

Adoption of Lean Management Principles in Small, Medium-Sized and Large Manufacturing Enterprises

DOI: 10.12776/qip.v29i3.2198

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Received: 11-6-2025 Accepted: 23-06-2025 Published: 30-11-2025

ABSTRACT

Purpose: The paper aims to determine the adoption of lean management principles in the manufacturing industry, focusing on SMEs and analysing whether there are differences between enterprises according to their size.

Methodology/Approach: The research was carried out using a questionnaire survey using objective sampling among managers of 433 manufacturing enterprises in the Czech Republic. Respondents rated the application of 26 lean management principles on a qualitative scale.

Findings: The results show that the principles most commonly applied are respect for employees, customer orientation, personal responsibility, and safety procedures. Adopting lean principles is significant, depending on the size of the enterprise. Large enterprises have an advantage in systematically applying complex principles, such as standardisation and visualisation. Medium and small enterprises focus more on universal principles such as respect for employees’

Research Limitation/Implication: These results point to the need for a differentiated approach in implementing lean principles depending on the size of the enterprise. For lean management in SMEs, it is necessary to overcome their barriers and deal with challenges, from financial constraints to cultural resistance.

Originality/Value of paper: The paper highlights the structural barriers of small and medium-sized enterprises in implementing complex lean principles. It contributes to the ongoing debate on why lean implementation in SMEs differs and why more demanding systems or advanced automation often fail.

Category: Research paper

Keywords: lean; management; lean principles; SMEs; quality management

Research Areas: Quality by Innovation; Quality Management

1 INTRODUCTION

Submission While lean management first became established in large enterprises, its principles have evolved to be relevant to organisations of all sizes, including SMEs (Womack, Jones and Roos, 1990). Initially, the adoption of lean in smaller enterprises was slow, and research focused mainly on large enterprises and SMEs was often neglected. SMEs have been found to face different challenges compared to large enterprises: they have limited resources and finances, face organisational resistance to change caused by the need for greater formalisation, deal with structural and operational problems with human resources and productivity, are affected by external factors related to the supply chain, strategic and implementation errors, and are more burdened by regional and contextual nuances.

The differences implied that the principles and methods of lean production had to be adapted to the conditions of SMEs. Over the last two decades, there has been a growing realisation of the basic ideas of lean manufacturing. Such as empowering employees while eliminating waste and emphasising quality management, can be adapted to smaller operations. Researchers began to address this gap around the mid-2000s (Achanga et al., 2006) by identifying how lean could succeed in small and medium-sized enterprises (Houti, Abbadi and Abouabdellah, 2019). Therefore, lean management is increasingly recognised as a key improvement approach to improving process and product quality for all organisations, not just large enterprises.

In some cases, the lean manufacturing toolkit has been simplified for SMEs (focusing on techniques such as 5S, visual management and process mapping that are feasible on a small scale). Recent literature has even produced SME-specific guidelines. For example, Hu et al. (2015) provide a ‘guideline roadmap’ for implementing lean manufacturing in small enterprises, highlighting factors such as employee empowerment and support strategies for small enterprises to implement by incrementally improving lean manufacturing. In this context, it is crucial to consider that introducing lean manufacturing implies a systematic approach to various principles and practices, including a clear focus on continuous quality improvement. In contrast, principles are elements of the strategic level and represent the ideals and laws of the system (Womack and Jones, 1996). According to Covey (2000), core principles serve as a compass, providing constancy of purpose and aligning organisational goals and actions, including a long-term focus on high quality and innovation.

Therefore, the key to successful implementation of lean is adopting lean principles, which form the basis for lean management methods that support the achievement of quality through innovation and contribute to continuous quality improvement at all levels of the organisation. Without a clear grasp of Lean principles, focusing on Lean tools is like sailing a ship without a rudder (Bell and Orzen, 2011). Lean principles form the basis of corporate culture and relate to various areas of management. Principles are timeless, whereas tools evolve as new changes (Bell and Orzen, 2011). Spear (1999) codified “the DNA of TPS” in terms of rules or

principles that guide the design, operation, and improvement of activities and processes in Toyota, with a strong focus on quality and precision in manufacturing operations. A common pitfall is treating lean as a set of tools rather than a holistic approach, which can lead to short-term gains but not sustainable improvements (Dias de Freitas, 2023) in quality performance.

