



UNIVERSIDADE CATÓLICA PORTUGUESA

Relationship between lean techniques and performance of a business: an analysis

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Resumo

No ambiente competitivo e em rápida mudança, onde as organizações se inserem hoje, a adoção dos princípios Lean torna-se um tópico relevante, oferecendo às organizações uma estratégia que permite aumentar a eficiência, reduzir o desperdício e promover a melhoria contínua, fazendo com que permaneçam ágeis, inovadoras e resilientes face aos desafios dinâmicos.

Esta dissertação de mestrado examina os Fatores Críticos de Sucesso da implementação de Lean Thinking. Na literatura parece haver um consenso relativo aos três Fatores Críticos de Sucesso que mais influenciam a implementação desta filosofia, sendo eles "Liderança e Gestão", "Educação e Formação" e "Empoderamento dos Funcionários".

Foi aplicado um questionário constituído por perguntas binárias, a indivíduos de diferentes indústrias e níveis hierárquicos, por forma a captar as suas perceções das atividades que são mais importantes, dentro destas três categorias, para assegurar um impacto positivo na performance da empresa. Os resultados sugerem que entre os Fatores Críticos de Sucesso estudados, apenas o fator "Liderança e Gestão" apresenta uma forte correlação com as variáveis de desempenho. Embora, os fatores "Educação e Formação" e "Empoderamento dos Funcionários" inicialmente não tenham mostrado associações fortes, análises adicionais revelaram que os participantes que utilizam uma gama mais ampla de ferramentas tendem a alcançar melhores resultados de desempenho. Estes resultados destacam a importância da "Liderança e Gestão" como Fatores Críticos de Sucesso primários, evidenciando a interdependência de todos os fatores.

Palavras-chave: Lean Thinking, Fatores Críticos de Sucesso, Liderança e Gestão, Formação e Educação, Empoderamento dos Funcionários.

Abstract

In today's rapidly changing and competitive business environment, the adoption of Lean principles become a relevant topic, offering organizations a strategic framework to enhance efficiency, reduce waste, and foster continuous improvement, thereby enabling them to stay agile, innovative, and resilient in the face of dynamic challenges. This dissertation examines the CSFs of implementing Lean Thinking. In the literature, there seems to be a consensus regarding the three critical success factors (CSF) that most influence the implementation of this philosophy, namely "Leadership and Management", "Education and Training" and "Employee Empowerment".

A questionnaire, consisting of binary questions, was applied to individuals from different organizations and hierarchical levels to capture their perceptions of the activities that are most important within these three factors to ensure a positive impact on the business performance. The results suggest that among the Critical Success Factors (CSFs) identified, only "Leadership and Management" exhibited a strong correlation with performance variables. Although "Training and Education" and "Employee Empowerment" initially didn't show strong associations, further analysis revealed that participants who utilized a wider range of tools tended to have better engagement and achieve better performance outcomes. These findings underscore the importance of "Leadership and Management" as primary CSFs, highlighting the interdependency of all factors.

Keywords: Lean Thinking, Critical Success Factors, Leadership and Management, Training and Education, Employee Empowerment

Abbreviations

CSF - Critical Success Factors

TPS - Toyota Production System

PDCA Cycle - Plan-Do-Check-Act Cycle

VSM - Value Stream Mapping

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1. Introduction

In this section, the foundational framework of the dissertation topic is discussed, articulating its definition, and elucidating its significance. The research objectives are explicitly delineated, accompanied by a detailed exposition of the methodological approach selected, and a comprehensive overview of the paper's structure is provided.

1.1 General Framework

Lean thinking is a management philosophy that focuses on delivering maximum value to customers while minimizing waste in processes, emphasizing continuous improvement, employee involvement, and efficient resource utilization (Womack and Jones, 1996). It gained relevance after the Second World War when the US automobile industry was in decline and the Japanese industry was on the rise. This divergence made other countries interested in what Japan was doing and gave Lean Thinking visibility. Nowadays the number of companies that employ this philosophy is on the rise and a lot of authors defend that it has several benefits such as increased productivity and efficiency (Womack and Jones, 1996), improved quality (Hines et al., 2004) enhanced customer satisfaction (Rother and Shook, 2003) and reduced costs (Liker,2003). Despite the benefits highlighted by these authors, a study by Mamoojee-Khatib et al. (2023) states that 70% to 90% of companies that tried applying this philosophy failed.

There are several studies centered on identifying Lean Thinking CSFs, but the majority are focused on organizations' specific characteristics such as size and sector. Starting from the point that the most relevant CSFs identified were:

"Leadership and Management", "Training and Education" and "Employee Empowerment", this dissertation aims to study practices within these three CSFs, that lead to a successful implementation of Lean.

1.2 Objectives and Research Methodology

The research conducted involved employing a survey methodology to gather comprehensive insights into organizational practices across various sectors. The survey was administered to employees at different hierarchical levels within multiple organizations, from seven different sectors. The survey's main aim is to capture the employees' insights regarding the implementation of practices associated with the three most frequently cited CSFs, in the relevant literature. The survey served as the foundational data for subsequent correlation analysis. By exploring the application of these practices and their impact on organizational outcomes, this study aims to contribute with valuable empirical evidence to the understanding of the effectiveness of CSFs in diverse organizational contexts.

Therefore, this dissertation will focus on answering the following research questions:

Research Question 1: How does the involvement and support of top management impact the successful implementation of Lean principles?

Research Question 2: How do training and education in Lean methodologies affect the implementation process and outcomes?

Research Question 3: How does employee empowerment affect the implementation process and outcomes?

The research design allows for a nuanced examination of the relationship between the identified CSFs, their implementation, and the resultant organizational performance.

1.3 Macrostructure

This thesis is structured into six chapters. The initial chapter encompasses the introduction to the dissertation topic, its objectives, the research methodology applied in its development, and an overview of its macrostructure. The second chapter is dedicated to a literature review, aiming to comprehend the advancements made in the field and identify any research gaps. Chapter three delineates the research problem and its associated questions. The fourth chapter explains the methods employed in the study, detailing inputs, outputs, and the performance measures utilized to assess the accuracy of each technique. Chapter five focuses on experimental results, commencing with dataset characterization, followed by descriptive analysis, experimentation outcomes, and a discussion of the results. The sixth chapter encapsulates the primary conclusions drawn from this study, outlining managerial implications and potential avenues for future research.

The final section comprises the bibliography, which serves as a compilation of references supporting the arguments, concepts, and theoretical foundations presented throughout the thesis.

2. Literature Review

This section presents the theoretical concepts of Lean Thinking, explaining its origins and principles according to the most recognized authors that founded and elaborated on this theory. It also explores the CSFs identified in the existing literature and the role of the most used tools and techniques.

2.1. Lean Thinking origin and evolution

Lean thinking is a management philosophy that traces its roots to the Toyota Production System (TPS), a managerial paradigm initiated by Taiichi Ohno, an engineer at Toyota (Womack and Jones, 1996). Originating in post-World War II, a period marked by resource constraints, the TPS epitomized a concerted effort to accommodate inexpensive, limited production of a large variety of models produced in small numbers (Ohno, 1988).

A pivotal juncture in the developmental trajectory of TPS occurred during the oil crisis of 1973, precipitated by the OPEC oil embargo in response to geopolitical events (Ohno, 1988). This economic disruption, affected nations such as Japan and the US, accentuating the vulnerabilities associated with global oil supply disruptions. With Japan heavily dependent on oil imports, constituting 90% of the Middle East, economic exigencies underscored the imperative for adaptive strategies (Shimokawa, 2010), thereby catalyzing the prominence of TPS.

These incidents propelled the Japanese automotive industry onto the global stage as a significant player, while the US industry experienced a downturn. This divergence prompted a close examination of Japan's success and generated a growing interest in the TPS (Ohno, 1988).

In contrast to Ford and GM's reliance on mass production and economies of scale, Toyota discovered that short lead times and adaptable production lines led to higher quality, improved customer responsiveness, enhanced productivity, and optimal space and equipment utilization. In the 1940s and 50s, Toyota aimed to counter contemporary challenges related to achieving prompt, adaptable processes that deliver top-quality, cost-effective products customized to meet customer preferences. This approach marked a departure from Ford's emphasis on cost efficiency through a limited variety (Liker, 2003).

The refinement and dissemination of TPS principles took place during the 1980s and 1990s, with key figures such as James P. Womack and Daniel T. Jones assuming pivotal roles. Coined in their influential 1990 publication, "The Machine That Changed the World," the term "Lean Thinking" succinctly captured the fundamental principles of waste reduction, optimization of workflow, and continuous improvement derived from the TPS framework.

This marked the formal recognition and global dissemination of Lean Thinking as a transformative managerial philosophy.

The progression of Lean principles is discernible through the significant contributions of Taiichi Ohno, Jeffrey Liker, and James P. Womack. These scholars have collaboratively molded and enhanced the understanding of Lean Thinking, with each one building upon the groundwork laid by the others to formulate a comprehensive framework applicable to various organizational contexts.

Taiichi Ohno, recognized as the mastermind behind the TPS, outlined the fundamental principles of Lean manufacturing. The TPS principles highlight crucial concepts like Just-in-Time production, Jidoka (autonomation), standardized work, and commitment to continuous improvement through the philosophy of Kaizen (Ohno, 1988).

According to Taiichi Ohno, the total elimination of waste is the foundation of the TPS. Waste is any activity that doesn't add value to the customer, in a process (Melton, 2005). Therefore, the identification of value is also essential, since it is what the customer is willing to pay for (Ohno, 1988).

There are two pillars that support this activity: just-in-time and autonomation, also known as Jidoka, as illustrated in the TPS house.

Just-in-time ensures that the necessary parts reach the assembly line precisely when and, in the amount, needed, aiming for minimal inventory. To work with minimal inventory is necessary to acknowledge that errors and equipment errors may occur. In response to these challenges, Toyota spearheaded the concept of autonomation, also known as Jidoka. This innovative approach involves infusing machines with a human touch, designed to autonomously detect abnormal situations. Human intervention is only necessitated when these situations arise, effectively preventing the production of defective products. Ohno's emphasis on refining manufacturing processes laid the foundation for the subsequent evolution of Lean Thinking (Ohno, 1988).

Jeffrey Liker, in his seminal work "The Toyota Way" extended and contextualized Lean Thinking within a broader organizational spectrum. Liker's identification of 14 principles encapsulates a holistic approach, incorporating facets beyond the production floor. These principles include the establishment of a culture fostering continuous improvement, the development of exceptional individuals and teams, and the recognition of extended networks comprising partners and suppliers (Liker, 2003). Liker's work expands on Ohno's principles, offering a nuanced and comprehensive framework applicable across organizational hierarchies.

