

# **Evaluating the Research Development on Critical Success Factors For Lean Six Sigma Implementation**

**Guilherme Bolzan Cieto**

MSc Student, Department of Industrial Engineering, São Carlos School of Engineering  
Universidade de São Paulo (USP)  
São Carlos, São Paulo, Brazil

**Roberto Antonio Martins**

Professor, Department of Industrial Engineering  
Universidade Federal de São Carlos (UFSCar)  
São Carlos, São Paulo, Brazil  
[guilherme.cieto@usp.br](mailto:guilherme.cieto@usp.br), [ram@dep.ufscar.br](mailto:ram@dep.ufscar.br)

## **Abstract**

Lean Six Sigma (LSS) is an approach that is widely recognised as useful for improving operational performance. Despite this recognition, it is difficult to implement and failures are common. It is necessary to understand the key factors that are critical to the successful LSS implementation. These factors are often referred to as Critical Success Factors (CSFs). Despite being a consolidated research area, recent reviews lack comprehensive exploration of LSS CSFs. This paper aims to present a comprehensive and critical review of this research area evolution, identifying the main CSFs and the relationships between them, the topics being researched in this field, and research gaps. A Systematic Literature Review (SLR) was used to develop this article. The results show that the published documents have been increasing in the domain, but impact have been decreasing. The review identified the ten most relevant CSFs. The most relevant factors is management commitment, which drive others. The CSFs were identified in micro, small and medium enterprises (MSMEs), in service organisations, used for assessment tools, LSS leadership, and used as an integrated approach in Industry 4.0. The latter is an emerging issue that requires more research. This article presents evidence that LSS CSFs are acknowledged and vary little from organisation to organisation. Additional empirical research is needed to validate whether the identified CSFs are the most relevant in real settings.

## **Keywords**

Lean Six Sigma, Critical Success Factors, Systematic Literature Review, Continuous Improvement, Thematic Analysis

## **1. Introduction**

Continuous improvement (CI) is a culture of sustained improvement to eliminate waste in all organisation's systems and processes, involving joint improvement work. It does not necessarily require large capital investment (Bhuiyan and Baghel 2005). The implementation of a robust CI strategy is essential for an organisation to achieve the necessary flexibility, quality, responsiveness, adaptability, performance and to reduce variation and defect (Kaye and Anderson 1999; McLean et al. 2017; Swarnakar et al. 2019). LSS is a CI approach that became an essential element for improving process performance (Antony et al. 2023).

Lean Six Sigma (LSS) integrates Lean and Six Sigma approaches for CI into a single combined approach. Lean, characterised by its multifaceted system encompassing various management practices including just-in-time (JIT), quality management systems, and cellular manufacturing, synergistically generates a high-quality system that aligns

product output with demand, minimising waste (Shah and Ward 2003). In contrast, Six Sigma is a scientific method that systematically improves processes, reduces variation, and develops new products and services by applying statistical methods to achieve dramatic reductions in consumer-defined defect rates (Linderman et al. 2003). The structured improvement method (DMAIC – acronym for Define, Measure, Analyse, Improve and Control) distinguishes Six Sigma from other improvement approaches (Schroeder et al. 2008). The primary distinctions between Lean and Six Sigma are observed in their systemic approaches and levels of detail in analytical tools and organisational structures. Lean adopts a systemic but less detailed approach, while Six Sigma offers a general framework for problem-solving with fewer standardised solutions (de Koning et al. 2006). The combined application of Lean and Six Sigma enhances their complementarity, making it an optimal strategy for substantial improvements across various competitive priorities (Pepper and Spedding 2010; Drohomerski et al. 2014).

However, CI implementation can be challenging, often leading to the failure or abandonment of initiatives (Antony et al. 2019; McLean et al. 2017). The Lean, Six Sigma and LSS are known to be prone to termination or failure (Antony and Gupta 2019). It is a common practice used in the development of CI strategies (Stankalla et al. 2018) to identify and report the elements that increase the chances of obtaining higher performance from them, called Critical Success Factors (CSFs) (Gastelum-Acosta et al. 2022). CSFs are key controllable actions aimed at achieving organisational objectives. Understanding LSS CSFs is crucial for its success, as it directly influences both financial and non-financial performances (Jeyaraman and Kee Teo 2010; Muraliraj et al. 2018; Ali et al. 2016).