In short, lean principles have evolved from the manufacturing practices of large enterprises into a broad management strategy that SMEs can adopt by adjusting the scope and scale of the tools to fit their capabilities and contributing to a culture of quality and innovation. The paper examines the adoption of lean management principles in manufacturing enterprises, focusing on SMEs. The research addressed the critical question of which principles are fundamental in lean management and adopted by enterprises regardless of their size. Furthermore, we analyse the specifics in small and medium enterprises.

2 LITERATURE REVIEW

The literature stream considers Lean management a philosophy that follows principles to eliminate all sources of waste (or muda) from the production processes (Womack and Jones, 1996). Lean principles, originating from the Toyota Production System (TPS), focus on maximising customer value while minimising waste. The core idea is to improve efficiency by streamlining processes and eliminating activities that do not add value (Hozak and Olsen, 2015). Lean manufacturing principles are basic assumptions from Japanese management practices that seek to optimise customer value by eliminating waste and streamlining processes (Mahadevan and Chejarla, 2023). These principles are deeply rooted in the delivery of optimal value through the efficient use of resources and minimising waste (Helmold, 2020). Lean manufacturing principles transcend departmental boundaries and can be applied to all organisations and structures. These principles are not just theoretical concepts, but carry the intent of the theory they represent, act as a bridge between theory and practice, and facilitate explanations (Skaar et al., 2020) of why methods work or do not. Many firms have widely accepted principles of lean thinking and have been applied successfully across many disciplines (Poppendieck, 2002).

The most important lean principles were created by its founder, Sakichi Toyoda. These five principles focus on (Toyota, 2024): fidelity to duty and enterprise development, diligence and creativity, practicality and avoiding frivolity, building a homelike, friendly atmosphere in the workplace, respect for spiritual matters, and gratitude. Bosch has designed its reference model for lean manufacturing, the so-called Bosch Production System (BPS), which is currently in use in some 250 plants worldwide. This system is based on Toyota's original TPS production system, which emphasises safety and environmental protection (Gnoni et al., 2013) and the QCD concept (quality, cost, delivery). The principles of BPS indicate the direction and goals of the system and include process orientation, pull principle,

avoiding errors, flexibility, standardisation, transparency, continuous improvement process (Kaizen), and personal accountability.

Table 1 – Lean principles literature sources

Lean principles	Authors
Waste elimination principle (Muda)	Ohno (1988), Shingo (2019), Rother and Shook (1999), Imai (1986)
The principle of flexibility	Gnomi et al. (2013)
Principle of continuous flow	Ohno (1988), Womack and Jones (1990), Liker (2004)
Standardisation principle	Taylor (2020), Liker (2004), Gnomi et al. (2013), Imai (1986)
Visualisation principle	Gnomi et al. (2013), Liker (2004), Ohno (1988), Imai (1986)
Pull principle	Womack and Jones (1990), Liker (2004), Gnomi et al. (2013)
Principle of transparency	Gnomi et al. (2013), Imai (1986)
Process focus principle	Hammer and Champy (2006), Gnomi et al. (2013), Imai (1986)
Principle of continuous improvement	Imai (1986), Liker (2004), Gnomi et al. (2013), Imai (1986)
The principle of training through mentoring	Imai (1986)
Coaching principle	Liker (2004), Soltero and Boutier (2012), Rother (2009)
Problem-solving principle	Liker (2004)
The principle of supporting teamwork	Liker (2004)
The principle of safety guidelines	Ohno (1988)
Learning organisation principle	Senge (1990), Liker (2004)
The principle of personal responsibility	Gnomi et al. (2013)
The principle of striving for excellence	Peters and Waterman (2006), Womack and Jones (1990)
The principle of employee engagement	Ohno (1988), Imai (1986)
The principle of supplier feedback	Liker (2004)
Separation of people and machines	Liker (2004)
The principle of respect for employees	Liker (2004), Krafcik (1988)
The principle of long-term focus	Liker (2004)
The principle of focusing on causes	Ohno (1988)
Added-value principle	Womack and Jones (1990), Rother (2009)
The principle of customer involvement	Womack and Jones (2003), Imai (1986)
The principle of workload-balancing	Ohno (1988)