James P. Womack and Daniel T. Jones further refined and propagated Lean Thinking in their influential text "Lean Thinking". They distilled the essence of Lean philosophy into five principles: specifying value, identifying the value

stream, creating flow, establishing pull, and seeking perfection (Womack & Jones, 1996). Womack and Jones adeptly adapted these principles to suit diverse industries, emphasizing the creation of value, reduction of waste, and the perpetual pursuit of continuous improvement.

The evolutionary trajectory of Lean Thinking is discernible in the progression from Ohno's foundational principles, which delineated the core operational aspects of Lean manufacturing, to Liker's nuanced insights into the broader organizational culture at Toyota. Womack and Jones subsequently synthesized these perspectives, offering streamlined principles applicable to a myriad of organizational contexts, beyond the limits of manufacturing. While Ohno underscored the intricacies of production processes, Liker incorporated organizational culture, and Womack and Jones broadened the application of Lean principles to encompass entire value streams, reflecting an evolution toward a more comprehensive and adaptable framework.

Liker (2003) alerts us to the fact that implementing Lean tools may initially give the appearance of a Toyota-like plant. However, over time there is a tendency for the workplace to revert to its previous operational state. He underscores that implementing these tools is merely the initial step, and workers must understand the culture. At Toyota, employees are actively encouraged to engage in the improvement process. Jeffrey Liker further states, "The more I have studied TPS and the Toyota Way, the more I understand that it is a system designed to provide the tools for people to continually improve their work" (Liker, 2003). He emphasizes that Lean Thinking is not just a set of tools but a cultural shift that places greater reliance on people.

2.2 Lean Thinking CSFs

Even though Lean Thinking has spread to several industries and has been applied all over the world, showing enormous benefits, it is important to mention that approximately 70% to 90% of companies that tried applying this philosophy failed (Mamoojee-Khatib et al., 2023, p. 1), which means that it is not enough to just apply the tools, it is necessary to understand the CSF of this philosophy.

According to Boynton and Zmud (1984), CSFs are “those few things that must go well to ensure success”. Although this is a generalized definition it can be applied in the context of this research to define what plays an important role in the success of Lean Thinking implementation.

Various studies focus on identifying the CSFs of specific sectors. According to Riduan Yunus et al (2017) in the construction sector, the three CSFs are management support, process-centered management and training and education. In the food processing sector, the CSFs are the skills of the workforce, in-house expertise, organizational culture, financial capabilities, and leadership and management (Dora et al., 2013). In healthcare, the CSFs are Multidisciplinary healthcare teams, Education and training healthcare staff, Healthcare staff commitment, Culture Change, Leadership, Healthcare management involvement, Healthcare team communication, External consultant, Clinical Pathways and Healthcare staff empowerment (Zepeda-Lugo et al., 2018). Although the specificity that each sector offers it seems that there is a convergence on the importance of the factors: “Management and Leadership”, “Employee Empowerment”, and “Training and Education”.

Netland (2016) analyzed 14 literature reviews on Total Quality Management, Six Sigma, Total Productive Maintenance, Just-in-time, and Lean, where 22 CSFs were identified and a consensus was found on the three that weigh more, being 'management commitment and involvement', 'training and

education' and 'employee participation and empowerment'. This author goes a step further and elaborates on the role of contingencies stating that the effectiveness of CSFs is maximized when they are adapted to specific environments. The effect of contingencies such as the corporation, the size of the factory, the implementation stage of Lean in the factory, and national culture are analyzed.

According to Netland (2006) in different corporations there appears to be a convergence on the importance of culture and the subsequent definition of priorities. Regarding the contingency size the views seem a little bit different, large organizations believe that establishing a reward and recognition system and external sources is the most relevant CSF while smaller organizations privilege the sharing of knowledge in the subject and establish a dedicated Lean team. When talking about the implementation stage managers believe that the first steps require leadership commitment and the involvement of employees while in the latest stages, the Lean tools and routines are the most important CSF. (Netland, 2006). This contrasts with the belief that applying the tools is just the first step stated by Liker (2003).

In summary, the contingency analysis found minor implications in what is the consensus of the three CSFs "Leadership and Management, "Training and Education" and "Employee Empowerment".

Leaders and managers play a critical role in guiding the Lean mindset (Liker, 2003; Womack & Jones, 1996; Rother, 2009; Rother & Shook, 2003; Morgan & Liker, 2006). They are responsible for setting the vision and guiding the organization through change (Liker, 2004). Additionally, they should promote a culture of continuous improvement, that encourages employees to identify and eliminate waste (Liker, 2003; Womack & Jones, 1996; Rother, 2009; Rother & Shook, 2003; Morgan & Liker, 2006). Management's commitment to Lean principles sets the tone for the entire organization, ensuring that resources are

allocated efficiently, and processes are streamlined (Liker, 2003; Womack & Jones, 1996; Rother, 2009; Rother & Shook, 2003; Morgan & Liker, 2006). If the organization's path and objectives are strategically defined around a culture of continuous improvement, it feels natural for employees to act accordingly (Morgan & Liker, 2006). Managers must lead by example, demonstrating a commitment to Lean Thinking in their decision-making and daily activities (Liker, 2003; Rother, 2009; Rother & Shook, 2003; Morgan & Liker, 2006). This sets the agenda for the other two important success factors to be seen as a priority (Morgan & Liker, 2006).

Training and education focus on lies in determining the optimal amount and type of training, encompassing general awareness sessions on change methodologies and specific skill-building exercises. In the intricate landscape of change initiatives, training, and education emerge as a multifaceted CSF, as underscored by Soti et al. (2010). Delgado et al. (2010) advocate for strategic investments in education, emphasizing the necessity of providing employees with the tools and methodologies crucial for navigating complex initiatives. The "who, what, and when" of training gain prominence, encompassing all organizational levels, aligning education programs with specific initiative requirements, and strategically timing interventions to ensure readiness.

"Employee Empowerment" involves giving employees more autonomy, authority, and responsibility to make decisions and solve problems (Womack et al., 1998; Rother, 2009; Morgan & Liker, 2006). Empowered employees are more likely to be engaged and motivated, which can lead to improved job satisfaction, productivity, and creativity (Liker, 2003; Womack et al., 2003; Morgan & Liker, 2006). They are also more likely to identify and solve problems quickly and efficiently, leading to faster resolution of issues and improved customer satisfaction (Liker, 2003; Rother, 2009; Morgan & Liker, 2006). In addition, empowered employees are more likely to come up with new ideas and solutions,

leading to innovation and competitive advantage (Liker, 2003; Rother, 2009; Morgan & Liker, 2006).

2.3. Lean Tools and Methodologies

Following the rationale that a Lean culture can only be developed inside an organization with strong leadership, and management oriented toward these goals. Some tools and techniques can be used as a foundation for implementing Lean Thinking.

5S serves as an entry point for organizations experimenting with Lean methodologies (Lake, 2008). It gained formal introduction through the framework proposed by Osada (1991) and Hirano (1995), implemented initially at Toyota Motor Corporation as part of the TPS. The elements of 5S—Seiri (organization), Seiton (set in order), Seiso (shine), Seiketsu (standardize), and Shitsuke (sustain)—form a cohesive methodology to instill organization, cleanliness, standardization, and discipline in the workplace, being designed to eliminate hidden inefficiencies within plants (Monden, 1998). 5S is more than a mere cleanup process, it is a philosophy that reshapes the workplace, fostering improved communication.

Alongside this, the Kanban system originated to regulate inventory levels, production, and component supply. The term "Kanban" in Japanese refers to a card or sign, symbolizing the inventory control card integral to a pull system (Press, 2020). Within Lean manufacturing, the primary focus of kanban is the elimination of overproduction, enhanced responsiveness to customer demand, and cost reduction through waste elimination. Graves et al. (1995) characterize Kanban as a Material Flow Control mechanism, ensuring the appropriate quantity and timing of necessary product production.

Another visual tool to define the flow of the entire production process, encompassing both material and information flow is value stream mapping (VSM). Its core definition revolves around capturing all activities, both value-added and non-value-added, necessary to bring a product or a group of products, utilizing the same resources, from raw material to end customers. The literature underscores the importance of VSM in identifying and mitigating various types of waste in the production process (Singh et al., 2010).

In addition to the use of visual tools, problem-solving methodologies are also crucial. In the process of problem resolution, a foundational imperative is the identification of the root cause. The root cause is the starting point that triggers a chain reaction of causes and effects, leading to the occurrence of a specific issue under investigation (Bjørn Andersen & Fagerhaug, 2006). Without an identified root cause, the likelihood of achieving a lasting and effective solution is compromised (Bjørn Andersen & Fagerhaug, 2006).

The 5 whys analysis and Plan-Do-Check-Act (PDCA) cycles are two approaches that can be used to attain this goal. Developed by Taiichi Ohno, the 5 whys analysis has the objective of addressing errors through a series of sequential "why" questions (Ohno, 1988). As advocated by Ohno, the objective of this analysis transcends surface-level corrections, it delves into the depth of the issue, fostering long-lasting and comprehensive corrective actions (Ohno, 1988). This analysis can be used in other tools such as the A3 report.

The A3 report, named after the A3 paper size, stands as a powerful and succinct problem-solving tool (Soti, Shankar, & Kaushal, 2010). The template for the A3 report encompasses: "Theme & Background", "Current Condition", "Root Cause Analysis", "Target Condition", "Implementation Plan", "Follow-up Plan", and "Results Report" (Soti, Shankar, & Kaushal, 2010). Answering these boxes helps synthesize and document the key results of problem-solving efforts

focusing on the important aspects of a problem and allowing them to take effective action (Scholtes, 1997).

On the other hand, the PDCA cycle, a management approach emphasizing continuous improvement, is a cyclical process that involves four steps: plan, do check, and act (Deming, 1986). The PDCA cycle emphasises the prevention of error recurrence by defining criteria and continuously assessing those outcomes. (Moen & Norman, 2009).

The cycle begins with planning, where goals are defined along with measurable objectives and methods to achieve them (Deming, 1986). The next stage is implementation, where the planned actions are carried out. Following this, the checking phase evaluates the outcomes, comparing them against the initial plan and identifying any deviations (Shewhart, 1939). The last stage, Act or Adjust, involves learning from the cycle. Successful approaches are adopted and perpetuated, while unsuccessful ones are analyzed for root causes, and adjustments are made to the plan for the next cycle (Juran, 1951).

2.4 Business Performance

The notion of business performance encompasses a spectrum of dimensions and is subject to diverse interpretations by different authors. Nuno Miguel Teixeira and Ines Margarida Lisboa (2021), define business performance as the efficient utilization of resources within business operations. Similarly, Cruz-Cunha et al. (2014) describe it as the alignment between a company's outcomes and its predetermined objectives.

