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Developing a Lean Warehousing Storage Model: A Case Study in Peruvian Retail SMEs

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Abstract

Retail SMEs play a crucial role in the global economy, particularly in Latin America and Peru, where they significantly contribute to employment generation, economic growth, and product diversification. However, they face operational challenges such as inefficient inventory management, poor demand planning, and inadequate storage methods, leading to economic losses and customer dissatisfaction. This study addresses these issues by implementing a Lean Warehousing model, focusing on demand planning, storage methodology, and differentiated stowage. The proposed model integrates ABC classification, FIFO/FEFO methodologies, and standardized work processes to optimize inventory management and reduce waste. The main challenges in the retail SME sector include stockouts, overstock situations, and high defect rates in shipments. These issues necessitate urgent intervention to improve operational efficiency and customer satisfaction. The proposed model provides a structured approach to managing these challenges by implementing advanced demand planning techniques and efficient storage practices.

Historical sales data and ABC analysis were used to forecast demand accurately, ensuring that stock levels matched customer requirements. The storage methodology focuses on organizing products based on usage frequency, while differentiated stowage prioritized products nearing expiration, minimizing waste and improving picking efficiency.
Key findings from the study revealed that the Fill Rate increased from 77.10% to 94.00%, defect-free shipments improved from 85.60% to 98.10%, on-time delivery remained constant at 99.10%, and the service level rose from 87.30% to 97.10%. These results demonstrate the effectiveness of the Lean Warehousing model in enhancing storage efficiency and operational performance. The model's implementation led to significant improvements in inventory management, reduced operational costs, and increased customer satisfaction by ensuring timely and defect-free deliveries.

The academic and socioeconomic impact of this research is substantial, as it provides a viable solution for optimizing warehouse operations in retail SMEs. By improving operational efficiency, the model contributes to the long-term sustainability and competitiveness of these companies. Additionally, the research offers valuable insights into future studies on the integration of advanced technologies and Lean practices in various industrial contexts. This study calls for further exploration into the application of Lean Warehousing principles in other sectors and geographies. Future research should focus on integrating automated systems and data analysis tools to enhance the model's efficiency. Active employee participation and continuous training in Lean principles are essential for the ongoing success and improvement of the implemented storage system, ensuring that retail SMEs can meet the demands of an increasingly competitive market.

Keywords
Lean Warehousing, Inventory Management, Retail SMEs, Demand Planning, ABC Multicriteria.

1. Introduction
Small and medium-sized enterprises (SMEs) engaged in the marketing of retail products play a crucial role in the global economy, in Latin America and specifically in Peru. These companies represent a significant part of the retail sector, contributing substantially to employment generation, economic growth, and the diversification of product supply for consumers (Vevere et al. 2022). In a highly competitive global environment, retail commercial SMEs face unique challenges ranging from inventory management to demand planning, which can negatively impact the quality of service they offer (Julia & Hendrawan 2021). Problems such as stock failures, off-spec orders, inefficient inventory control and poor storage methods are common in this sector, which can lead to economic losses and customer dissatisfaction (Sudarshan 2023).

The importance of addressing these problems in retail commercial SMEs lies in the need to improve operational efficiency, increase customer satisfaction, and ensure the long-term viability of these companies (Abe & Mugobo, 2021). Resolving these issues not only benefits companies themselves by improving their profitability and competitiveness, but also positively impacts the overall economy by fostering a more robust and dynamic business environment (Chand 2022). By improving inventory management, demand planning, and storage processes, retail commercial SMEs can optimize their operations, reduce costs, and provide better service to their customers, which in turn can result in increased customer loyalty and higher revenues (Pantano et al.2020).

Despite the relevance of these challenges in the retail business SME sector, there is a significant knowledge gap in the literature regarding the application of specific tools to effectively address these problems. The implementation of a production model based on Lean Warehousing tools, such as Demand Planning, Storage Methodology, Multicriteria Classification, Standardized Work, FEFO Method and FIFO, can be instrumental in closing this gap and improving operational efficiency in retail commercial SMEs (Manioudis 2023). These tools offer a structured and systematic approach to optimize inventory management, demand planning and storage processes, which can lead to a significant improvement in the quality of service and profitability of these companies (Jaini et al. 2021). In short, retail commercial SMEs play a vital role in the global, regional, and local economic landscape. However, they face significant operational challenges that affect their ability to deliver quality service and remain competitive. It is essential to address these problems by implementing tools such as Lean Warehousing to optimize internal processes, improve operational efficiency, and ensure the long-term sustainability of these companies in an increasingly demanding and competitive business environment (Wegerif 2020).

2. Literature Review
2.1 Lean Warehousing Methodology in Retail SMEs
The implementation of Lean Warehousing in the storage processes of retail SMEs has been a subject of interest in recent research. Bazán (2023) suggests that applying Lean tools and methodologies in retail businesses can result in competitive advantages. This is supported by the study (Shokri 2019), which emphasizes the systematic roadmap provided by Lean Six Sigma methodologies in reducing scrap rates within manufacturing organizations. Alshurideh (2023) also highlights the importance of process quality improvement and Lean practices in enhancing manufacturing competitiveness in SMEs, stressing the need for a comprehensive understanding of factors contributing to successful Lean implementation. Additionally, Loske et al. (2021) discuss the empirical assessment of musculoskeletal system strain in retail intralogistics, underlining the significance of ergonomics and social sustainability in logistics work, which are crucial for Lean Warehousing implementations.