Source: Author's literature review

Womack and Jones (1990) defined five principles of lean manufacturing: specifying value, working for excellence, mapping the flow of value, creating a

continuous flow, and establishing a pull system. Similarly, Wilson (2010) presents the principles of lean manufacturing, including the customer perspective, waste reduction, product value, pull system, elimination of non-value activities, right processes right the first time, perfect quality, just-in-time delivery, streamlining inventory, synchronising processes, and harnessing people's creativity. Similarly, Liker (2004) mentions 14 principles (tenets) of lean manufacturing in his book: long-term philosophy, continuous process flow, pull system, load balancing, quality first time, standardisation of tasks, visual inspection, proven technologies, leaders, teamwork, consideration for stakeholders, gemba walking, judicious decision making, quick implementation, and learning organisation. Ohno (1988) considers the main principles of lean management to be the elimination of waste (Muda), continuous improvement, employee involvement and respect for people, autonomous quality control, just-in-time principle, process visualisation and transparency, and Genchi Genbutsu (root cause research).

Process management (Hammer and Champy, 2006) can be seen as a key principle of Lean management. It consistently focuses the organisation on processes, eliminates waste, integrates activities and ensures smooth process flow. Soltero and Boutier (2012) list seven types of Kata philosophy, including the improvement kata, coaching kata (teaching to learn), job safety (duplex kata), problem solving, job instruction (learn to teach), job relations (teamwork kata) and job methods. From this perspective, coaching is a repetitive routine through which managers and leaders teach everyone else to follow the improvement kata. Both Senge (1990) and Liker (2004) affirm the importance of long-term and systematic development of employee capabilities leading to a learning organisation. Senge's (1990) learning organisation is an end, while Lean views it as a tool or principle to achieve long-term effectiveness. According to Peters and Waterman (2006), the principles of striving for excellence and lean management include continuous improvement, customer orientation, people involvement and development, and emphasis on quality and flexibility. It is important to note that SMEs increasingly view lean management as an efficiency improvement programme and a strategic approach to achieving excellence and ensuring long-term success (Dinis-Carvalho et al., 2023).

A study on meatball production in the manufacturing sector demonstrated how lean principles could streamline processes. By applying lean techniques, the enterprise reduced the average waiting time by 87.62% and increased total output by 19.15% (Matthew and Laurence, 2024). Shanbhag's (2024) study on lean project management revealed improvements in efficiency, collaboration, and customer satisfaction through reduced waste, continuous improvement, and enhanced team collaboration. Recent research has explored the integration of lean principles with Industry 4.0 technologies. The study emphasised the potential for increased coordination, speed and efficiency when these approaches are implemented holistically (Anbessia and Singh, 2024). Lean principles help enterprises optimise resource utilisation, streamline operations, and improve

customer satisfaction. It involves systematic waste identification and the application of lean tools for process optimisation (Sedelnikova, 2023).

Many studies focus on the challenges that small enterprises face when implementing Lean management principles. There are six main groups of these challenges in the literature. The first main problems are resource limitations and financial constraints. It includes limited access to capital (Soltani and Bhandari, 2023) because SMEs often operate with restricted budgets and lack expertise via external consultants. The lack of investment in lean tools is also a consequence of the scalability problem of lean frameworks, which are primarily designed for large enterprises. The second challenge concerns cultural and organisational resistance to change, especially among workers in enterprises. In the case of managers, this often involves issues with leadership and management commitment to follow a long-term vision (Jaiswal et al., 2021) or the existence of mentoring programmes that create management gaps. The third challenge is structural and operational barriers that manifest in employee departures, productivity declines (Minh and Kien, 2021), or misconceptions about lean applicability in management (Wensheng and Yturralde, 2024). The fourth challenge is explained by the supply chain, external issues of integrating suppliers and customers, and market volatility (Pingyu and Yu, 2010). The fifth challenge highlights strategic and implementation missteps. That means formal ad hoc adoption without roadmaps, strategies (Minh and Kien, 2021), or adequate performance measurement of successful implementation steps. Finally, there are regional challenges for SMEs and related contextual nuances, such as developing economic difficulties in Asia (Pingyu and Yu, 2010). Another example is the lack of collaborative networks (Wensheng and Yturralde, 2024).