Evaluation of business performance is multifaceted (Neely, 2011), extending beyond traditional financial metrics. In line with Lean principles, which emphasize holistic performance assessment, frameworks like the balanced scorecard advocate for a comprehensive approach. The balanced scorecard,

introduced by Robert Kaplan and Norton (1992), incorporates four perspectives: financial, customer, internal processes, and learning and growth. This framework facilitates the assessment of various aspects dimensions such as customer focus, workforce capability, and operational excellence, reflecting a broader understanding of performance beyond financial indicators (Kaplan & Norton, 1992).

Just as Lean Thinking emphasizes the elimination of waste and continuous improvement (Ohno, 1988), business performance evaluation transcends financial metrics to encompass efficiency, productivity, and quality, echoing the principles espoused by Liker (2003) and Womack and Jones (1996). To measure the impact of Lean thinking, some performance indicators become essential to measure specific outcomes that are expected from this theory such as demand forecasting, error and defect reduction, workplace safety, lead times, employee engagement, innovation, and problem-solving skills.

3. Problem Definition and Research Questions

This section provides the identified problem, in the research context, and subsequently presents the-defined research questions that guide the study's focus and objectives.

3.1 Problem Definition

Lean thinking emphasizes waste reduction and value creation for customers and has demonstrably improved efficiency, productivity, and quality across diverse industries (Womack and Jones, 1996). In a meta-analysis conducted by Yang et al. (2021), noteworthy positive effects were identified across diverse sectors, including manufacturing, healthcare, and service industries, particularly in terms of enhanced productivity and quality. Further supporting the benefits of Lean, a 2020 study by Lu & Hsu (2020) in the *International Journal of Production Economics*, found that its implementation in a healthcare setting led to a 31% reduction in patient waiting times and a 20% decrease in medication errors.

While several research suggests significant benefits of implementing this philosophy it also points out that the success rate of implementing Lean is deficient.

Therefore, it's important to understand Lean CSF and the measures or activities that can be adopted to effectively implement it. Previous studies seemed to find a consensus on three major CSFs: "Leadership and Management", "Training and Education" and "Employee Empowerment". Understanding this CSF will facilitate an effective implementation allowing organizations to achieve success sooner and save on failure costs.

Aspects such as the promotion of a Lean Culture, integration of Lean principles with strategic planning, and the promotion and monitoring of Lean tools and principles are considered within the realm of “Leadership and Management” (LM)

“Training and Education” (TE) evolves around the education strategy, the time given within working hours to develop Lean skills, the type of training provided, and the efforts to monitor and assess the efficacy of these policies.

Aspects related to the encouragement of employees to participate in problem-solving activities and the availability to receive analyze and reward feedback given by employees is a part of the “Employee Empowerment” (EE) dimension.

Finally, the “Organizational Performance” (OP) encompasses aspects related to measuring the impacts on efficiency, productivity, quality, employee morale and innovation.

The independent variables presented in Table 1 are "Leadership and Management", "Training and Education" and "Employee Empowerment".

	Variable	Items
Independent Variable	Demographics	Gender
		Age
		Education level
		Years of professional experience
		How many years of experience do you have working with Lean Thinking?
		What is your hierarchical position in the organization?
		Which is the sector of the company where Lean principles are applied?
		What is the size of that organization?
		Which type of organization is?
	LM	Is there active promotion of a Lean culture by the top management within your organization?
		Does top management regularly communicate the importance of Lean principles and the goals of Lean initiatives to all employees?
		Are Lean principles integrated into your organization's strategic planning and decision-making processes?
		Is there a documented Lean strategy or roadmap that outlines the organization's approach to Lean implementation?
		Is there a culture of accountability among leaders and managers for Lean project outcomes and continuous improvement?
		Is there a mechanism for leaders and managers to actively mentor and develop the problem-solving skills of their teams?
		Does top management actively participate in "Gemba walks" to better understand the workplace and identify opportunities for improvement?
		Are Lean performance metrics and key performance indicators (KPIs) regularly reviewed by top management to assess progress and make strategic decisions?
	EE	Does your organization actively promote a culture of employee engagement and involvement in Lean Thinking as a core value?
		Is there a culture of open communication where employees feel comfortable sharing their observations about process inefficiencies?
		Are employees at all levels of the organization given the opportunity to be involved in problem-solving efforts related to Lean projects?
		Are employees encouraged to participate in cross-functional teams or improvement projects related to Lean initiatives?
		Does your organization have a recognition or reward system in place to acknowledge and appreciate employee contributions to Lean initiatives?
		Are employees regularly updated on the progress and outcomes of Lean projects that they are involved in?
	TE	Does your organization have a clear policy or strategy for continuous improvement in Lean training and education efforts?
		Are managers and supervisors trained in Lean principles to effectively lead and support Lean projects?
		Are employees trained in Lean methodologies to help them understand and apply Lean principles and tools in their work?
		Are employees given time during their work hours to participate in Lean training and education activities?
		Does your organization track and document the training and education progress of employees in Lean methodologies?
		Does your organization regularly assess the effectiveness of its Lean training programs based on employee feedback and outcomes?
		Have you received training in specific Lean methodologies and tools?
		Which Lean tools or methodologies are frequently used in your organization?

Table 1 - Independent Variables

The dependent variable is Operational Performance as presented in Table 2.

	Variable	Items
Dependent Variable	OP	Did the implementation of Lean principles result in noticeable improvements in efficiency?
		Have you observed an increase in productivity levels among employees post-Lean implementation?
		Has Lean implementation allowed for more accurate demand forecasting and inventory management?
		Has Lean Thinking led to a reduction in defects or errors in your products or services?
		Has there been a noticeable improvement in workplace safety and a decrease in incidents or accidents?
		Have lead times for responding to customer orders or inquiries been reduced since Lean implementation?
		Has employee morale and engagement improved as a result of Lean practices?
		Have you witnessed an increase in innovation and problem-solving abilities among employees after Lean implementation?
		Has Lean implementation contributed to a more responsive and adaptable business model to changing market conditions?
		Has Lean implementation in your organization resulted in an increase in product or service quality?
		Has the organization experienced revenue growth or increased market share as a result of Lean initiatives?

Table 2 - Dependent Variable

3.1 Research Questions

Building upon the issue outlined in the preceding section, this study aims to analyze the impact of the given three CSFs, previously identified, in organizations' performance by assessing activities or behaviors within which scope.

To delve deeper into this topic, this dissertation will focus on responding to the research questions identified in Table 3.

Research Questions	Objectives
<p>How does the involvement and support of top management impact the successful implementation of Lean principles?</p>	<p>Questions related to top management's active promotion of Lean culture, communication of Lean goals, integration of Lean objectives in KPI, and participation in Lean activities aim to explore the role of leadership in Lean success.</p>
<p>How do training and education in Lean methodologies affect the implementation process and outcomes?</p>	<p>Questions about the investment made in training and education in Lean philosophy and its methodologies, the time provided by the organization to enroll in these activities as well as documentation of training progress, and assessment of training effectiveness are designed to understand the impact of education on Lean implementation</p>
<p>How does employee empowerment affect the implementation process and outcomes?</p>	<p>By inquiring about the style of communication, mechanisms to provide feedback, opportunities for engagement in Lean activities and problem-solving efforts, recognition, and reward systems the survey seeks to understand the impact of employee empowerment in Lean implementation.</p>

Table 3 - Research Questions

4. Research Methods

The research methods section describes the study's methodology, including how data was gathered, who participated, and how data was analyzed.

4.1 Method Definition

The selection of a methodological paradigm holds a significant impact on the research journey, influencing the tools employed, the data acquired, and the subsequent interpretation of findings.

Since the topic of this dissertation revolves around Lean Thinking implementation, employing a methodological paradigm can facilitate the understanding and enhancement of its CSFs and the activities that enable effective implementation. The present research utilizes a quantitative approach, leveraging a survey methodology that aims to understand and improve the effectiveness of lean implementation.

Surveys are a common quantitative tool that enables the systematic collection of data from a particular population (Creswell & Creswell, 2017). They can provide essential data, such as demographic information, and can be tailored to gain insights into the activities that organizations perform within the scope of the three most cited CSFs in literature and their impact on efficiency, productivity, and quality. By collecting and analyzing these data, it is possible to identify trends, compare different groups, and draw conclusions about the population.

This survey was structured as a binary questionnaire, featuring questions that allowed respondents to choose between "Yes" or "No" responses. Additionally, some extended questions were applied to delve deeper into the methodologies and tools used by the studied organizations to sustain some actions previously evaluated. For instance, the question "Is there a mechanism for employees at all

levels to provide feedback and suggestions related to Lean implementation?" is followed by the question "If you answered "yes", please specify the mechanism(s) your company employs". This allows us to investigate which tools are used to accomplish measures taken regarding a specific CSF. This survey was designed with 5 components. The first one is demographic, enabling the consideration of factors such as the sector, size, or typology of the organization, as well as the information regarding the years of experience with lean or the hierarchical position of the inquiries.

In this first set of questions is asked "Do you work in an organization that implements Lean principles?", and if the answer is "No" the survey ends there allowing us to filter and focus on the part of the population that has engaged directly with this philosophy, ensuring the quality of the answers.

The following three sections were designed to address the three identified CSFs "Leadership and Management", "Training and Education" and "Employees Empowerment ". A set of questions was designed within the scope of which aspect to go further and understand the specific actions taken by the organization within which realm.

The last section of the survey is direct to evaluate the outcomes and it allows us to match what is done (input), and the results achieved (output). Questions about efficiency, productivity, employee engagement, innovation, and quality were made to measure the impact of lean implementation in the studied organizations.

4.1.1 Data collection and measurement instruments

For this investigation, several professionals with Lean experience were identified and contacted via LinkedIn, between December and January. The survey was made available to professionals from within 7 sectors regardless of the typology or size of the organization.

In academic research, careful consideration of the sample size is essential. The sample size directly influences the validity and precision of study outcomes. It refers to the number of participants or data points included in the analysis.

A larger sample size generally leads to more robust and reliable results, enhancing the credibility of the research findings. According to Kibuacha (2021), the sample size is calculated as in Equation 1.

$$\text{Sample size} = \frac{(Z\text{-score})^2 \times \text{StdDev} \times (1 - \text{StdDev})}{(\text{confidence interval})^2} \quad (1)$$

Despite various methods available for calculating sample size, such as the one illustrated above, the reduced population size in my study—limited to individuals employed by an organization implementing Lean Thinking in Portugal—dictates a sample size of 33. Although initially 50 responses were collected, the final sample size was determined based on the quality of the answers, resulting in 33 participants.

4.2 Correlation Analysis

Correlation analysis looks at how two variables are related, assuming they have a linear relationship. It measures how strong and in which direction this connection is, in an interval between -1 and +1 (Witte & Witte, 2017). A value of +1 means they're perfectly positively related, -1 means perfectly negatively related, and 0 means there's no linear relationship (Gogtay & Thatte, 2017).