2.2 Demand Planning Methodology in Retail SMEs
Demand Planning methodologies are crucial in the storage processes of retail SMEs. Robertson et al. (2022) explore the impact of digital maturity on the organizational resilience of SME retailers, emphasizing the importance of digital tools in adapting to challenges like the COVID-19 pandemic. This aligns with the study by (Qureshi et al.2022), which focuses on accomplishing sustainability in manufacturing systems for SMEs through Lean implementation, stressing the need to revisit Lean implementation plans to align with sustainable strategies. Moreover, Pandi (2024) provides insights into the impact of Lean methodologies on SMEs, concentrating on efficiency, profitability, and growth through Lean strategies, which are essential aspects of demand planning.

2.3 ABC Multicriteria Methodology in Retail SMEs

The application of ABC Multicriteria methodologies in the storage processes of retail SMEs has attracted attention in the literature. Andersson and Pardillo-Baez (2020) discuss how the Six Sigma framework can enhance the awareness and management of supply-chain risks, emphasizing the importance of risk management in storage operations. This is in line with the study by (Thanki & Thakkar 2019), which investigates the lean-green performance of Indian manufacturing SMEs, highlighting the adoption of innovative technologies and manufacturing excellence initiatives like Lean and Green practices. Furthermore, Mohammad & Oduoza (2019) focus on Lean-excellence business management for manufacturing SMEs, stressing the integration of Lean principles with methodologies such as Six Sigma and balanced scorecards to support Lean transformations effectively. Additionally, Dresch et al. (2019) highlight how Lean tools can enhance productivity in Brazilian manufacturing SMEs, demonstrating the practical implications of Lean methodologies in improving operational efficiency.

2.4 FEFO and FIFO Methodology in Retail SMEs

The utilization of FEFO (First-Expired-First-Out) and FIFO (First-In-First-Out) methodologies in the storage processes of retail SMEs is essential for inventory management. Rizkiyani & Unzilatirrizqi (2021) focus on postharvest handling in SMEs, emphasizing the importance of observation and documentation studies in optimizing processes. This is supported by the study by (Abbes et al.2021, which presents an integrated Lean Six Sigma approach in a case study from a clothing SME, showcasing the benefits of structured frameworks in process improvement efforts. Moreover, Sahoo (2020) assesses Lean implementation and benefits in Indian automotive component manufacturing SMEs, highlighting the methodological basis of case studies in understanding Lean practices. Additionally, Prasad et al. (2020) analyze the interdependency of Lean manufacturing practices in Bulgarian SMEs, emphasizing the use of interpretive structural modeling to identify key relationships between Lean practices, which are essential for implementing FEFO and FIFO strategies effectively.

2.5 Standardized Work Methodology in Retail SMEs

Implementing Standardized Work methodologies in the storage processes of retail SMEs is crucial for ensuring operational efficiency. Belhadi et al. (2019) evaluate critical success factors for Lean implementation in SMEs using the Analytic Hierarchy Process, emphasizing a structured research methodology for effective Lean implementation. This is in line with the study by (Qureshi et al.2023), which assesses Lean 4.0 for Industry 4.0 readiness, highlighting the importance of combining traditional Lean practices with Industry 4.0 technologies for sustainable manufacturing supply chains. Furthermore, Bo et al. (2020) discuss Lean tools, knowledge management, and Lean sustainability, emphasizing the moderating effects of study conventions in promoting sustainable practices. Additionally, Yadav et al. (2019) appraise barriers to Lean implementation in SMEs, showcasing the challenges that organizations may face in adopting Standardized Work methodologies effectively.

3. Methods

3.1 Basis of the Proposed Model

Figure 1 presents a storage model based on the Lean Warehousing philosophy, aimed at optimizing the storage process through the implementation of efficiency principles and waste reduction characteristics of the Lean methodology. This model integrated three main components: storage methodology, standardization of picking and differentiated stowage, and demand planning. The storage methodology focused on the efficient organization of space and available resources to maximize warehouse utilization. The standardization of picking and differentiated stowage sought to uniformize the processes of picking and categorizing products, ensuring that each item was placed in the most suitable location to facilitate access and handling. Demand planning aimed to anticipate and manage inventory needs proactively, ensuring that stock levels adjusted to demand fluctuations. Together, these components were designed to improve service levels, reduce response times and operational costs, and enhance the overall efficiency of the storage system within a Lean Warehousing environment.