Following related work, we established a working hypothesis about the adoption of lean management principles in small and medium-sized enterprises. There are significant differences in assessing the adoption of lean principles according to different sizes of enterprises.

3 METHODOLOGY

The purpose of the paper is to determine the adoption of lean management principles in the manufacturing industry and to analyse whether there are differences between enterprises according to their size. The paper focuses on identifying the most implemented lean principles, especially in small and medium-sized enterprises.

An online questionnaire survey focused on lean management occurred in 2021-2022 in the Czech Republic. The non-probability purposive sampling method was used for the selection of enterprises. Managers were asked about adopting 26 lean management principles in their manufacturing enterprises. Respondents in the questionnaires rated the questions on a scale from 1 (least significant) to 5 (most important). A total of 433 completed questionnaires for small, medium and large

enterprises. The enterprises that participated in the survey can be characterised by size into small enterprises with up to 49 workers ($n = 84$), medium-sized enterprises with 50-249 workers ($n = 155$) and large enterprises with more than 250 workers ($n = 98$).

The following statistical hypotheses were formulated from the working hypothesis within the investigation:

- H0: (null hypothesis): There is no significant difference in assessing the adoption of lean manufacturing principles by different sizes of enterprises.
- HA: (alternative hypothesis): There are significant differences in assessing the adoption of lean manufacturing principles by different sizes of enterprises.

Subsequently, these hypotheses were verified by statistical analysis in R software. Nonparametric Kruskal-Wallis tests were used to assess the effect of firm size on adopting lean manufacturing principles. It was due to the results of the Shapiro-Wilk tests, which did not show a normal distribution. For a deeper analysis of the significant differences given, pairwise comparisons between pairs of proportions with correction for multiple tests are calculated. In the results, p-values expressing a level of statistical significance are reported.

4 RESULTS AND DISCUSSION

In this section, the main results of the research are summarised in two parts: overall implementation of lean management principles and comparison of the adoption of these principles in enterprises according to size.

4.1 Overall Implementation of lean management principles

Figure 1 shows the results of the analysis of the implementation of each lean management principle in all manufacturing enterprises regardless of the size of the enterprise, using a Likert scale ranging from 1 (“principle not implemented at all”) to 5 (“principle fully implemented”). The principles are ranked in percentage from least to most implemented, which allows for a quick orientation on the extent of their use in practice. Significant differences in implementing each lean management principle can be seen in the first overview. Particularly significant differentiation can be observed for principles such as respect for employees, customer orientation, personal responsibility or safety procedures, where high values of positive responses are recorded.

The analysis results show that general principles such as respect for employees, customer orientation, safety standards, and personal responsibility are the most common in the manufacturing sector. These high values indicate the emphasis on aspects related to employee engagement, customer satisfaction, and the quality of the working environment. The customer orientation has the highest complete implementation rate (36.26%), which confirms the importance that enterprises

place on understanding and meeting customer expectations. Respect for employees is also significantly represented (33.95% full implementation), reflecting the efforts to strengthen employee participation in continuous improvement processes. Other frequently applied principles include safety standards (29.56% full implementation), which contribute to the protection of employees and the quality of the working environment, and personal responsibility (27.71% full implementation), which underlines the importance of individual employee contribution to the overall effectiveness of the enterprise. The principles of added value (36.26% full implementation) and visualisation (23.79% full implementation) also show a high application level

