womack & Jones, 2002).

Unlike Six Sigma, which emphasizes statistical reduction of process variation, Lean focuses on identifying and eliminating activities that do not add value to customers. The term Lean Manufacturing was later popularized by Krafcik in 1988 to describe Toyota's production practices characterized by minimal waste and continuous operational improvement (George, 2002; Bhasin, 2013).

Lean introduced a different perspective toward operational excellence by emphasizing process simplification, inventory reduction, pull production systems and continuous flow. Several principles became central to Lean implementation, including value creation, value stream optimization, process flow improvement, pull-based production and pursuit of perfection (Womack & Jones, 2005).

One of the most recognized contributions of Lean is the identification of waste (muda) within organizational processes. Initially, seven categories of waste were identified: transportation, inventory, motion, waiting, overproduction, overprocessing and defects. Subsequent developments expanded these categories to include underutilization of employee creativity and environmental waste (Vinodh et al., 2011; Wong et al., 2014).

To support implementation, Lean introduced several improvement tools including 5S, Kanban, Value Stream Mapping (VSM), Cause-and-Effect Analysis, Kaizen, and visual management systems. However, successful Lean implementation requires more than technical tools; it also demands organizational culture transformation and long-term commitment toward continuous improvement (Drohomeretski et al., 2014).

Lean Six Sigma

Although Lean and Six Sigma independently generated significant improvements across industries, each methodology also demonstrated limitations when implemented separately. Lean succeeded in accelerating processes and eliminating waste but often lacked analytical rigor for controlling process variation. Conversely, Six Sigma effectively reduced variation but sometimes required longer implementation cycles and insufficiently addressed operational flow efficiency (Snee, 2010).

To overcome these limitations, organizations began integrating Lean and Six Sigma into a unified methodology known as Lean Six Sigma (LSS). The integration emerged in the early 2000s as a strategic effort to combine the strengths of both approaches into a single operational excellence framework (Linderman et al., 2003; Cherrafi et al., 2017).

Within Lean Six Sigma, Lean contributes through waste elimination and flow optimization, while Six Sigma contributes through data-driven analysis and defect reduction. This integration enables organizations to simultaneously improve speed, quality, productivity and customer satisfaction (Antony et al., 2005).

Lean Six Sigma therefore evolved beyond a collection of operational tools and became a comprehensive management philosophy focused on customer value creation, process excellence and sustainable organizational performance. Figure-based explanations in earlier literature suggest that Lean mainly improves information and material flow between processes, whereas Six Sigma strengthens performance within processes themselves (Laureani & Antony, 2012).

Today, Lean Six Sigma has evolved into one of the most influential improvement methodologies across manufacturing, healthcare, education, financial services, construction and SMEs. More recently, Lean Six Sigma has also been integrated with digital technologies such as Industry 4.0, artificial intelligence and predictive analytics, expanding its role from process improvement toward

organizational transformation and sustainable competitive advantage.

Critical Success Factors of Lean Six Sigma

Discussions of leadership commitment, training, employee involvement, customer focus, organizational culture, strategic alignment, and continuous improvement from later sections into this subsection.

LITERATURE SEARCH METHODOLOGY

Research Design

This study employs a Systematic Literature Review (SLR) approach to identify and synthesize previous studies related to the Critical Success Factors (CSFs) of Lean Six Sigma (LSS) implementation in Small and Medium Enterprises (SMEs). The SLR method was chosen because it provides a structured and transparent process for reviewing existing literature and identifying research trends, gaps, and key findings.

The review process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, which consists of four stages: identification, screening, eligibility assessment, and inclusion. This approach ensured that only relevant and high-quality studies were selected for analysis.

The study focused on three main objectives: (1) examining the development of Lean Six Sigma research across different sectors, (2) analyzing research methodologies and publication trends, and (3) identifying the dominant Critical Success Factors influencing successful Lean Six Sigma implementation in SMEs.