The identification of LSS CSFs can assist many organisations in designing and implement a LSS programme more effectively. Recent literature reviews have either partially addressed CSFs, focused on specific contexts like healthcare, or limited their scope to certain methodological criteria, such as case study analyses (Patel and Patel 2021; McDermott et al. 2022; Francescato et al. 2023). This points out the need for a more thorough and diverse exploration of LSS CSFs in various organisational settings.

## **1.1 Objectives**

This paper aims to present a comprehensive and critical review on LSS CSFs. The objectives are to assess the evolution of research in this knowledge domain, to identify the main CSFs and their relationships, to identify the themes in which these CSFs are discussed, and to identify research gaps.

## **2. Research Design**

We used the Systematic Literature Review (SLR) method that is a reproducible and transparent process for review. It provides an auditable trail of researchers' decisions and is an efficient method for evaluating extensive literature, helping to limit researchers' bias (Tranfield et al. 2003).

The search string, ("lean six sigma" OR "lss" OR "six sigma lean") AND ("critical success factors" OR csf\*), was applied to title, abstract, and keywords fields of the scientific indexers Web of Science and Scopus. The result was 253 relevant documents. After removing duplicates, we read the abstracts followed by a reading of full selected documents. The study's inclusion criteria for literature considered only those papers that examined any dimension of the LSS CSFs. Papers focusing on different improvement methodologies or not discussing CSFs were excluded from review. A total of 61 documents successfully met these inclusion criteria and underwent a comprehensive review.

## **3. Results**

This section poses the results of the review. First, we present a descriptive analysis of our sample. Then, we summarise the main themes that emerged from the documents analysis.

### **3.1 Descriptive analysis**

Table 1 describes the sample's characteristics. We note the field has been established for at least fifteen years and since then has been published in a wide variety of sources. That may indicate a transdisciplinary approach to this knowledge domain. The average number of citations per document is significant, at almost 49 citations per document. The rate of collaboration is high. Only three of the 165 authors published three documents individually. The selected documents include 49 journal articles, three conference papers and nine literature reviews.

Figure 1 illustrates the progression of publication volumes, the average yearly total citations (TC) per document and the average yearly TC. This graph reveals an upward trajectory in the number of publications over time. In contrast,

there is a downward trend in both the average yearly TC per document annually and the average yearly TC. As Zupic and Čater (2015) explain, citation frequency serves as an impact indicator. The observed trends could be attributed to the recency of publications, which may not have had sufficient time to accumulate citations. Alternatively, these trends might reflect a reduced impact due to either the maturity of the research field or possibly suboptimal research approaches employed.

Table 1. Main bibliometric data of analysed documents

DATA DESCRIPTION		RESULTS
Documents	Timespan	2008 - 2023
	Sources (Journals, Books, etc)	30
	Documents	61
	Annual growth rate	16,59%
	Document average age	5,23
	Average citations per document	48,69
	Author's keywords	167
	Single-authored documents	3
Authors	Authors	165
	Authors of single-authored documents	3
Document Types	Article	49
	Conference paper	3
	Review article	9

