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From People to Performance: Leveraging Soft Lean Practices for Environmental Sustainability in Large-Scale Production

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Abstract: Lean manufacturing can be considered a socio-technical system integrating both technical tools and human-centered, or soft, practices. While extensive research has examined technical aspects, the contribution of soft Lean practices focused on human behavior to environmental sustainability remains underexplored. This study addresses this gap by examining how soft Lean practices can help overcome barriers to environmental performance in large-scale production systems (LSPSs), using Italy's food manufacturing sector as a case study. A multi-case study methodology was employed, involving five companies. Data were collected through interviews conducted across top management, middle management, and operational staff levels to capture diverse perspectives. Using variables extracted from the literature and a deductive coding approach, the study identifies (1) the specific soft Lean practices adopted and the perceived environmental performance barriers at each hierarchical level, (2) differences in interpretation of these practices and barriers across hierarchical levels, and (3) how soft practices can mitigate obstacles to sustainable performance. The results demonstrate that soft Lean practices, when aligned with organizational structure and culture, can effectively mitigate barriers to environmental improvement. This research contributes to the Lean and sustainability literature by offering a multi-level perspective and practical insights into integrating human-centered approaches within industrial sustainability strategies.

Keywords: sustainability; barriers; social practice; people; lean manufacturing; large-scale production systems

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1. Introduction

Environmental sustainability has become a critical concern for manufacturing companies, especially those operating within large-scale production systems (LSPSs), which are characterized by extensive operations, complex hierarchies, and high resource consumption. These companies are under increasing pressure to address challenges such as rising energy and resource costs, environmental degradation, and stakeholder demands for sustainable practices [1]. As such, manufacturers must fundamentally rethink their strategies to reduce their environmental footprint and enhance sustainability performance [2]. Institutional forces, including international frameworks and national regulations, further compel firms to adopt environmental measures aimed at preserving planetary health and ensuring long-term viability [3,4]. Achieving sustainability in LSPSs is particularly complex due to the interdependencies among subsystems, spatial distribution of operations, and reliance on machinery and labor-intensive processes. These systems, such as those found in the food,

textile, and steel industries, face substantial barriers that impede the transition to more sustainable models [5]. In this context, Lean manufacturing emerges as a powerful approach, offering strategies to improve efficiency, reduce waste, and ultimately lower environmental impacts [6]. Empirical studies support the effectiveness of Lean in driving sustainability outcomes across diverse industrial settings [7]. Lean manufacturing is widely recognized as a socio-technical system encompassing both hard (technical) and soft (social) practices [8]. While hard practices focus on tools and processes, such as Kanban, cellular manufacturing, and quick changeovers [9], soft practices involve people-centric elements like leadership, empowerment, organizational culture, and collaboration [10]. These two dimensions are interdependent: the success of technical tools often hinges on the presence of enabling soft practices [11]. The recent literature highlights the connection between the soft dimension of Lean and environmental sustainability [12]. Some contributions emphasize that the cultural aspect of Lean can serve as a factor enhancing environmental performance [13]. Other studies suggest that soft practices act as enablers for achieving high environmental performance. In fact, in the absence of such practices, the effectiveness of hard Lean tools in addressing environmental sustainability challenges is significantly reduced [14]. Despite their critical role, soft Lean practices are often underutilized or misunderstood in large-scale manufacturing environments. Implementation failures are frequently attributed to the neglect of the social dimension, resulting in resistance, disengagement, and eventual regression to traditional systems [15]. While companies recognize the potential of soft practices, they often struggle to integrate them meaningfully into operational routines and decision-making frameworks [16]. This is because existing studies on the relationship between soft Lean practices and environmental sustainability have not thoroughly examined the mechanisms through which this relationship occurs. This gap is particularly significant in large-scale production systems (LSPSs), where organizational complexity and layered hierarchies hinder the implementation of people-oriented strategies. Therefore, it is crucial to explore how soft Lean practices can serve as enablers of environmental performance within the context of large production systems.

Gaps in the Literature and Research Questions

Despite the considerable importance of soft Lean practices, there are gaps in the current academic literature. The first macro gap is related to the difficulty of investigating this phenomenon, given the qualitative nature of soft practices [17]. Unlike Lean technical practices, where several studies show that some hard Lean practices have been key in improving environmental performance in production contexts, this is different for soft practices [18]. The soft Lean dynamics often manifest themselves within the perimeters of Lean projects. At the same time, companies encounter various barriers when developing Lean projects to improve environmental performance [19]. These obstacles inhibit the efforts of Lean projects, preventing companies from improving their performance [20]. Despite the complex dynamics involved in Lean projects, the current literature lacks studies that analyze how soft Lean practices can be a key factor in projects aimed at improving environmental performance. This aspect represents a great opportunity. To define how soft Lean practices impact the dynamics of Lean projects, they can be linked to the concept of barriers. In particular, to define how soft Lean practices can mitigate the barriers that manufacturing companies encounter during Lean projects to improve environmental performance [16]. Consequently, the first research question is RQ1: "How do soft Lean practices mitigate the barriers that large-scale production systems manufacturing companies face in improving environmental performance?" The second gap that has emerged from the literature on this topic is the different perceptions that different hierarchical figures within Lean projects may have on soft Lean practices. Since soft practices are based on human relationships and are

key levers for the success of lean initiatives, it is crucial to understand how different figures adopt and perceive these at various hierarchical levels. Very few studies have analyzed this aspect [21]. A significant gap remains in understanding the soft factors of Lean and how these are perceived within companies. The same is true for the perception of barriers. It is fundamental and still under-researched to analyze how difficulties related to improving environmental performance are perceived within companies [12]. The second question to research associated with this gap is RQ2: "How are soft lean practices and barriers perceived at different hierarchical levels?". To summarize, this study aims to examine the role of soft practices in mitigating barriers to improving environmental performance in the manufacturing context. Furthermore, the authors want to highlight differences in perceptions of these practices and barriers across hierarchical levels. To investigate this phenomenon, this article presents a multiple case study analysis. The authors selected five Lean environmental performance improvement projects implemented within five Italian food manufacturing companies. Each project represents a case of LSPSs characterized by complex operations and sustainability challenges. For each project, three people from different hierarchical levels were interviewed. In conclusion, to answer the two research questions, the article presents in Section 1 an overview of the research context. Section 2 will define a set of soft Lean practices and barriers, which will serve as input for the methodology part. Section 3 presents the case study section criteria and interview protocol. Next in the results section is the coding of the interviews. In Section 5, the results will be discussed to answer the research questions. Section 6 concludes with the implications of this research for academia and industry.

2. Theoretical Background

In this section, the authors present an overview of the research context through a literature review. In addition, the authors have defined two frameworks that are fundamental to the purpose of this article. The first framework combines soft Lean practices, while the second presents barriers to improving environmental performance. Both frameworks were extracted from a review of papers that analyze the topics covered. Subsequently, to ensure that the two frameworks have the right trade-off between completeness and non-redundancy of practices and barriers, they were validated by a pair of academic experts in the Lean sector. The academic experts involved have at least 10 years of experience in teaching and applying Lean culture concepts, and currently teach concepts related to the Lean management approach at a top European university. In both frameworks, the practices and barriers were divided into clusters. The clusters used in this study are clusters already present in the literature, cited in the following chapters. The subdivision of the clusters of practices and barriers is fundamental for greater clarity in the interpretability of the results of this study.

2.1. Soft Lean Practices

As mentioned earlier, soft lean practices, also referred to as "social" practices, focus on people and relationships [22]. In contrast, hard practices, or "technical" practices, relate to the technical tools and techniques of lean manufacturing [23]. Thanks to today's literature on this topic, it is possible to define a set of soft Lean practices divided into two macro clusters: Managerial and Employee (Table 1).

Managerial Cluster: This cluster includes management-oriented soft lean practices, focusing on strategic decision-making, corporate goal-setting, and effective communication. It represents the key activities required to successfully implement soft lean practices in the context of performance, providing key strategic and communication guidance. The following practices are included in this cluster.