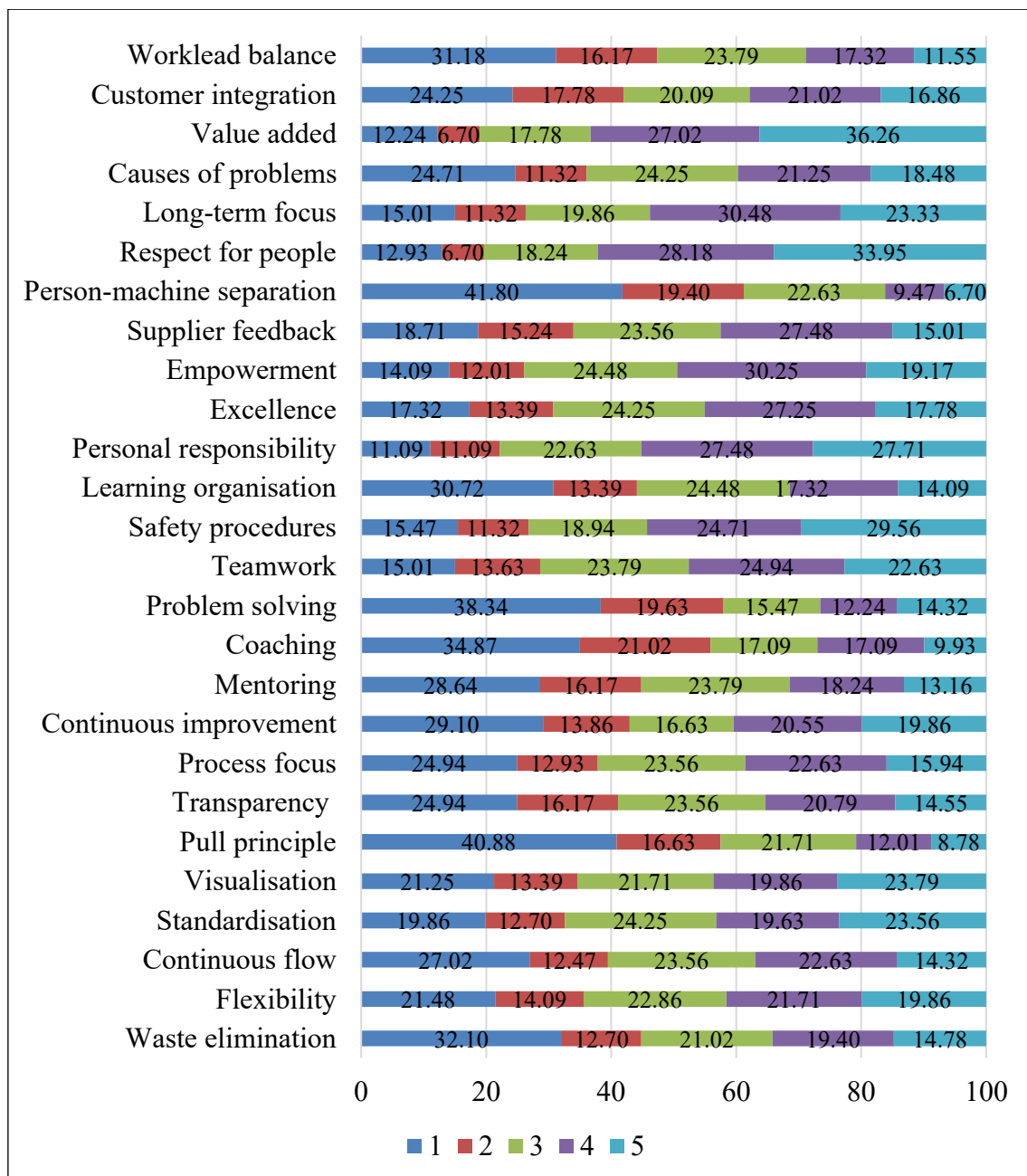


Figure 1 – The most adopted lean manufacturing principles ($n = 433$)
(Between 1 – principle not implemented at all to 5 – principle fully implemented)

In contrast, the least implemented principles are the separation of man from machine, the principle of pull and problem solving, coaching, or waste reduction (Muda concept). These areas show significant reserves in the application of lean management. The principle of separating people from machines is not implemented in 41.80% of enterprises, which may lead to a reduction in production efficiency and a decrease in automation. Similarly, the pull principle, necessary to regulate production flow and reduce inventory, does not show implementation in 40.88% of enterprises. Moreover, the problem-solving principle, crucial for detecting and eliminating the causes of inefficiencies, is poorly implemented in 38.34% of the entities. Other principles, such as coaching (34.87%), waste elimination (32.10%), workload balancing (31.18%) and learning organisation (30.72%), also show low implementation rates. This low implementation indicates the lack of strategic orientation of enterprises to develop internal flexibility and adaptability.

