LEAN IMPLEMENTATION IN MANUFACTURING

Bridging the Gap Between Process Optimisation and Human Capital

Angelo Rosa
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Lean Implementation in Manufacturing

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INVESTOR IN PEOPLE

To all practitioners and scholars committed to continuous improvement.

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Contents

List of Abbreviations or Acronyms *ix*

About the Authors *xi*

Acknowledgements *xiii*

Introduction *1*

Chapter 1 Literature Review and Emerging Gaps *7*

Chapter 2 Research Design and Methodology *43*

Chapter 3 Strategies for Overcoming Barriers *95*

Conclusions *125*

Index *133*

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List of Abbreviations or Acronyms

FCM	Fuzzy Cognitive Map
HRM	Human Resource Management
JIT	Just-In-Time
KPI	Key Performance Indicator
PDCA	Plan–Do–Check–Act
ROE	Return on Equity
TPM	Total Productive Maintenance
TQM	Total Quality Management

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Introduction

In the current era of rapid technological advancement, organisations are required to operate in increasingly global and competitive markets. However, competition today is not limited to market share alone; it also requires a strong focus on attracting and retaining talent and acquiring strategic production resources (Bartlett & Ghoshal, 2002; Green, 2019; Patel & Abidi, 2023). Consequently, organisations must not only provide customer value, that is, products and services that customers are willing to pay for, but also build organisations capable of engaging qualified employees and establishing long-term relationships along the supply chain.

This dual challenge has progressively shifted the locus of competition from purely operational efficiency to the capacity of organisations to design coherent socio-organisational systems that align technological infrastructures, human capabilities and strategic objectives over time (Yunusa, 2025). In this context, organisational models are no longer evaluated solely on their short-term performance outcomes but on their ability to sustain adaptability, learning and employee commitment in turbulent environments (Douglas & Haley, 2024).

It is well known that achieving a sustainable competitive advantage in these conditions requires a solid organisational model, and one of the most effective frameworks seems to be Lean Production (Stone, 2012).

Lean Production offers a systematic approach to identifying and eliminating waste, continuously improving value streams and focusing on customer needs (Mrugalska & Wyrwicka, 2017). Its implementation fosters virtuous cycles that enhance product quality, employee engagement and the organisational climate. Beyond its operational logic, Lean has increasingly been interpreted as a comprehensive managerial philosophy capable of reshaping organisational routines, decision-making processes and coordination patterns across hierarchical levels. This broader interpretation positions Lean not merely as an efficiency-oriented system but as an enabling architecture for organisational learning and continuous adaptation (Teich & Faddoul, 2013).

Lean Production, therefore, cannot be considered merely a set of tools but rather a long-term path based on commitment, patience and continuous improvement (Kaizen) (Okpala et al., 2024), supported by excellent processes and the active involvement of all employees.

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It is, in fact, essential to emphasise that Lean principles necessarily also embrace the human dimension. Communication, teamwork and distributed leadership are critical elements in a successful Lean organisation (Colazo, 2021). Lean practices cannot work without employee empowerment and promotion of participatory decision-making (Roslin et al., 2019).

From this perspective, Lean represents a paradigmatic shift away from mechanistic and control-oriented models of work organisation towards a socio-technical configuration in which cognitive, relational and behavioural dimensions are actively mobilised (Komkowski et al., 2025).

The Lean philosophy, in fact, overcomes Taylorist assumptions that separate thinking from acting, promoting worker involvement through quality circles, problem-solving groups and continuous training initiatives (Pfeiffer, 2016). Such practices are not merely supportive mechanisms but constitute the core through which Lean organisations transform individual knowledge into collective capability.

This approach seeks to combat the so-called eighth waste, that is, the underutilisation of human potential (Bryant et al., 2021), which has always been a central challenge for modern manufacturing.

Despite the growing body of research on Lean Production and quality improvement methodologies in organisations, much of the existing literature appears to have focused primarily on its technical and operational aspects (Bellisario & Pavlov, 2018), such as process optimisation, waste reduction and performance measurement, underestimating the socio-organisational dynamics that sustain Lean transformation over time. Studies often treat the 'human side' of Lean as a secondary outcome rather than a strategic enabler of success (Hines & Magnani, 2024).

As a result, Lean implementation is frequently conceptualised as a linear process, in which predefined practices are expected to produce predictable outcomes (Bevilacqua et al., 2017), neglecting the recursive and adaptive nature of organisational change.

Consequently, empirical understanding of how factors related to less objective and operationalised variables, such as human resource commitment or organisational culture, interact and evolve during the implementation process remains limited. Furthermore, most empirical approaches rely on static, survey-based methods that fail to capture the feedback mechanisms and interdependencies that characterise Lean systems.

This methodological limitation is particularly problematic in the study of Lean, as its effectiveness depends on the dynamic interplay between technical interventions and human responses that unfolds over time.

Therefore, starting from this point of view, this study is developed as an investigation into the organisational and human resources dimensions useful for Lean implementation. The originality of this work lies in its explicit attempt to conceptualise Lean implementation as a dynamic socio-technical system, rather than as a collection of isolated best practices (Li & Erorita, 2025). To explore this, a mixed methodology based on expert interviews was adopted, combining the Delphi method with Fuzzy Cognitive Mapping (FCM). The Delphi

technique (Linstone & Turoff, 1975) enables consensus building among experts in contexts characterised by uncertainty and complexity. Its use in this study allows the identification of shared interpretive frameworks among practitioners and scholars directly involved in Lean initiatives.

