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Original Article

Lean-SLP Operational Management Model for Logistics Cycle Time Reduction: A Case Study in the Motorcycle Distribution Sector in Peru

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Abstract - *The study addresses the logistical inefficiencies of small and medium-sized enterprises (SMEs) in the motorcycle distribution sector, particularly in Latin America. Previous research has focused on large companies, leaving a gap in understanding how Lean methodologies can be adapted to SMEs in this context. This research seeks to minimize the logistics cycle time by integrating a Lean operational model with Systematic Layout Planning (SLP). The model proposed rearranges the warehouse configuration and implements 5S to improve the material flow while minimizing redundant actions. Crucial results indicate that logistics cycle time decreased from 5 days to 3 days while picking capacity increased from 53 to 120 units per shift. Such improvements increase operational effectiveness and customer satisfaction and serve as an adaptable approach for comparable enterprises. Further research could look into incorporating more sophisticated technologies for broader applicability and sustainability of the model.*

Keywords - *Operational Management, Lean Warehousing, Warehouse Layout Redesign, Process Improvement, Supply Chain Efficiency.*

1. Introduction

Light vehicle SMEs, including motos, have great value in Latin America and Peru. Their contribution goes beyond being an economical and urban mobility asset but towards the economy as a whole. Motorcycles are an important solution to offer cheap and effective transportation in high population density areas (International Motorcycle Manufacturers Association) [1]. Latin America as a whole has seen a steep increase in the usage of motorcycles due to the need for affordable transport options [2]. In Peru, a lot of motos SMEs have come up and created many job opportunities which helps the economy at a grassroots level [3]. But, even with the deep importance of these businesses, they still struggle with many constraints that impact their ability to be competitive in the market.

One of the most important problems in the logistics of the motorcycle industry's SMEs is its high logistics cycle time, which is worsened by the mismanagement of reception and dispatch processes. The unstandardized methods of order preparation and ineffective inventory control result in excessive downtime, which is less than optimal and hinders customer satisfaction and profitability in these firms [4]. Studies have indicated that these cycle times can significantly be reduced with the implementation of efficient logistics and, as a result, improve the competitiveness of the SMES in the market [5]. Also, the inability to monitor the supply chain processes and lack of integration of information and technology worsen the situation by increasing operational costs and reducing responsiveness to market demand [6].

Resolving these logistical issues is important for enhancing the operational efficacy of SMEs as well as guaranteeing their enduring sustainability. The application of methods like Lean Manufacturing and Systematic Layout Planning has been proven to effectively improve the optimization of logistics processes and shrink cycle times [7]. These methods are designed for the elimination of waste for improved efficiency, and greater value creation utilizing available resources for continuous improvement [8]. There is literature supporting the premise that adopting these practices will result in marked improvements in logistics performance, leading to enhanced satisfaction of the clientele and an increased market share [9].

Even with the body of literature about logistics and supply chain management, there is still a gap concerning the motorcycle value chain in Latin America at the SME level. Larger firms or older industrial sectors often dominate the research focus, thus leaving SMEs in the background [10].

This study addresses the gap by creating a production model that assimilates Lean Manufacturing components, like 5S and Systematic Layout Planning. This model is designed to enhance operational efficiency and provide a blueprint that SMEs can tailor to their requirements[11]. The primary contribution of this work is the attempt to design customized lean frameworks for this particular type of motorcycle SMEs, which may offer a useful template for other firms in similar situations [12].

Unlike earlier studies, which looked at the implementation of Lean in a broad scope, this study looks into the motorcycle industry and how SMEs on a sector specific focus stand to gain [13]. The work done in this paper aims to be exhaustive in an examination of the logistical prose and application of the continuous improvement approach so that this research contributes to the already existing body of knowledge and also offers recommendations that can be readily adopted by SMEs to enable them to face competition in the changing market [14].

As a final point, the motorcycle SME industry is undoubtedly important for Latin America and the economy of Peru. Still, there are some severe gaps in their logistics systems that need to be corrected. Lean Manufacturing and Systematic Layout Planning provide reliable frameworks for improving operational efficiency and shortening cycle times. My work tries to address this by proposing a comprehensive production model designed to meet the requirements of SMEs in this industry to increase their enduring viability and competitiveness, thus filling the gap in the literature.

2. Literature Review

2.1. Lean Warehousing: Transforming Logistics in Light Vehicle Dealerships

The methodology of Lean Warehousing has received particular attention regarding the improvement of logistical processes in Small and Medium Enterprises (SMEs) dealing with light vehicles like motorcycles. As Abushaikha et al. [15] noted, applying waste elimination practices within the warehouse can positively impact operational performance, which will result in enhanced business performance. This was also the case with Villarreal et al. [16], who routed operations the Lean way.

Villarreal’s findings suggest that distribution logistics should improve customer relations and service, not only efficiency. Furthermore, Sternberg et al. [17] on waste in transport operations dealt with identifying waste in transport operations and supported the idea that inefficiencies must be removed for success to be achieved in logistics. Garza-Reyes et al. [18] state that although the Lean methodology has been utilized in multiple sectors, its focus remains scarce in the realm of logistics and transport. Thus, this becomes an opportunity for SMEs in the light vehicle industry.

2.2. Implementation of the 5S Methodology in Warehouses

As with other businesses, warehouses also benefit from greater operational efficiency through a clear organization and systematic 5S implementation. In the case of SMEs in the motorcycle industry, this methodology helps to minimize search times and enhances safety in the workplace. Figueroa-Rivera et al. [19] show that 5S contributed to a productivity increase of over 26.7% in picking through standardisation. Furthermore, He et al. [20] suggest that implementing computer vision technologies combined with 5S can further optimize warehouse inventory management. In another perspective, Buonamico et al. [21] provide a metric-based assessment of Lean Warehousing that guides the implementation of 5S by setting measurable targets, making it an appropriate supporting strategy. Lastly, Orosco and Ramos [22] identify the need to study warehouse processes to eliminate non-value-adding activities, which aligns beautifully with 5S principles.

