

Examining Lean Management Principles in SMEs Through Empirical Data Analysis and Systematic Review [†]

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Abstract

While Lean methodologies have been widely adopted in large enterprises, their application in small and medium enterprises remains an area requiring further exploration. This study aims at a hybrid approach combining a systematic literature review based on the PEO framework and PRISMA methodology with comprehensive data analysis from 780 respondents to examine the direct relation between Lean and SMEs. Various statistical methods were used to identify different patterns and themes. The findings suggest that while resource constraints pose significant challenges for SMEs in adopting Lean, tailored approaches with a significant reliance on leadership commitment can considerably enhance operational efficiency, resilience, costs, and waste reduction. Insights from the analysis further revealed a preference for operational methods with limited adoption of complex and strategic methods of Lean across SMEs. The paper concludes with practical recommendations for SMEs and lays a foundation for future directions in terms of integration with ESG and sustainability.

Keywords: small and medium enterprises; SMEs; Lean; Lean methods/tools; optimization; process improvement



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1. Introduction

The emergence of rapid globalization, evolving consumer expectations, and technological advancements is putting organizations under great pressure to improve their operational efficiency, adaptability, and resilience. Initially developed on the principles of the Toyota Production System—TPS—Lean has surfaced as a powerful methodology for optimization, improving workflows, waste reduction, and fostering a culture of continuous improvement [1]. While Lean methodologies are widely adopted in large manufacturing organizations, their implementation in SMEs offers a unique set of challenges and opportunities due to structural limitations, technological integration, and resource constraints [2,3].

SMEs—small and medium enterprises—are critical contributors in economic ecosystems in terms of innovation, industrial diversification, and employment opportunities. Despite this significance, their limited access to capital, formal training structures, and technological integration can often impede holistic Lean implementation [4]. Lean, on the other hand, is a value-centric methodology that aims to eliminate non-value-adding activities and improve overall process efficiency [5]. With the passage of time, it has expanded into sectors such as construction, healthcare, mobility, and services from manufacturing, depicting its significance in improving workflows, processes, customer satisfaction, and

sustainability [6]. The supply chain is another critical domain that accumulates resources, information, and coordination of the flow of goods from origin to end consumers [7].

This integration, which has not been explored significantly, can foster agility, operational efficiency, waste reduction, and improved management [8]. The success of this integration of Lean and supply chains in SMEs requires us to address the challenges that can affect transportation coordination, supplier collaboration, and variable situations.

This study aims to examine Lean principles in SMEs and further explores their effect on supply chains in achieving waste reduction, process optimization, enhanced efficiency, and identification of critical factors that can impact the positive integration of Lean. Study gaps have highlighted the need for context—specific Lean methodologies for SMEs that account for a number of factors such as resources, level of implementation, effective methods, and leadership involvement [9]. This research will focus on Lean tools that are commonly used by SMEs, the perception of benefits employees have, and the significance of leadership involvement. The following research questions are formulated to structure the basis of the study:

RQ1. What type of Lean tools and practices are known and frequently used within SMEs?

RQ2. What are the perceived organizational benefits and risks of Lean implementation in SMEs?

RQ3. Is there a significant relationship between leadership involvement and Lean transformation?

2. Materials and Methods

This study employs a mixed-methods research design, combining both qualitative and quantitative approaches to investigate the role and effectiveness of Lean in small and medium enterprises. The design of the overall research is intentionally kept multi-dimensional, encompassing descriptive, evaluative, and exploratory elements in both specific and general reasoning. This integrative design facilitates a comprehensive understanding of current Lean practices and an assessment of their operational impact on SMEs and their supply chains.

For the SLR—systematic literature review—part, a mapping study was conducted here that systematically examines the body of the available literature that concerns Lean implementation with SMEs. The SLR is based on the PEO framework, which is a structured approach that is beneficial for formulating categories and keywords, particularly for systematic reviews and qualitative studies. It further facilitates the development of a search query that was used to search for the relevant literature in databases. The search query was then used in the search function of Scopus. After initiating the search, 2046 extracted articles were processed with the help of the PRISMA framework [10]. PRISMA—Preferred Reporting Items for Systematic Reviews and Meta-Analysis—is a methodology that provides a standardized approach for conducting and reporting systematic reviews while ensuring transparency and reproducibility. The finalized number of articles for review was 42 after the initial pool was scrutinized and went through PRISMA.