- Communication: Communication is the set of methods and tools a company uses to transmit information, ideas, opinions, knowledge, and goals. It means communicating and informing about Lean manufacturing, listening to employees, elucidating the necessity for change, and cultivating a collective understanding of goals [24].
- Top management commitment: The extent to which top management can engage and motivate the organization by actively participating and dedicating time to continuous improvement initiatives [25].
- Working conditions: Working conditions form the basis of employment and working relationships, spanning a wide range of topics like working hours, minimum rest periods, work structuring, compensation and the psycho-physical conditions in work environment. This variable is connected to how employees perceive job safety, health, and stress [26].
- External consultants: Hiring an external consultant is particularly helpful in the early stages of implementation of Lean manufacturing, since they can provide methods and procedures and clearly define processes and procedures [25].
- Leadership: It is the ability to formulate, pursue, and achieve predefined objectives and strategic directions, involving workers at different hierarchical levels and maximizing efficiency through the communication of lean principles [25].
- Cultural mindset: To solve this issue, the idea is to create a Lean culture, which can be obtained through activities like monitoring, mentoring, and education [27,28].
- Financial/non-financial rewards: Financial rewards given to employees who have worked well pursuing Lean transition and non-financial rewards, like recognition for good performances, support the change and the processes used [28].

Table 1. Soft Lean practices framework.

Soft Lean Practices Clusters	Soft Lean Practices
Managerial Cluster	Communication Top management commitment Working conditions External consultants Leadership Cultural mindset Financial/non-financial rewards
Employee Cluster	Training and standardized work Employees' engagement Kaizen event Cross functional executive involvement Continuous improvement Teamwork Bottom-up/top-down approaches

Employee Cluster: This cluster includes soft lean practices focusing on employees' involvement and operational commitment to the organization. It includes activities to enhance employee participation and contribute to achieving corporate goals. The following practices are included in this cluster.

- Training and standardizing work: To carry on a lean project, organizations must train and standardize their employees [29].
- Employees' engagement: This means incentivizing the active participation of employees in the decision-making process, problem-solving, goal setting, planning, and performance monitoring. It positively affects the action alignment of lean manufacturing in day-to-day activities, resulting in higher sustainability performance [30].

- Kaizen event: It is a targeted and well-organized improvement project that involves a dedicated and cross-functional team to enhance a specific work area with clearly defined goals in an accelerated timeframe [28].
- Cross-functional executive involvement: It is a strategic approach adopted in organizations that involves individuals from different departments working together on projects, breaking down traditional silos, and promoting teamwork among employees with diverse expertise [30].
- Continuous improvement: It is a systematic approach aimed at improving efficiency and quality through continuous and incremental improvements in production processes. It is based on active employee participation [23].
- Teamwork: It is a term employed when individuals involved in a project, team members, or different segments of a company collaborate to attain a shared objective [25].
- Bottom-up–top-down approaches: The bottom-up approach is a decentralized control structure that improves personal involvement and moves decision-making downward in the company where the information exists. In other words, it consists of the active participation of employees in identifying issues and proposing solutions that sustain and speed up the lean transition [31]. Instead, the top-down approach relies on employing specialized techniques to accomplish specific goals; it involves the implementation of solutions that have been defined and examined by a limited group of experts [12].

2.2. Barriers Related to Improvement of Environmental Performance

To achieve a clear overview of the difficulty manufacturing companies face in improving their environmental performance, the authors developed a literature review to select a set of barriers. The barriers selected in the final framework fall into five macro-categories: Human Resources, Knowledge, Economics, Managerial, and Technology (see Table 2).

Table 2. Barriers framework.

Barriers Cluster	Barriers
Human Resource Barriers	Resistance to change Lack of employee involvement Lack of cooperation between departments Lack of skilled labor, expertise, and qualified graduates Cross-functional conflict
Knowledge Barriers	Lack of environmental knowledge Lack of Lean thinking Dysfunctional corporate culture Poor educational activities
Economic Barriers	Economic constraints Lack of awareness of economic benefits Long delays in achieving economic results
Managerial Barriers	Lack of top management support Lack of guidance Lack of CI guidelines Lack of continuous assessment of SDG
Technology Barriers	Poor process uniformity Absence of a precise monitoring and control system Poor infrastructure and lack of resources

Human Resources barriers involve specific obstacles related to human resource management in environmental sustainability, focusing on people and their relationships, both personal and project-related.

- Resistance to change: Traditional practices are being adopted by industries operating for a very long time; the organizations' members show resistance to change toward a sustainable culture [32].
- Lack of employee involvement: Navigating this process can be lengthy and challenging. Therefore, fostering engagement and active participation in these projects is crucial to ensure their successful completion [33].
- Lack of cooperation between departments: Communication and collaboration between departments is the most important factor for managing change and making people participate in daily enhancement activities [34].
- Lack of skilled labor, expertise, and qualified graduates: Human resources have been identified as one of the most important resources of any organization seeking success and undertaking change processes [34].
- Cross-functional conflict can arise in a company when employees from different functions or departments collaborate on common projects. These tensions may stem from divergent goals, procedures, or visions, impacting synergy [19].

Knowledge barriers concern specific skill-related obstacles regarding practices and knowledge about environmental sustainability. These barriers include the difficulty of closing the knowledge gap across hierarchical levels. Addressing these barriers is essential to implementing sustainability-oriented successfully.

- Lack of environmental knowledge: In the context of lean manufacturing for improving environmental performance, it refers to the need for more specific expertise on the ecological impacts of production processes. This deficiency limits the ability to adopt and implement lean practices that optimize both operational efficiency and environmental sustainability, thereby compromising the achievement of corporate sustainability goals [35].
- Lack of lean thinking: It denotes a need for adherence to the fundamental principles of lean methodology. This condition arises when an organization needs to fully and effectively integrate concepts such as waste elimination and continuous improvement [35].
- Dysfunctional corporate culture: Organizational culture is fundamental to implementing lean manufacturing to improve environmental performance [36].
- Poor educational activities: Particularly in today's context, where industries are predominantly customer-driven, and customers prioritize sustainability, it is imperative to offer comprehensive training to both employees and clients on sustainable practices and their associated benefits [33].

Economic barriers are specific barriers related to financial resources when implementing projects related to environmental issues. These barriers include the challenges of economic planning.

- Economic constraints: Implementing Lean manufacturing within an organization will bring paradigm shifts in the industry, so investment is needed to incorporate these changes. In many cases, organizations do not provide sufficient funds for environmental activities [33].
- Lack of awareness of economic benefits: It is a significant barrier for companies adopting Lean manufacturing to enhance environmental performance. This issue arises when companies involved in these projects need to fully understand how these activities can lead to long-term economic benefits [16].
- Long delays in achieving economic results: Prolonged lead times needed to achieve economic benefits can hamper the effectiveness of environmental projects, which may deter companies from committing to these initiatives [37].

Managerial barriers: This cluster includes the challenges associated with management and organizational commitment, focusing on leadership support and manager commitment as pivotal elements.

- Lack of top management support: This includes a lack of long-term vision, organizational culture, commitment, implementation strategies, and inefficient policies from the management team that will be likely to fail these initiatives [38].
- Lack of guidance: The absence of strong leadership complicates the implementation process, leading to decreased engagement levels among team members and a lack of coordination between objectives and the organization's strategic goals [32].
- Lack of CI guidelines: It refers to the condition in which an organization needs formal guidelines, structured methodologies, or defined protocols that support and guide the continuous improvement process aimed at reducing environmental impact [39].
- Lack of continuous assessment of SGGs: This lack prevents the company from effectively evaluating the impact of its environmental projects and initiatives, making necessary course corrections, and ensuring the sustainable achievement of established environmental objectives [36].

Technology barriers: This cluster covers specific obstacles to adopting and integrating technologies for projects related to environmental issues. These barriers include the challenge of selecting and implementing advanced technologies that support more sustainable projects.