2.3. Systematic Layout Planning: Optimizing Warehouse Space

Systematic Layout Planning (SLP) provides a methodology for maximizing efficient warehouse space utilisation. This allows for SMEs in the motorcycle industry to enhance their facility layouts towards material flow optimization and reduction in travel times. In the opinion of Clemente-Pecho et al. [23], the combination of SLP with Lean Warehousing strategies is useful in removing delays during product placement regarding employee safety and comfort. Mendes-Faia et al. [24] have also pointed out the significance of optimal design in distribution logistics, which may be derived for planning warehouse layouts. The work by Bernardino and Paias [25] on routing and storage issues also makes a case for the strategic design of the warehouses to enhance operational efficiency. Liu et al. [26] note that managed advanced technologies applied to inventory control in storage centers require well-designed work areas or stations integrated with tools to efficiently control work activities.

2.4. Manufacturing in Warehouses: Process Integration

The integration of manufacturing activities within the warehouse environment has the potential to increase organizational efficiency greatly. Argiyantari et al. [27] explain the case of applying Lean in transportation and how it can improve logistics in the light vehicle industry. Dressler et al. [28] build on this by looking at the impact of Lean transport improvements on distribution logistics.

Furthermore, Escuder et al. [29] argue that the concepts of waste removal in urban logistics could also be applied in warehouses, highlighting the growing applicability of Lean principles in manufacturing. Lastly, He [30] notes that the use of smart technologies in the logistics distribution process boosts efficiency while also enabling flexibility in response to market needs.

2.5. Kaizen: Continuous Improvement Culture in Warehouses

The Kaizen philosophy, or continuous improvement, is particularly relevant to the logistics operational development of SMEs in the motorcycle industry. Applying Kaizen in warehouses can provide step-by-step improvements that greatly enhance operational effectiveness. As Rahman et al. [31] describe in regard to vehicle scheduling and routing, there are better ways to perform logistics with the adoption of continuous improvement practices. Moreover, Villarreal et al. [28] show how continuous improvement in the field of transportation can also serve as an example of warehouse operations, suggesting that there are multiple levels at which Kaizen culture can be implemented. Mavi et al. [32] discuss cross-docking, focusing on how improvement in distribution logistics can be enhanced through continuous efforts. In their research on merchandise sorting in smart warehouses, He et al. [20] further reinforce the idea that continuous improvement is necessary to respond to new technologies and market changes.

3. Contribution

3.1. Proposed Model

The proposed model, illustrated in Figure 1, was developed for an SME dedicated to the commercialization of motorcycles, focusing on improving the order picking and storage process. This model integrated the Lean Manufacturing philosophy through the 5S methodology with Systematic Layout Planning (SLP) to optimize material flow, reduce operational times, and eliminate unnecessary movements within the warehouse. During the diagnostic phase, issues related to congestion in loading and unloading ramps, delays in product location, and inefficient trajectories in the order-picking process were identified. The implementation of 5S helped structure the work environment, facilitating the organization and standardization of activities, while SLP provided a systematic approach to redesign the layout, ensuring a continuous and smooth workflow. This methodological synergy increased operational efficiency, improving accuracy and reducing non-productive times, consolidating a replicable model aligned with Lean Supply Chain Management principles.

3.2. Model Components

In the field of internal logistics management, Small and Medium-sized Enterprises (SMEs) face significant challenges in achieving optimal operational efficiency, particularly in critical processes such as order picking and storage. These processes are key supply chain components, directly impacting customer service levels and the company's ability to respond quickly to market demands. The proposed model, illustrated in Figure 1, was developed as a comprehensive solution to address the main operational inefficiencies identified in an SME dedicated to commercialising and distributing motorcycles. Based on a combination of the 5S methodology and Systematic Layout Planning (SLP), this model focuses on reorganizing physical space and standardizing processes to eliminate non-value-added activities, optimize material flow, and reduce operational times.

Integrating these methodological tools addresses the need to adopt continuous improvement practices typical of Lean Supply Chain Management, adapted to the specific characteristics of SMEs in the sector. Unlike models implemented in large companies with greater technological and financial resources, this proposal focuses on practical, low-cost solutions to maximise available space and improve the coordination of internal logistics activities. Figure 1 presents the designed model, which reflects each implementation stage and its main outputs, aligned with waste reduction and operational efficiency improvement objectives.

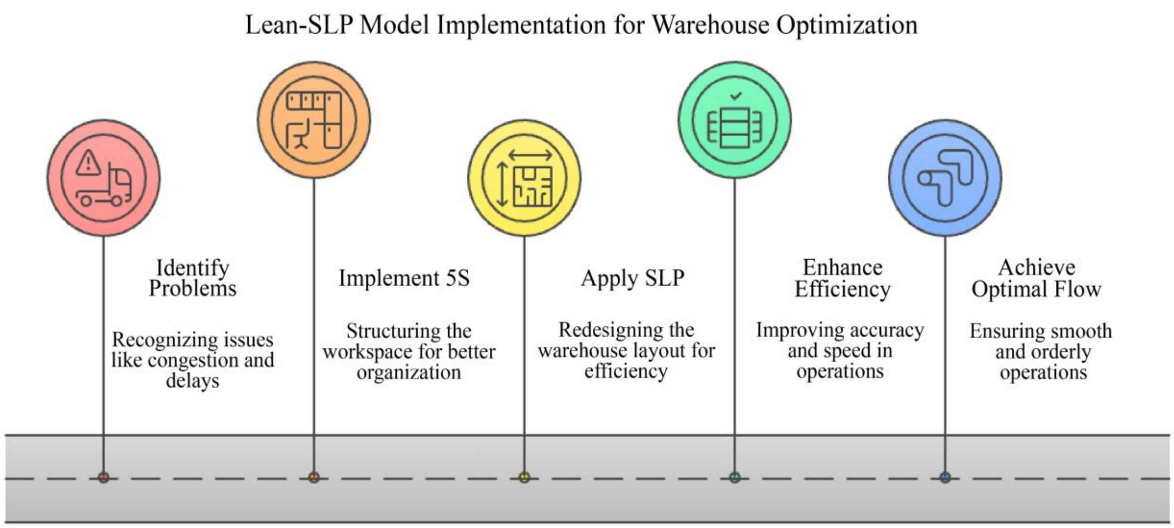

Fig. 1 Proposed model

3.2.1. Diagnosis and Problem Analysis

Understanding the fundamental causes for the inefficiencies in the warehouse was highly dependent on the diagnostic phase. Substantial analysis of operations uncovered numerous impediments impacting logistics performance.