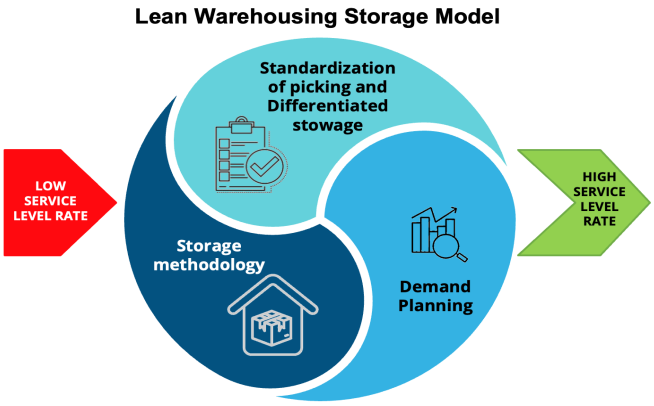

Figure 1. Proposed Model

3.2 Description of the model components

The Lean Warehousing storage model is a sophisticated approach designed to enhance the efficiency and effectiveness of warehouse operations. Rooted in the principles of Lean methodology, this model focuses on minimizing waste and maximizing value in every aspect of warehousing. The model incorporates several interconnected components that collectively streamline the storage and retrieval processes, improve service levels, and reduce operational costs. By integrating storage methodology, standardization of picking and differentiated stowage, and demand planning, the Lean Warehousing storage model ensures a cohesive and comprehensive strategy for managing warehouse resources. The following sections detail each component of the model, highlighting its significance and the methodology behind its implementation.

Storage Methodology

The storage methodology within the Lean Warehousing model focused on the efficient organization of space and resources. The primary objective was to maximize the use of the warehouse by minimizing waste, a core principle of Lean philosophy. This involved evaluating the layout and design of the storage areas to ensure the optimal flow of goods and materials. Techniques such as value stream mapping were employed to identify and eliminate non-value-added activities, thus streamlining operations and enhancing productivity (Dotoli et al. 2015; Rossini et al. 2021). Implementing this methodology required a systematic approach to categorize and store items based on their usage frequency, ensuring that high-turnover items were easily accessible, while less frequently used items were stored in less accessible areas (Modula 2023).

Standardization of Picking and Differentiated Stowage

The standardization of picking processes and differentiated stowage was another critical component of the Lean Warehousing model. This phase aimed to create uniform procedures for picking and storing items, reducing variability and improving efficiency. Standardized picking involved implementing consistent methods for order picking, which could include batch picking, zone picking, or wave picking, depending on the specific requirements of the warehouse (Torri et al. 2021). Differentiated stowage, on the other hand, focused on categorizing products based on specific criteria such as size, weight, and demand frequency. This ensured that items were stored in the most appropriate locations to facilitate quick retrieval and reduce handling time (Kundu et al. 2020; Dotoli et al. 2013).

Demand Planning

Demand planning was integral to maintaining an efficient and responsive warehousing system. This process involved forecasting future inventory needs based on historical data and market trends to ensure that stock levels were aligned with customer demand. Accurate demand planning helped prevent both stockouts and overstock situations, thereby reducing carrying costs and improving service levels (Prasetyawan & Ibrahim 2020). Advanced analytical tools and software were often utilized to enhance the accuracy of demand forecasts, allowing for real-time adjustments to inventory levels. This proactive approach enabled warehouses to respond swiftly to changes in demand, ensuring that the right products were available at the right time (Rossini et al. 2018).

Integration and Implementation
The integration of these components within the Lean Warehousing model required careful planning and execution. Initially, a thorough analysis of the existing warehouse operations was conducted to identify areas for improvement. This involved collecting and analyzing data on various aspects of the warehouse, including layout, inventory levels, and order fulfillment processes (Dotoli et al. 2015). Once the baseline data were established, lean principles such as the 5S methodology (Sort, Set in Order, Shine, Standardize, Sustain) were applied to organize and maintain the warehouse environment (Modula 2023).

Continuous improvement was a fundamental aspect of Lean Warehousing. Regular audits and performance reviews were conducted to ensure that the implemented changes were yielding the desired results. Feedback from warehouse employees, who were encouraged to participate in the improvement process, played a crucial role in identifying new opportunities for optimization (Gopakumar et al.2008). Training programs were also implemented to educate employees on lean principles and best practices, ensuring that they were equipped with the knowledge and skills needed to maintain a lean warehousing system (Yin 2009).In conclusion, the Lean Warehousing storage model, through its focus on efficient storage methodology, standardized picking and differentiated stowage, and proactive demand planning, significantly enhanced warehouse operations. By eliminating waste and optimizing resource utilization, this model not only improved productivity and reduced operational costs but also elevated service levels, ensuring that warehouses could meet customer demands effectively and efficiently.

3.3 Model Indicators
To evaluate the effectiveness of the proposed storage model, specific metrics were developed to monitor and manage its results within the case study. These metrics offered a systematic approach to evaluating performance, ensuring that all crucial aspects of the production process were thoroughly measured and analyzed. This facilitated a thorough assessment of the impact of the model on the level of seriousness and delivery compliance of orders served.