The selected articles were analyzed using descriptive and thematic analysis. Descriptive analysis was used to examine publication trends, sectors, journals, and research methodologies, while thematic analysis was employed to identify and classify the Critical Success Factors reported in the literature. Through this approach, the study provides a comprehensive overview of Lean Six Sigma implementation in SMEs and highlights the key factors contributing to its success.

Search Strategy and Database Selection

The literature search was conducted using the Scopus database, which was selected because it is one of the largest and most comprehensive databases of peer-reviewed academic publications. Scopus provides extensive coverage of journals in the fields of quality management, operations management, industrial engineering, and business studies, making it suitable for identifying relevant studies on Lean Six Sigma and SMEs.

The search process was carried out using a combination of keywords related to Lean Six Sigma implementation and Critical Success Factors. The main keywords included “Lean Six Sigma,” “Lean Six Sigma implementation,” “Critical Success Factors,” “SMEs,” “continuous improvement,” and “process improvement.” These keywords were selected based on their relevance to the research objectives and their frequent use in previous studies.

To improve search accuracy, several search strings were developed using Boolean operators.

Examples of the search strings used in this study include:

“Lean Six Sigma” AND SMEs

“Lean Six Sigma implementation” AND SMEs

“Critical Success Factors” AND “Lean Six Sigma”

“Lean Six Sigma” AND “continuous improvement”

“Lean Six Sigma” AND “process improvement”

The search was limited to peer-reviewed journal articles published in English. The retrieved articles were subsequently screened and evaluated according to the predefined inclusion and exclusion criteria to ensure their relevance to the objectives of this study.

Tabel 1. Database Selection

Criteria	Inclusion	Exclusion
Publication type	Journal articles	Conference papers, books, theses
Language	English	Non-English
Topic	Lean Six Sigma, CFs, SMEs	Unrelated topics
Database	Sccopus	Other databases
Accessbility	Full-text available	Full-text unavailable

To ensure the relevance and quality of the selected studies, predefined inclusion and exclusion criteria were applied during the screening and eligibility assessment stages. These criteria were developed to identify studies that directly addressed Lean Six Sigma implementation and Critical Success Factors within organizational contexts, particularly SMEs.

Only peer-reviewed journal articles published in English and indexed in the Scopus database were included in this review. Studies focusing on Lean Six Sigma implementation, continuous improvement, process improvement, and Critical Success Factors were considered relevant for further analysis. Conversely, conference papers, books, theses, non-English publications, and studies unrelated to Lean Six Sigma or SMEs were excluded.

The inclusion and exclusion criteria used in this study are presented in Table 1.

Table 2. Inclusion and Exclusion Criteria

Criteria	Inclusion Criteria	Exclusion Criteria
Publication Type	Peer-reviewed journal articles	Conference papers, books, book chapters, theses, dissertaions
Database	Scopus-indexed publications	Publications from other databases
Language	English	Non-English publications
Topic	Lean Six Sigma, Critical Success Factors, SMEs, continuous improvement, process improvement	Studies unrelated to Lean Six Sigma or SMEs
Accessbility	Full-text available	Full-text unavailable
Research Focus	Studies discussing implementation, barriers, benefits, or success factors of Lean Six Sigma	Studies without implementationrelated evidence

Following the application of these criteria, the selected articles were subjected to a detailed review and analysis to identify publication trends, research characteristics, and the Critical Success Factors influencing Lean Six Sigma implementation in SMEs.

PRISMA Screening Process

The article selection process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure a transparent and systematic review procedure. The PRISMA approach consists of four stages: identification, screening, eligibility assessment, and inclusion.