One of the most significant issues included traffic congestion at the loading and unloading ramps, which stemmed from insufficient planning of vehicle circulation and poor coordination between receiving and dispatching activities. This scenario brought about undue and cumulative delays, adversely impacting delivery schedules and space availability for new operations.

Furthermore, congestion at the loading and unloading uncontrollably created a lack of structure for product location. The order picking in this scenario was made very complex owing to logically unorganized systems, driving us to unnecessarily prolonged movements and diminishing the accuracy scope for product selection. They also negatively impacted productivity by forcing poorly designed travel routes to optimal flows within the operations warehouse.

The interconnected challenges significantly compromised productivity while creating potential safety hazards for employees and the product.

3.2.2. Implementation of the 5S Methodology

The first stage of the organizational model included putting into practice the 5S methodology, which has been reviewed in chapter three, to promote a safe, tidy and efficient workplace. Each process within the 5S was followed systematically to achieve maximum and long-lasting results.

Sort (Classification)

Regarding the warehouses, all tools, equipment, and materials were carefully scrutinized as the first step of the 5S process. Necessary tools, materials, and equipment essential for everyday operations were separated from useless items or items that did not have added value to the operations of the warehouse.

Space and simplicity were attained when unnecessary items were disposed of, and more ordered and controlled workflows were attained. This helps identify surplus or duplicate materials for removal and subsequently improves materials and inventory management.

Set in Order (Organization)

The classification phase has been completed; now is the turn of the organizational phase of the warehouse. Ergonomics of each piece of material for each type of material were defined so that product storage and retrieval (order picking) would be highly looking to enhance retrieval efficiencies during order picking, and arrangement systems were set to assist quick identification levels.

Shine (Cleaning)

Cleaning the work area involved more than simply getting rid of the dirt. It also included preventive maintenance of equipment and early anomaly detection. This phase was crucial to maintaining warehouse operations and avoiding problems stemming from mechanical disruptions, hazardous conditions, or faulty equipment.

Standardize (Standardization)

As in every other area, documenting best practices and creating standard operating procedures was essential for achieving consistency in the execution of activities. Manuals and visual aids were created to describe each process, aiming at systematizing operations to reduce variability.

Sustain (Discipline)

The last step of the 5S is to develop a culture of continuous improvement and operational discipline. Staff was trained and sensitized to understand the need to maintain the achieved conditions and the need to shift to a more proactive mindset about problem identification and resolution.

3.2.3. Systematic Layout Planning (SLP)

After smoothing the work environment using the 5S methodology, the redesign of the warehouse layout was initiated with the application of Systematic Layout Planning (SLP). This methodology allowed the efficient reorganization of space to improve the order and flow of materials and optimize the use of available space.

Functional Relationship Analysis

As the first step of the SLP process, the interrelationships among the various operational divisions of the warehouse were scrutinized. A relationship diagram was designed to show the degrees of interaction that have the potential to prioritize which linkages need closer spatial proximity in order to reduce the distance travelled within the system.

Layout Design Alternatives

In addition to the relationship analysis, other analyses are to be done, including brainstorming several layout alternatives. Each alternative was assessed with respect to the proposed criteria, which included reduction of travel distances, ease of material movement, and safety during operations. The one chosen was the one with the U-shaped flow structure, which allowed for complete circulation while reducing cross-traffic between activities.

Implementation of the New Layout

Regarding the new layout, steps were instituted to prevent disruptions of operations. A shift plan had to be developed to facilitate a smoother change to reduce the impact on routine work activities. After implementation, audits were carried out to check adherence to the planned design and enable adjustments based on actual needs.

3.2.4. Results and Achieved Improvements

The results obtained after implementing the proposed model were remarkable in terms of achieving operational efficiency. Customer service levels were increased as product selection accuracy improved, and the average order picking time was reduced by over 30%. Furthermore, the survey staff movement warehouse layout reorganization improved the ramps' tracking fluency, increased staff-reducing distance travelled by 40%, increased physical effort, and increased productivity. Congestion was also eliminated and further noted to enable smooth operations throughout the loading and unloading process.

Combining the 5S methodology with the Systematic Layout Planning approach significantly enhanced the order picking and storage processes in the small and medium enterprises (SMEs) within the motorcycle distribution sector. These methodologies worked together to effectively alleviate the identified operational inadequacies, ensuring the delivery of measurable and enduring results over time. This method is an effective and easily replicable strategy for other SMEs with similar internal logistics problems, aiding the sector's competitiveness.

3.3. Model Indicators

Tailored assessment criteria designed to measure the effectiveness of operational improvements were used to evaluate implementing the Lean-SLP model concerning warehouse optimization in light vehicle (motorcycle) distribution SMEs. These metrics were constructed to evaluate significant performance parameters concerning the reduction of logistic cycle time. This exhaustive evaluation examines all the changes made concerning the optimization of the internal processes and the material flow that was implemented. The model allowed for increased overall warehouse efficiency through effective oversight and improvement initiatives while adhering to Lean manufacturing principles and practices in the supply chain, fostering Lean thinking.