- Absence of a precise monitoring and control system: To effectively drive transformation, it is crucial to measure, monitor, and maintain control over data, employees, and processes [40].
- Poor infrastructure and lack of resources: In contrast, inadequate infrastructure diminishes the confidence of involved individuals and hampers the pace of the implementation process. Similarly, a low availability of resources, people, materials, and technologies delays the development of the process and its benefits. In addition, poor estimation of project costs creates an inaccurate distribution of resources and inaccurate financial information that affects the decision-making process [32].
- Poor process uniformity: Within companies, it is common to find variety in different areas, such as in processes, production, and the practices adopted. However, standardization and uniform programming help to minimize this variability and disparities, helping to reduce waste and the need for rework activities [41].

3. Methodology

This section shows how the authors investigated the phenomenon under analysis in this article. To answer the research questions, the authors analyzed multiple case studies of Italian companies in the food sector that have developed a Lean project framework for improving environmental performance. Thanks to the multi-case study approach, it was possible to obtain external validity of the theory. In addition, case study analysis minimizes observer bias, allowing for more robust and testable directions to be determined [42]. The steps in this methodology are divided into three parts: (i) case study selection—identifying criteria to have a reliable case study sample; (ii) data collection—how to collect data to extract insights from the case studies; (iii) content analysis—what approach to use to extract insights from the collected data [43].

3.1. Case Study Selection and Description

To minimize the contextual factors related to the analysis of multiple case studies, a set of companies with the following homogeneity factors was selected [44]. These factors

identify the analysis context of all case studies. Context factors for case study selection include the following:

- Company size: Large multinational companies operating in multiple countries with over 100 employees and over 50 million in revenue.
- Manufacturing sector: Food.
- Geographic area: All case studies were conducted in production facilities in Italy.
- Duration of the Lean project: All case studies have a defined analysis timeframe. The analysis focuses on Lean projects lasting 1 to 2 years.
- Successful Lean implementation:
    - Case studies analyze projects using Lean methodology to improve a specific environmental performance.
    - Case studies are considered successful when, by comparing environmental performance before and after the Lean project, the company has observed an improvement of at least 15% in the eco-efficiency indicator related to the analyzed environmental performance.

Once the contextual factors were identified, five different case studies were selected and analyzed. Five descriptive variables define each chosen case study:

- Environmental performance: Each selected case study analyzes a specific environmental performance that the company has sought to improve.
- Eco-efficiency index: Each environmental performance is linked to an eco-efficiency indicator constructed from economic and environmental impact components.

The data presented in Table 3 were extracted from the final presentations of the activities of the five analyzed projects. In particular, the project presentations show the steps through which each project was carried out, and quantitatively measure the AS-IS and TO-BE level of the environmental performance under analysis. The characteristics describing the companies in Table 3 show how the analyzed case studies are different from each other but, at the same time, share the same contextual factors. The factor that makes the final sample of case studies heterogeneous is related to environmental performance and the analyzed eco-efficiency indicator. Each case study explores different performances and eco-efficiency indices. Both the soft Lean practices and the barriers to implementation identified through the literature review, and subsequently studied in the analysis of case studies, act transversely on all environmental performances. Therefore, it is interesting to have a set of case studies covering a wide range of environmental performances, thus making the results generalizable and not focused on a single environmental performance. As anticipated, the selected case studies belonged to the food sector and were chosen to be both comparable for more accurate comparisons and diversified in terms of improved environmental performance through the implementation of the Lean project in question. In describing the case studies, the five companies will be referred to as Company A, Company B, Company C, Company D, and Company E.

Table 3. Case studies final sample.

Company	Barrier	Eco-Efficiency Index	Duration of the Project (Years)	Performance Improvement of Eco-Efficiency Index (%)
A	Energy consumption	Output produced per day (units)/ Energy used per day (KW)	1.5	15
B	Plastic consumption	Output produced per day (units)/ Plastic Packaging waste generated per day (kg)	1	35

Table 3. *Cont.*

Company	Barrier	Eco-Efficiency Index	Duration of the Project (Years)	Performance Improvement of Eco-Efficiency Index (%)
C	Air emissions	Output produced per day (units)/ CO_2 emissions (kg)	1	15
D	Water consumption	Output produced per day (units)/ Water use for one output (L)	2	27
E	Toxic/hazardous chemical waste	Output produced per day (units)/ Surfactants (kg)	1	35

3.2. Data Collection

To collect data, semi-structured interviews were conducted from the selected case studies with people involved in Lean projects from each company. Three people were interviewed for each company, each belonging to a different hierarchical level. The three hierarchical levels are top management, middle management, and operators. Top management are the highest-level executives in the organization and are responsible for setting the overall corporate strategy. They make crucial decisions that affect the entire company and are accountable for achieving strategic goals. Middle management serves as liaisons between top managers and operators. They translate top managers' strategies and directives into concrete operational plans and successfully manage teams to implement initiatives. Operators are the line workers who perform daily tasks and operate directly on production processes. They are closest to practical operations and often possess detailed knowledge of processes and potential inefficiencies. Specifically, the people interviewed hold different roles in the company according to their hierarchical level, as shown in Table 4. The diversity of people interviewed allowed for a wider range of viewpoints. Because of this diversity, it was possible to understand better how people with different roles interpreted, perceived, and participated in the various projects. Each interviewee provided a distinct point of view on the Lean project and its consequences based on their hierarchical positions and responsibilities.

Table 4. Roles of people interviewed.

Barriers Cluster	Barriers
Top manager	General manager Operation manager Director of production Plant manager Head of different departments
Middle manager	Continuous improvement manager Shift manager Production manager
Operator	Line operators Line managers

The interviews were conducted in a semi-structured way; that is, each respondent was asked questions about the Lean project under analysis. However, interviewees could also speak freely and express their desired concepts beyond the specific questions. This approach allowed for the collection of more complete and in-depth information, thus enriching the data analysis. All the interviews lasted approximately 40–50 min. The questions were divided into two main clusters. The first part of the interview focused on analyzing what and how soft Lean practices played a role during the Lean project. The second part was devoted to understanding what and how barriers led to difficulties in improving the project's environmental performance. The questions were tailored according

to the hierarchical level. Before proceeding to the interview related to soft practices and barriers, introduction questions were developed to obtain an overview of the company, understand the role of the interviewee, and explain the successful lean project implemented by the company to achieve environmental sustainability goals. At this stage, details were also requested regarding the environmental performance that the project aimed to improve, the numerical levels of this performance before and after the project, whether the improvement goal was achieved, and whether the company planned to continue using this approach in the future.

3.3. Content Analysis

The interviews conducted for each case study were recorded and then transcribed to be able to do the coding. Coding is a methodological process of tagging and synthesizing specific sections of the text of an interview through the assignment of keywords or representative concepts. This process is essential for converting unstructured qualitative data, obtained during interviews into structured data, systematically organized, and ready for analysis [45]. Due to their semi-structured nature, deductive coding was adopted for the interviews. Deductive coding is an analytical approach that applies predefined categories and concepts based on existing theories and models to the qualitative data collected. This method involves using a pre-established theoretical framework to guide data analysis and validate the emergence of themes and variables defined in the research design phase [46]. In the context of this research, the two previously developed frameworks were used to perform deductive coding. The first framework concerns soft lean practices; the second focuses on barriers. During the deductive coding phase, the data collected through the interviews were coded using these two frameworks. Thus, soft practices and barriers were used as the main codes. Extracts from the interviews were initially categorized into first-order concepts, which are first-order concepts that emerge directly from the data. Next, these first-order concepts were linked to framework labels (soft lean practices and barriers) to identify recurring themes and significant variables for analysis.

4. Results

The following section presents the results of the interviews conducted in the five case studies. The results presented in the following sections derive from the coding of the interviews conducted. Through deductive coding, the authors were able to determine whether each practice and barrier belonging to the previous frameworks was used or experienced by each interviewee.