Here are some common understandings of correlation coefficients:

- 0.9 to 1.0 (or -0.9 to -1.0): Very strong positive (or negative) correlation.
- 0.7 to 0.9 (or -0.7 to -0.9): Strong positive (or negative) correlation.
- 0.5 to 0.7 (or -0.5 to -0.7): Moderate positive (or negative) correlation.

- 0.3 to 0.5 (or -0.3 to -0.5): Weak positive (or negative) correlation.
- 0 to 0.3 (or 0 to -0.3): Little to no linear correlation.

It is important to keep in mind that correlation does not imply causation and that there is not always a cause-and-effect link between variables based just on the strength of the association (Witte & Witte, 2017). A thorough comprehension of the data requires considering several elements and analyses, among which correlation analysis is only one type of statistical analysis tool (Witte & Witte, 2017).

5. Results

The results section will unveil the outcomes of the investigation, systematically elucidating findings related to Lean Thinking CSFs. It will delve into empirical evidence and address the findings, offering a thorough examination with implications for theory, practice, and future research.

5.1. Dataset characterization

We distributed a survey consisting of 48 questions, which can be found in Appendix 1, through LinkedIn to gather data for our database. From the 50 responses received, we selected 33 based on their quality and proceeded to examine and analyze their relationships.

When conducting correlation analysis, it is important to consider two main types of variables: the dependent variable (also known as the response variable) and the independent variable (also known as the explanatory variable). The goal is to understand how changes in the independent variable relate to changes in the dependent variable. In our study, we have identified one dependent variable—Operational Performance—and 4 independent variables: Demographics, Leadership and Management, Training and Education, and Employee Empowerment.

5.2 Descriptive Analysis

To gain a deeper understanding of the survey participants, we performed a comprehensive analysis of demographics, professional background, and workplace characteristics. This analysis focused on nine key factors: demographics (gender, age, education, and experience), Lean experience (exposure to and expertise in Lean principles), and organizational context

(position, industry, size, and ownership structure). By providing a detailed, quantitative breakdown of this data, we aim to build a clear picture of our respondents.

The sample studied consists of people who work or have worked in organizations that implement Lean Thinking in Portugal. The survey received 33 responses, with women making up the majority at 55%. Men comprised the remaining 45%, indicating a balanced gender distribution, as shown in Figure 1.

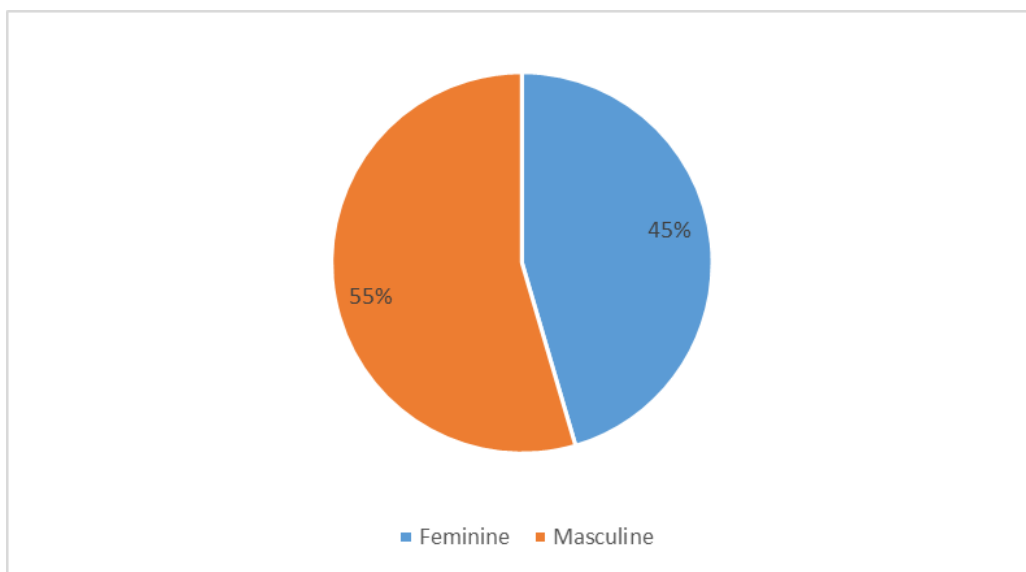


Figure 1 - Gender of the respondents

Figure 2 reveals a median-aged distribution, with the largest share of respondents falling between 30 and 45 years old. The 46-60 age group has fewer respondents.

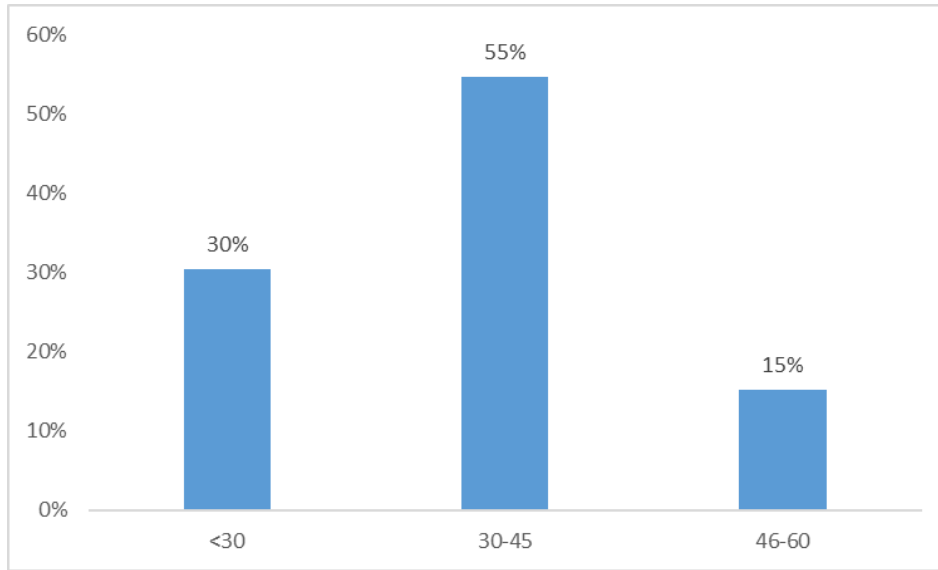


Figure 2 - Age of the respondents

Figure 3 shows that the majority of those who took part in this study have master's degrees. Followed by 24% who have a bachelor's degree and 15% who have a postgraduate degree. Only 15% haven't pursued an education specialization.

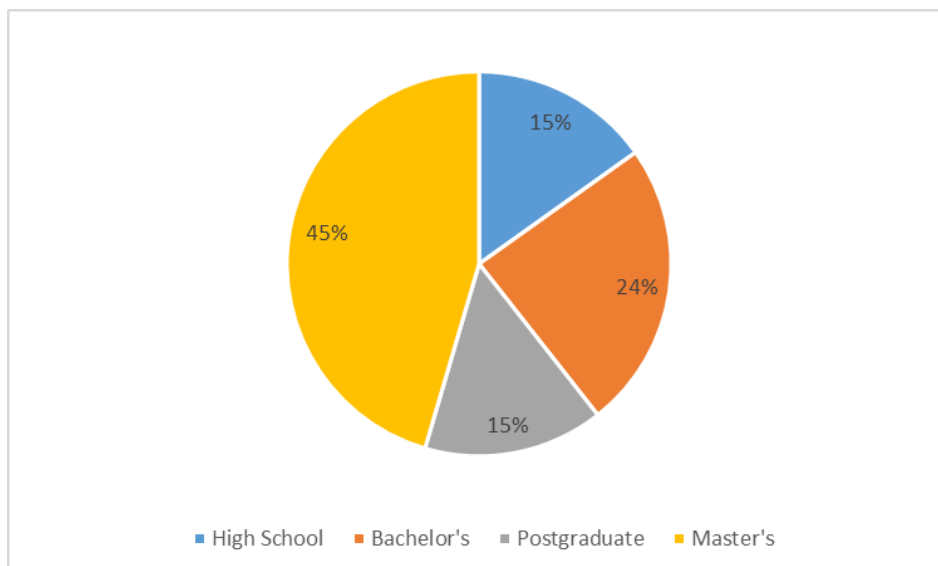


Figure 3 - Education levels of the respondents

Figure 4 reveals a concentration of respondents with extensive work experience. The majority (63% or more) possess over 15 years of experience. An additional 18% have experience ranging from 11 to 15 years. While a smaller segment (9%) has less than one year of experience, the overall data suggests a workforce with a strong foundation in professional experience.

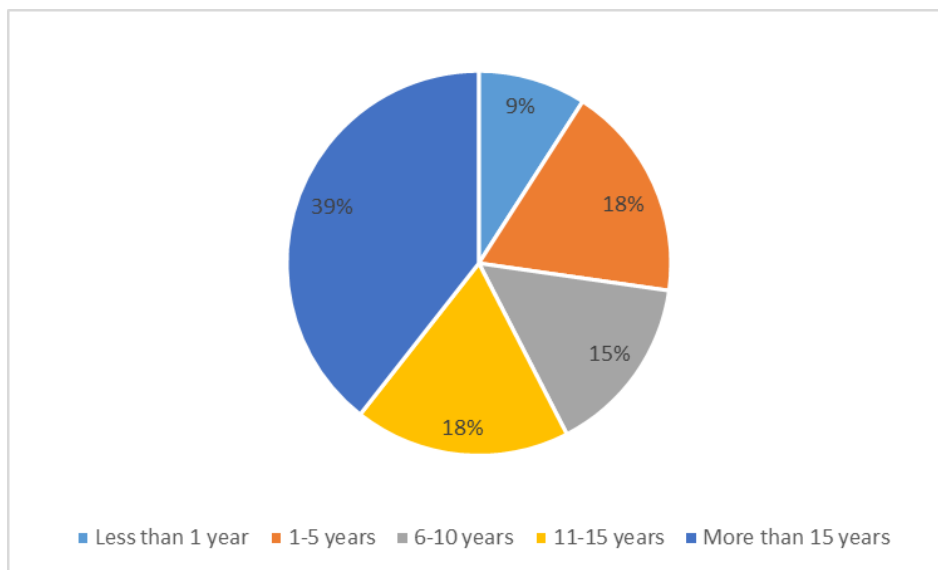


Figure 4 - Years of professional experience of the respondents

Figure 5 reveals a diverse range of experience with Lean principles among participants. While the largest group (36%) boasts 4 to 6 years of experience, a significant portion (27%) has been involved for 1 to 3 years. Even with a smaller group (9%) having less than a year of experience, the overall distribution suggests a strong foundation in Lean theory across the participants. Additionally, the findings suggest that individuals who engage in Lean practices tend to remain committed to it for extended periods, often spanning many years.