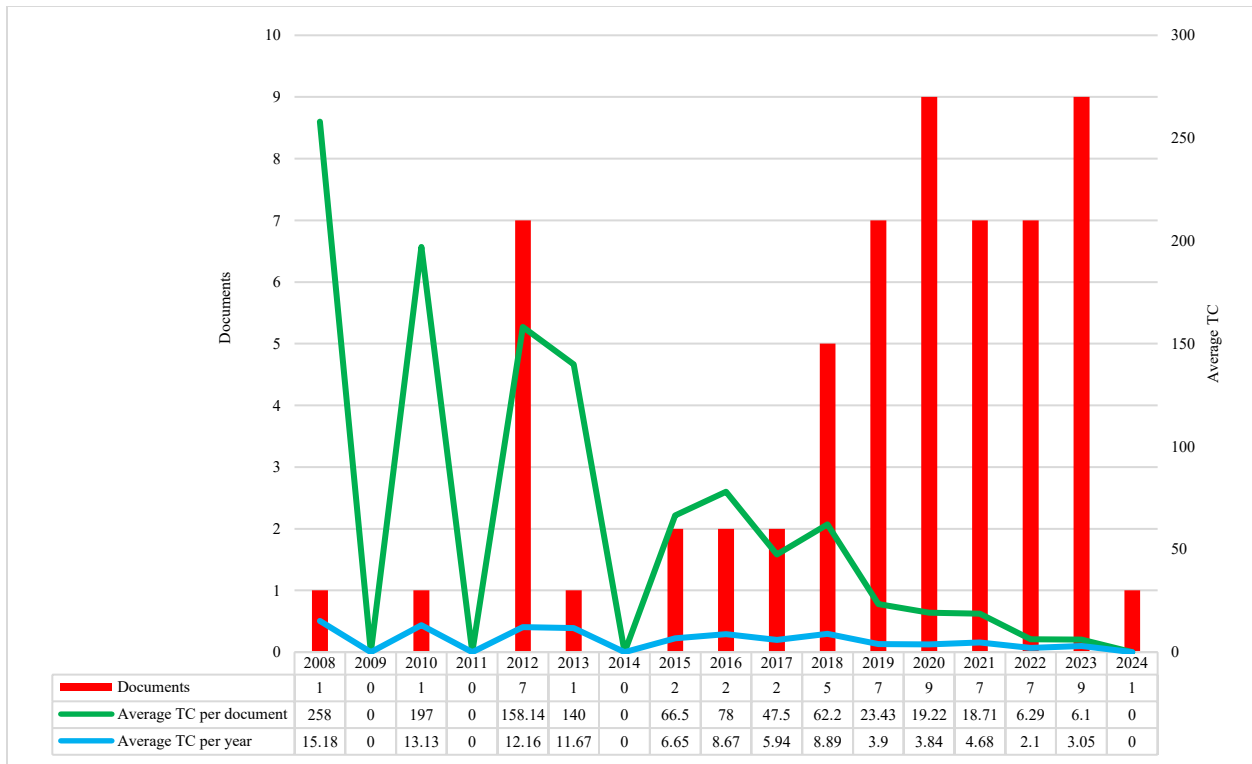


Figure 1. Number of documents per year, average TC per document per year and average TC per year

Table 2 highlights the top five authors who have contributed significantly to the research on the domain. Antony, J. is the most prolific, having authored and co-authored 14 articles and recognised as a leading expert. Other notable authors include Laureani, A., Bhat, S., Singh, A., and Swarnakar, V., who have also made substantial contributions to the field. The index of fractionalised documents presented in the table indicates a level of collaboration among these authors with other researchers in their publications.

Table 2. Five most productive authors

<b>AUTHOR</b>	<b>DOCUMENTS</b>	<b>DOCUMENTS FRACTIONALISED</b>
Antony, J.	14	4,18
Laureani, A.	5	2,17
Bhat, S.	3	0,56
Singh, A.	3	0,70
Swarnakar, V.	3	0,67

Table 3 shows the most common sources in which the documents included in the sample have been published. The International Journal of Lean Six Sigma, a focused LSS journal, is the main source publishing 13 articles. Moreover, the TQM Journal and the International Journal of Quality and Reliability Management play also a relevant role, publishing eight and six articles respectively.