4.1. Soft Lean Practices Results

Detailed results regarding soft practices are now reported and presented through a table structured by clusters and hierarchical levels. This representation is derived from the coding of the interview transcripts, where an "X" is present, which means that the practice was used at least once by at least one of the interviewees (Table 5). Generally, all soft practices were used, except teamwork in top managers and financial/non-financial rewards in operators. Their higher decision-making and strategic role can explain top managers' need for teamwork practice. They might delegate the implementation of collaborative activities to lower-level middle managers and operators, focusing rather on broader and more strategic decisions. As for operators, the non-use of financial/non-financial rewards could be explained by the rewards not being given to lower levels for achieving specific goals. In his or her position, the operator might be more focused on the practical implementation of decisions made at higher levels, putting strategies into practice and helping to implement projects without necessarily receiving specific financial or non-financial incentives. The

next step was to analyze how many soft practices related to the different clusters were used for each hierarchical level to see if there were any clusters in which no soft practice was used by all the hierarchical levels considered. Table 6 reveals an interesting fact: no soft practice belonging to each cluster is unused. Middle managers have used all available soft practices, explaining this phenomenon; "unmanaged soft practices per category" refers to soft practices that none of the three hierarchical levels has adopted. Finally, to make the analysis more visually accessible, the percentages of soft practices used—divided by cluster on the three hierarchical levels—were represented graphically (see Figure 1). As can be seen, middle managers used all soft practices, while, as reported earlier, top managers and operators did not.

Table 5. Soft Lean Practices emerged per the hierarchical level.

Clusters	Soft Lean Practices	Top Manager	Middle Manager	Operator
Managerial Cluster	Communication	X	X	X
	Top management commitment	X	X	X
	Working conditions	X	X	X
	External consultants	X	X	X
	Leadership	X	X	X
	Cultural mindset	X	X	X
	Financial/non-financial rewards	X	X	---
Employee Cluster	Training and standardized work	X	X	X
	Employees' engagement	X	X	X
	Kaizen event	X	X	X
	Cross functional executive involvement	X	X	X
	Continuous Improvement	X	X	X
	Teamwork	---	X	X
	Bottom-up/Top-down approaches	X	X	X

Figure 1. Emerged soft practices per hierarchical level and clusters (%) graph.

Table 6. Distribution of soft Lean practices emerged per hierarchical level and clusters.

Cluster	Emerged Practices per Hierarchical Level			Emerged Practices per Hierarchical Level (%)			
	Top Manager	Middle Manager	Operators	Top Manager	Middle Manager	Operators	Total Soft Practices per Clusters
Managerial	7	7	6	100%	100%	86%	7
Employee	6	7	7	86%	100%	100%	7
Total	13	14	13				14

4.2. Barriers Results

Below are the barrier results, organized in a table that distinguishes between hierarchical levels and clusters. The representation of barriers in this table results from coding the interviews conducted. The table uses the symbol "X" to indicate the presence of a perceived barrier: If at least one of the respondents encountered the barrier, an "X" is placed in the corresponding cell (see Table 7). If there is no such symbol, it means that none of the respondents reported the presence of that specific barrier. As can be seen from the table, the two hierarchical levels that perceived the most barriers were top managers and middle managers. These two groups identified barriers widely, covering all clusters analyzed. In particular, top managers reported a wide range of barriers, indicating a broad perception of difficulties in the organization. Middle managers also noted many barriers, reflecting their intermediate position and the need to interface with different levels of the organization. In contrast, operators perceived only half as many barriers as the other two hierarchical levels. Interestingly, the barriers identified by operators are limited to three specific clusters, excluding the economic and managerial clusters. The next step was to figure out, for each hierarchical level, how many barriers were perceived for each cluster to achieve a more in-depth analysis. Table 8 clearly shows a significant difference in the perception of barriers among the various hierarchical levels. In particular, top managers perceived 14 out of 19 barriers, middle managers identified 13 out of 19 barriers, and operators recognized only 7 out of 19 barriers. This disparity in the perception of obstacles points to a difference in the experiences and perspectives of the different hierarchical levels, which will be studied and explored in subsequent chapters. In addition, the table also shows how many barriers did not emerge in each cluster, representing barriers not perceived by any of the hierarchical levels. It can be seen that in only one cluster were all barriers perceived, while in three other clusters, the absence of a barrier was noted. Finally, in one cluster, two barriers were not perceived. This provides additional insights that will be analyzed in more detail in later sections. Thanks to Figure 2, it is possible to observe again the difference in the perception of barriers between the various hierarchical levels. An interesting aspect is the similarity in the trend of perceived barriers between the top two hierarchical levels, top managers and middle managers. In addition, the technology cluster emerges as the only one completely perceived by top and middle managers, and it also has a high percentage of perceived barriers by operators.

Table 7. Barriers emerged per the hierarchical level.

Clusters	Barriers	Top Manager	Middle Manager	Operator
Human Resource Barriers	Resistance to change	X	X	X
	Lack of employee involvement	X	X	X
	Lack of cooperation between departments	X	X	---
	Lack of skilled labor, expertise and qualified graduates	X	X	X
	Cross-functional conflict	---	X	---
Knowledge Barriers	Lack of environmental knowledge	---	---	---
	Lack of lean thinking	X	X	X
	Dysfunctional corporate culture	X	X	X
	Poor educational activities	X	X	
Economic Barriers	Economic constraints	---	---	---
	Lack of awareness of economic benefits	X	X	---
	Long delays in achieving economic results	X	X	---

Table 7. *Cont.*

Clusters	Barriers	Top Manager	Middle Manager	Operator
Managerial Barriers	Lack of top management support	X	---	---
	Lack of guidance	X	---	---
	Lack of ci guidelines	---	X	---
	Lack of continuous assessment of SDG	---	---	---
Technology Barriers	Poor process uniformity	X	X	X
	Absence of a precise monitoring and control system	X	X	X
	Poor infrastructure and lack of resources	X	X	---

Table 8. Distribution of barriers emerged per hierarchical level and clusters.

Cluster	Emerged Barriers per Hierarchical Level			Emerged Barriers per Hierarchical Level (%)			
	Top Manager	Middle Manager	Operators	Top Manager	Middle Manager	Operators	Total Barriers per Clusters
Human Resources	4	5	3	80%	100%	60%	5
Knowledge	3	3	2	75%	75%	50%	4
Financial	2	2	0	67%	67%	0%	3
Managerial	2	1	0	50%	25%	0%	4
Technology	3	3	2	100%	100%	67%	3
Total	14	14	7				19