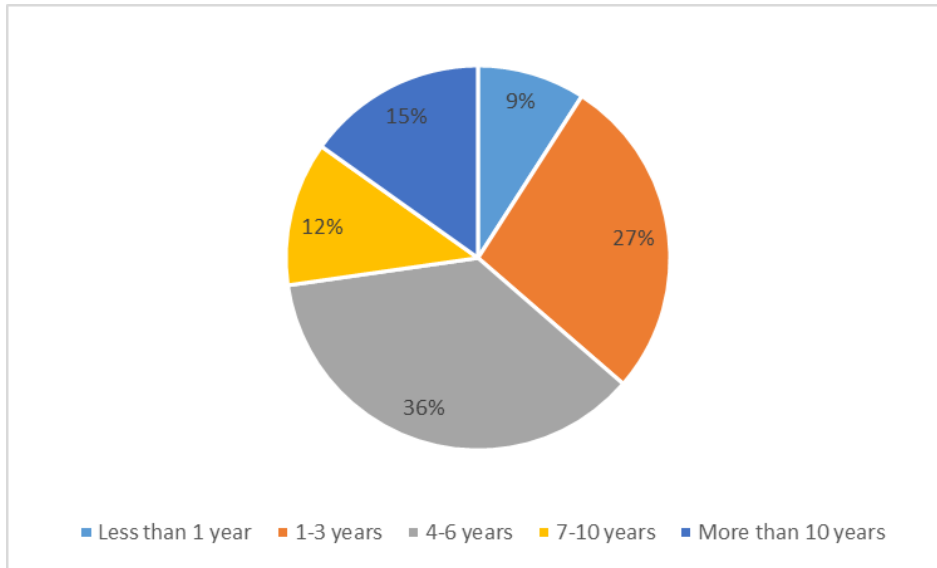


Figure 5 - Years of experience with Lean Thinking of the respondents

Figure 6 represents the hierarchical position of the respondents. Most of the respondents are Frontline workers (45%). Perceptions of a Lean initiative can vary depending on one's hierarchical position, as each role entails different responsibilities within the initiative. The study's diverse representation across various hierarchical levels suggests that incorporating multiple perspectives will enrich its findings.

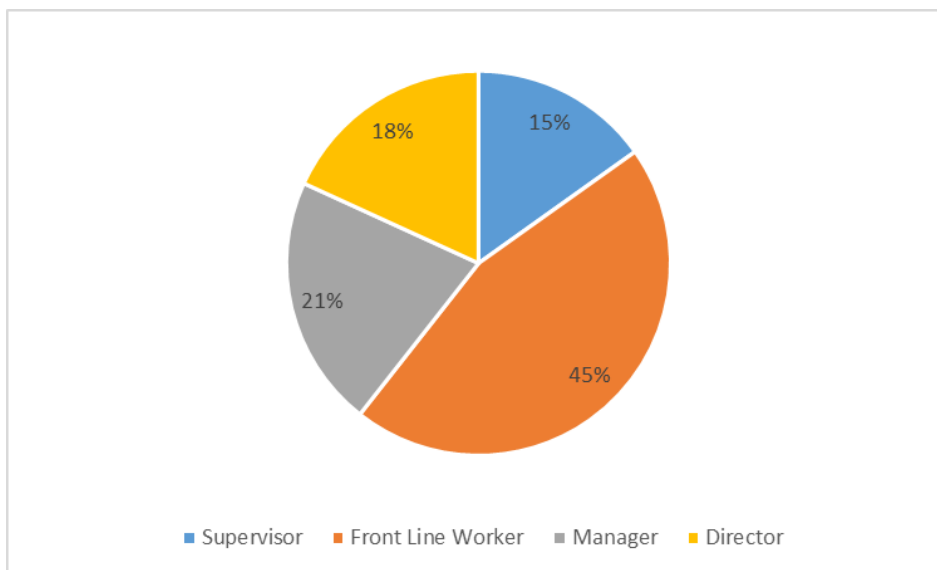


Figure 6 - Hierarchical position of the respondents

In Figure 7, a diverse distribution is evident across seven distinct industry sectors: financial, food, logistics, manufacturing, retail, services, and transportation. While the energy sector comprises the majority of respondents (18%), significant representation is also noted in sectors such as financial (15%), manufacturing (15%), logistics (12%), and consultancy (12%). This diversity in participant backgrounds offers a wide spectrum of perspectives, fostering the potential for more comprehensive conclusions.

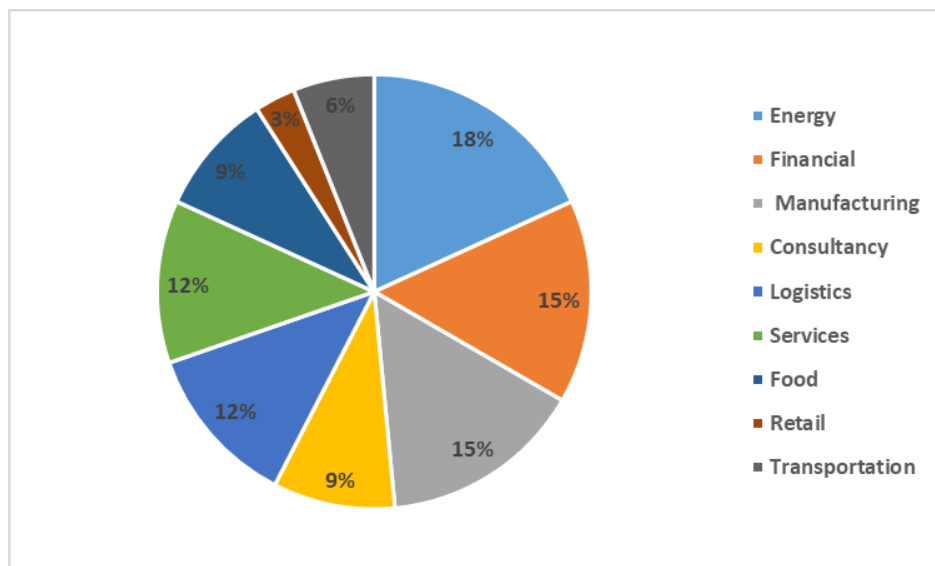


Figure 7 - Percentage of respondents by sector

Figure 8 shows that the majority of participants, accounting for 85%, are employed in large enterprises, while smaller representations are observed for small (1%) and medium-sized enterprises (12%). Consequently, this study will primarily concentrate on perceptions within the context of large enterprises.

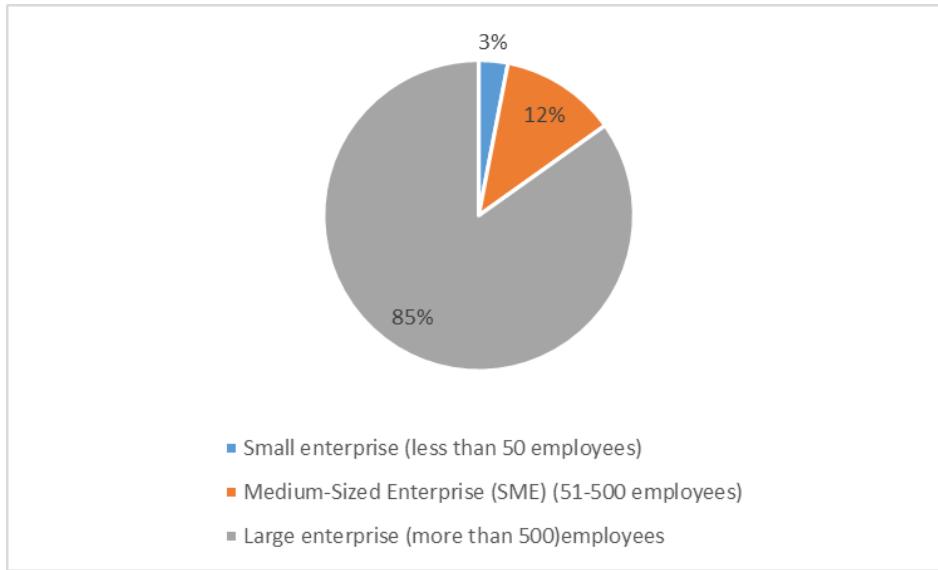


Figure 8 - Organization size

Figure 9 illustrates that 97% of the respondents work in Private companies, with only 3% of the respondents working in public organizations. Therefore, this study will base its findings mainly on perceptions from private organizations.

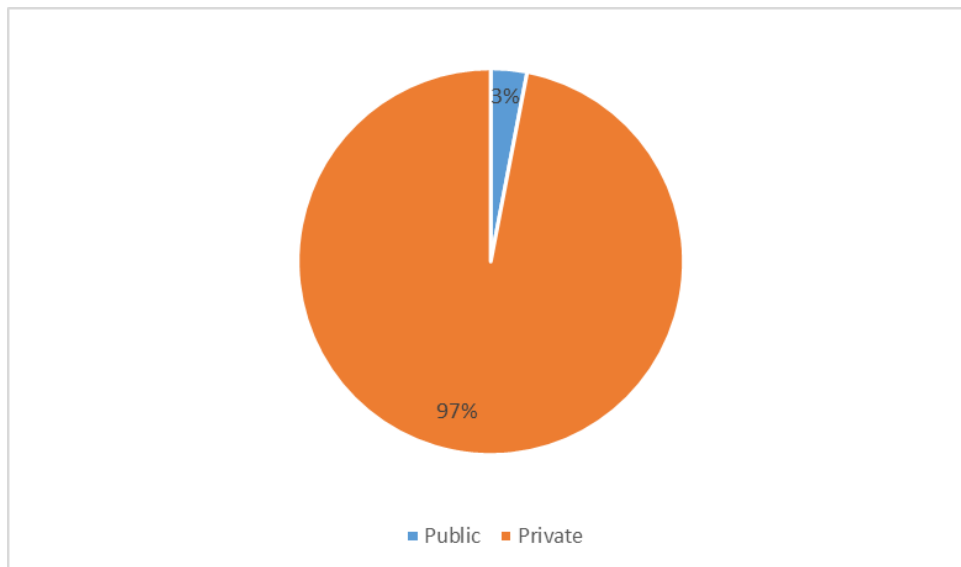


Figure 9 - Organization Ownership

5.1 Correlation analysis

Based on the analyzed data, a correlation analysis has been conducted and is available for reference in Appendix 2. The positive correlation observed between question 11 and questions 41, 43, 45, and 47 indicates a potential relationship between the promotion of Lean culture by top management and various performance outcomes of Lean implementation within an organization. Specifically, it suggests that when there is active promotion of Lean culture by top management (question 11), there tends to be a higher likelihood of experiencing positive outcomes associated with Lean implementation. These outcomes include reductions in defects or errors in products or services (question 41), decreased lead times for responding to customer orders or inquiries (question 43), enhanced innovation and problem-solving abilities among employees (question 45), and improvements in product or service quality (question 47).