Table 3. Five main sources

<b>SOURCE</b>	<b>DOCUMENTS</b>
International Journal of Lean Six Sigma	13
TQM Journal	8
International Journal of Quality and Reliability Management	6
International Journal of Productivity and Performance Management	3
Total Quality Management and Business Excellence	3

Table 4 shows the ten most referenced papers in the field, highlighting their significant impact on research related to LSS CSFs. These highly cited works predominantly predate 2015, aligning with the trends illustrated in Figure 1. Notably, the most cited paper critiques the LSS CSF literature for its generic nature, suggesting the need for a more systemic approach to organisational change and improvement (Näslund 2008). While the primary focus of these influential documents is on identifying CSFs (Abu Bakar et al. 2015; Hilton and Sohal 2012; Jeyaraman and Kee Teo 2010; Laureani and Antony 2012; Psychogios et al. 2012), they also explore diverse themes, including the application of LSS in Higher Education Institutions (HEIs) (Antony et al. 2012), in MSMEs (Lande et al. 2016; Timans et al. 2012), and in mapping the interrelations between various CSFs (Fadly Habidin and Mohd Yusof 2013).

Table 4. Ten most cited documents

<b>DOCUMENT</b>	<b>TC</b>	<b>TC PER YEAR</b>
(Näslund 2008)	258	15,18
(Antony et al. 2012)	209	16,08
(Jeyaraman and Kee Teo 2010)	197	13,13
(Hilton and Sohal 2012)	188	14,46
(Timans et al. 2012)	176	13,54
(Laureani and Antony 2012)	172	13,23
(Fadly Habidin and Mohd Yusof 2013)	140	11,67
(Lande et al. 2016)	131	14,56
(Psychogios et al. 2012)	109	8,38
(Abu Bakar et al. 2015)	99	9,9

### **3.2 Thematic analysis**

The research identifies seven key themes within the domain LSS CSFs. The most extensive theme revolves around identifying CSFs. Other themes encompass studies on the interrelations between CSFs and their application in various contexts, such as MSMEs, and the service sector, with a particular focus on HEIs, healthcare, and public services. Additional themes include the integration of CSFs with Industry 4.0, their use in assessment tools, and the role of leadership in LSS CSFs.

#### **3.2.1 Identification of CSFs**

A predominant focus of the articles reviewed was the CSFs identification for implementing LSS. Table 5 details the ten most cited CSFs. Several of them are also common to other improvement approaches, including Total Quality Management (TQM), Lean, and Six Sigma, as noted by Sreedharan et al. (2018).