Fill Rate: This indicator measures the percentage of customer demand met without backordering. It indicates inventory management effectiveness.

$$\text{Fill Rate} = \frac{Total\ Units\ Shipped}{Total\ Units\ Ordeerd} \times 100 \tag{1}$$

Defect-Free Shipment: indicates the percentage of shipments without defects, reflecting quality control effectiveness.

$$\text{Defect} - \text{Free Shipment} = \frac{Total\ Defect - Free\ Shipments}{Total\ Shipments} \times 100 \tag{2}$$

On-Time Delivery: This indicator measures the percentage of orders delivered within the agreed timeframe, indicating reliability.

$$\text{On} - \text{Time Delivery} = \frac{Total\ On - Time\ deliveries}{Total\ deliveries} \times 100 \tag{3}$$

Service Level: this indicator measures the percentage of orders fulfilled without stockouts, indicating product availability.

$$\text{Service Level} = \frac{Total\ Orders\ Fulfilled\ without\ Stockouts}{Total\ Orders} \times 100 \tag{4}$$

4. Validation
4.1 Initial Diagnosis
In Figure 2, the problem tree summarizes the diagnostic conducted in the case study to identify the reasons and root causes contributing to the main problem. It was observed that the service level rate was 87.31%, below the industry standard of 95%, resulting in an economic impact of 10.5% of revenue, equivalent to 89,594 PEN for year. At the first level, two main reasons were identified: stock-out (60.49%) and orders out of specification (39.51%). At the second

level, stock-out was mainly attributed to poor demand planning (46.91%), inefficient receipt and inventory counting processes (13.58%), inadequate storage methodology (25.93%), and inefficient truck load distribution (8.15%). Regarding orders out of specification, the main root cause was the lack of material differentiation by product type (5.43%). This approach allowed understanding both the symptoms of the problem and their underlying causes, highlighting the need for improvements in planning, storage, and receipt and distribution methodologies, which significantly impacted the efficiency and operational costs of the analyzed company.

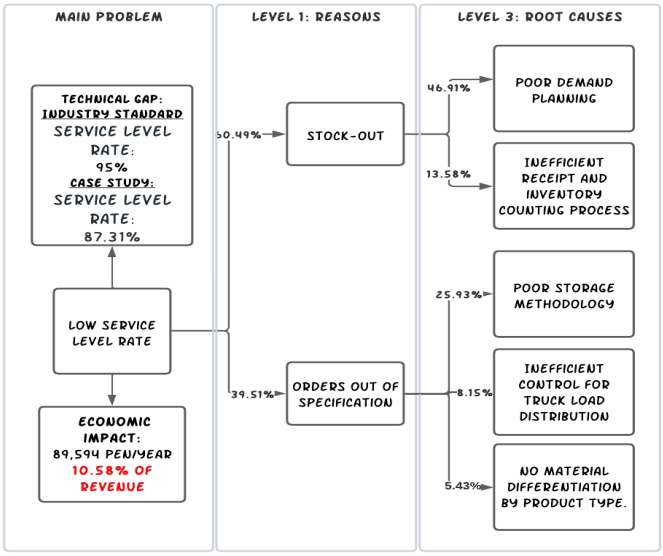

Figure 2. Problem Tree

4.2 Implementation of the model in the case study

Implementation of the Demand Planning

For the development of demand planning, historical sales data of the last two years was collected for 39 products, classifying them by ABC analysis. Class A products, accounting for 80% of sales, were the main focus. Sales were evaluated last year, obtaining that the best-selling products were: Bottle glass b/s perist. 4oz, Bottle glass b/s perist. 8oz, Liquid cleaner 700 ml, Bottle pp b/s perist. decor. 8oz 00260 and Bottle pp b/a perist. plus 240ml/8oz, totaling 611,040 units, which accounted for 80% of total sales of more than 800,000 PEN. Table 1 shows the ABC sales analysis for demand planning.

Table 1.ABC Sales Analysis - Demand Planning

ABC Analysis	Sales	Sales %	Sales Acum. %	Classification
Bottle glass b/s perist.4oz	254,820	31.41%	31.41%	A
Glass bottle b/s perist. 8oz	199,349	24.57%	55.97%	A
Liquid cleaner 700 ml	77,369	9.54%	65.51%	A
pp bottle b/s perist.decor. 8 oz 00260	67,079	8.27%	73.78%	A
Biberon pp b/a perist.plus 240ml/8oz	53,423	6.58%	80.36%	A
Biberon pp b/s perist.decor. 4 oz	35,662	4.40%	84.76%	B
Pacifier step 1	16,172	1.99%	86.75%	B
Star biter	12,868	1.59%	88.34%	B
Toothbrush set p 1,2,3	10,188	1.26%	89.59%	B
Refil liquid cleaner in bag 650ml	8,066	0.99%	90.59%	B
Others	76,389	9.41%	100%	C
Total	811,385	100.0%		

For these products, the time series forecast technique was used to evaluate their trend and seasonality, which allowed for the definition of the most suitable prognostic model for each product. These models were implemented, obtaining significant results in the accuracy of forecasts, improving demand planning, and reducing the lack of stock. The results showed an improvement in forecast accuracy by an average of 95%, which contributed to more efficient inventory management and customer satisfaction by reducing lead times and incomplete orders. Class A products represented 80.36% of total sales, with bottles and liquid cleaners as the main products, totaling 611,040 units out of 811,385 units sold.

Analysis of forecast models

The analysis of forecast models was based on the evaluation of trends and seasonality using Minitab 19 software. For the glass bottle without a peristaltic system of 4 ounces, the historical data showed an upward trend and seasonality with periods of 12 months. The prognostic model selected was that of Multiplicative Decomposition because the data indicated a simultaneous increase in values and the seasonal pattern. This model presented a Mean Absolute Deviation (MAD) of 44.29 units and a Mean Quadratic Deviation (MSD) of 4.625 units, confirming its accuracy with a Mean Absolute Percentage Error (MAPE) of 5.88%, indicating an accuracy of 94.12%.