In addition to the positive correlation observed between question 11 and questions 41, 43, 45, and 47, there's another noteworthy correlation involving question 13 and questions 41 and 44. This indicates a potential relationship between the integration of Lean principles into an organization's strategic planning and decision-making processes (question 13) and two specific outcomes of Lean implementation. Specifically, it suggests that when Lean principles are integrated into strategic planning and decision-making processes, there's a higher likelihood of experiencing reduced lead times for responding to customer orders or inquiries (question 41) and improved employee morale and engagement (question 44). This further underscores the importance of organizational alignment and strategic integration of Lean principles in achieving positive outcomes. Question 14 also has a strong correlation with question 48 showing that having a documented Lean strategy or roadmap that

outlines the organization's approach to Lean implementation leads to revenue growth or increased market share. Lastly, question 18 is positively correlated with question 38 showing that establishing and reviewing KPIs results in noticeable efficiency improvements.

These strong positive correlations prove that as stated in the literature "Leadership and Management" is a CSF for lean implementation. Having a clear orientation, defining clear objectives, and measuring them is crucial in establishing a culture orientated to Lean Principles.

Although dimensions representing "Leadership and Management" have consistently demonstrated significant correlations with operational outcomes, as evidenced in the literature, the same cannot be said for other factors such as "Employee Empowerment" and "training and education." Despite their recognized importance, these dimensions have not exhibited comparable levels of correlation in the analysis.

Nevertheless, it's crucial to recognize that "Leadership and Management" consistently emerge as the most cited and deemed the most critical in order of importance. This underscores their fundamental role in driving organizational success. However, the correlation analysis reveals certain gaps, indicating potential areas where further investigation is warranted. Understanding these gaps is essential, as they may influence the observed results.

Therefore, continued study of the effects of these factors on the successful implementation of Lean practices is imperative for refining strategies and maximizing outcomes.

5.2 Lean Tools Analysis

By examining the median of responses across the three dimensions, illustrated in Figure 10, it becomes evident that organizations within the sample exhibit

greater engagement in implementing initiatives within the “Leadership and Management” dimension. The utilization of the median, as opposed to the mean, provides a more robust analysis by mitigating the influence of outliers, thus enhancing the accuracy of our findings.

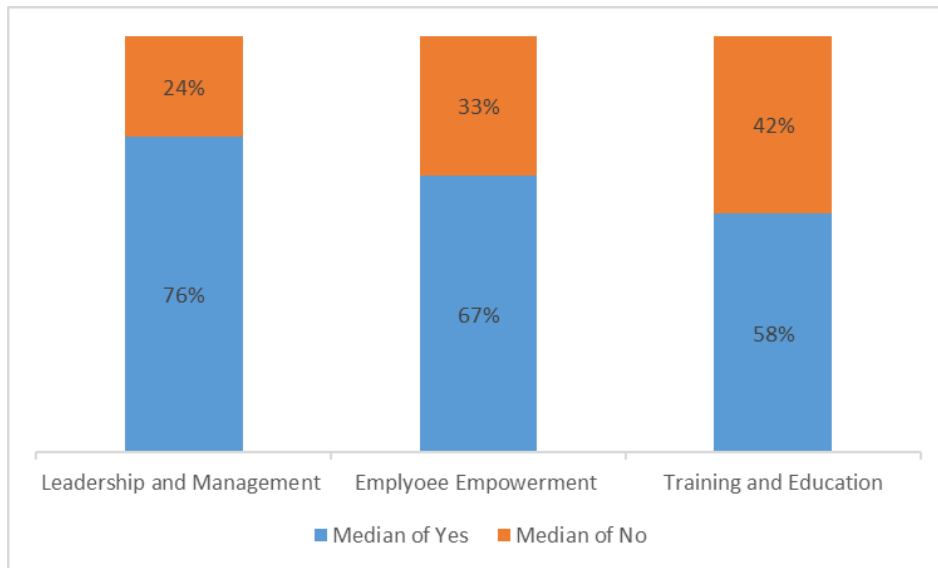


Figure 10 - Median of responses by CSF

Of the 33 respondents, the majority (94%) use lean tools as illustrated in Figure 11.

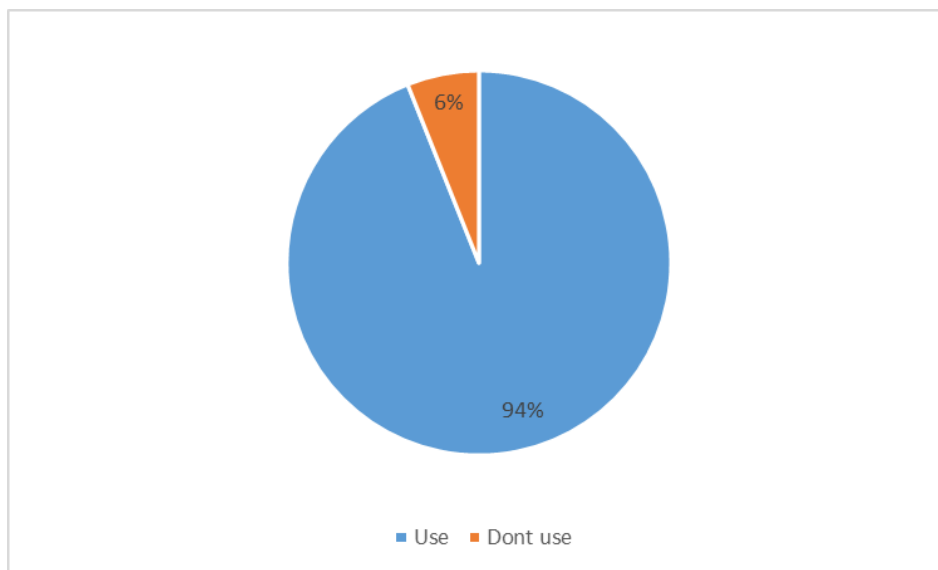


Figure 11 - Use of Lean tools

It is also interesting to learn that the most used tools are 5S, Root Cause Analysis, PDCA Cycles and Kaban. This is in line with what was explored in the literature review section since these tools can serve as the initial step to Lean implementation because of their simplicity in adoption and flexibility. On the other hand, tools such as Just-in-time, SMED and Six Sigma that are relevant in the literature show lower levels of adoption as illustrated in Figure 12.

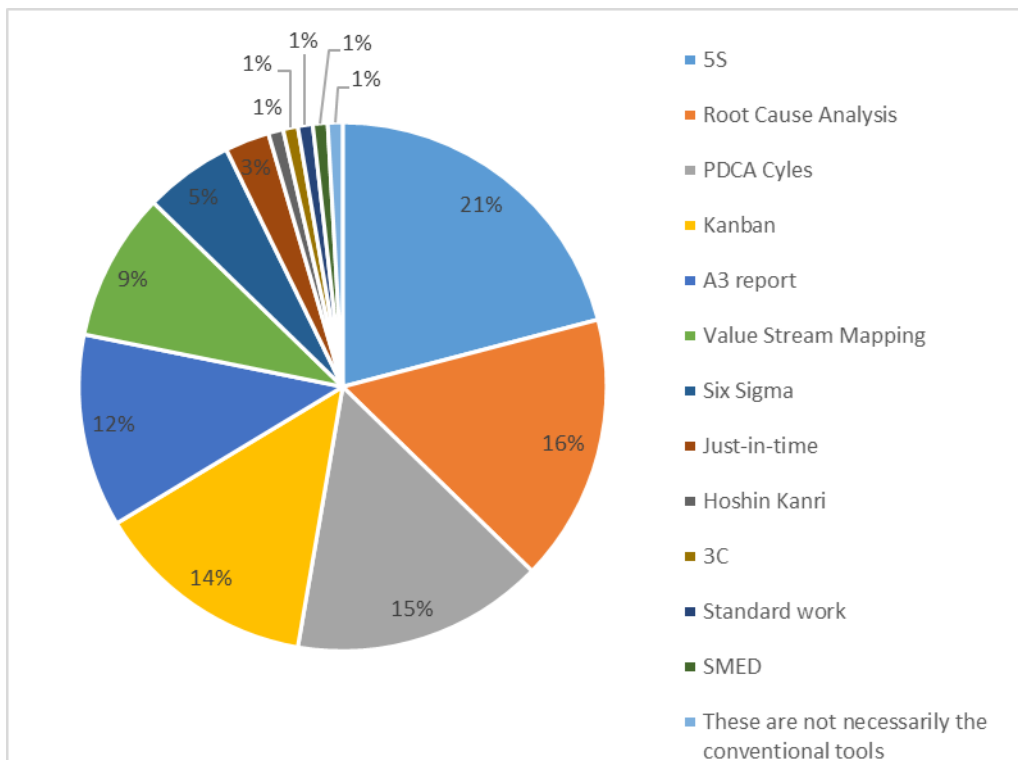


Figure 12 - Lean tools used

Analyzing the 33 responses, it is possible to conclude that on average, are used 3,33 tools in the organizations that employ the participants of this survey.

By analyzing Figure 13, it is also possible to conclude that the participants who work in organizations that use more than three tools have reported better improvements in their organization's post-lean implementation.

This graph analyses the percentage of responses "Yes" or "No" to the questions defined as dependent variables. In the dependent variables, the effect of lean implementation on efficiency, productivity, quality, demand forecasting,

reduction of errors and defects, workplace safety, lead times, employee engagement, innovation and problem-solving skills, business model and revenue are measured.

The respondents who use more than three tools tend to believe that Lean implementation has led to better organizational results. It is also important to note that in the dimension of revenue growth, the two groups tend to believe that Lean hasn't led to improvements in revenue growth which can be explained by most participants being front-line workers who usually don't work directly on this topic.