Table 5. Ten most cited CSFs for LSS deployment

CRITICAL SUCCESS FACTOR	REFERENCES
Management support and commitment	(Abu Bakar et al. 2015; Ali et al. 2016; Douglas et al. 2015; Francescatto et al. 2023; Jayaraman et al. 2012; Jeyaraman and Kee Teo 2010; Laureani and Antony 2012; Muraliraj et al. 2018; Mustapha et al. 2019; Narottam et al. 2020; Näslund 2008; Noronha et al. 2023; Patel and Patel 2021; Sousa et al. 2023; Sreedharan V. et al. 2018; Walter and Paladini 2019; Zala et al. 2020)
Training and education	(Abu Bakar et al. 2015; Ali et al. 2016; Francescatto et al. 2023; Jayaraman et al. 2012; Jeyaraman and Kee Teo 2010; Laureani and Antony 2012; Muraliraj et al. 2018; Mustapha et al. 2019; Narottam et al. 2020; Noronha et al. 2023; Patel and Patel 2021; Sousa et al. 2023; Sreedharan V. et al. 2018; Walter and Paladini 2019; Zala et al. 2020)
Communication	(Francescatto et al. 2023; Jayaraman et al. 2012; Jeyaraman and Kee Teo 2010; Laureani and Antony 2012; Muraliraj et al. 2018; Mustapha et al. 2019; Näslund 2008; Noronha et al. 2023; Patel and Patel 2021; Sousa et al. 2023; Sreedharan V. et al. 2018)
Organisational culture	(Douglas et al. 2015; Jayaraman et al. 2012; Jeyaraman and Kee Teo 2010; Laureani and Antony 2012; Muraliraj et al. 2018; Mustapha et al. 2019; Patel and Patel 2021; Sousa et al. 2023; Sreedharan V. et al. 2018; Walter and Paladini 2019; Zala et al. 2020)
Project selection, prioritisation, tracking and review	(Abu Bakar et al. 2015; Francescatto et al. 2023; Jayaraman et al. 2012; Jeyaraman and Kee Teo 2010; Laureani and Antony 2012; Muraliraj et al. 2018; Narottam et al. 2020; Patel and Patel 2021; Sousa et al. 2023; Zala et al. 2020)
Reward and recognition system	(Abu Bakar et al. 2015; Jayaraman et al. 2012; Jeyaraman and Kee Teo 2010; Laureani and Antony 2012; Muraliraj et al. 2018; Mustapha et al. 2019; Narottam et al. 2020; Patel and Patel 2021; Zala et al. 2020)
Strategic orientation	(Abu Bakar et al. 2015; Laureani and Antony 2012; Muraliraj et al. 2018; Narottam et al. 2020; Näslund 2008; Patel and Patel 2021; Walter and Paladini 2019; Zala et al. 2020)
Master Black Belt competency	(Abu Bakar et al. 2015; Ali et al. 2016; Francescatto et al. 2023; Jayaraman et al. 2012; Jeyaraman and Kee Teo 2010; Muraliraj et al. 2018; Narottam et al. 2020)
Organisational infrastructure	(Abu Bakar et al. 2015; Douglas et al. 2015; Francescatto et al. 2023; Laureani and Antony 2012; Patel and Patel 2021; Sreedharan V. et al. 2018; Zala et al. 2020)
Leadership	(Abu Bakar et al. 2015; Francescatto et al. 2023; Laureani and Antony 2012; Muraliraj et al. 2018; Narottam et al. 2020; Patel and Patel 2021)

The literature on CSFs for LSS presents a broad spectrum, with authors often using varied terminology to describe similar factors. Nonetheless, multiple articles recurrently score the significance of certain CSFs based on frequency of citation. Key factors highlighted in the literature include management commitment, training and education, communication, organisational culture, project selection, and the recognition and reward system to encourage and promote LSS initiatives. Leadership is less cited but is often recognised as being of primary relevance and is discussed exclusively in section 3.2.7.

Management support and commitment is related to LSS success and impact both financial and non-financial performances (Ali et al. 2016; Jayaraman et al. 2012, Zala et al. 2020). Top management holds the ability to influence all organisational levels, fostering an understanding of LSS relevance and aligning individuals towards shared objectives (Walter and Paladini 2019). It is a fundamental factor for dealing with organisational culture and conflicts associated with LSS deployment. Moreover, it plays a vital role in decision making to ensure resources allocation, to

foster the system adaptation and to drive the cultural change (Sousa et al. 2023). Training and education are recognised as important elements of LSS (Mustapha et al. 2019) and are positively associated with LSS success (Ali et al. 2016). An effective LSS training programme includes a platform to develop leaders and provides the essential knowledge to deploy LSS, such as tools and a problem-solving approach (Jeyaraman and Kee Teo 2010). Training must be applied to all individuals in an organisation to be effective, including top management (Sousa et al. 2023), and should not only focus on technical training but also address the motivation for LSS implementation (Zala et al. 2020). Training employees in LSS techniques requires financial resources (Jayaraman et al. 2012) but reduces the time and labour costs involved in LSS deployment (Walter and Paladini 2019). Communication is essential to overcome the resistance to change. Effective communication can explain the need for change, outline the expected benefits of LSS implementation and motivate employees (Jayaraman et al. 2012; Jeyaraman and Kee Teo 2010; Mustapha et al. 2019; Sousa et al. 2023). LSS requires a change in organisational culture (Jayaraman et al. 2012; Jeyaraman and Kee Teo 2010; Mustapha et al. 2019). If this change is not properly addressed in the early stages of LSS implementation, the initiative will perish as it depends on cultural, structural, procedural and workforce mindset changes (Sousa et al. 2023). Project selection, prioritisation, tracking and review are essential factors for achieving short and long-term benefits in LSS implementation. Proper selection instills confidence in management and employees regarding LSS effectiveness (Sousa et al. 2023). Identifying the appropriate criteria is essential for conducting the selection process (Jeyaraman and Kee Teo 2010). Operations research methods are useful tools for carrying out this process (Zala et al. 2020). Reward and recognition systems motivate and encourage employees to engage in LSS, serving as a behavioural driver (Jeyaraman and Kee Teo 2010). Rewards can take the form of monetary compensation or recognition using communication tools within the organisation (Zala et al. 2020). Strategic orientation is the CSF that represents the importance of aligning LSS projects with the strategies and objectives of the organisation (Walter and Paladini 2019). It is recognised that Master Black Belts must possess competency in project management skills given that LSS is a project-driven approach (Jeyaraman and Kee Teo 2010). Strong infrastructure is relevant to implement LSS. Organisations must have physical infrastructure, including laboratories, machinery, computer networks, and softwares, as well as financial investment to provide training, professional counseling, and rewards (Zala et al. 2020).