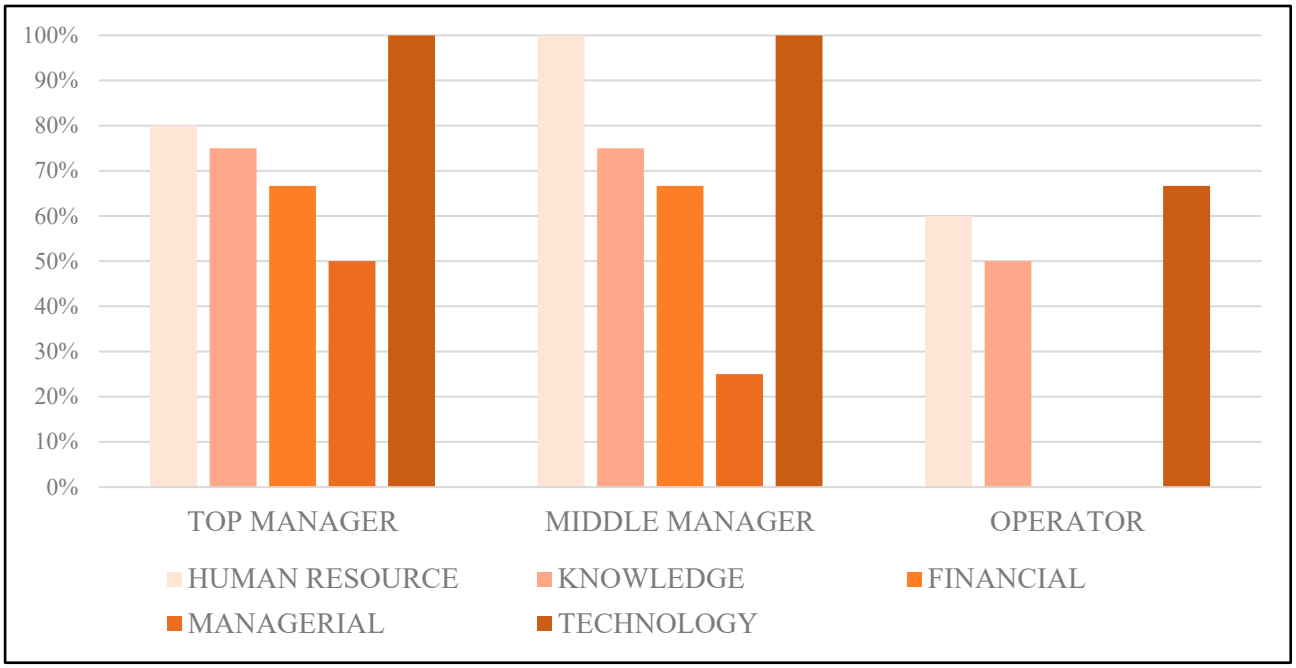

Figure 2. Emerged barriers per hierarchical level and clusters (%) graph.

5. Discussion

Through the coding of the interviews, the authors were able to gain several insights useful for achieving the objectives of this research. In this section, the research results will be critically discussed with the aim of bringing to light new knowledge on the role of Lean soft practices.

5.1. Different Perceptions of Hierarchical Levels of Soft Practices and Barriers

The first relevant insight that emerged from the interviews concerns how soft practices and barriers were used and perceived. To identify the different perceptions of hierarchical

levels of soft practices and barriers, Figure 3 is presented. It provides a more comprehensive overview of the results of the interviews related to the various case studies. Figure 3 provides a clear and immediate view of trends in soft practices and perceived barriers. Figure 3 is divided into the five case studies, each analyzed at the level of the three hierarchical levels. In Figure 3, an "X" indicates that a soft practice or a barrier was perceived. It is easy to see a similar trend among the different case studies and the difference between soft practices and barriers. In particular, soft practices were almost all used, while barriers were perceived to a lesser extent. The final step was to calculate the frequencies of soft practices and barriers. By "frequencies", we mean the number of times out of the five case studies analyzed that soft practices were used, and the number of times barriers were perceived for each hierarchical level. The total frequency in Figure 3 represents the number of times soft practices or barriers came up in the different interviews. The maximum possible value is 15, as three people from each of the five companies were interviewed. This calculation provides a quantitative measure of the adoption of soft practices and the perception of barriers, allowing a more accurate assessment of their prevalence and relevance at each hierarchical level.

Legend: Top manager = T.M. ; Middle Manager = M.M. ; Operator = O.		Case A			Case B			Case C			Case D			Case E		
		T.M.	*M.M.*	*O.*	*T.M.*	*M.M.*	*O.*	*T.M.*	*M.M.*	*O.*	*T.M.*	*M.M.*	*O.*	*T.M.*	*M.M.*	*O.*
Soft Lean Practices	*Communication*	X	X	X	X	X		X	X	X	X	X	X	X	X	X
	Top management commitment	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
	Working conditions			X	X	X	X				X	X	X			
	External consultants	X	X	X	X	X		X	X	X	X	X	X	X	X	
	Leadership	X	X	X		X		X		X	X	X	X	X	X	X
	Cultural mindset	X	X	X	X	X	X		X	X		X		X	X	
	Teamwork		X	X		X	X		X	X		X				
	Training & standardized work	X	X	X	X	X	X		X	X	X		X		X	
	Employees' engagement	X	X	X	X	X	X		X	X		X	X	X	X	X
	Kaizen event	X	X	X	X	X										
	Financial/non-financial rewards				X	X		X			X			X	X	
	Bottom-Up / Top-Down approaches		X	X	X	X	X						X	X	X	
	Cross functional executive involvement	X	X	X	X				X	X			X	X	X	X
	Continuous Improvement	X	X	X	X	X		X	X	X	X	X	X	X	X	X
Barriers	*Resistance to change*					X		X		X		X	X	X	X	X
	Lack of employees involvement	X			X	X		X					X			
	Lack of cooperation between departments				X	X										
	Lack of skilled labour, expertise and graduates' people				X					X	X	X	X	X	X	
	Cross-functional conflict														X	
	Lack of environmental knowledge															
	Lack of Lean thinking		X	X		X		X	X	X	X	X		X	X	
	Dysfunctional corporate culture				X	X		X			X	X	X			
	Poor educational activities							X	X							
	Lack of CI guidelines					X									X	
	Lack of continuous assessment of SDG															
	Economic and financial constraints															
	Lack of awareness of economical benefits							X						X	X	
	Long delays in achieving economic results	X			X	X								X	X	
	Lack of top management support	X			X						X					
	Lack of guidance	X			X											
	Poor process uniformity	X	X	X	X	X	X	X	X	X						X
	Absence of a precise monitoring and control system		X	X				X								
	Poor infrastructure and lack of resources				X	X										

Figure 3. Soft practice and barriers total frequency per case study.

After the frequencies were calculated, the data obtained were plotted to analyze the trend graphically. Figure 4 shows the frequency for each soft Lean practice investigated in the study. As shown in Figure 4, none of the practices were perceived by the entire population surveyed (in fact, no practice has a frequency of 15). The graph in Figure 4 shows that there is no dominant cluster of practices. Nevertheless, the frequency of soft Lean practices is evenly distributed over each practice and for each hierarchical level. If we calculate the frequency of perception by hierarchical level, we notice that the values are very close. In particular, the number of soft practices reported by top managers was 46, by middle managers 54, and by operators 45. The centrality of the middle manager

is shown in this analysis. In fact, the hierarchical figure perceives and consequently uses soft practices the most during the interviews. The high overall perception of soft practices may be related to the characteristics shared by the companies involved in the analysis. As shown above, all case studies were selected in companies where Lean projects have been developed for at least one year. Furthermore, all the case studies found a significant performance improvement. Consequently, the intense positive perception of soft practices is related to the good implementation of Lean culture in the analyzed companies.