For survey analysis, data was collected via a comprehensive questionnaire, distributed digitally. It included a variety of Likert-scale questions; open-ended items; percent-based responses; and multiple selections of responses for variables like benefits, risks, challenges, Lean methods, etc. The shortlisted study sample consisted of 780 respondents closely affiliated with SMEs, holding roles such as subordinates, team leaders/middle managers, and senior managers. The respondents were primarily from SMEs operating in Hungary,

representing diverse sectors, including services and manufacturing, reflecting the sectoral diversity of our study for Lean adoption within the SME landscape.

The survey was conducted using a non-probability purposive sampling approach that focused specifically on respondents who were actively involved in Lean activities within Hungarian SMEs. This method ensured that the collected data was relevant and aligned with the objectives of the study. It should be noted that while this approach does not aim to produce a fully statistically representative sample, it remains appropriate for this type of exploratory research. It is also important to note that the findings provide robust insight into patterns and relationships within the context of the target. As participation was voluntary, the dataset may be subject to self-selection bias, with potentially higher responses from firms already inclined toward Lean practices, directly or indirectly.

Data analysis was conducted primarily using Microsoft Excel with an integrated data analysis tool pack. Some selective statistical procedures were cross-checked and calculated on SPSS (version 30). This multilayered approach allowed for both nuanced interpretation and broad pattern recognition across variables.

3. Results

Based on our study, the following results and findings were identified from both SLR and survey analysis.

3.1. Findings from SLR—Systematic Literature Review

Several themes were explored in the SLR, such as frequently used Lean methods/tools, critical success factors, and the challenges and barriers of Lean implementation in SMEs. Lean tools such as 5S and JIT have played a critical role in the enhancement of process efficiency, overall service delivery, and customer satisfaction [11]. Conversely, tools like scheduling and value stream mapping have been instrumental in identifying issues and inefficiencies [12]. In general, the most used tools based on the themes of the SLR were VSM; 5S; Kaizen; Kanban; TPM; JIT; standardized work; and last but not least, root cause analysis. As far as the critical success factors are concerned, the SLR themes emphasized leadership commitment, continuous improvement, stakeholder engagement, employee training, and technology integration [2,3]. This set of factors is further endorsed by the Shingo model [13], which promotes a holistic approach involving cultural enablers, continuous improvement, and enterprise alignment. For challenges and barriers, factors such as limited resources, lack of skilled workforce, high demand variability, limited digital transformation, and economic constraints were highlighted the most [4,14,15].

3.2. Findings from the Survey Analysis

Our analysis indicates varying adoption levels of Lean methodologies, as mentioned in Figure 1, where 5S is the most frequently used within SMEs, emphasizing a strong focus on workplace organization. The idea collection and qualification matrix factors indicate skills management and active employee involvement. Advanced methods, such as Jidoka, Muda–Mura–Muri, or Hoshin–Kanri, are minimally applied.

Additionally, our study aimed to identify the perception of respondents of the benefits of Lean. The following main benefits, as mentioned in Table 1, were indicated by the respondents during survey analysis.

The results summarized in Table 2 indicate the percentage of respondents implying each type of risk. The most evident issues highlighted by 27.4% of the respondents were stress and conflict. This suggests that if Lean practices are poorly implemented or not supported by adequate changes in management culture, this can increase psychological strain and interpersonal challenges within the workforce. Fluctuation or emigration (13.57%) and

additional costs (13.09%) were also noticeable, suggesting that organizational instability and unforeseen financial obstacles can come from Lean transitions. A reasonable proportion of employees (12.68%) indicated that unpaid extra work and effort directed toward customers was an issue, indicating potential disparities in workload and compensation. Additionally, responses of unequal workload distribution (11.04%) and teamwork deterioration (4.70%) reflect a perception of potential disruption in fairness and collaboration, which are factors that are normally crucial to sustaining Lean in resource-constrained SME environments. A loss of trust in managers/owners (5.52%) promotes the risk of psychological safety if Lean practices and methodology are being imposed from top to bottom without any adequate engagement with the employees or sharing of values.