### **3.2.2 Relationships between LSS CSFs**

Some studies have tried to explain the dynamics of relationships between CSFs. They have used different approaches and tools to develop conceptual frameworks of these relationships such as Natural Language Processing (Perera et al. 2021), Fuzzy DEMATEL (Raval et al. 2021), Interpretative Structural Modelling (Swarnakar et al. 2019), Step-wise Weight Assessment Ratio Analysis (Yazdi et al. 2021) and Best-Worst Method (Kumar et al. 2023). The articles consistently rank the CSFs in accordance with their relevance, often identifying leadership and management commitment as paramount (Fadly Habidin and Mohd Yusof 2013; Hilton and Sohal 2012; Raval et al. 2021; Swarnakar et al. 2019). Other significant CSFs include communication, culture, and education and training (Hilton and Sohal 2012). In the model proposed by Swarnakar et al. (2019), top management commitment and support is deemed the most critical factor, influencing others such as employee engagement and communication, which in turn affect skills and expertise and education and training, ultimately leading to cultural change.

### **3.2.3 LSS CSFs in MSMEs**

A significant number of articles have examined LSS CSFs in the MSMEs context (Albliwi and Al-Harbi 2020; Flor Vallejo et al. 2020; Lande et al. 2016; Mishra et al. 2021; Panayiotou et al. 2022a; Ramkumar and Satish 2019; Sodhi 2023; Stankalla et al. 2018; Attar 2023; Timans et al. 2012). Table 6 compares CSFs identified in large organisations (Aljazzazen and Schmuck 2022; Jayaraman et al. 2012; Mustapha et al. 2019; Panayiotou et al. 2022b; Psychogios et al. 2012; Sohal et al. 2022) with those identified in MSMEs (Albliwi 2020; Attar 2023; Flor Vallejo et al. 2020; Kumar et al. 2023; Lande et al. 2016; Ramkumar and Satish 2019; Timans et al. 2012). The most relevant CSFs are the same in both groups and compose the general most relevant CSFs from Table 5. Minor differences exist in citation frequency ranks, which are not highly significant. Notably, employee involvement is more frequently cited in the MSMEs sample, indicating its higher relevance in this context. Despite the natural differences between large organisations and MSMEs, the results show similarities in the LSS CSFs of LSS for both groups as observed by Stankalla et al. (2018) (Table 6.).