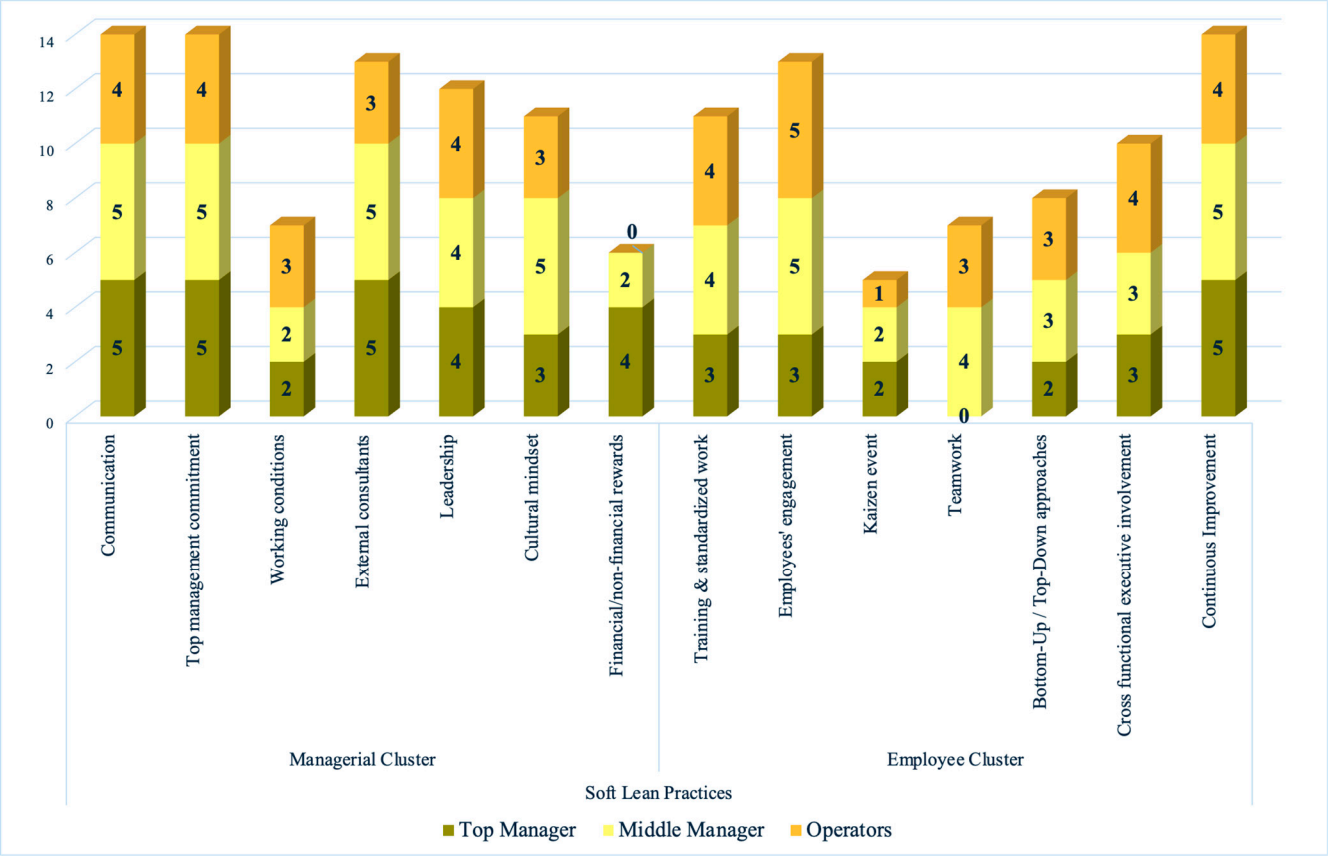

Figure 4. Frequency of soft Lean practices.

Similarly, Figure 5 shows the frequencies of perceptions of barriers. In contrast to practices, barriers have lower frequencies. In addition, the frequencies are unevenly distributed among the various barriers. If we analyze the frequencies for each hierarchical level, the authors discover that Top managers and middle managers perceive barriers more than operators. Top managers perceive twice as many barriers as operators, with a total frequency of 31 for Top managers compared to 14 for operators. Notably, no operators interviewed reported experiencing problems with barriers in the Economic and Managerial clusters. It must be noted, however, that, in general, the Economic and Managerial clusters are the least perceived clusters overall. This may indicate a good awareness of the economic benefits of Lean projects for environmental sustainability and reflects good managerial leadership in the companies surveyed. On the other hand, the greatest concerns, especially from top and middle managers, are related to the barriers in the Human Resources, Knowledge, and Technology clusters. This shows the fear of the higher hierarchical levels in managing projects that involve human resource management, of the need for Lean knowledge, and the integration of new technologies in the market. To summarize, we can say that soft practices are uniformly perceived by all hierarchical levels, with by middle managers perceiving them more strongly. On the other hand, barriers

are less frequently perceived, and, in addition, all hierarchical levels do not uniformly perceive them. Operators, in particular, perceive fewer than half the barriers compared to top managers when considering the absolute frequency of these barriers.

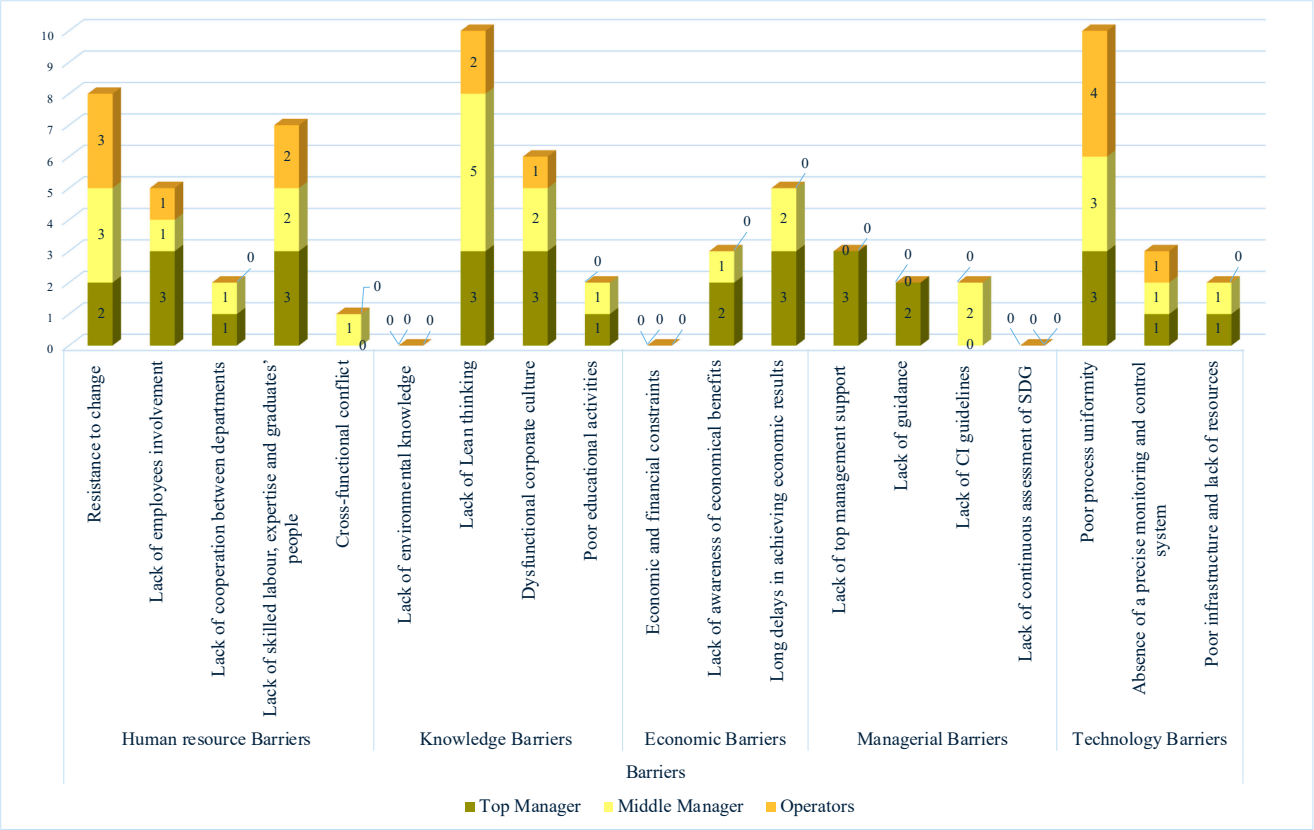

Figure 5. Frequency barriers.

5.2. How Soft Practices Mitigate Barriers: Developing Mechanisms

To respond to the main objective of this study, that is to understand the role of Lean soft practices in overcoming barriers related to the improvement of environmental performance, the authors interpreted the impact of soft practices on the barriers. To provide a clear vision of the role of soft practices, it was necessary to identify a link between Lean soft practices and the barriers. To identify this connection, it was necessary to go back to the coding of the interviews. For each hierarchical figure, each soft practice was linked to specific barriers to implementation. This was achieved following the results of the coding of the interviews. This made it possible to identify which practices were best suited to mitigate each barrier. The links between soft practices and barriers were filtered and compared with the interview testimonies for further verification. The links between practices and barriers were defined, assigning a name and description to each group. Following this approach, the soft practices have been linked to the barriers for each hierarchical figure through specific organizational mechanisms. These organizational mechanisms represent the way in which soft practices mitigate the barriers to the implementation of lean manufacturing to improve environmental performance. In fact, each mechanism represents and describes how the soft practices for each link category mitigate the relevant barriers. The mechanisms were formulated to make the causal explanations between soft practices and barriers more explicit. Each mechanism provides information on how certain practices succeed in mitigating certain obstacles, offering a deeper understanding of their mitigating effect. In total, seven different themes were identified. Not all mechanisms are shared between the three hierarchical figures because the results of the coding vary with respect to the hierarchical figure. The

middle manager is the only hierarchical figure to share mechanisms with the other two figures. The interviews showed that, in the implementation of lean manufacturing for the improvement of environmental performance, the middle manager acts as a bridge between the top managers and the operators. Based on the information obtained from the coding of the interviews, it was decided to define one theme for the top manager position, two themes shared between the top manager and the middle manager, three themes shared between the middle manager and the operators and one theme belonging only to the operator figure. The soft Lean practices and the barriers associated with each mechanism are shown in Table 9. Each mechanism extracted from the interviews is based on specific organizational theories. Below are definitions for each mechanism. Each mechanism is paired with one established theory that frame the underlying organizational dynamics. To better express empirically the value of the identified mechanisms, a quote expressed during the interviews was associated with each of them.