Summarising the results of the analysis, it is evident that manufacturing enterprises have significant reserves to systematically implement some critical lean management principles. The study shows that although most enterprises are focused on employees and customers, insufficient attention is paid to systemic and strategic principles that could increase long-term operational efficiency and flexibility. There is room for improvement, particularly in automation, systematic problem solving, and the introduction of continuous improvement and learning principles, which can significantly positively affect the overall performance and sustainability

4.2 The impact of enterprise size on lean management

Figure 2 contains a radar chart showing the degree of implementation of selected lean management principles in enterprises according to the size of the enterprise. Each axis shows one lean principle, while the distance from the centre shows the relative level of implementation of that principle within each group of enterprises. Figure 2 clearly illustrates that the most significant area (i.e., the highest level of implementation) is seen in large enterprises, while medium and small enterprises show noticeably lower values.

Large enterprises dominate significantly in the areas of standardisation (around 50%), continuous flow of production (above 40%), visualisation (around 40%) and process focus (around 35%). These results indicate the ability of large enterprises to apply more complex and resource-intensive principles systematically. These enterprises also show high value for the principles of continuous improvement and long-term focus, indicating their systematic and strategic approach to lean management.

Medium-sized enterprises have implementation values between large and small enterprises for most of the observed principles. In some areas, such as teamwork, safety standards, and personal responsibility, they perform relatively well, although their level of implementation is usually below the 20% threshold. This

level shows that medium-sized enterprises can partially integrate more complex lean principles with more limited capacity than large enterprises.



Figure 2 – The most adopted lean manufacturing principles by enterprise size (ChatGPT by OpenAI was utilised to create this visualisation)

Small enterprises show the lowest overall level of implementation of most lean principles. Their main strengths are flexibility (almost 30%) and personal responsibility (around 20%). It corresponds to their need to adapt quickly to market changes and emphasise individual employee initiative in dealing with operational situations.

The results of the Kruskal-Wallis tests (Table 2) show statistically significant differences between firms for most of the principles studied. This means that the size of the enterprise significantly affected the adoption of lean manufacturing principles. The degree of this significance is captured by the p-values, which are very low and therefore, in most cases, the differences are significant even at $\alpha =$

0.001 (***)). The results were not crucial for personal responsibility, respect for people, and customer integration.

Table 2 – Evaluation of lean management principles according to enterprise size

Principle	H	p-value	Significance
Waste elimination principle (Muda)	34.613	0.000	***
The principle of flexibility	11.297	0.004	**
Principle of continuous flow	37.317	0.000	***
Standardisation principle	65.202	0.000	***
Visualisation principle	23.349	0.000	***
Pull principle	47.810	0.000	***
Principle of transparency	22.872	0.000	***
Process focus principle	50.823	0.000	***
Principle of continuous improvement	36.397	0.000	***
The principle of training through mentoring	28.806	0.000	***
Coaching principle	22.544	0.000	***
Problem-solving principle	46.595	0.000	***
The principle of supporting teamwork	12.312	0.002	**
The principle of safety guidelines	32.497	0.000	***
Learning organisation principle	29.151	0.000	***
The principle of personal responsibility	2.447	0.294	
The principle of striving for excellence	7.527	0.023	*
The principle of employee engagement	7.811	0.020	*
The principle of supplier feedback	9.657	0.008	**
The principle of separation of people and machines	33.406	0.000	***
The principle of respect for employees	4.645	0.098	
The principle of long-term focus	23.466	0.000	***
The principle of focusing on causes	19.014	0.000	***
Added-value principle	8.821	0.012	**
The principle of customer involvement	5.508	0.064	
The principle of workload-balancing	24.413	0.000	***

Source: Author's calculation

Note: significant differences in Column “Significance”

Thus, if we were to analyse the principles for which the Kruskal-Wallis test found a difference between size categories using post hoc tests. The principles of smooth flow, standardisation, traction, process focus, and separation of machines and people show the most significant differences in terms of size. For these principles, the sizes of the enterprises differ between the categories studied. The results of the post hoc tests also showed that the differences between small and large enterprises

are more pronounced in the degree of adoption of lean principles. This may be due to the higher level of lean implementation in large enterprises.