Table 6. Comparative analysis of the most relevant CSFs for large organisations versus MSMEs

CRITICAL SUCCESS FACTOR	LARGE ORGANISATIONS		MSMEs ORGANISATIONS	
	CITATIONS	RANK	CITATIONS	RANK
Management support and commitment	6	1	7	1
Training and education	5	2	4	4
Organisational culture	3	3	3	8
Project selection, prioritisation, tracking and review	3	3	4	4
Reward and recognition system	3	3	3	8
Communication	2	6	6	2
LSS knowledge	2	6	4	4
Strategic orientation	2	6	5	3
Employee involvement	1	9	4	4

### 3.2.4 LSS CSFs in service organisations

The identification of CSFs for LSS deployment in service organisations is an established research area (Lameijer et al. 2021; Psychogios et al. 2012). Lameijer et al. (2021) found that CSFs for LSS implementation in companies focused on digital emerging technologies differ, emphasising the need for adapting LSS to align with company values, incorporating on-the-job training, and utilising iterative project management approaches or agile methods. LSS practices, originally from the private sector, are increasingly being applied in public services (Caiado et al. 2020). There are parallels between LSS CSFs in public services and public values (Juliani and Oliveira 2019). In HEIs, CSFs closely align with those outlined in Table 5, encompassing aspects such as leadership, project selection, and various others (Antony et al. 2012). Research in healthcare organisations also shows similarities with these CSFs (Bhat et al. 2019; McDermott et al. 2022; Sohal et al. 2022), yet Gonzalez-Aleu et al. (2018) suggest that some highly cited CSFs may not be as critical in hospital settings, indicating a need for further research in this area.

Table 7. Comparative analysis of the most relevant CSFs for manufacturing industries versus service organisations

CRITICAL SUCCESS FACTOR	MANUFACTURING		SERVICES	
	CITATIONS	RANK	CITATIONS	RANK
Training and education	9	1	3	6
Management support and commitment	7	2	6	1
Project selection, prioritisation, tracking and review	7	2	4	2
Communication	5	4	4	2
Organisational culture	5	4	4	2
Reward and recognition system	5	4	3	6
Financial capability	4	7	4	2
Leadership	2	14	3	6

Table 7 displays a comparison of the most relevant LSS CSFs between manufacturing industries and service organisations. It shows the frequency of citations for CSFs identified exclusively in manufacturing environment (Jayaraman et al. 2012; Jeyaraman and Kee Teo 2010; Kumar et al. 2023; Sodhi et al. 2019; Swarnakar et al. 2019; Timans et al. 2012; Yazdi et al. 2021; Zala et al. 2020) versus a service environment (Aljazzazen and Schmuck 2022; Caiado et al. 2020; Gonzalez-Aleu et al. 2018; Lameijer et al. 2021; McDermott et al. 2022; Sohal et al. 2022). Results shows that the most frequently cited CSFs are consistent across the two groups, and their relevance does not vary much. This suggests that even different organisations often encounter similar challenges during LSS implementation. However, its noteworthy that Training and Education is less relevant in the service organisations sample than in the



manufacturing one. This analysis also showed that Leadership is more frequently cited in service companies than in manufacturing. These results indicate that possibly exists minor differences in CSFs based on the type of the organisation, but they are probably not significant and its identification still requires further research for a more comprehensive understanding.

### **3.2.5 CSFs for LSS integrated with Industry 4.0**

The concept of Industry 4.0, originating from Germany, encompasses the evolution of manufacturing systems characterised by extensive connectivity through wireless networks, advanced autonomous control, and monitoring (Samanta et al. 2024). It comprises nine fundamental elements, including simulation, Internet of Things, big data, robotics, cloud computing, augmented reality, additive manufacturing, cybersecurity, and systems integration (Yadav et al. 2021). The synergy of LSS with Industry 4.0 promises to revolutionise LSS by enhancing productivity flexibility, and supply chain connectivity (Antony et al. 2023). This integration is anticipated to yield benefits like minimal error margins, the ability to handle large amounts of data, and reduced human intervention (Yadav et al. 2021; Samanta et al. 2024). While LSS and Industry 4.0 share several CSFs, their integration introduces unique ones such as data availability, use of data processing software, automatically adjustable processes, predictive systems, automation, design thinking capabilities, training programmes in emerging technologies, reliable data collection, and focus on technologically innovative practices (Samanta et al. 2024; Yadav et al. 2021). However, the exploration of CSFs in this combined context is still limited, presenting a potential research opportunity (Antony et al. 2023).