3.3.1. Logistic Cycle Time

This indicator defines the total time taken to execute all the steps in the logistics process, from ordering the goods to delivering the goods ordered by clients. A reduction in this period leads to improved operational efficiency and increased customer satisfaction.

$$\text{Logistic Cycle Time} = \text{Delivery Date} - \text{Order Date}$$

3.3.2. Percentage of Incidents at Ramp Operations

This indicator tracks the percentage of incidents that occur during loading and unloading operations. A lower percentage reflects better coordination and safer ramp operations.

$$\text{Incident Percentage} = \left(\frac{\text{Total Incidents}}{\text{Total Services}}\right) \times 100$$

3.3.3. Picking Capacity

This indicator quantifies the number of units picked per shift, providing insight into the productivity of warehouse operations. Increasing this capacity reduces order preparation time.

$$\text{Picking Capacity} = \frac{\text{Total Time per Shift}}{\text{Time per Unit}}$$

4. Validation

4.1. Validation Scenario

The validation scenario was conducted in a case study of an SME in the automotive sector, specifically dedicated to the commercialization of light vehicles, mainly motorcycles. With over five decades of experience, this company operates in Lima and other regions of Peru. In recent years, the organization has experienced steady growth, positioning itself as one of the leading players in motorcycle sales nationwide. However, the logistics process related to order preparation and delivery exhibited significant inefficiencies. These shortcomings directly affected the logistics cycle time, exceeding the sector's established standards, impacting customer satisfaction, and generating additional costs. The operational analysis revealed issues such as congestion at loading and unloading ramps and delays in product location, highlighting the need for a comprehensive improvement in the logistics process.

4.2. Initial Diagnosis

As stated in the case study, the principal problem was traced down to the logistics cycle time with a lead time of five days, while the industry standard ranged between two to three days. Such practices lead to an approximate annual economic detriment of $149,835.12, which is around 2% of the company's total sales. This gap was primarily tied to the operational inefficiencies within the receiving and dispatching activities, which composed 59.65% of the underlying reasons for the issue. Moreover, unproductive time during order preparation, accounting for 28.95%, also added to the gap. Root causes included congestion at the loading and unloading ramps (59.65%), delays in locating the product (15.78%), and unnecessary movements inside the warehouse (13.20%), respectively. Because of these different factors, it became clear that there was a need to design an organized approach to reduce cycle time, increase logistics performance, and improve the efficiency of the whole operation.

4.3. Validation Design

This operational management model, grounded on Lean Tools and SLP, was validated through pilot processes in the case study. In this validation, the logistics cycle time for an SME (Small-Medium Enterprises) focused on the distribution of light vehicles (motorcycles) was attempted to be optimized. This four-month process included the implementation of Lean principles like 5S for organizing and stabilizing operations. Moreover, it included redesigning the warehouse using SLP to improve the flow of materials and stabilize operations as well. The validation was quantitatively structured towards achieving impact and operational feasibility to guarantee a continuous improvement approach centered around Lean.

The detailed solution design specifically focused on the logistic cycle time of an SME that commercializes light vehicles, more so focused on motorcycles. The model was implemented using Lean Manufacturing tools and Systematic Layout Planning (SLP) methodology to rectify the shortcomings identified at the initial diagnosis. With this approach, there was optimization of material flow, organization of the spatial workplace, and enhancement of the internal warehouse operations. The solution design was incrementally developed by addressing each problem statement to maximize operational efficiency, safety, and productivity and drive further improvements.

4.3.1. Implementation of the 5S Methodology

After all value stream mapping is performed, 5S is the first framework that deals with organizing the workspace and removing waste. It was executed in phases, each with measurable results that helped sustain the improvements.

Sorting (Seiri)

The first phase focuses on the dismantling of warehouses and the scrapping of any excess implements. It provided a space for picking for space-constrained places. It further improved inventory accuracy by removing assistive obsolete items, which reduced storage costs. An inventory analysis was done, and space utilization was 18 percent. Also, a retrieval of 220 items was achieved.

Set In Order (Seiton)

Every warehouse zone was reorganized for accessibility to lower the time spent searching for materials and products. Modification of visual aids also makes identification of places easy, which leads to the reduction of operational errors. Also, the average time to search for a product was reduced by 25 Percent. It went from 6 to 4.5 minutes.

Shine (Seiso)

Daily cleaning and maintenance routines were introduced in the workstations to guarantee operational efficiency and safety. By using the standards for cleaning, the ware gave a 12 percent change in incidents reported. With this new standard, errors in heavy item storage were also corrected, meaning better refinement of severely unsafe operator conditions. Cleaners were able to maintain tools of the workplace becoming incident free, which in turn creates better conditions for the employees.

Standardization (Seiketsu)

Best practices for each procedure, from receiving goods to preparing and dispatching orders, were streamlined and documented into operational procedures. Staff were trained using standard procedures and were guided through procedures using visuals. Consistency and quality in daily operations were achieved with a reduction in task variability by 20% due to standardisation efforts.

Sustain (Shitsuke)

In the last stage, efforts drove attention to how the improvements obtained could be sustained while cultivating a mentality of advancement. Audits conducted to check conformance with 5S practices showed a 92% conformity rate on the first round of evaluations. This level of compliance is crucial for enduring improvement and increases the staff's reliance on the model. Without this operational discipline, ensuring model sustainability would have been impossible.

Figure 6 presents a radar chart comparing the performance of the 5S methodology in the motorcycle warehouse across three stages: before implementation (blue line), after implementation (orange line), and the established objective (grey line). Each axis represents one of the five pillars of 5S: Seiri (1S), Seiton (2S), Seiso (3S), Seiketsu (4S), and Shitsuke (5S). The results show significant improvements after the intervention, approaching the target values. Seiri and Seiton demonstrated the most substantial progress, particularly in reorganizing the motorcycle storage area and classifying high-rotation models. These improvements led to a reduction in the logistics cycle time from 5 days to 3 days and an increase in the motorcycle picking capacity from 53 units per shift to 120 units, significantly optimizing warehouse operations.