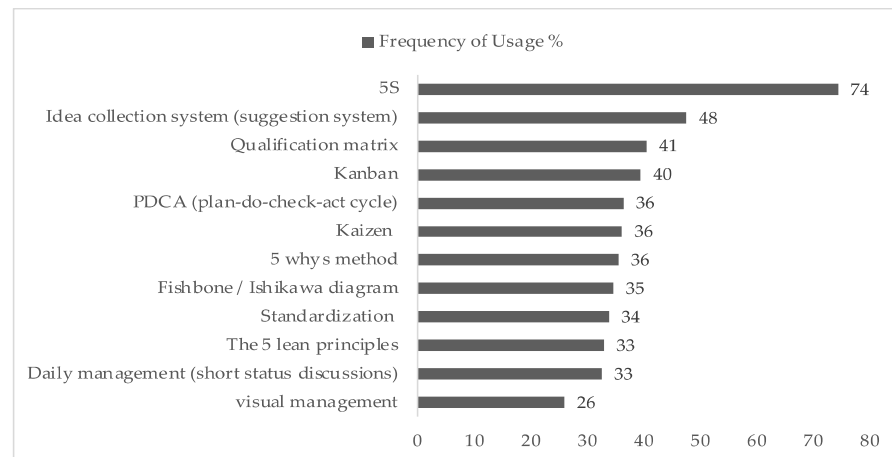


Figure 1. Frequently used Lean tools as per survey analysis.

Table 1. Perceived benefits of Lean principles.

Benefits	Score	Percentage %
I work with more transparent processes	611	23.4
I learn new things	371	14.2
My work becomes easier	299	11.4
Teamwork improves	251	9.6
I make fewer mistakes; the quality will be better	242	9.3
Distribution of work in the team becomes more even	192	7.3

Table 2. Perceived risks of Lean principles based on poor implementation.

Perceived Risks	Score	Percentage %
Stress and internal conflict	402	27.4
Fluctuation (emigration)	199	13.6
Additional costs	192	13.1
Unpaid efforts/extra work toward customers	186	12.7
Unequal workload	162	11.0
Overtime	100	6.8
Loss of trust (toward managers/owner)	81	5.5
Team spirit/teamwork deterioration	69	4.7
Loss of job	44	3.0
Wage decline/wage tension	32	2.2

A few respondents tagged job loss (3.00%) and wage tension (2.18%) as additional risks. This can reveal underlying fears about the methodology when it is employed as a

cost-cutting tool rather than a value-creating strategy, leading to reduced job security and dissatisfaction with compensation.

Furthermore, a multiple regression analysis was conducted to analyze the factors influencing the perceived positive results of Lean application. “Application of Lean brings positive results” was kept as the dependent variable, whereas independent variables included the following: practical application is only important in selective areas, commitment of top management with Lean, and commitment of middle management with Lean. The R-squared value was 0.182, and the adjusted R-squared value was 0.179. The value of the F statistic was 55.65, and the *p*-value was less than 0.001; these elements collectively indicate that the model was fit and statistically significant.

As seen in Table 3, the regression model indicates that leadership commitment is a significant key driver of successful Lean implementation. In particular, stronger commitment from both top management and middle management, with coefficients of 0.254 and 0.157, respectively, was significantly associated with more positive outcomes ($p < 0.001$). Conversely, respondents who believed Lean is only applicable to selective functional areas reported lower perceived success with a coefficient of -0.104 . The model highlights approx. 18.2% of variance, supporting the idea that both leadership alignment and broad application are essential for Lean effectiveness.

Table 3. Regression analysis values.