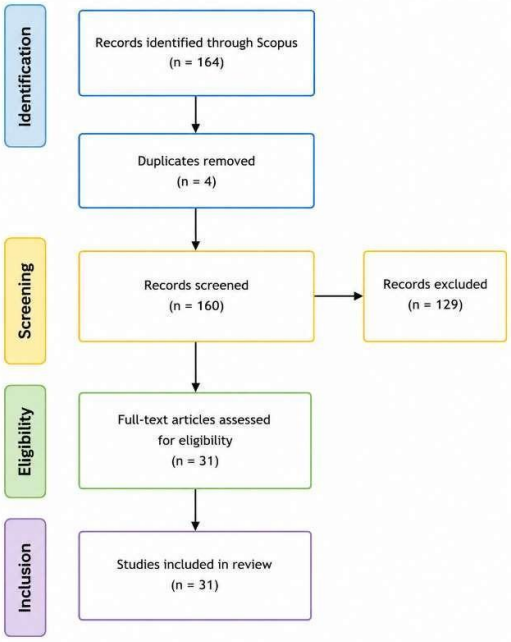
In the identification stage, a literature search was conducted in the Scopus database using predefined keywords related to Lean Six Sigma, Critical Success Factors, and SMEs. The initial search yielded 164 articles. After removing duplicate records, 160 articles remained for further evaluation. During the screening stage, titles and abstracts were reviewed to assess their relevance to the research objectives. Articles that did not address Lean Six Sigma implementation, SMEs, or Critical Success Factors were excluded. As a result, 129 articles were removed from the review process.

The remaining 31 articles proceeded to the eligibility stage, where full-text assessments were conducted. Each article was evaluated against the predefined inclusion and exclusion criteria, including publication type, language, accessibility, and relevance to the study objectives.

After the eligibility assessment, all 31 articles satisfied the selection criteria and were included in the final review. These articles formed the basis for the descriptive analysis, thematic synthesis, and identification of Critical Success Factors influencing Lean Six Sigma implementation in SMEs.

The PRISMA screening process used in this study is illustrated in Figure 1.

Figure 1. PRISMA Flow Diagram of Article Selection Process



Data Analysis Technique

The selected articles were analyzed using descriptive analysis, bibliometric analysis, and thematic analysis to achieve the objectives of this study.

First, descriptive analysis was conducted to summarize the characteristics of the selected literature. This analysis focused on the distribution of articles by industrial sector, research methodology, publication year, and journal source. The results provided an overview of research trends and the development of Lean Six Sigma studies within different contexts, particularly SMEs.

Second, bibliometric analysis was employed to identify publication patterns and the distribution of research within the Lean Six Sigma field. This analysis helped determine the most productive journals, dominant research areas, and publication trends over time. Bibliometric analysis provides a quantitative overview of the evolution of knowledge and research interest related to Lean Six Sigma implementation.

Third, thematic analysis was used to identify, classify, and synthesize the Critical Success Factors (CSFs) reported in the selected studies. Similar themes and concepts were grouped into broader categories, allowing the identification of the most frequently cited factors influencing successful Lean Six Sigma implementation in SMEs. The thematic analysis also facilitated the development of a conceptual understanding of the relationships among the identified success factors.

By combining these three analytical techniques, the study provides a comprehensive overview of the current state of Lean Six Sigma research and highlights the key factors contributing to successful

implementation in SMEs.

RESULTS

Sector Distribution of Lean Six Sigma Research

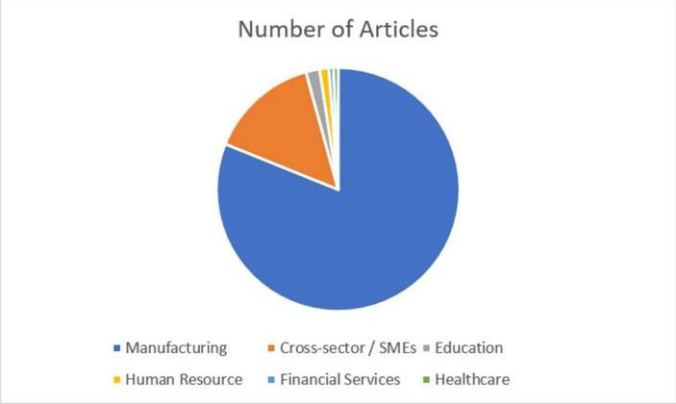
The sector-wise analysis was conducted to examine the distribution of Lean Six Sigma (LSS) research across different industrial contexts. The results reveal that LSS studies remain highly concentrated in the manufacturing sector, reflecting its long-standing role as the primary environment for quality improvement and operational excellence initiatives. Manufacturing-related publications accounted for 81.1% of the reviewed articles, indicating the continued importance of process optimization, waste reduction, and quality enhancement within production systems.