The summary of the results of the comparison of the adoption rate of lean management principles in enterprises by size shows that the size significantly impacts the extent of implementation of the principles. Large enterprises use their higher capacities for a more in-depth and systematic implementation. On the contrary, smaller enterprises are forced to focus more on flexible and straightforward principles due to limited resources. This fact suggests the need for a differentiated approach to supporting the implementation of lean principles, depending on the size and capabilities of individual enterprises.

5 CONCLUSION

The principles of lean manufacturing represent the basic philosophies and guiding principles of lean thinking. Therefore, they provide an overall strategic direction and a framework for implementing lean management through tactical tools and methods applied under specific conditions. The principles are generally enduring and offer a stable foundation for various lean management initiatives. Organisations can achieve higher quality only with a comprehensive approach that includes philosophy and practical tools. However, the degree of implementation of these lean principles is not the same in all enterprises. This paper aims to investigate the adoption of lean management principles in the manufacturing industry and reveal the differences between enterprises according to their size.

In summary of the results, we can identify areas of strength and reserves in implementing lean management in industrial enterprises. The principles most commonly applied in the manufacturing sector are respect for employees, customer orientation, personal responsibility, and safety practices. All of these elements have a direct connection to the quality of the processes and the products. On the other hand, key principles such as the pull principle, separation of people from machines, problem solving, and waste reduction are less frequently adopted. Thus, systemic approaches to lean management require more attention, especially if they lead to a comprehensive quality improvement. Enterprises should strategically reinforce these less-implemented principles to achieve more comprehensive productivity, efficiency results, and quality performance. Emphasis should also be placed on actively eliminating waste and promoting automation, contributing to the overall competitiveness, sustainability, and innovation quality of production processes.

We conclude that the size is a key factor influencing the scope and depth of the lean implementation. It has been shown that the influence of this factor on the adoption of lean principles is significant in almost all the principles studied. In particular, the analysis found the most considerable differences between small and large enterprises. Large enterprises have an advantage in the systematic and long-term application of complex lean manufacturing principles, focusing on

standardisation and visualisation and building robust quality management systems. On the other hand, medium and small enterprises focus more on universal principles such as respect for employee responsibility. These have a direct impact on the quality culture. Although more flexible and able to respond quickly to change, small enterprises often lack the capacity and resources to develop complex lean principles systematically. Medium-sized enterprises fall between these two extremes and show a slight advantage in teamwork, safety, and essential elements of quality management over smaller enterprises.

The findings highlight the need for a differentiated approach in implementing lean principles depending on the size of the enterprise. Consulting enterprises or internal transformation projects should customise their tools and choose different priorities and principles. For lean management in SMEs, it is necessary to overcome their barriers and deal with challenges, from financial constraints to cultural resistance. Addressing these requires customised strategies based on phased implementation (adopt low-cost tools first), leadership development (train managers to lean and change management), employee-centric approaches (training and mentoring programmes to reduce resistance), and leveraging digital tools (using IoT or cloud-based platforms) and aspects of quality management.

Future work should consider structural, financial, and cultural conditions and strive to evaluate the effectiveness of lean management principles implementation. It will be helpful to create a guide that can help SMEs implement the main lean principles, start the continuous quality improvement process, and implement innovative approaches and methods. Lean management SMEs offer a practical, flexible, and cost-effective framework for improving processes, productivity, quality, and overall competitiveness. The key to successful implementation is to adequately adapt lean principles to the enterprise's size, resources, and environmental context.

ACKNOWLEDGEMENTS

This research was supported by the conceptual development of the research organisation (RVO) of the University of West Bohemia in Pilsen.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest. The funders had no role in the design of the study, in the collection, analysis, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

DISCLOSURE OF ARTIFICIAL INTELLIGENCE ASSISTANCE

The authors acknowledge the use of artificial intelligence tools in the preparation of this manuscript. Specifically, DeepL and Grammarly were utilised to support language translation and language correction. ChatGPT by OpenAI was utilised to create a visualisation of Figure 2. All AI-assisted content was carefully reviewed, edited, and validated by the authors to ensure scholarly integrity, originality, and compliance with ethical standards. The authors affirm full responsibility for the content of the manuscript, including any material generated or supported by artificial intelligence.



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