Fig. 2 Radar Chart of 5S Implementation Results in the Motorcycle Warehouse

4.3.2. Redesign of the Warehouse Layout

The application of Systematic Layout Planning (SLP) enabled the redesign of the warehouse layout, ensuring more efficient material flow and reducing travel distances during order preparation.

Analysis of Functional Relationships

The initial analysis revealed that 75% of picking activities were concentrated on 25% of the total inventory. This finding justified the need to relocate high-rotation products near the dispatch area. A relational diagram was created to evaluate the interaction between different warehouse areas, prioritizing those with the higher frequency of use.

Figure 3 shows a relational table of activities performed in the warehouse area, used to identify and analyze the relationship between different operations within the logistics process. Each cell in the table reflects the type of relationship between activities, classified into categories of high proximity (A), important (I), occasional (O), useful (U), and unnecessary (E). This analysis is essential for the application of Systematic Layout Planning (SLP), as it helps prioritize the most relevant connections and redesign the warehouse layout to improve material flow and reduce operation times. Activities with higher interaction frequency, such as receiving, documentation, and picking, stand out for their critical proximity, indicating the need to position them strategically to optimize process efficiency. This tool provides a structured foundation for decision-making in warehouse spatial reorganization, ensuring more efficient and streamlined operational management.

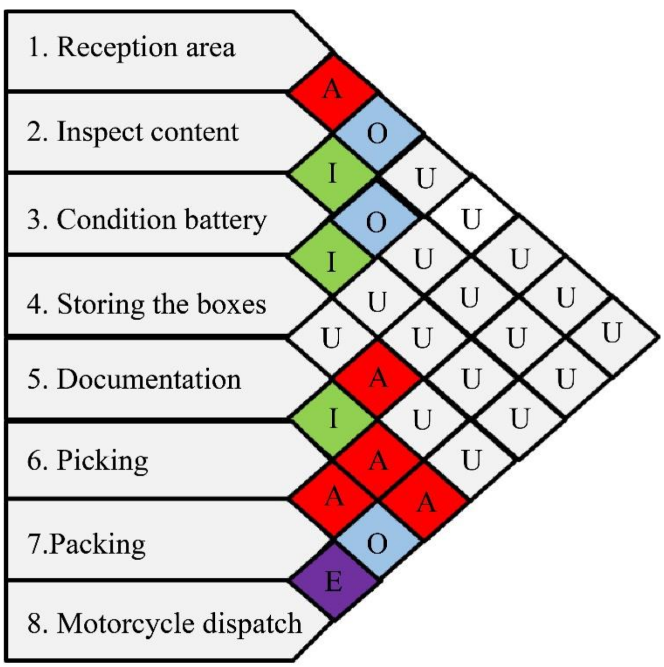

Fig. 3 Relational Table of Warehouse Activities for Functional Flow Optimization

Figure 4 shows the activity relationship diagram, a graphical representation of the connections between different operations in the warehouse process. This diagram is crucial for identifying the frequency and intensity of interactions between activities, helping to visualize the operational flow. The lines connecting the nodes represent the degree of proximity or interaction: red lines indicate high-frequency relationships, green lines represent moderate frequency, and blue lines indicate occasional interactions. Critical activities such as receiving (Node 1), picking (Node 6), and dispatching (Node 8) show strong connections, suggesting the need to prioritize their proximity in the warehouse layout. This tool is fundamental in applying Systematic Layout Planning (SLP) as it provides valuable insights into how to organize the physical space to minimize travel distances and optimize material flow, ultimately improving operational efficiency.

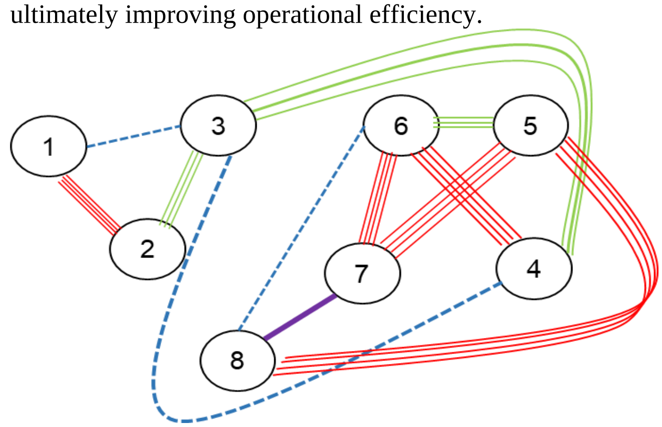

Fig. 4 Activity Relationship Diagram for Warehouse Process Optimization

Design and Evaluation of Alternatives

Three layout alternatives were designed and evaluated based on criteria such as distance reduction, safety, and accessibility. The selected alternative reduced the average travel distance by 30%, from 220 meters to 154 meters per picking cycle. This improvement translated into faster order preparation and increased operational capacity.

Implementation of the New Layout

The new layout was implemented in phases to avoid disruptions in daily operations. Over 1,200 inventory locations were reorganized, prioritizing the accessibility of high-rotation products. Upon completion, the new layout reduced the logistics cycle time from 5 days to 3 days, achieving a competitive level compared to the industry standard.

Figure 5 illustrates the optimized layout of the warehouse, designed to improve the flow of materials and reduce unnecessary movements during the logistics process. The red arrows represent the optimized flow path, ensuring a logical and continuous sequence for key operations such as receiving, storage, picking, packing, and dispatch. High-priority areas like motorcycle storage and dispatch zones were strategically positioned to minimize travel distances and improve operational efficiency. The layout also integrates clear divisions for spare parts storage, material handling areas, and offices to avoid process overlap and ensure a smooth workflow. This redesign reduced the average picking distance by 30% and logistics cycle time from 5 to 3 days, enhancing productivity and aligning operations with Lean principles.