The second-largest category consisted of cross-sector and SME-related studies, representing 14.6% of the publications. This finding suggests growing academic interest in adapting Lean Six Sigma principles to smaller organizations and diverse industrial settings. However, compared with manufacturing, research focusing specifically on SMEs remains relatively limited.

Other sectors such as education, healthcare, financial services, and human resource management accounted for only a small proportion of the literature. Although Lean Six Sigma has demonstrated potential benefits in service-oriented environments, its application outside manufacturing remains underexplored. This distribution highlights significant opportunities for future research, particularly in SMEs and non-manufacturing sectors where operational improvement initiatives continue to gain importance.

Table 3. Distribution of Articles by Sector

Sector	Number of Articles	Percentage
Manufacturing	133	81.1%
Cross-sector / SMEs	24	14.6%
Education	3	1.8%
Human Resource	2	1.2%
Financial Services	1	0.6%
Healthcare	1	0.6%
Total	164	100%



Manufacturing

Manufacturing remains the dominant sector for Lean Six Sigma implementation due to the structured nature of production processes, availability of performance data, and strong emphasis on quality and efficiency improvement. Most studies focus on waste reduction, defect minimization, productivity improvement, and operational excellence.

SMEs

SMEs have increasingly adopted Lean Six Sigma to improve competitiveness, reduce operational costs, and enhance customer satisfaction. However, implementation remains challenging because of limited resources, lack of expertise, and lower process standardization.

Healthcare

Healthcare organizations apply Lean Six Sigma to improve service quality, reduce patient waiting times, and minimize medical errors. Despite its potential, healthcare-related studies remain limited within the reviewed literature.

Education

Educational institutions utilize Lean Six Sigma to improve administrative processes, service quality, and organizational performance. Research in this sector is still emerging and represents a small proportion of the literature.

Financial Services

Lean Six Sigma applications in financial services primarily focus on improving transaction efficiency, reducing process variation, and enhancing customer satisfaction through process optimization.

Human Resource Management

Human resource applications of Lean Six Sigma focus on improving recruitment processes, employee performance management, and organizational effectiveness. This area remains one of the least explored sectors.

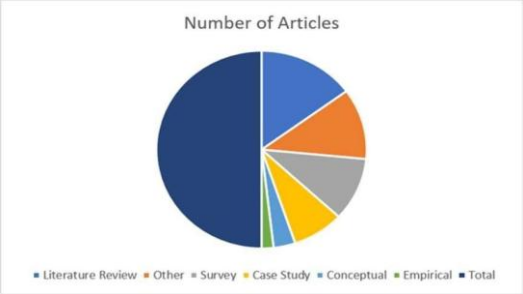
Distribution by Research Methodology

The selected studies were further classified according to the research methodologies employed. The analysis indicates that literature review studies constitute the largest methodological category, accounting for 29.9% of the publications. This reflects a strong emphasis on synthesizing existing knowledge and identifying implementation trends within the Lean Six Sigma field.

Survey studies represented 20.7% of the publications, while case studies accounted for 15.9%. These methodologies are widely used to investigate implementation experiences and organizational practices. Conceptual and empirical studies represented relatively small proportions, suggesting that theory-testing and quantitative validation remain limited.