For the 8-ounce peristaltic-free glass bottle, multiple prognostic models were analyzed due to the upward trend and lack of seasonality. The models evaluated were the Linear Trend, Quadratic and Growth Curve Analysis. The linear model was selected to present a MAPE of 5.79%, a MAD of 37.90 units and an MSD of 1,976.50 units, with a forecast accuracy of 94.21%. The adjusted trend equation was "Y(t) = 544.3 + 9.79 t", showing a close adherence to the data. Analysis of the 8-ounce polypropylene decorated bottle showed an 8-month upward trend and seasonality. The Multiplicative Decomposition model was preferred, presenting a MAD of 28.91 units and an MSD of 1,203 units

Table 2. Forecast of the next 12 periods - Perist bottle. plus 240ml/8oz

Period	Forecast	Period	Forecast
25	178	31	391
26	282	32	268
27	352	33	488
28	439	34	393
29	260	35	231
30	394	36	269

. The MAPE was 5.88%, with an accuracy of 94.12%. The adjusted trend equation was "Y(t) = 265 + 18.29 t". In the case of the 700 ml liquid cleaner, an upward trend was identified with a seasonality of 12 months. The Multiplicative Decomposition model showed a MAD of 17.9 units and an MSD of 660 units. The MAPE of 7.462% indicated an accuracy of 92.538%. The adjusted trend equation was "Y(t) = 161.5 + 9.013 t". The forecasts for the next 12 months are in Table 2. The real demand trend analysis using a growth curve model for an 8-ounce glass bottle is shown in Figure 3 .

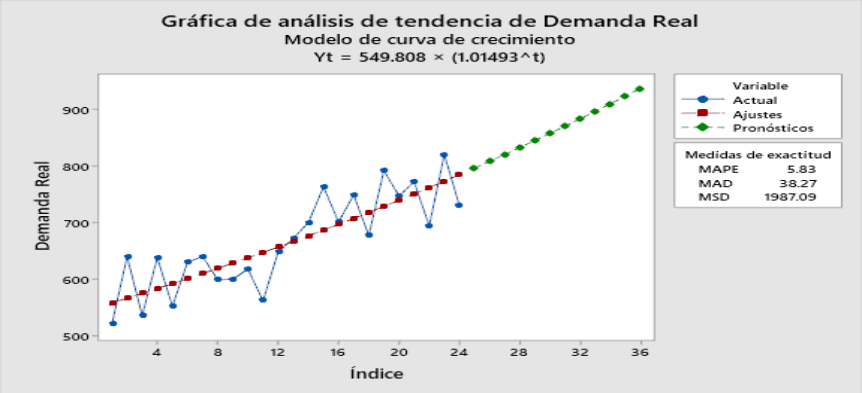

Figure 3. Trend analysis growth curve - Bottle glass b/s perist. 8oz

Implementation of the storage methodology

The methodology for the storage system development focused on optimizing inventory management using the ABC classification and FIFO/FEFO methodologies. Historical data of one year on the picking frequencies of warehouse products were essential for the analysis. The ABC classification was based on the 80/20 rule, categorizing products into A, B, and C groups. Category A products represented 80% of the picking frequency, B products 15%, and C products 5%. This categorization allowed for a systematic approach to inventory management. The proposed layout did not involve altering existing shelving systems but instead focused on product placement according to their classification. For FIFO, the first products received were positioned at the bottom level, ascending as new products arrived. FEFO prioritized products nearing expiration, placing them at the bottom level, ensuring quick access for picking and minimizing waste. These strategies aimed to improve picking accuracy and efficiency, leveraging simple tools like Microsoft Excel for data management. The anticipated outcome was a more organized warehouse, enhancing overall operational efficiency by aligning storage practices with product characteristics and usage patterns. Figure 4 visually represents the proposed design and methodology, helping in understanding the text and illustrating the practical application of FIFO and FEFO strategies.