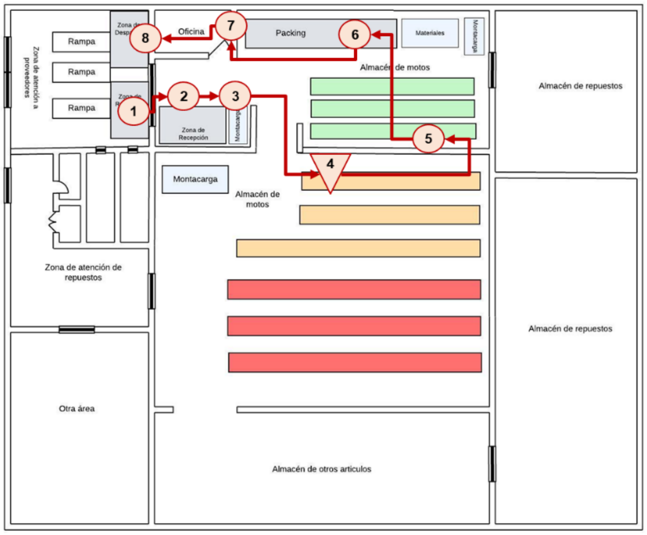

Fig. 5 Optimized Warehouse Layout for Material Flow Efficiency

4.3.3. ABC Inventory Classification

ABC classification was crucial for optimizing inventory management and ensuring an efficient allocation of storage resources.

Category A: High Rotation Products

This category included 15% of the inventory, representing 80% of total sales value. Products in this category were placed in the most accessible warehouse zones, reducing picking time by 30%. This improvement allowed the company to respond more quickly to market demands, increasing dispatch capacity by 20%.

Category B: Medium Rotation Products

Medium-rotation products, representing 30% of the inventory, were stored in intermediate warehouse areas. This strategy balanced accessibility and space utilization, maintaining operational efficiency.

Category C: Low Rotation Products

Low-rotation products, which constituted 55% of the inventory but only 5% of total sales value, were stored in less accessible areas. This decision freed up critical space for high-demand products, improving warehouse distribution and reducing congestion in high-traffic areas.

Figure 6 presents the ABC analysis of the motorcycle line, classifying inventory into categories A, B, and C based on their contribution to total inventory value. Category A, which represents 14.41% to 76.22% of the accumulated inventory value, includes high-priority models such as XR150L, XR190L, and CB190R, which contribute significantly to the company's revenue. These models were assigned prime storage locations to ensure quick access and reduce picking time. Category B covers 7.10% to 18.54% of the inventory, comprising moderate-demand items stored in intermediate positions to balance accessibility and space efficiency. Category C, representing less than 5.02% of the total value, includes low-rotation models positioned in less accessible areas to optimize the use of available space. This classification facilitated a more efficient allocation of resources, reducing inventory management costs while improving order preparation speed.

Modelo	Cantidad (unidades)	Valor de inventario (dólares)	Porcentaje (%)	Porcentaje Acumulado (%)	Clase
XR150L	2435	$ 3,050,627.29	14.41%	14.41%	A
XR190L	1968	$ 3,047,340.14	14.39%	28.80%	A
CB190R	2104	$ 2,868,045.99	13.55%	42.35%	A
GL125	2979	$ 2,141,366.84	10.11%	52.46%	A
XRE300	701	$ 1,906,617.31	9.00%	61.46%	A
CB250 TWISTER	657	$ 1,621,054.90	7.66%	69.12%	A
CB125F TWISTER	1925	$ 1,503,580.47	7.10%	76.22%	A
XR190CT	467	$ 803,289.79	3.79%	80.02%	A
WAVE110S	988	$ 737,190.30	3.48%	83.50%	B
TRX420FE1K	139	$ 695,679.16	3.29%	86.78%	B
ELITE	622	$ 605,782.52	2.86%	89.65%	B
CBR300RH	170	$ 421,481.35	1.99%	91.64%	B
TRX250TEJ	103	$ 394,685.33	1.86%	93.50%	B
CBR300R	129	$ 313,508.30	1.48%	94.98%	B
OTROS	526	$ 1,062,771.76	5.02%	100.00%	C
TOTAL	15913	$ 21,173,021.45	100%		

Fig. 6 ABC Analysis of the Motorcycle Line for Inventory Management Optimization

The detailed design and implementation of the Lean-SLP model generated significant improvements in warehouse performance, optimizing logistics cycle time and strengthening the competitiveness of the case study. Each applied tool contributed quantifiable results to operational efficiency, consolidating a replicable model for other SMEs facing similar challenges.

4.4. Results

Table 1 presents the key results of implementing and validating the Lean-SLP operational management model in the motorcycle warehouse. The results show a significant improvement in the evaluated indicators, with the logistics cycle time reduced from 5 days to 3 days, representing a 40% decrease. This reduction optimized the order preparation and dispatch process, aligning it with industry standards. Additionally, the percentage of incidents at loading and unloading ramps decreased from 17.28% to 10.81%, reflecting a 37% improvement in operational flow and area safety. Lastly, the picking capacity increased from 53 to 120 units per shift, resulting in a 126% growth, strengthening warehouse productivity and ensuring a faster response to demand. These findings validate the effectiveness of the proposed model and highlight its potential for broader application.

5. Discussion

The results obtained in this study align with the findings in the existing literature on Lean practices and Systematic Layout Planning (SLP) in logistics. Abushaikha et al. [15] demonstrated that implementing Lean principles in warehouse management significantly improves operational performance, mirrored in the reduction of the logistics cycle time in the present study. Similarly, Clemente-Pecho et al. [23] highlighted that combining Lean Warehousing with SLP reduces delays and improves spatial organization, which is consistent with the improvements observed in warehouse layout efficiency. Additionally, Figueroa-Rivera et al. [19] emphasized the effectiveness of 5S in increasing picking productivity, a finding that resonates with the 126% increase in picking capacity achieved in this case study. These comparisons confirm the validity of applying Lean methodologies in the motorcycle distribution sector and demonstrate their adaptability to the specific context of SMEs in Latin America.