Tabel 4. Research Methodology Distribution

Methodology	Number of Articles	Percentage
Literature Review	49	29.9%
Other	38	23.2%
Survey	34	20.7%
Case Study	26	15.9%
Conceptual	11	6.7%
Empirical	6	3.7%
Total	164	100%



Journal Distribution

The journal distribution analysis was conducted to identify the most influential publication outlets in Lean Six Sigma research. The findings show that publications are concentrated within journals specializing in quality management, operational excellence, and continuous improvement.

The International Journal of Lean Six Sigma emerged as the leading publication source with 16 articles, followed by The TQM Journal with 11 articles and the International Journal of Quality and Reliability Management with 8 articles. These journals play a significant role in disseminating knowledge and advancing research related to Lean Six Sigma implementation.

Table 4. Top Publishing Journals

Journal	Number of Articles
International Journal of Lean Six Sigma	16
The TQM Journal	11
International Journal of Quality and Reliability Management	8
International Journal of Productivity and Quality Management	7
International Journal of Six Sigma and Competitive Advantage	5
Proceedings of IEOM	5
Lecture Notes in Mechanical Engineering	3
LACCEI Proceedings	3
Total Quality Management and Business Excellence	3
Benchmarking	3

Year-wise Distribution

The year-wise distribution analysis was conducted to examine the evolution of Lean Six Sigma research over time. The results indicate a substantial increase in publication activity during the last decade, reflecting growing academic and industrial interest in Lean Six Sigma as a comprehensive approach to operational excellence and continuous improvement.

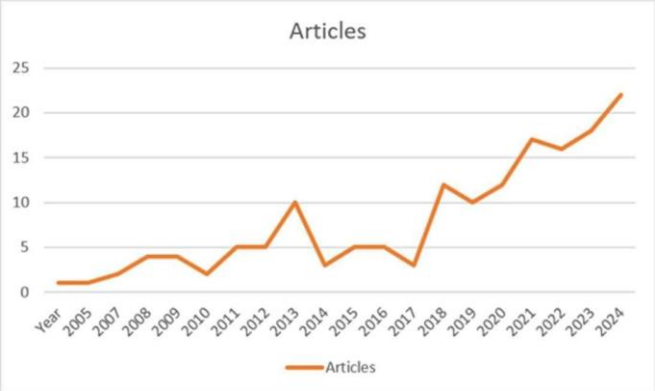
The earliest publications identified in this review appeared in 2005. Between 2005 and 2013, the number of publications remained relatively low, with fewer than five articles published annually. A noticeable increase began in 2014, when the number of publications reached ten articles. Research output continued to grow steadily in subsequent years, particularly after 2019.

The strongest growth occurred between 2022 and 2025. During this period, publication counts increased from 17 articles in 2022 to 18 articles in 2024 and reached a peak of 22 articles in 2025. This trend demonstrates increasing scholarly interest in Lean Six Sigma applications beyond traditional manufacturing environments, including sustainability, digital transformation, Industry 4.0, supply chain resilience, and SME competitiveness.

The upward publication trend suggests that Lean Six Sigma has evolved from a quality improvement methodology into a broader strategic management approach. The growing number of studies also reflects organizations' increasing need to improve operational efficiency, reduce waste, enhance quality performance, and strengthen long-term competitiveness in dynamic business environments.

Figure 2. Publication Trend by Year

Year	Articles
2005	1
2007	1
2008	2
2009	4
2010	4
2011	2
2012	5
2013	5
2014	10
2015	3
2016	5
2017	5
2018	3
2019	12
2020	10
2021	12
2022	17
2023	16
2024	18
2025	22
2026	7*



DISCUSSION

Lean Six Sigma in the Manufacturing Sector

The findings indicate that the manufacturing sector remains the dominant context for Lean Six Sigma (LSS) implementation, accounting for 81.1% of the reviewed publications. This dominance can be attributed to the structured nature of manufacturing processes, the availability of measurable performance indicators, and the strong emphasis on quality improvement and operational efficiency. Manufacturing organizations have traditionally adopted Lean Six Sigma to reduce defects, eliminate waste, improve productivity, and enhance customer satisfaction.