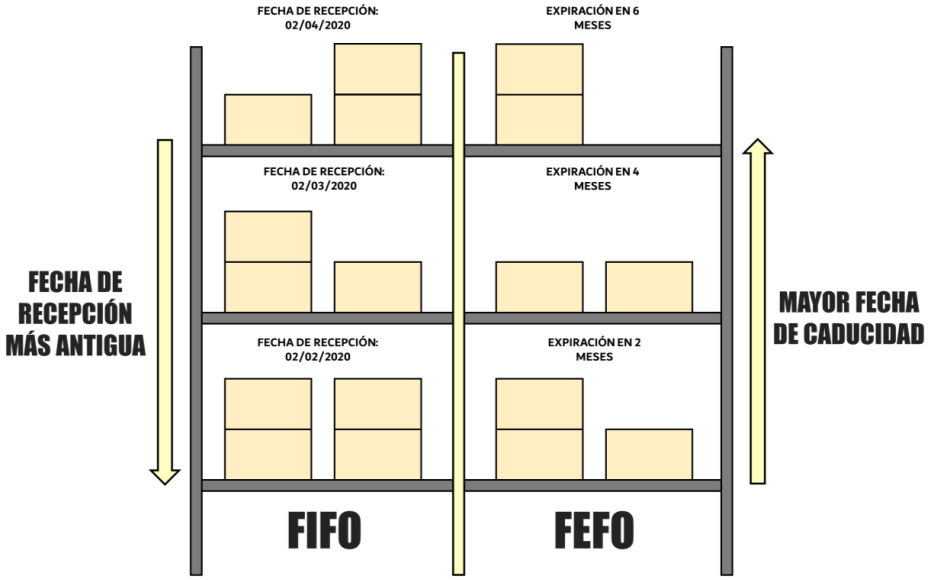

Figure 4. Proposed FIFO and FEFO methodology

Figure 5 shows the proposed inventory distribution under the ABC multicriteria classification in the warehouse. The areas are divided into order reception, observations, write-offs, dispatch, packaging, and administrative sections. The layout optimizes the 25x10 meter space, facilitating access to products based on their classification.

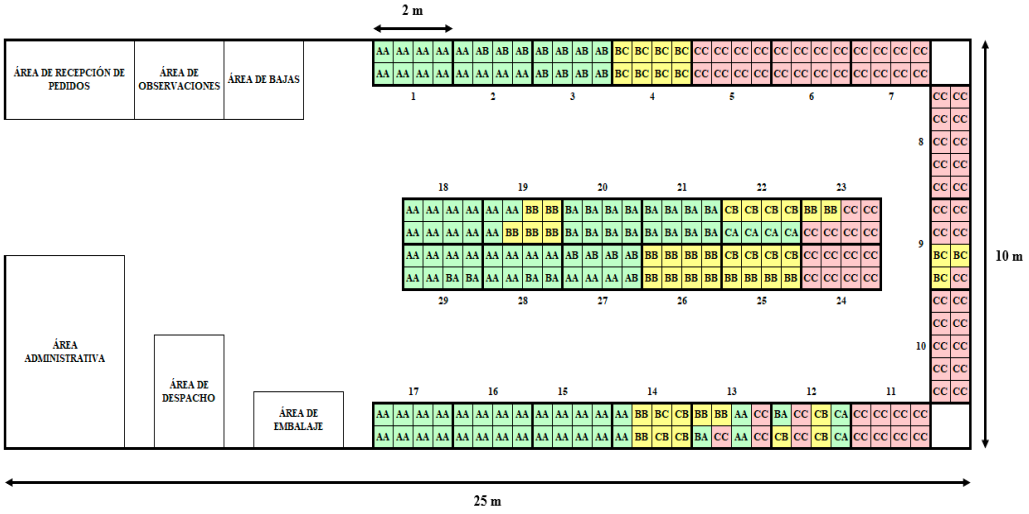

Figure 5. Distribution of inventory under multi-criteria ABC - Proposed

The development of the differentiated packing and stowage model began with identifying product families the company handles. Subsequently, these families were classified based on their material, which could either be PA (acrylic plastic or plastic) or V (glass). The differentiated stowage component currently lacks a specialized format, resulting in a random distribution of orders in trucks. Critical elements for proper loading and stowage include securing materials within the truck, physical distribution based on weight and forces, and friction between bundles of goods. The current process does not adequately address these factors. The proposed stowage differentiation begins with two criteria: material type and order weight in kilograms.

The stowage priority during truck loading follows a specific order: PA – A products (heavyweight acrylic plastic) are placed at the truck's bottom, followed by PA – M (moderate weight), and so on until reaching V – B (lightweight glass). This prioritization ensures proper distribution of boxes within the truck, preventing internal product damage during transit. The effectiveness of the proposed model is measured using the "Shipped Without Damage" (SWD) indicator, which assesses the percentage of undamaged orders out of the total orders fulfilled. The SWD indicator ensures that the model's implementation results in minimal product damage during shipping, aiming for at least 95% of orders to be delivered without damage.

Table 3 shows an example of sorting stowage boxes based on their classification. The classifications include V - B (lightweight glass), PA - B (lightweight acrylic plastic), V - M (moderate-weight glass), V - A (heavyweight glass), PA - M (moderate-weight acrylic plastic), and PA - A (heavyweight acrylic plastic).

Table 3. Sorting of stowage boxes - Example

Box	Clasification
Box 1	V - B
Box 2	PA - B
Box 3	V - M
Box 4	V - A
Box 5	PA - M
Box 6	PA - A

5. Results

Table 4 presents the key results of validating the proposed Lean Warehousing model to address the research problem. The Fill Rate increased from 77.10% to 94.00%, representing a 21.92% improvement. Defect-Free Shipments significantly improved from 85.60% to 98.10%, with a 14.60% variation. On-time delivery remained constant at

99.10%, with no variation. Lastly, the Service Level increased from 87.30% to 97.10%, showing an 11.23% improvement. These results demonstrated the effectiveness of the proposed model in enhancing storage efficiency.