5.1. Study Limitations

Even though the results are encouraging, the study has some shortcomings. The verification step was done within a short period, which failed to capture any long-term sustainability. Additionally, the model was executed in one Peruvian SME, which restricts the model's applicability to other industries or geographical areas. Furthermore, the scope of technological integration that could further improve warehouse operation was limited due to a lack of resources. Notwithstanding these limitations, the study offers a valuable contribution along with a replicable framework for companies dealing with logistical issues.

5.2. Practical Implications

The outcomes derived from this study have been addressed for Small and Medium-sized Enterprises (SMEs) within the motorcycle distribution industry. Applying Lean and SLP techniques enables major gains in logistic cycle time and operational efficiency. The proposed model cut the logistics cycle time by 40%, improving order-picking accuracy and order-related activities within the warehouse. These factors, in turn, improve customer satisfaction, cost of operations, and competition within the market. SME managers can implement the model as an affordable yet effective way to eliminate prevalent gaps in warehouse operation and efficiency.

5.3. Future Works

The model can be validated by collecting data from other regions and industries to include in the scope of the study, as it is currently limited to a few SMEs.

Table 4. Results of the pilot

Indicator	Unit	As-Is	To-Be	Results	Variation (%)
Logistic cycle time	days	5	2.8	3	-40%
Percentage of incidents at ramp operations	%	17.28%	10.00%	10.81%	-37%
Picking capacity	units/shift	53	110	120	126%

The potential exists to improve the precision and productivity of warehouses by incorporating modern technologies like IoT devices and Warehouse Management Systems (WMS). Within these parameters, other longitudinal studies should be conducted to determine the effects of the model on operational efficiency, sustainability, and other performance indicators over time. Additionally, incorporating Lean principles and further research on applying predictive analytics in risk mitigation within warehouse management could also be studied.

6. Conclusion

Integrating Lean Manufacturing and Systematic Layout Planning (SLP) within the internal logistics functions of SMEs that are involved in the distribution of motorcycles improves operational performance significantly, as this study shows.

These findings are verified by the optimum results, where logistics cycle time was drastically reduced from five to three days, and the picking capacity was 53 to 120 motorcycles per shift. These findings highlight the role of Lean principles in the preparation of orders and the warehouse layout by minimizing movement and material flow expenses and enhancing the operational efficiency of the SME.

This research contributes in the dual context of being Longitude-based and logistically focused on Latin American motorcycle SMEs, which fall short of fulfilling grown market needs, to improve their intricate system framework. This step is necessary not to sabotage the growth of such SMEs in the motorcycle sector.

From bicycle assembly to research and development, there are virtually limitless comparative advantages for developing competencies relative to the global technology supply chain, where SMEs are globally competitive. It scientifically addresses the gap of motorcycle SMEs in Latin America, which is under researched by focusing on Lean logistics applications in this context.

The study offers a practical framework for accomplishing the goal by creating an adaptable model aligned with lean methodologies, like the synthesis of Lozano and Eguia (2010), expanding the Application of Lean Principles to Warehousing and Distribution Centers.

The effort is expected to proportionately reduce costs while improving SMEs' logistics, which has been known for diminishing returns.

The study makes a valuable contribution to the field by offering a replicable model that integrates warehouse layout optimization with Lean tools, thereby providing practical guidelines for enhancing logistics processes in SMEs. This study prioritizes affordable and scalable solutions, which ensures broader applicability in resource-limited environments, in contrast to previous research that concentrated on large companies. It also underscores the significance of ongoing development in warehouse management, which fosters a culture of innovation and efficiency.

The performance of the proposed model could be improved by incorporating sophisticated technologies, such as warehouse management systems and Internet of Things (IoT) devices, in future research. Longitudinal studies are recommended to evaluate the long-term sustainability of the improvements and assess their impact on customer satisfaction and overall business growth. Expanding the model to other regions and sectors would provide valuable insights into its generalizability and adaptability.

References

[1] Robert Conti et al., "The Effects of Lean Production on Worker Job Stress," *International Journal of Operations & Production Management*, vol. 26, no. 9, pp. 1013-1038, 2006. [CrossRef] [Google Scholar] [Publisher Link]