The reviewed studies consistently report several benefits of Lean Six Sigma implementation in manufacturing environments. One of the most significant benefits is quality improvement, achieved through the reduction of process variation and defects. Organizations also experience substantial waste reduction by eliminating non-value-added activities and improving process flow. Furthermore, Lean Six Sigma contributes to cost reduction through lower rework rates, reduced inventory levels, and improved resource utilization. These improvements collectively support process excellence, enabling organizations to achieve higher levels of operational performance and competitiveness.

Despite these advantages, several barriers continue to hinder successful implementation. Many studies highlight the absence of a universally accepted implementation framework, making it difficult for organizations to standardize deployment practices. In addition, training limitations often restrict employees' ability to apply Lean Six Sigma tools effectively. Another challenge is the availability and quality of operational data, as successful Lean Six Sigma implementation relies heavily on data-driven decision-making and performance measurement.

Overall, the findings suggest that while Lean Six Sigma provides substantial operational and strategic benefits for manufacturing organizations, successful implementation requires adequate organizational support, employee competence, and access to reliable performance data.

Lean Six Sigma in the SMEs Sector

Compared with large manufacturing organizations, SMEs operate under different organizational conditions characterized by limited resources, flexible structures, and less formalized processes. As a result, Lean Six Sigma implementation in SMEs requires a more adaptive and simplified approach.

The reviewed literature demonstrates that SMEs adopt Lean Six Sigma primarily to improve operational efficiency, reduce process waste, and increase productivity. Many studies report improvements in process flow, shorter cycle times, and better utilization of available resources.

Another frequently reported benefit is enhanced customer satisfaction, resulting from improved product quality and more reliable service delivery. Lean Six Sigma also contributes to competitive advantage by enabling SMEs to improve performance while controlling operational costs. Furthermore, many SMEs report significant cost reductions through lower defect rates, reduced waste, and improved process standardization.

However, SMEs face several implementation barriers that are less prominent in larger organizations. The most common challenge is limited financial resources, which restrict investments in training, technology, and external consultancy support. Many SMEs also suffer from a lack of Lean Six Sigma expertise, making it difficult to apply statistical and analytical tools effectively. In addition, resistance to change often emerges because employees may perceive improvement initiatives as additional workload or organizational disruption. Finally, weak top management commitment can undermine long-term implementation success, as continuous improvement initiatives require sustained leadership support and strategic direction.

Benefits	Barries
Operational efficiency	Limited financial resources
Customer satisfaction	Lack of expertise Competitive
Advantage	Resistance to change
Cost reduction	Weak managerial commitment
Waste reduction	Limited training opportunities
Improved productivity	Lack of structured data
Better process standardization	Limited technological readiness
Continuous improvement culture	Difficulty sustaining improvements

The findings suggest that Lean Six Sigma offers substantial opportunities for SMEs to improve operational performance and competitiveness. Nevertheless, implementation strategies must be adapted to SME-specific constraints and organizational characteristics.

Critical Success Factors for Lean Six Sigma Implementation in SMEs

The thematic analysis identified several Critical Success Factors (CSFs) that consistently influence the success of Lean Six Sigma implementation in SMEs. These factors extend beyond the technical application of Lean Six Sigma tools and reflect broader organizational capabilities and readiness.

Among the identified factors, top management commitment emerged as the most frequently cited determinant of successful implementation. Strong leadership support is essential for allocating resources, establishing strategic priorities, and sustaining continuous improvement initiatives. Employee involvement was also identified as a critical factor, as successful Lean Six Sigma projects require active participation and engagement from employees across organizational levels. Another important factor is training and education, which help develop the technical and analytical competencies necessary for applying Lean Six Sigma methodologies. The literature also emphasizes the importance of maintaining a strong customer focus, ensuring that improvement initiatives are aligned with customer requirements and value creation objectives.