Table 4. Results of the validation of the proposed model

Indicator	As-Is	To-Be	Resutls	Variation (%)
Fill Rate	77.10%	95%	94.00%	21.92%
Defect Free Shipment	85.60%	99%	98.10%	14.60%
On Time Delivery	99.10%	100%	99.10%	0.00%
Nivel de Servicio	87.30%	98%	97.10%	11.23%

6. Conclusions

The main findings of the study indicate that the implementation of the Lean Warehousing storage model resulted in significant improvements in warehouse efficiency. The Fill Rate increased from 77.10% to 94.00%, reflecting a 21.92% improvement. The percentage of defect-free shipments rose from 85.60% to 98.10%, representing a 14.60% variation. On-time delivery remained constant at 99.10%, while the service level improved from 87.30% to 97.10%, showing an 11.23% improvement. These results demonstrate the effectiveness of the proposed model in optimizing inventory management, reducing operational costs, and enhancing customer satisfaction. The importance of this research lies in its ability to address critical issues in inventory and storage management within retail SMEs. SMEs are fundamental to the global economy, particularly in regions like Latin America and Peru, where they represent a significant portion of the retail sector and contribute to economic growth and job creation. Implementing an efficient and standardized storage model is crucial for improving operations, reducing economic losses, and increasing the competitiveness of these companies in a highly competitive environment.

The contributions to the field are notable, as the Lean Warehousing storage model provides a structured methodology that can be applied in various industrial contexts. The research offers a clear framework for ABC classification, the implementation of FIFO and FEFO methodologies, and demand planning, facilitating the adoption of Lean practices in SMEs. Additionally, the improvement in operational performance indicators and the reduction of defects in shipments underscore the viability and effectiveness of the proposed model.Final observations suggest that while the results are promising, further studies are recommended to delve deeper into the implementation of advanced technologies and their integration with Lean practices. Incorporating data analysis tools and automated systems could further enhance the efficiency of the storage model. Future research could also explore the adaptation of the model in other industrial sectors and geographies, as well as assess its long-term impact on the sustainability and operational resilience of SMEs. Active employee participation and continuous training in Lean principles are also key aspects to ensure the success and continuous improvement of the implemented storage system.

References

Abbes, N., Sejri, N., Boubaker, J., & Cheikhrouhou, M. , An integrated lean six sigma approach to modeling and simulation: a case study from clothing sme. Autex Research Journal, 22(3),305-311,2021. https://doi.org/10.2478/aut-2021-0028

Abe, I. and Mugobo, V. , Post-covid-19 retail landscapes. Harvard Deusto Business Research, 10(2), 337-345, 2021. https://doi.org/10.48132/hdbr.364

Alshurideh, M., Enhancing manufacturing competitiveness in UAE smes: the influence of process quality improvement and lean practices. International Journal of Business Analytics and Security (Ijbas), 3(2), 93-104, 2023. https://doi.org/10.54489/ijbas.v3i2.260

Belhadi, A., Touriki, F., & Elfezazi, S., Evaluation of critical success factors (csfs) to lean implementation in SMEs using ahp. International Journal of Lean Six Sigma, 10(3), 803-829, 2019. https://doi.org/10.1108/ijlss-12-2016-0078

Bo, Z., Niu, Z., & Liu, C, Lean tools, knowledge management, and lean sustainability: the moderating effects of study conventions. Sustainability, 12(3), 956,2020. https://doi.org/10.3390/su12030956

Chand, D. (2022). Transformation of retail sector: a critical review of Indian retailers. International Journal of Research in Marketing Management and Sales, 4(2), 51-55. https://doi.org/10.33545/26633329.2022.v4.i2a.153

Dotoli, M., Epicoco, N., Falagario, M., Costantino, N., & Turchiano, B. An integrated approach for warehouse analysis and optimization: a case study. *Computers in Industry, 70*, 56-69,2015. https://doi.org/10.1016/j.compind.2014.12.004

Dresch, A., Veit, D., Lima, P., Lacerda, D., & Collatto, D. , Inducing Brazilian manufacturing SMEs productivity with lean tools. International Journal of Productivity and Performance Management, 68(1), 69-87,2019. https://doi.org/10.1108/ijppm-10-2017-0248

Gopakumar, B., Sundaram, S., Wang, S., Koli, S., & Srihari, K., A simulation based approach for dock allocation in a food distribution center. In *Proceedings of the Winter Simulation Conference* (pp. 2750–2755), 2008.

Jaini, A., Zulkiffli, W., Ismail, M., Mohd, F., & Hussin, H. (2021). Understanding the influence of visual merchandising on consumers' impulse buying behavior: analyzing the literature. International Journal of Academic Research in Business and Social Sciences, 11(12). https://doi.org/10.6007/ijarbss/v11-i12/11277

Julia, A. and Hendrawan, R. (2021). Stock valuation on idx-listed retail companies using dcf with fcff and relative valuation (2021-2025 projection). The International Journal of Business & Management, 9(7). https://doi.org/10.24940/theijbm/2021/v9/i7/bm2107-056

Kundu, K., Cifone, F., Costa, F., Portioli-Staudacher, A., & Rossini, M. (2020). An evaluation of preventive maintenance framework in an Italian manufacturing company. *Journal of Quality in Maintenance Engineering*. https://doi.org/10.1108/JQME-02-2020-0007

Loske, D., Klumpp, M., Keil, M., & Neukirchen, T. (2021). Logistics work, ergonomics and social sustainability: empirical musculoskeletal system strain assessment in retail intralogistics. Logistics, 5(4), 89. https://doi.org/10.3390/logistics5040089