[2] Gregor Bouville, and David Alis, "The Effects of Lean Organizational Practices on Employees' Attitudes and Workers' Health: Evidence from France," *The International Journal of Human Resource Management*, vol. 25, no. 21, pp. 3016-3037, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[3] Sandun Perera, Ganesh Janakiraman, and Shun-Chen Niu, "Optimality of (s, *S*) Inventory Policies under Renewal Demand and General Cost Structures," *Production and Operations Management*, vol. 27, no. 2, pp. 368-383, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[4] Ankur Goyal et al., "Sustainable Manufacturing through Systematic Reduction in Cycle Time," *Sustainability*, vol. 14, no. 24, pp. 1-16, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[5] Zheng Liu et al., "Research on Intelligent Decision of Low Carbon Supply Chain Based on Carbon Tax Constraints in Human-Driven Edge Computing," *IEEE Access*, vol. 8, pp. 48264-48273, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[6] Manali Sheth et al., "Measuring Delivery Route Cost Trade-Offs Between Electric-Assist Cargo Bicycles and Delivery Trucks in Dense Urban Areas," *European Transport Research Review*, vol. 11, pp. 1-12, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[7] Sandra Melo, and Patrícia Baptista, "Evaluating the Impacts of Using Cargo Cycles on Urban Logistics: Integrating Traffic, Environmental and Operational Boundaries," *European Transport Research Review*, vol. 9, pp. 1-10, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[8] Mariusz Kmiecik, "Logistics Coordination Based on Inventory Management and Transportation Planning by Third-Party Logistics (3PL)," *Sustainability*, vol. 14, no. 13, pp. 1-19, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[9] Fernando Fontes, and Victor Andrade, "Bicycle Logistics as a Sustainability Strategy: Lessons from Brazil and Germany," *Sustainability*, vol. 14, no. 19, pp. 1-29, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[10] Kailash Choudhary, and Kuldip Singh Sangwan, "Adoption of Green Practices throughout the Supply Chain: An Empirical Investigation," *Benchmarking: An International Journal*, vol. 26, no. 6, pp. 1650-1675, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[11] Zbigniew Galias, "Periodic Orbits of the Logistic Map in Single and Double Precision Implementations," *IEEE Transactions on Circuits & Systems II Express Briefs*, vol. 68, no. 11, pp. 3471-3475, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[12] Wen Yang et al., "Comparison Between Subsidy and Cap-and-Trade Policy on Electric Logistics Vehicles Leasing System," *Advances in Economics and Management Research*, vol. 6, no. 1, pp. 390-396, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[13] Bin Hu et al., "Optimization Model of Carbon Footprint of Fresh Products in Cold Chain from the Energy Conservation and Emission Reduction Perspective," *Mathematical Problems in Engineering*, vol. 2021, no. 1, pp. 1-11, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[14] Jackson Njau Waweru, "Economic Benefits of Integrating Supply Chain in the Electricity Sub-Sector in Kenya," *International Journal of Supply Chain and Logistics*, vol. 7, no. 1, pp. 37-59, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[15] Ismail Abushaikha, Loay Salhieh, and Neil Towers, "Improving Distribution and Business Performance through Lean Warehousing," *International Journal of Retail & Distribution Management*, vol. 46, no. 8, pp. 780-800, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[16] Bernardo Villarreal, Jose Arturo Garza-Reyes, and Vikas Kumar, "A Lean Thinking and Simulation-Based Approach for the Improvement of Routing Operations," *Industrial Management & Data Systems*, vol. 116, no. 5, pp. 903-925, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[17] Henrik Sternberg et al., "Applying a Lean Approach to Identify Waste in Motor Carrier Operations," *International Journal of Productivity and Performance Management*, vol. 62, no. 1, pp. 47-65, 2012. [CrossRef] [Google Scholar] [Publisher Link]

[18] Jose Arturo Garza-Reyes et al., "A Lean-TOC Approach for Improving Emergency Medical Services (EMS) Transport and Logistics Operations," *International Journal of Logistics Research and Applications*, vol. 22, no. 3, pp. 253-272, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[19] Ernesto Figueroa-Rivera, Andres Bautista-Gonzales, and Juan Carlos Quiroz-Flores, "Increased Productivity of Storage and Picking Processes in a Mass-Consumption Warehouse Applying Lean Warehousing Tools: A Research in Peru," *LACCEI Conference Proceedings*, Boca Raton, Florida- USA, pp. 1-11, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[20] Shouhui He, Yan Wang, and Hongda Liu, "Image Information Recognition and Classification of Warehoused Goods in Intelligent Logistics Based on Machine Vision Technology," *Signal Processing*, vol. 39, no. 4, pp. 1275-1282, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[21] Nicolás Buonamico, Laurent Muller, and Mauricio Camargo, "A New Fuzzy Logic-Based Metric to Measure Lean Warehousing Performance," *Supply Chain Forum: An International Journal*, vol. 18, no. 2, pp. 96-111, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[22] Luz Orosco, and Edgar Ramos, "Implementation of Lean Warehousing to Reduce Food Waste of a Distribution Company," *LEIRD Conference Proceedings*, pp. 1-9, 2023. [CrossRef] [Publisher Link]

[23] Fabiola Clemente-Pecho, Alejandro Ruiz-Cerón, and Martin Saenz-Moron, "Proposal for Improvement in Warehouse Management Using Lean Warehousing Methodology to Increase the Service Level of a Distribution Company," *LACCEI Conference Proceedings*, vol. 1, no. 8, pp. 1-9, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[24] A. Mendes-Faia et al., "Application of PdCe-HMOR Catalyst as NO_x CH_4-SCR System for Heavy-Duty Vehicles Moved by Natural Gas," *Topics in Catalysis*, vol. 59, no. 10-12, pp. 982-986, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[25] Raquel Bernardino, and Ana Paias, "Metaheuristics Based on Decision Hierarchies for the Traveling Purchaser Problem," *International Transactions in Operational Research*, vol. 25, no. 4, pp. 1269-1295, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[26] Hao Liu et al., "An RFID and Sensor Technology-Based Warehouse Center: Assessment of New Model on a Superstore in China," *Assembly Automation*, vol. 39, no. 1, pp. 86-100, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[27] Berty Argiyantari, Togar Mangihut Simatupang, and Mursyid Hasan Basri, "Transportation Performance Improvement through Lean Thinking Implementation," *International Journal of Lean Six Sigma*, vol. 13, no. 3, pp. 622-647, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[28] Bernardo Villarreal et al., "Improving Road Transport Operations through Lean Thinking: A Case Study," *International Journal of Logistics Research and Applications*, vol. 20, no. 2, pp. 163-180, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[29] Matias Escuder et al., "Can Lean Eliminate Waste in Urban Logistics? A Field Study," *International Journal of Productivity and Performance Management*, vol. 71, no. 2, pp. 558-575, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[30] Zhenhua He, Liang Chen, and Bin Liu, "Application of Integrating Reinforcement Learning and Intelligent Scheduling in Logistics Distribution," *Intelligent Decision Technologies*, vol. 18, no. 1, pp. 57-74, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[31] M. Azizur Rahman et al., "Intelligent Vehicle Scheduling and Routing for a Chain of Retail Stores: A Case Study of Dhaka, Bangladesh," *Logistics*, vol. 5, no. 3, pp. 57-74, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[32] Reza Kiani Mavi et al., "Cross-Docking: A Systematic Literature Review," *Sustainability*, vol. 12, no. 11, pp. 1-19, 2020. [CrossRef] [Google Scholar] [Publisher Link]