FCM, on the other hand, is a modelling technique that merges fuzzy logic with neural network principles (Dickerson & Kosko, 1994), allowing researchers to capture causal relationships and feedback loops between interdependent factors. By enabling the simulation of alternative implementation scenarios, FCM allows observation of how organisational and human factors co-evolve, generating nonlinear effects that cannot be detected through conventional empirical designs (Weiser et al., 2020).

The integration of these two methods, therefore, can offer a dynamic and systemic representation of Lean implementation, overcoming the limitations of static analytical approaches.

Through an extensive literature review, the study identifies a series of key success factors and organisational barriers to Lean implementation, subject to the experts and subsequently to the causal mapping. The analysis revealed four dominant factors: knowledge of Lean tools, in-depth training, communication and information sharing, and management commitment.

Rather than treating these factors as independent drivers, the study demonstrates how their effectiveness depends on their mutual reinforcement and temporal alignment. In particular, the latter plays a crucial role in countering organisational culture, often the most persistent obstacle to Lean adoption. Finally, dynamic simulations based on the FCM model demonstrated how different practices evolve over time and how, after an initial investment phase, Lean implementation tends to generate efficiency gains under resource-isometric conditions. This finding challenges the assumption that Lean necessarily requires continuous resource accumulation, highlighting instead its potential to reconfigure existing organisational assets more effectively (Ivanov, 2022).

These findings contribute to the understanding of Lean transformation as a sociotechnical process driven by human involvement and managerial alignment (Liu et al., 2025).

The remainder of this volume is structured into three main parts. The first chapter presents the theoretical foundations of Lean implementation, tracing its evolution, principles and the role of human resources in enabling organisational transformation. The second chapter outlines the methodological approach and reports the findings generated through the Delphi study and the FCM analysis. Finally, the third chapter discusses strategic implications and provides practical recommendations for overcoming organisational barriers, fostering a Lean culture and supporting sustainable transformation.

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Chapter 1

Literature Review and Emerging Gaps

Abstract

This chapter reviews the evolution of Lean Production from its origins in the Toyota Production System (TPS) to its contemporary interpretation as a socio-technical philosophy that integrates processes, people and organisational learning. After outlining the foundational principles of Lean, such as value creation, waste reduction, flow, pull and continuous improvement, this chapter highlights the central importance of human and cultural dimensions in sustaining Lean transformation. Moreover, Lean is presented not merely as a set of operational tools but as an organisational mindset grounded in respect for people, shared responsibility and long-term improvement.

The literature on Lean implementation is examined across three interconnected domains: the technical domain, which includes tools, standardised practices and process stability; the organisational domain, focused on human resource management, empowerment, training, communication and managerial commitment; and the socio-cultural domain, which concerns trust, norms, leadership behaviours and the development of a supportive Lean culture. For each domain, this chapter identifies key success factors and common barriers that hinder adoption. These include the misuse of Lean tools, capability gaps, resistance to change, cultural misalignment and fragmented communication. The chapter concludes by synthesising performance outcomes associated with successful Lean adoption, such as operational flexibility, quality improvements, lead time reduction, organisational well-being and financial gains, while highlighting persistent gaps and inconsistencies in the existing literature, particularly regarding the interaction and relative influence of different enabling factors and obstacles.

Keywords: Lean production; lean thinking; socio-technical systems; organisational culture; human resource; success factors

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1.1 Lean Methodologies and Their Evolution

According to Rodriguez et al. (2016), Lean Production is a system of organisational practices and management principles that aims to achieve operational excellence through the continuous reduction of waste and the increase of customer value. Originating in the Japanese manufacturing context, Lean Production has progressively evolved from a set of production techniques to a comprehensive organisational philosophy that promotes efficiency, flexibility and the involvement of people at all levels of the organisation (Nicholas, 2018). Such an evolution reflects the shift from a strictly technical framework to a broader sociotechnical approach (Liu et al., 2025).

The origins of Lean Thinking can be traced back to the Toyota Production System (TPS), developed by Taiichi Ohno and Shigeo Shingo in the post-war period as a response to Japan's resource constraints and the growing demand for high-quality products (Ohno, 2019). The TPS integrates two complementary principles: Just In Time (JIT) and jidoka. The former is a demand-driven production approach that ensures that materials are supplied exactly when needed, thereby minimising inventory costs. The latter refers to the principle of intelligent automation, in which machines and production processes are designed to detect abnormalities or defects and automatically stop, thereby emphasising the essential role of human intervention. When a stoppage occurs owing to an error, the operator investigates and resolves the issue, preventing its recurrence and fostering continuous improvement. Together, these principles establish the foundation for a production system capable of reducing inefficiencies while sustaining both quality and flexibility.

The term 'Lean Production' was later coined by Womack et al. (2007) in 'The Machine That Changed the World', which compared Japanese automotive practices to Western mass production. The authors emphasised that the competitive advantage of Japanese companies, such as Toyota, stemmed not only from technology but also from an organisational culture based on waste elimination, respect for people and continuous improvement (Kaizen). From this perspective, Lean Thinking represents the synthesis of technical and human factors aimed at achieving excellence through simplicity and learning (Bouranta et al., 2022).

Over time, the concept of waste (muda) has become central to Lean philosophy. Ohno (2019) identified seven canonical forms of waste, ranging from overproduction and waiting time to unnecessary transportation and defects, laying the foundations for an approach originally conceived to eliminate non-value-adding activities along the production flow. Over time, subsequent studies have shown that this taxonomy was only a starting point: the recognition of the 'underutilisation of human potential' as an eighth form of waste (Wickramasinghe et al., 2014) shifted the centre of gravity of Lean philosophy, highlighting that loss does not concern solely material resources or operational inefficiencies but also the failure to harness employees' skills, knowledge and initiative. While the TPS had always implicitly embedded a strong human component, through jidoka, with its emphasis on accountable intervention, and