Table 9. Overview of the mechanisms developed.

Hierarchical Levels Involved	Mechanisms	Organizational Theories	Soft Lean Practices Exploited	Mitigated Barriers
Top manager	Promotion of operational resourcefulness	Absorptive Capacity Theory	Working conditions Training and standardized work Employee engagement Leadership Cultural mindset Financial/non-financial rewards	Lack of skilled labor, expertise and qualified graduates Poor educational activities Poor process uniformity Absence of a precise monitoring and control system
Top manager – Middle manager	Promotion of inter-functional proactivity	Social Practice Theory	Employee engagement Kaizen event Cross functional executive involvement Continuous improvement Bottom-up/Top-down approach	Lack of cooperation between departments Dysfunctional corporate culture Lack of guidance Poor infrastructure and lack of resources
Top manager – Middle manager	Clarification of common goals to achieve environmental performance	Goal-Setting Theory	Communication Top manager commitment Cross functional executive involvement Teamwork Bottom-up/Top-down approach	Resistance to change Lack of employee involvement Lack of cooperation between departments Lack of lean thinking Lack of awareness of economic benefits Long delays in achieving economic results Lack of top management support
Middle manager – Operator	Change management process	Change Model	Communication Top manager commitment External consultants Training and standardized work Continuous improvement Leadership Cultural mindset	Resistance to change Lack of lean thinking Dysfunctional corporate culture Lack of guidance Absence of a precise monitoring and control system
Middle manager – Operator	Development of technical skills	Organizational Learning Theory	Working conditions External consultants Training and standardized work	Lack of skilled labor, expertise and graduates' people Poor educational activities Absence of a precise monitoring and control system Poor infrastructures and lack of resources
Middle manager – Operator	Adaptation to the lean approach to support Eco-Performances	Social Practice Theory	Training and standardized work Kaizen event Continuous improvement Financial/non-financial rewards	Lack of lean thinking Lack of CI guidelines Poor process uniformity

Table 9. *Cont.*

Hierarchical Levels Involved	Mechanisms	Organizational Theories	Soft Lean Practices Exploited	Mitigated Barriers
Operator	Incentive for operational proactivity	Empowerment Theory	Employee engagement Cross functional executive involvement Leadership Teamwork Bottom-up/Top-down approach	Resistance to change Poor process uniformity Absence of a precise monitoring and control system

Promotion of operational (top manager): This mechanism aligns closely with the Absorptive Capacity Theory, which explains an organization's ability to identify, assimilate, and apply external knowledge [47]. Top managers encourage and supports the innovation, creativity, and autonomy of people within an organization during project implementation. It involves fostering an enterprising mindset among team members, ensuring involvement, collaboration, support, and guidance for both individuals and functions. This mechanism is specific to top managers, as only at this level do they have the strategic vision needed to push employees to explore new opportunities and drive continuous change within the organization.

> *Top manager quote: "One of the objectives in every project is to create a leader within the team [. . .] Pro-active participation was requested from the beginning. This project is in the hands of Middle Managers. I was involved in the initial phase and then left as the project progressed".*

Clarification of common objectives (top manager and middle manager): This mechanism can be understood through the Goal-Setting Theory [48]. This mechanism ensures alignment of all team members on the same goals, preventing misunderstandings, especially on environmental performance goals. It involves top and middle hierarchical levels: top managers set strategic directions, while middle managers facilitate communication and ensure that each member understands his or her role. This transparent collaboration creates a sense of shared responsibility and common commitment to project success, with a focus on environmental performance.

> *Top manager quote: "When I made the data available (related to the goal of achieving environmental performance), with graphs and numbers [. . .] so the managers knew how the project was going and what the goal was. I saw that the increase in the result was significantly better, so I realized that I had to try to be as transparent as possible".*

Promotion of inter-functional proactivity (top manager and middle manager): This mechanism reflects the principles of the Social Practice Theory [49]. This mechanism promotes collaboration between different functions and individuals in the organization, fostering a proactive work environment. It is assigned to higher hierarchical levels as top managers define the strategic and cultural vision. In contrast, middle managers facilitate operational implementation, ensuring that communication and collaboration between departments is effective for project success.

> *Middle manager quote: "Various staff members were involved in the project. I would say that the various teams of operators worked in synergy. At the beginning it was a bit difficult for me to coordinate the different teams, but with time it improved, as soon as you see the results you can see that the work went much better".*

Adaptation to the lean approach to support environmental performances (middle manager and operator): This mechanism is best interpreted through the lens of the Social Practice Theory [49], which focuses on how shared routines, norms, and behaviors shape

organizational action. This mechanism enables the integration and adaptation of Lean principles into a work environment, promoting a culture of collaboration and involvement to improve environmental performance. It is assigned to middle managers, who lead the process and facilitate training, and operators, who apply it directly. This combination ensures gradual and sustainable change, minimizing resistance and meeting environmental goals.

> *Middle manager quote: "In agreement with the Top Manager, the protocols were optimized, and after conducting several tests, I drew up a written protocol. This document was placed near the corresponding machinery, making it easily accessible to everyone".*

Development of technical skills (middle manager and operator): This mechanism corresponds with the Organizational Learning Theory [50], which highlights the importance of continuous learning and capability-building in adapting to new challenges. This mechanism aims to fill practical and technical gaps during the implementation of new projects, focusing on operators who directly execute activities. Middle managers support implementing training programs and process standardization while operators apply these solutions. This approach ensures that operators acquire the necessary skills and that processes are optimized, improving overall team productivity.

> *Middle manager quote: "In the first phase of the project we realized that we lacked skills. We (middle managers and operators) participated in boot camps and training activities on quality, training on Lean principles and 5S".*

Change management process (middle manager and operator): The dynamics of change management observed at this level correspond to classical models, such as the Change Model proposed by [51]. This mechanism is crucial to project success and focuses on lower hierarchical levels, such as middle managers and operators. It aims to reduce resistance to change and promote a mindset of continuous improvement. Middle managers provide support and guidance while operators apply changes in the field, ensuring that the project proceeds without significant obstacles and that staff are prepared for challenges.

> *Middle manager quote: "At the beginning they certainly start a little more slowly [. . .] getting someone who has been doing something for many years to change an action is complicated at first. But as soon as they realize (the operators) that the new action leads to better results, both in terms of environmental performance and because it improves the way they work, they welcome the change. They (the operators) now find their daily tasks less tiring. They have noticed an improvement in their tasks, not only in terms of fatigue, but also in terms of the time it takes them to do the same thing they did before".*

Incentive for operational proactivity (operator): This mechanism, supported by the Empowerment Theory, emphasizes autonomy, competence, and relatedness as motivators of behavior [52]. This mechanism stimulates active participation and involvement of operators in the project, creating a collaborative and proactive culture. It encourages the free expression of ideas and increasing the team's sense of ownership and satisfaction. It belongs exclusively to the level of the operators because they must be the ones who directly participate and feel valued, thus contributing to the overall effectiveness and efficiency of the project.