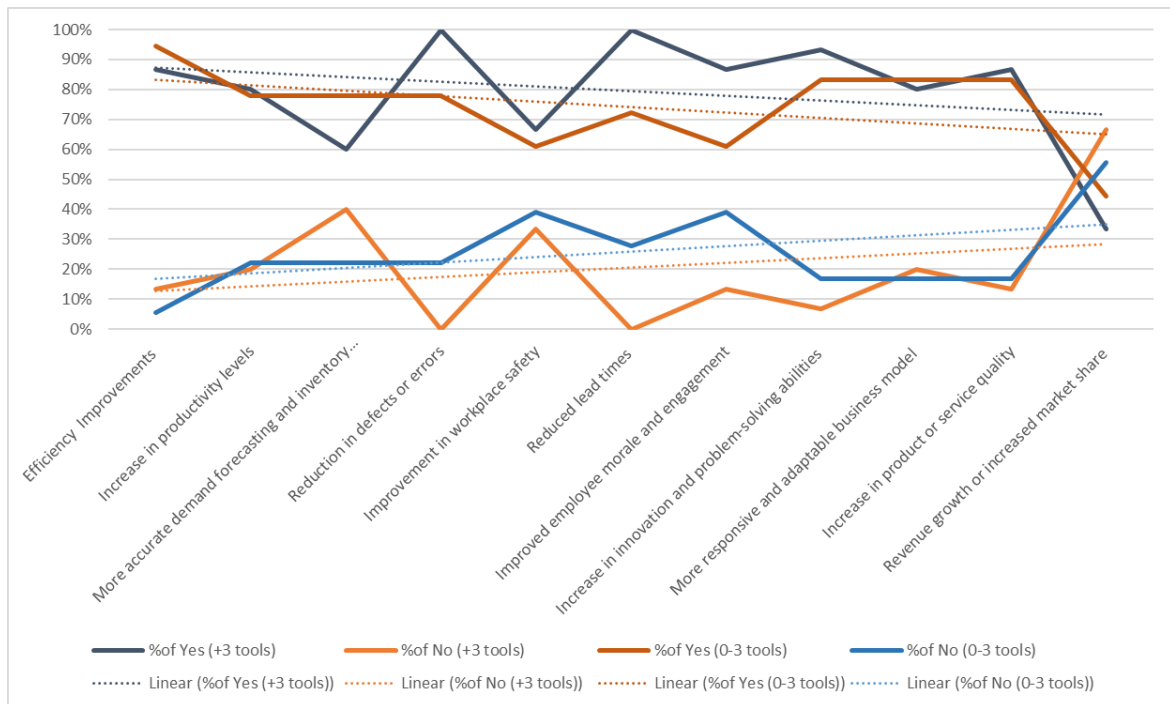


Figure 13 - Use of tools vs effect on performance

Figure 14 shows the perceptions of people on the three CSFs studied considering whether they use more or less than three Lean tools. It is possible to conclude that when it's used more tools the three CSFs are more established.

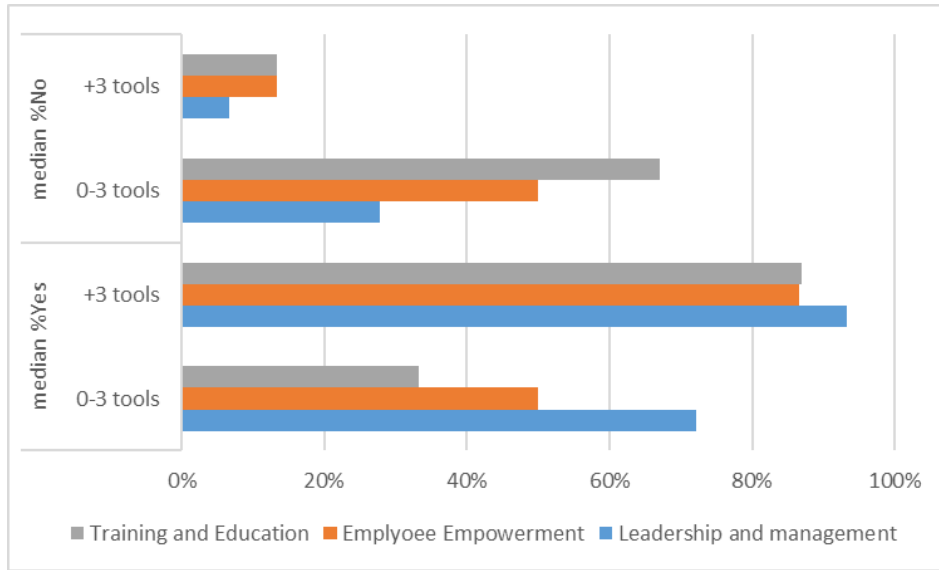


Figure 14 - Use of tools vs 3 CSFs

Looking more generally at Figure 15 it's possible to conclude that the participants tend to believe that lean implementation leads to benefits on the organizational performance. The dimensions that have a more positive response are efficiency, reduction in defects or errors, innovation, and problem-solving skills, increase in product /service quality and reduction of lead times. The dimension of revenue growth has more negative answers than positive

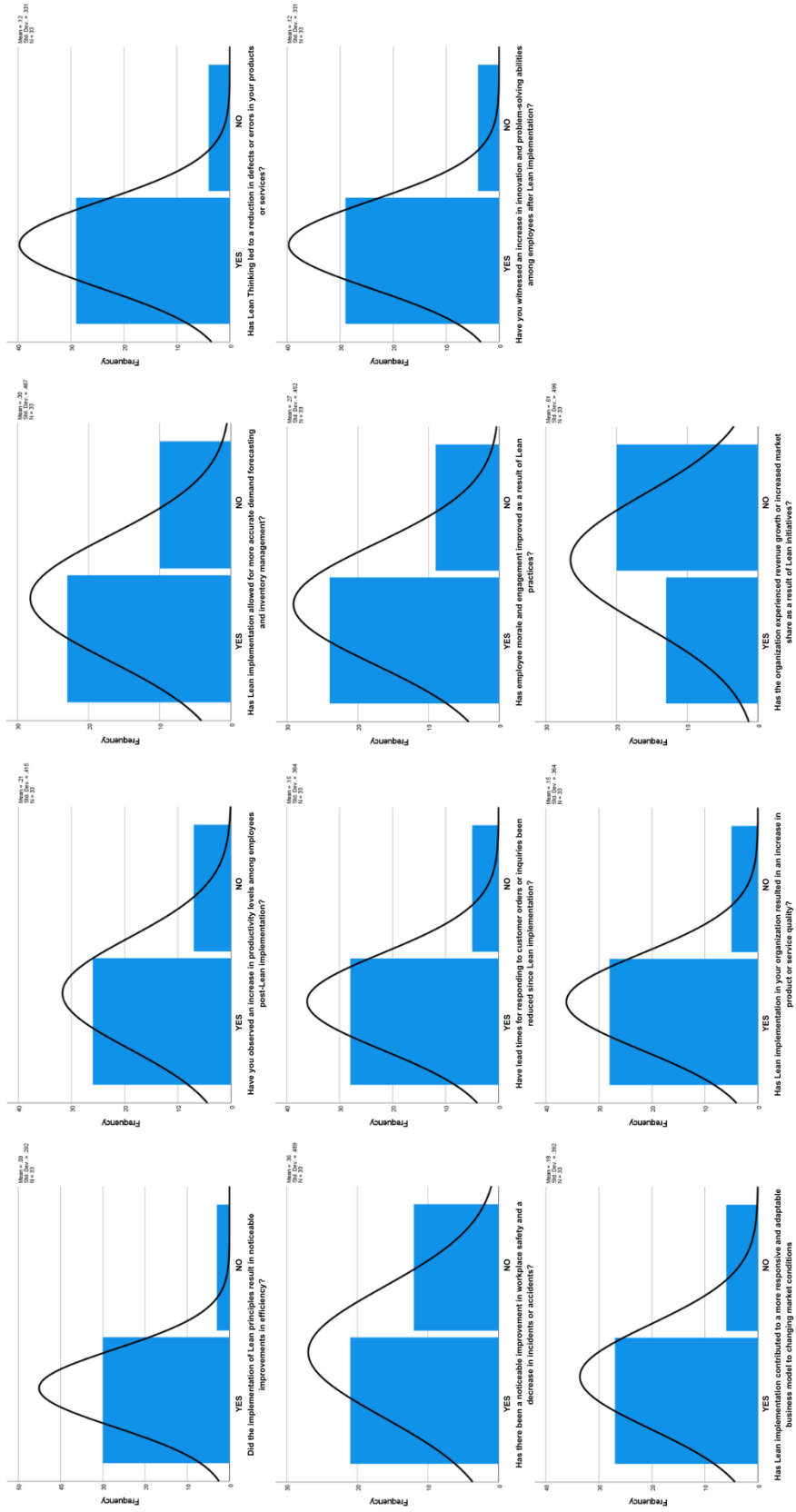


Figure 15 - Histograms dependent variables

5.2 Discussion of Results

The findings of this dissertation suggest that among the three CSFs identified in existing literature, only “Leadership and Management” exhibit a strong correlation with Lean performance variables. “Leadership and Management” play pivotal roles as they set the agenda, establish the vision, and shape the organizational culture, underscoring their significance. While the correlation analysis did not reveal strong associations between the CSFs "Training and Education" and "Employee Empowerment" and the dependent variables, a deeper exploration into the latter unveils a noteworthy trend. Through a combined analysis with tool usage, it becomes evident that participants who utilize a greater variety of tools tend to demonstrate enhanced engagement across all aspects measured by the CSFs and exhibit more favorable outcomes in terms of performance. Additionally, participants perceive Lean implementation to yield improvements across all measured performance dimensions, except for revenue growth. These results underscore the paramount importance of “Leadership and Management” as the primary CSF, while also highlighting the Interdependency of all CSFs. Effective tool utilization necessitates both education and empowerment, ultimately contributing to superior performance outcomes.

6. Conclusion

This section includes an overview of the information covered in each chapter of this dissertation. Furthermore, the limitations of this study and the management implications of the findings are addressed.

6.1 General Conclusions and Limitations

In this dissertation, the exploration of Lean Thinking CSFs begins in the Introduction section, where the significance of Lean as a management philosophy is established alongside its benefits and challenges. Recognizing the importance of understanding employee perceptions of CSFs within Lean implementation, the research methodology, objectives, and research questions are outlined, focusing on CSFs and their impact on Lean successful implementation.

Transitioning into the Literature Review section, an exploration of the Lean framework unfolds, starting with its origins and evolution rooted in the TPS and pivotal moments such as the 1973 oil crisis. The section illuminates the divergent trajectories of the Japanese and US automotive industries, leading to a heightened interest in TPS and the formalization and dissemination of Lean Thinking. Key figures like Taiichi Ohno, Jeffrey Liker, and James P. Womack are examined for their contributions, tracing the progression from foundational principles to a comprehensive framework adaptable across organizations. Additionally, the review delves into sector-specific CSFs and the role of contingencies in maximizing CSF effectiveness. Lean tools and methodologies such as 5S, Kanban, and problem-solving approaches are explored for their role in fostering Lean culture and continuous improvement.

Moving to the Problem Definition and Research Questions section, the problem statement and research questions regarding Lean implementation are articulated. Acknowledging the significant benefits of Lean alongside its implementation challenges, three CSFs - "Leadership and Management", "Training and Education", and "Employee Empowerment" - are identified as pivotal. Specific aspects within each CSF, like promoting Lean culture and encouraging employee participation, are delineated. Aiming to analyze the impact of these CSFs on organizational performance the following research questions were answered:

Research Question 1: How does the involvement and support of top management impact the successful implementation of Lean principles?