Manioudis, M. (2023). The historical evolution of the Greek retail trade: a first overview of its organizational-functional and spatial restructuring. Journal of Innovation and Entrepreneurship, 12(1). https://doi.org/10.1186/s13731-023-00343-7

Modula. (2023). What is Lean Warehousing? Benefits, 5S Principles & Best Practices. Retrieved from https://www.modula.eu

Mohammad, I. and Oduoza, C. (2019). Lean-excellence business management for manufacturing SMEs focusing on kri. International Journal of Productivity and Performance Management, 69(3), 519-539. https://doi.org/10.1108/ijppm-11-2018-0389

Pandi, M. (2024). Impact of implementation of lean methodologies on SMEs: a study on Allahabad smes. International Journal of Research in Management, 6(1), 402-407. https://doi.org/10.33545/26648792.2024.v6.i1e.169

Pantano, E., Pizzi, G., Scarpi, D., & Dennis, C. (2020). Competing during a pandemic? retailers' ups and downs during the covid-19 outbreak. Journal of Business Research, 116, 209-213. https://doi.org/10.1016/j.jbusres.2020.05.036

Prasad, S., Baltov, M., Rao, A., & Lanka, K., Interdependency analysis of lean manufacturing practices in case of Bulgarian SMEs: interpretive structural modeling and interpretive ranking modeling approach. International Journal of Lean Six Sigma, 12(3), 503-535,2020. https://doi.org/10.1108/ijlss-09-2019-0100

Prasetyawan, Y., & Ibrahim, N. G. (2020). Warehouse improvement evaluation using lean warehousing approach and linear programming. In *IOP Conference Series: Materials Science and Engineering*. https://doi.org/10.1088/1757-899X/012033

Qureshi, K., Mewada, B., Alghamdi, S., Almakayeel, N., Qureshi, M., & Mansour, M. (2022). Accomplishing sustainability in manufacturing system for small and medium-sized enterprises (SMEs) through lean implementation. Sustainability, 14(15), 9732. https://doi.org/10.3390/su14159732

Qureshi, K., Mewada, B., Kaur, S., & Qureshi, M. (2023). Assessing lean 4.0 for industry 4.0 readiness using pls-sem towards sustainable manufacturing supply chain. Sustainability, 15(5), 3950. https://doi.org/10.3390/su15053950

Rizkiyani, S. and Unzilatirrizqi, Y. (2021). Postharvest handling of coffee in small and medium enterprises (SMEs) Tugu Juang Coffee, Pulsar Village, Pemalang Regency. Journal of Technology and Food Processing (Jtfp), 1(01), 7-16. https://doi.org/10.46772/jtfp.v1i01.337

Robertson, J., Botha, E., Walker, B., Wordsworth, R., & Balzarova, M. (2022). Fortune favors the digitally mature: the impact of digital maturity on the organizational resilience of SME retailers during COVID-19. International Journal of Retail & Distribution Management, 50(8/9), 1182-1204. https://doi.org/10.1108/ijrdm-10-2021-0514

Rossini, M., Portioli, A., & Kassem, B. , Supply chain planning: a quantitative comparison between lean and info-sharing models. *Production and Manufacturing Research, 6*(4), 264–283, 2018. https://doi.org/10.1080/21693277.2018.1509744

Sahoo, S. ,Assessing lean implementation and benefits within Indian automotive component manufacturing SMEs. Benchmarking an International Journal, 27(3), 1042-1084, 2020. https://doi.org/10.1108/bij-07-2019-0299

Shokri, A. , Reducing the scrap rate in manufacturing SMEs through lean Six Sigma methodology: action research. Ieee Engineering Management Review, 47(3), 104-117,2019. https://doi.org/10.1109/emr.2019.2931184

Sudarshan, D. (2023). Marketing strategies and customer's perception of modern retail units in Kurnool district of Andhra Pradesh. International Journal of Trendy Research in Engineering and Technology, 07(04), 01-08, 2023. https://doi.org/10.54473/ijtret.2023.7401

Thanki, S. and Thakkar, J. ,An investigation on lean–green performance of Indian manufacturing SMEs. International Journal of Productivity and Performance Management, 69(3), 489-517,2019. https://doi.org/10.1108/ijppm-11-2018-0424

Torri, M., Kundu, K., Frecassetti, S., & Rossini, M.,Implementation of lean in IT SME company: an Italian case. *International Journal of Lean Six Sigma, 2021*. https://doi.org/10.1108/ijlss-05-2020-0067

Vevere, V., Shina, I., & Ganina, S. (2022). Corporate social responsibility as a factor promoting customer loyalty in the latvian retail sector. European Integration Studies, (16), 135-149. https://doi.org/10.5755/j01.eis.1.16.31325

Wegerif, M. , "Informal" food traders and food security: experiences from the COVID-19 response in South Africa. Food Security, 12(4), 797-800, 2020. https://doi.org/10.1007/s12571-020-01078-z

Yadav, V., Jain, R., Mittal, M., Panwar, A., & Sharma, M., An appraisal on barriers to implementing lean in SMEs. Journal of Manufacturing Technology Management, 30(1), 195-212, 2019. https://doi.org/10.1108/jmtm-12-2017-0262, 2019

Yin, R. K. (2009). *Case Study Research: Design and Methods*. Sage Publications Inc.

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