### **3.2.6 CSFs used in assessment tools**

Two studies focused on using CSFs to create assessment tools for LSS capabilities. Moya et al. (2019) developed a tool by categorising 13 CSFs into five areas: human resource management, project management, strategy, process management, and external relations. They identified that the first four areas share similar relevance, posing a challenging scenario for MSMEs involved in LSS project development. In another study, Gastelum-Acosta et al. (2022) designed a tool for assessing compliance with LSS CSFs, identifying nine key constructs and a benefit factor that serves the purpose of evaluation.

### **3.2.7 LSS Leadership**

Leadership emerges from this study as a pivotal element among the CSFs for LSS implementation (Alnadi and McLaughlin 2020; Laureani and Antony 2017; Laureani and Antony 2018; Loh et al. 2019; Motiani and Kulkarni 2021). Various studies have examined leadership within the LSS framework, defining it as the strategic exercise of influence towards goal achievement, with different leadership styles being more effective in different contexts (Alnadi and McLaughlin 2020; Loh et al. 2019; Motiani and Kulkarni 2021). Particularly, the transformational leadership style is noted for its effectiveness in facilitating change, creating a change roadmap, encouraging stakeholders to accept and engage in change, leading teams, and sustaining LSS programme (Motiani and Kulkarni 2021). For LSS to be sustainable, it is crucial that management's commitment is perceived throughout the entire organisation (Laureani and Antony 2018). Leaders must prioritise LSS over other projects and address any fears related to job security. They should engage with employees to convey the benefits of change and deploy LSS as not a toolkit or quick fix, but as a philosophy that will change the organisational culture over time (Laureani and Antony 2017).

## **4. Final remarks**

The results highlight the LSS CSFs as a solidifying domain, showing a growing rate of publications. Notably, more recent articles have garnered fewer citations, which may suggest a potentially reduced relevance. The research identified the ten most important CSFs in the literature and six additional themes in LSS CSFs discourse: their interrelationships, applications in MSMEs and service organisations, integration with Industry 4.0, utility in assessment tools, and the significance of leadership. Leadership and management commitment are emphasised as the most pivotal CSFs, acting as primary drivers of other factors. It is observed that the CSFs for LSS implementation remain consistent across different organisational sizes and types. The literature presents tools for evaluating an organisation's readiness for LSS implementation, and the amalgamation of LSS with Industry 4.0 introduces both common and novel CSFs.

The study uncovers a paradoxical trend in this domain: despite increasing scholarly interest, there's a decline in the impact of these articles. The consistency in CSFs across varied contexts suggests a need for more empirical research, especially in validation, as disparities exist between literature and practical scenarios (Gonzalez-Aleu et al. 2018). Future research could integrate LSS CSFs concepts with established theories like Change Management or Leadership

Theory to develop a comprehensive LSS theory. The emergence of new CSFs from the convergence of LSS and Industry 4.0 warrants deeper investigation.

The SLR has successfully delineated the current state of research in this area, outlining key CSFs for LSS implementation, emergent themes, and identified research gaps. This paper aimed not just to enumerate these CSFs, but also to critically analyse the knowledge in the domain, thereby enriching the understanding of LSS CSFs research. That is valuable information for those who will engage in LSS implementation. Other researchers can benefit from the results by setting up new investigations to close the identified gaps.

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## Biographies

**Guilherme Bolzan Cieto** holds a Bachelor's degree in Industrial Engineering from the Federal University of São Carlos and is currently a MSc candidate in Industrial Engineering at the University of São Paulo. He also works as a consultant in Production Planning and Control. His research interests include Continuous Improvement, Production Planning and Control, Change Management and Circular Economy.

**Dr. Roberto Antonio Martins** holds Bachelor's, MSc and PhD degrees in Industrial Engineering from the University of São Paulo and is currently a Full Professor at the Department of Industrial Engineering at the Federal University of São Carlos. His research interests include Performance Measurement Systems for Sustainable Supply Chain Management and the use of Big Data Analytics in Operations Management.