At the organizational level, strategic alignment plays a key role in connecting Lean Six Sigma projects with broader business objectives. Similarly, a supportive organizational culture encourages collaboration, learning, and continuous improvement. Several studies further highlight the importance

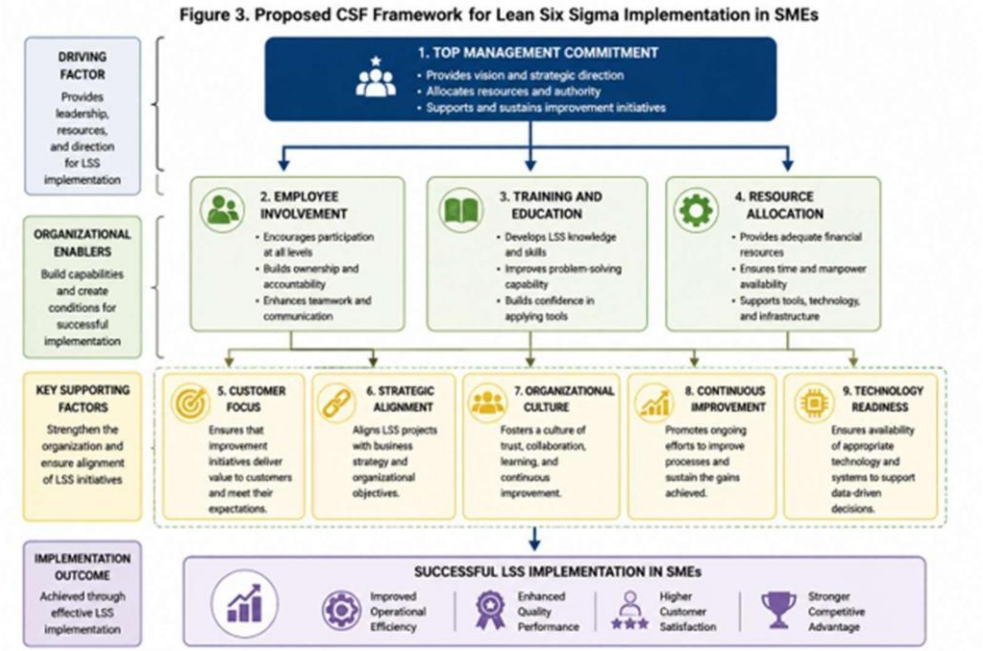
of maintaining a continuous improvement orientation, ensuring that Lean Six Sigma becomes embedded within daily organizational practices rather than being implemented as a one-time initiative.

Finally, resource allocation and technology readiness were identified as enabling factors that support data collection, performance monitoring, and implementation sustainability. SMEs that effectively allocate resources and adopt appropriate technologies are more likely to achieve successful Lean Six Sigma outcomes.

Table 6. Critical Success Factors Identified in Previous Studies

Critical Success Factor	Description
Top management commitment	Leadership support and strategic direction
Employee involvement	Participation and engagement in improvement activities
Training and education	Development of Lean Six Sigma knowledge and skills
Customer focus	Alignment of improvement efforts with customer needs
Strategic alignment	Integration of LSS initiatives with organizational objectives
Organizational culture	Supportive culture for learning and continuous improvement
Continuous improvement	Ongoing commitment to process enhancement
Resource allocation	Availability of financial, human, and operational resources
Technology readiness	Capability to support data-driven decision making

Figure 3. Proposed CSF Framework for Lean Six Sigma Implementation in SMEs



The proposed framework positions Top Management Commitment as the primary driving factor that influences employee involvement, training and education, and resource allocation. These organizational enablers support the development of a continuous improvement culture, customer

focus, and strategic alignment. Together, these factors contribute to successful Lean Six Sigma implementation, which ultimately leads to improved operational efficiency, quality performance, customer satisfaction, and competitive advantage in SMEs.