Variable	Coefficient	Standard Error	T-Stat	<i>p</i> -Value	Effect Direction
Intercept	3.026	0.141	21.39	1.22×10^{-79}	
Practical application is only important in selective areas	-0.104	0.026	-4.04	5.83×10^{-5}	Significant –ve
Commitment of top management to Lean	0.254	0.039	6.47	1.75×10^{-10}	Significant +ve
Commitment of middle management to Lean	0.157	0.042	3.71	0.0002	Significant +ve

Moreover, an analysis of the effective communication channels for Lean was also performed, which indicated that education and training are the most effective methods, with the highest average score at 3.6. Regular, planned, and scheduled meetings followed closely with a score of 3.4. Further channels included in the list, in order of significance, were informal conversations, emails, bulletin boards, company website/intranet/SharePoint, and newsletters, which had the lowest scores.

4. Discussion

This study extends existing Lean management research by offering empirical evidence that was drawn specifically from Hungarian SMEs, which is a segment that remains underrepresented in global Lean knowledge. By integrating a systematic literature review with a comprehensive survey, the outcome of our study moves beyond purely theoretical discourse to highlight how Lean adoption operates in practice within resource-limited contexts. The methodological combination used in this study demonstrates how global Lean frameworks must be locally adapted to reflect operational effectiveness in terms of theory and practice.

It can be noted that the findings confirm a significant skew in the adoption of Lean methods. The most frequently applied tools, such as 5S, Idea collection, suggestion systems, etc., are operational and relatively convenient to apply. These tools require less organizational restructuring and are often introduced as stand-alone practices rather than a holistic transformation. More strategic tools were used by fewer than 10% of respondents, which

is consistent with the findings of the SLR showing that SMEs are not involved much in methods requiring cross-functional alignment [16,17].

The data revealed several high-impact perceived benefits of Lean adoption. The respondents highlighted increased process transparency, skill development, simplified work tasks, and enhanced teamwork as key outcomes. This emphasized the point that Lean can potentially improve efficiency and employee morale in resource-constrained settings and in the initial phases [11,18].

A major contribution of this study is the regression analysis, which demonstrates the strong impact of leadership commitment on perceived Lean success. This showed that top management commitment had the highest influence, followed by middle management. However, the belief that Lean should be applied in selective functional areas was negatively associated with successful outcomes. These results also align with prior research identified in the SLR, suggesting that leadership is a key enabler in successful Lean transformations. Organizations that assimilate Lean in leadership behavior and strategies are more likely to succeed and sustain improvements over time [19]. Similarly, it was also argued in a study that Lean failures often stem from a lack of alignment between executive direction and operational goals [20]. As an additional focus, the findings have implications for supply chain resilience and adaptability. Lean practices like standardization reduce variability, and clear process flows strengthen supply chain performance by improving internal reliability and opportunities to mitigate dynamic situations.

Although this research is centered on SMEs within Hungary, the insights hold broader relevance for similar economies where resource limitations and dynamic market demands pose significant barriers to Lean implementation. Future adaptation of these findings encourages sector-specific training, funded or non-funded SME capacity-building programs, and leadership development. This emphasizes the value of policy interventions that emphasize cultural alignment, practical tool adoption, and leadership engagement in sustaining Lean improvements at the SME level.

5. Conclusions

This study set out to examine how Lean principles are adopted and perceived within SMEs. By combining a systematic literature review with an empirical analysis of 780 SME responses, this research bridges practice and theory and offers evidence-based insights. The findings revealed that tools that are convenient to implement and do not require many resources are more frequently used within SMEs, such as 5S, Kaizen, PDCA, visualization, etc. Conversely, leadership commitment, especially from top and middle management, is a significant factor for the perceived success of Lean principles in SMEs. The respondents also reported improved teamwork, process transparency, removal of bottlenecks, and efficiency as key benefits. By enhancing operational efficiency, minimizing waste, and fostering social value through improved employee engagement and holistic alignment, Lean can support sustainability goals.

The limitations of this study included a regional focus only on Hungarian SMEs and reliance on a single database for the systematic literature review. In the future, we will aim to extend this research across additional countries and databases for more rigorous reviews and analysis.

In a nutshell, this paper advances the understanding of Lean management in SMEs by bridging research insights and robust empirical data on tool usage, perceived risk and benefits, and the pivotal role of leadership commitment. This can additionally underscore the persistent gap in Lean knowledge and its practical application in small firms. Building on this approach, future studies should expand the regional scope, examine ESG linkages, and integrate financial performance indicators in greater depth.

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