> *Operator quote: "We made procedures for everything. We divided the work among the whole team. So, the whole team participated in defining the new way of doing certain activities. It's not that one person does that job, and the others have to watch. We tried to involve everyone, because these new activities impact everyone's work".*

This study significantly advances our understanding of how soft Lean manufacturing practices mitigate barriers encountered by manufacturing companies aiming to enhance environmental performance. As elaborated in the discussion, the deductive coding of

interviews facilitated the identification of specific organizational mechanisms linking soft practices to corresponding barriers. These organizational mechanisms function as critical constructs, connecting defined actions, represented by soft practices, to clearly identified problems, described by barriers. In particular, the interviews revealed that specific soft practices activate organizational mechanisms capable of mitigating precise barriers. This reinforces the concept that soft practices play a fundamental role in overcoming barriers, ensuring that Lean projects focused on environmental performance can succeed. Furthermore, these mechanisms were customized according to hierarchical roles within companies, resulting in seven distinct mechanisms. The role of the middle manager emerges as notably central, acting as an essential liaison who bridges the operational needs of employees with the strategic objectives of the company. The middle manager's centrality is further reinforced by the analysis of hierarchical perceptions, which reveals that middle managers report the highest frequency and intensity in perceiving soft practices among all hierarchical levels studied. This consistent and elevated perception across the middle management level underscores the critical importance of soft practices within successful Lean initiatives. Additionally, it confirms that soft practices are not only enablers of Lean projects but also serve as essential mechanisms for overcoming resistance and facilitating change. Generally, the selected case studies identified a high perception of soft practices across all hierarchical levels, all representing successful examples of Lean projects focused on enhancing environmental performance. Specifically, companies chosen for this research had conducted Lean initiatives lasting at least one year, resulting in significant improvements across various environmental performances. Correspondingly, barriers were less perceptible across all hierarchical levels and case studies. This inverse relationship between the heightened perception of soft practices and the reduced perception of barriers further reinforces the mitigating role of soft practices, demonstrating their effectiveness in addressing obstacles that hinder improvements in environmental performance. Further examining hierarchical perceptions of barriers, it was evident that operators reported the fewest perceived barriers. This suggests that, through appropriate implementation of soft practices, operators can effectively minimize their perception of Lean project-related challenges, allowing them to concentrate more on daily operational tasks. Conversely, top managers, adopting a broader strategic perspective, were more conscious of strategic barriers but exhibited decreased awareness of operational issues. This delineation signifies a highly positive dynamic wherein soft practices effectively redistribute responsibilities and operational problem-solving from top managers to middle managers and operators, thus enabling each hierarchical level to focus optimally on its designated functions. These insights underscore the essential role and effectiveness of soft Lean practices, mediated through well-defined organizational mechanisms, in overcoming barriers and achieving sustained environmental performance improvements.

6. Conclusions

This study explored how soft Lean manufacturing practices contribute to improving environmental performance in the context of Lean project implementation within large-scale production systems (LSPSs). Specifically, it examined how these human-centered practices are perceived and employed across different hierarchical levels and how they help overcome the organizational and structural barriers often encountered in LSPS environments. Drawing on five case studies in the Italian food manufacturing sector, each representing complex LSPSs, the study gathered qualitative insights from 15 semi-structured interviews with individuals from top management, middle management, and operational staff. In response to RQ1 "How do soft Lean practices mitigate the barriers that large-scale production systems manufacturing companies face in improving environmental performance?",

the study identified seven distinct organizational mechanisms through which soft practices act to counteract key barriers. These mechanisms, which vary by hierarchical role, illustrate the importance of aligning human-centric strategies with LSPS dynamics. Particularly, middle managers were found to play a pivotal role in translating strategic sustainability goals into actionable operations. Their ability to bridge organizational layers is critical in mitigating barriers caused by LSPS complexity, such as distributed operations, coordination issues, and resource constraints. Regarding RQ2, "How are soft Lean practices and barriers perceived at different hierarchical levels?", the findings revealed consistent recognition of the value of soft practices across all organizational levels. However, the perception of barriers diverged depending on role and responsibility. Operators, who are closely embedded in daily processes, reported fewer barriers, likely due to the enabling impact of soft practices. In contrast, top managers focused on higher-level strategic constraints, highlighting the layered nature of barriers in LSPSs. These insights emphasize how soft Lean practices support the decentralization of problem-solving and foster cross-level engagement in driving sustainable change. In sum, this study reinforces the essential role of soft Lean practices in navigating the structural and operational complexities of LSPSs.

6.1. Contribution to Academia

From an academic perspective, this study contributes to the broader literature on Lean manufacturing and environmental sustainability in large-scale industrial settings. First, it addresses a significant research gap by demonstrating how soft Lean practices function as enablers of sustainable development in LSPSs, particularly through their capacity to mitigate human and organizational barriers that arise in complex systems. Second, by applying a multi-level hierarchical lens, the study adds a new dimension to understanding Lean implementation. It highlights how perceptions and roles differ between managers, middle managers and operators, offering granular insights into the dynamics of change in LSPS. In doing so, it advances strategic and organizational research by emphasizing the need to align human behavior and management practices with system-level sustainability goals. Ultimately, this research contributes to creating a well-founded scenario for the application of Lean soft practices as strategic tools in the sustainable transformation of large-scale production systems.

6.2. Contribution to Practitioners

This research provides valuable practical insights for companies aiming to enhance their environmental performance through Lean implementation. The findings demonstrate that Lean manufacturing is not only a tool for operational efficiency but also a strategic enabler for sustainability. Understanding the hierarchical differences in how Lean practices and barriers are perceived allows companies to tailor their Lean strategies to specific organizational levels, improving implementation success. This study highlights that companies leveraging soft Lean practices strategically can reduce resistance to change and improve adoption rates. Middle managers play a crucial role in translating strategic goals into operational execution, making their engagement essential in Lean projects. Identifying and addressing hierarchical differences in barrier perception allows for better-aligned Lean initiatives, leading to improved environmental and business performance. Implementing targeted soft Lean practices fosters a proactive organizational culture, making sustainability-driven Lean projects more effective and resilient. By clarifying how soft practices activate specific mechanisms to mitigate barriers, this study offers actionable recommendations for companies looking to improve Lean project implementation. These insights provide guidance on how businesses can enhance both their operational performance and their environmental sustainability efforts, ensuring long-term competitive advantage.

6.3. Limitation and Further Research

To conclude, this section highlights the study's limitations and suggests possible future research directions. First, it is important to note that the research is based on a limited sample of only five case studies in the same industry. A possible direction for future studies would be to expand the number of case studies and extend them to different sectors to obtain a broader and more generalized view of the phenomenon analyzed. Another area for improvement is the data collection method based solely on interviews. This type of method may be subject to response bias. In particular, hierarchical levels, such as middle managers and operators, may tend to conform to the expectations of top managers, limiting the variety of perspectives and feedback. In addition, interviews may also introduce bias when interpreting the results. Since the topic of soft practices and barriers is qualitative, classifying practices as "used" or "not used" and barriers as "perceived" or "not perceived" may be problematic and influenced by the interviewer's subjectivity. To address these limitations, it is recommended that future research explore new survey methodologies and aim for as unbiased an analysis as possible. Adopting alternative data collection and analysis approaches could help reduce subjectivity and improve the reliability of results. In addition, we could say that, while the methodological approach is rigorously structured, future research is encouraged to replicate this analysis across a broader range of industrial sectors to evaluate the generalizability and complexity of the identified mechanisms. It is advisable to retain the multi-case study methodology adopted herein, as it facilitates the generation of detailed, hierarchical, and context-sensitive insights into organizational dynamics. Moreover, given that all selected cases represent successful Lean implementations, future investigations could benefit from the inclusion of unsuccessful cases to understand the consequences of absent or ineffective soft practices. Specifically, we propose the adoption of a polar case study design, incorporating both successful and unsuccessful Lean initiatives. Such a comparative framework would enable a critical examination of whether the same organizational mechanisms are observed across divergent outcomes.

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