FUTURE RESEARCH DIRECTIONS AND LIMITATIONS

Future Research Directions

The findings of this review highlight several opportunities for future research on Lean Six Sigma (LSS) implementation in SMEs. First, there is a need to develop SME-specific implementation frameworks. Most existing Lean Six Sigma models were originally designed for large manufacturing organizations and may not fully address the resource constraints, managerial limitations, and operational flexibility commonly found in SMEs. Future studies should therefore focus on designing simplified and scalable implementation frameworks tailored to SME characteristics.

Second, future research should explore the integration of Lean Six Sigma with Industry 4.0 technologies. The growing adoption of automation, Internet of Things (IoT), artificial intelligence, and advanced analytics creates opportunities to enhance data-driven decision-making and process optimization. Understanding how these technologies can support Lean Six Sigma implementation may contribute to more effective continuous improvement initiatives.

Third, the concept of Digital Lean Six Sigma deserves further investigation. Digital technologies have the potential to improve real-time monitoring, predictive quality management, and process control. Future studies should examine how digital transformation can strengthen Lean Six Sigma deployment and organizational performance.

Fourth, additional research is needed within food-sector SMEs, which emerged as one of the most relevant SME contexts in the reviewed literature. Food SMEs face unique challenges related to quality consistency, waste reduction, food safety, inventory management, and customer satisfaction. More sector-specific studies would help develop practical implementation guidelines for this important industry.

Finally, future research should examine the relationship between Lean Six Sigma and sustainability initiatives, particularly within the context of the circular economy. Integrating Lean Six Sigma with environmental management practices may help organizations achieve both operational excellence and sustainable business performance.

Limitations

Several limitations should be acknowledged when interpreting the findings of this study. First, the review was limited to publications indexed in the Scopus database, which may have excluded relevant studies available in other databases such as Web of Science, Emerald, Springer, or Google Scholar.

Second, only English-language publications were included in the review. As a result, studies published in other languages may not be represented in the findings.

Third, the review focused exclusively on peer-reviewed journal articles, excluding conference proceedings, books, theses, dissertations, and industry reports that may contain valuable insights regarding Lean Six Sigma implementation.

Finally, the classification of sectors and research methodologies involved a degree of researcher interpretation, creating the possibility of classification bias. Although efforts were made to ensure consistency throughout the review process, some categorization decisions may involve subjective judgment.

CONCLUSION

This study provides a systematic review of the Critical Success Factors influencing Lean Six Sigma implementation in Small and Medium Enterprises (SMEs). The findings demonstrate that Lean Six Sigma continues to evolve as an important strategic methodology for improving quality, operational efficiency, and organizational competitiveness across multiple sectors. Although manufacturing remains the dominant area of application, the growing number of SME-related studies indicates increasing recognition of Lean Six Sigma as a valuable improvement approach for smaller organizations.

The review identified several key Critical Success Factors that consistently contribute to successful Lean Six Sigma implementation. These factors include top management commitment, employee involvement, training and education, customer focus, strategic alignment, organizational culture, continuous improvement orientation, resource allocation, and technology readiness. The findings suggest that implementation success depends not only on the application of Lean Six Sigma tools and techniques but also on organizational readiness and leadership support.

From a practical perspective, the study provides guidance for SME owners and managers in prioritizing improvement initiatives and allocating resources toward the most influential success factors. From a theoretical perspective, the findings contribute to the growing body of knowledge on Lean Six Sigma by offering an updated synthesis of implementation success factors within the SME context.

Overall, the study highlights the need for more adaptive, flexible, and SME-oriented Lean Six Sigma implementation frameworks. As organizations continue to face increasing pressure to improve efficiency, quality, and sustainability, Lean Six Sigma is expected to remain a valuable approach for achieving continuous improvement and long-term competitive advantage.

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