Research Question 2: How do training and education in Lean methodologies affect the implementation process and outcomes?

Research Question 3: How does employee empowerment affect the implementation process and outcomes?

In the Methodology section, the methodological approach to researching Lean Thinking implementation is outlined. A quantitative approach utilizing surveys is chosen for its systematic data collection capabilities, focusing on the three most cited CSFs. Correlation analysis is introduced to understand binary outcomes and assess the impact of factors on Lean implementation success. The survey structure, data collection process, and sample size considerations are detailed, laying the groundwork for regression analysis as a valuable tool in understanding Lean implementation dynamics. From the 33 respondents it was possible to conclude that among the identified Critical Success Factors (CSFs),

only “Leadership and Management” show a strong correlation with Lean performance variables. These roles are crucial in setting agendas, defining visions, and shaping organizational culture. While "Training and Education" and "Employee Empowerment" didn't show strong associations initially, further analysis reveals that participants who utilize a wider range of tools tend to have better engagement and achieve more favorable performance outcomes. Despite perceiving improvements in various performance dimensions through Lean implementation, revenue growth remains an exception. These findings emphasize the paramount importance of “Leadership and Management” as primary CSFs, while also highlighting the interdependency of all factors. Effective tool utilization requires both education and empowerment, leading to superior performance.

Acknowledging limitations in sample size and methodology, future research avenues are contemplated, including the potential for a more complex methodology like meta-analysis. By aggregating evidence from multiple studies, meta-analysis offers a comprehensive overview of Lean practices and CSFs, enhancing the reliability, precision, and credibility of findings, ultimately contributing to a deeper understanding of Lean implementation effectiveness.

6.2 Managerial Implications

This study emphasizes the importance of “Leadership and Management” in successfully implementing Lean Thinking and highlights its interconnectedness with other CSFs such as “Employee Empowerment” and “Training and Education. When considering Lean implementation, it's crucial to acknowledge its high failure rate. To ensure successful implementation, careful planning is necessary. Managers should recognize the significance of their role in fostering

and maintaining the Lean culture. They need to actively engage in setting agendas, defining visions, and shaping organizational culture to drive Lean adoption effectively. They play a crucial role in providing direction, resources, and motivation for Lean initiatives.

While “Leadership and Management” emerge as primary drivers of Lean success, effective tool utilization requires both education and empowerment. Managers should understand the synergistic relationship between these factors and strive to integrate them cohesively into their Lean strategy.

Investing in training and education in Lean methodologies is essential for enhancing the implementation process and outcomes. Managers should ensure that employees receive adequate training to understand Lean principles and tools effectively. Continuous learning and skill development are vital for sustaining Lean practices and fostering a culture of continuous improvement.

Managers should encourage autonomy, involvement, and ownership among employees to cultivate a sense of responsibility and commitment towards Lean implementation. Empowered employees are more likely to contribute innovative ideas, problem-solving skills, and enthusiasm, leading to improved performance outcomes.

Understanding the relationships between CSFs will decrease the failure rate and help companies achieve better results sooner, ultimately saving on failure and waste costs.

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Appendix

Appendix 1: Questionnaire applied

1. Gender
2. Age
3. Education Level
4. Years of professional experience
5. Do you work in an organization that implements Lean principles?
6. How many years of experience do you have working with Lean Thinking?
7. What is your hierarchical position in the organization?
8. Which is the sector of the company where Lean principles are applied?
9. What is the size of that organization?
10. Which type of organization is?
11. Is there active promotion of a Lean culture by the top management within your organization?
12. Does top management regularly communicate the importance of Lean principles and the goals of Lean initiatives to all employees?
13. Are Lean principles integrated into your organization's strategic planning and decision-making processes?
14. Is there a documented Lean strategy or roadmap that outlines the organization's approach to Lean implementation?
15. Is there a culture of accountability among leaders and managers for Lean project outcomes and continuous improvement?

16. Is there a mechanism for leaders and managers to actively mentor and develop the problem-solving and Lean skills of their teams?
17. Does top management actively participate in Gemba walks to better understand the workplace and identify opportunities for improvement?
18. Are Lean performance metrics and key performance indicators (KPIs) regularly reviewed by top management to assess progress and make strategic decisions?
19. Does your organization actively promote a culture of employee engagement and involvement in Lean Thinking as a core value?
20. Is there a culture of open communication where employees feel comfortable sharing their observations about process inefficiencies?
21. Is there a mechanism for employees at all levels to provide feedback and suggestions related to Lean implementation?
22. If you answered 'yes,' please specify the mechanism(s) your company employs.
23. Are employees at all levels of the organization given the opportunity to be involved in problem-solving efforts related to Lean projects?
24. If you answered 'yes,' please specify through which mechanism(s)
25. Are employees encouraged to participate in cross-functional teams or improvement projects related to Lean initiatives?
26. Does your organization have a recognition or reward system in place to acknowledge and appreciate employee contributions to Lean initiatives?
27. If you answered 'yes,' please specify the system your company employs.
28. Are employees regularly updated on the progress and outcomes of Lean projects that they are involved in?
29. Does your organization have a clear policy or strategy for continuous improvement in Lean training and education efforts?

30. Are managers and supervisors trained in Lean principles to effectively lead and support Lean projects?
31. Are employees trained in Lean methodologies to help them understand and apply Lean principles and tools in their work?
32. Are employees given time during their work hours to participate in Lean training and education activities?
33. Does your organization track and document the training and education progress of employees in Lean methodologies?
34. Does your organization regularly assess the effectiveness of its Lean training programs based on employee feedback and outcomes?
35. Have you received training in specific Lean methodologies and tools?
36. If yes, please specify the methodologies/tools.
37. Which Lean tools or methodologies are frequently used in your organization?
38. Did the implementation of Lean principles result in noticeable improvements in efficiency?
39. Have you observed an increase in productivity levels among employees' post-Lean implementation?
40. Has Lean implementation allowed for more accurate demand forecasting and inventory management?
41. Has Lean Thinking led to a reduction in defects or errors in your products or services?
42. Has there been a noticeable improvement in workplace safety and a decrease in incidents or accidents?
43. Have lead times for responding to customer orders or inquiries been reduced since Lean implementation?

44. Has employee morale and engagement improved as a result of Lean practices?
45. Have you witnessed an increase in innovation and problem-solving abilities among employees after Lean implementation?
46. Has Lean implementation contributed to a more responsive and adaptable business model to changing market conditions?
47. Has Lean implementation in your organization resulted in an increase in product or service quality?
48. Has the organization experienced revenue growth or increased market share as a result of Lean initiatives?

Appendix 2: Correlation Coefficients

		Operational Performance										
		38	39	40	41	42	43	44	45	46	47	48
Demographics	1	-0,15	-0,14	-0,22	-0,05	0,11	0,03	-0,01	0,14	0,10	0,03	0,30
	2	0,23	-0,01	0,03	-0,07	-0,27	-0,05	0,12	0,07	0,09	0,08	-0,06
	3	0,04	0,12	0,19	-0,04	0,25	-0,18	-0,30	-0,21	0,05	0,05	0,08
	4	0,24	0,03	0,13	-0,03	-0,23	0,05	0,51	0,30	0,24	0,11	-0,13
	6	0,09	-0,13	0,00	-0,16	-0,17	0,00	0,41	0,16	0,00	0,07	-0,11
	7	0,06	0,13	0,21	0,12	0,09	0,03	0,11	0,04	0,49	0,24	0,03
	8	0,11	-0,09	-0,26	0,02	-0,27	0,11	0,05	0,18	-0,21	-0,06	0,23
	9	0,13	-0,11	-0,02	-0,05	-0,42	-0,01	0,10	-0,05	-0,15	-0,38	-0,33
	10	-0,56	-0,34	-0,27	0,07	0,13	0,08	-0,29	-0,48	0,09	0,08	-0,15
	Leadership and Management	11	0,16	0,40	0,08	0,62	0,23	0,76	0,50	0,62	0,23	0,53
12		0,19	0,21	-0,10	0,29	-0,02	0,38	0,23	0,29	0,29	0,20	0,25
13		0,20	0,26	-0,05	0,43	0,12	0,62	0,60	0,43	0,30	0,36	0,31
14		0,04	0,17	-0,12	0,39	0,28	0,50	0,38	0,39	0,23	0,50	0,52
15		0,12	0,13	0,02	0,30	-0,01	0,45	0,41	0,30	-0,03	0,23	0,23
16		0,12	-0,06	-0,32	0,06	-0,01	0,23	0,06	0,06	-0,23	0,23	0,07
17		-0,03	0,06	-0,10	0,29	-0,02	0,20	0,23	0,10	-0,04	0,20	0,12
18		0,51	0,17	0,03	-0,03	-0,16	0,11	0,23	0,18	0,06	-0,08	0,09
Employee Empowerment	19	0,22	0,25	-0,06	0,32	-0,11	0,41	0,43	0,32	0,33	0,23	0,33
	20	-0,06	-0,10	-0,12	-0,07	0,25	0,42	0,29	0,48	-0,09	-0,08	0,15
	21	-0,12	0,03	-0,05	0,14	0,12	0,36	0,18	0,43	0,06	0,10	0,12
	23	-0,05	0,02	-0,28	0,26	-0,20	0,35	0,33	0,07	-0,07	-0,01	0,04
	25	-0,23	-0,06	-0,20	0,12	-0,11	0,23	0,28	0,32	0,16	0,05	0,06
	26	-0,22	-0,09	-0,08	-0,12	-0,03	-0,05	0,01	0,07	0,18	0,13	-0,06
	28	-0,01	0,09	-0,20	0,32	0,03	0,41	0,43	0,32	0,16	0,23	0,33
Training and Education	29	-0,28	0,14	0,08	0,24	0,29	0,31	0,15	0,24	0,22	-0,03	0,34
	30	-0,07	0,30	-0,05	0,43	0,02	0,49	0,29	0,24	0,22	0,14	0,34
	31	-0,30	-0,04	-0,09	0,21	0,24	0,29	0,11	0,21	0,03	-0,06	0,14
	32	0,01	0,13	0,13	0,15	-0,06	0,08	0,18	0,15	-0,15	-0,10	0,01
	33	-0,11	0,23	0,00	0,38	0,07	0,43	0,21	0,19	0,16	0,26	0,06
	34	0,05	0,28	0,28	0,31	-0,07	0,36	0,23	0,12	0,23	0,18	0,22
	35	0,09	0,27	0,13	0,26	0,09	0,40	0,17	0,49	-0,06	-0,02	0,44

Note: Questions 5, 22, 24, 27, 36, and 37 were not considered in the correlation analysis. Question 5 serves as a data quality control measure. Questions 22, 24, 27, 36, and 37, which focused on specifying the lean tools employed, were excluded to ensure the analysis maintains a broader scope.