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Original Article

Lean-Driven Warehouse Model Integrating Slotting and SLP to Raise Fill Rate in Medical Equipment SMEs

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***Abstract** - Inefficient warehousing is still a problem for Small and Medium-sized Enterprises (SMEs) in emerging economies, where research on how to improve fill rates is still lacking. This study looks at how to make order fulfillment more reliable in a Peruvian small business that imports medical equipment. We suggest a lean-driven warehouse model that combines Standard Work, multi-criteria ABC Slotting, and Systematic Layout Planning (SLP) and is specifically designed for places with limited resources. We used pilot testing and discrete-event simulation to evaluate the interventions. They led to big improvements: the fill rate went up from 89.02% to 92.70% (+3.68 pp), the total cycle time went down by 25.43%, the picking travel distance went down by 17.81%, and the warehouse occupancy went up by 14.67%. These results show that the proposed approach is both technically workable and practically useful in real warehouse operations. Beyond the efficiency improvements reported, the study adds empirical evidence to the still-limited literature on logistics in SMEs from emerging markets, and it provides a basis for future research on warehouse optimization strategies that can be scaled and sustained over time.*

***Keywords** - Lean Warehousing, Slotting Optimization, Systematic Layout Planning, Fill Rate Improvement, SMEs in Emerging Economies.*

1. Introduction

Peru's foreign trade has been growing steadily in recent years, largely driven by imports. According to CEIC Data, Peruvian imports in September 2023 were 15% higher than in September 2022. [1] In addition, a report by Chamorro, R. indicates that total Peruvian imports in 2022 reached USD 60,073.6 million, highlighting an increase of 18.1% with respect to 2021 and representing approximately 24.52% of the national GDP for the period. [2] Although the sector generates many jobs, key data from a 2024 INEI report shows that only 29.5% of workers in the industry enjoy full legal benefits, while the remaining 70.5% are in the informal sector. In addition, 45.3% of employees in SMEs with 11 to 50 workers are in informal employment, exposing them to legal risks and leaving them less skilled. [3] Several studies have identified that SMEs in the international trade sector face recurring logistical challenges, especially in imports. Among the most relevant are constant difficulties in forecasting demand, poor inventory management, limited distribution channels, high shipping costs, and customs problems stemming from the high regulatory complexity of international transportation. [4-6]. The case study was conducted at a Peruvian SME in the international trade sector, specifically the medical equipment import subsector. The main problems identified were inefficient inventory management, frequent errors in the assembly of medical products, lack of structural organization, and high variability in order preparation times. These problems were identified because the company provided internal warehouse data, including records of picking and packing times, current SKUs, internal classification by merchandise type, rejected orders per month, and internal audits. Fill Rate was chosen as the leading indicator to demonstrate improvement. This KPI shows what share of demand is covered right away with the stock on hand, without generating backorders. It reflects how well the system can fulfil complete orders on the first attempt and is closely related to the efficiency of operations and inventory planning. [7]. The SME has a Fill Rate of 89.02%. At the same time, there is no single Fill Rate standard applicable to the import sector or to SMEs, since this indicator is directly affected by inventory disorganization, errors in stock records, lack of periodic control, and poor demand planning. [8] However, Bruzda, J. et al. report that in logistics systems of medium-sized companies, target Fill Rate levels are usually between 95 % and 98 % to reduce contractual penalties and improve customer service. [9] For this reason, 95% is used in this research as the Fill Rate reference value in order to evaluate the performance of the proposed model. The Fill Rate below the reference value is explained, first, because 35% of the factors affecting it are related to rejected orders due to preparation errors. The leading causes are divided into two: the inadequate location of key activities within the warehouse

(20%) and the lack of standardization in the packaging process (15%). The second reason affecting the Fill Rate is the inefficient distribution of products within the warehouse, which accounts for 65% of the overall problem. This block is composed of two key causes: incorrect allocation of bins according to product rotation order (25%) and incorrect allocation of spaces according to merchandise type (40%).

This research differs from previous work by addressing a real logistics problem for an SME importer of medical products in an emerging economy, where the use of engineering methodologies remains limited. Unlike approaches that apply tools such as Lean Manufacturing, Slotting, and SLP in isolation or to large, consolidated, or medium-sized companies, this research proposes an integrated, replicable, and low-cost model, adapted to the operational constraints of the sector and the size of the company, that enables the sector to become more competitive. [10] Thus, it contributes to the applied literature with a replicable solution that significantly improves logistics performance, delves into the gaps and data of SMEs, uses the Fill Rate indicator as the axis, and generates quantitative evidence that helps close the existing data gap in the sector.

Lean-driven gains are well established in manufacturing and have also been reported in warehousing. Yet, for importing SMEs in emerging economies, there is still little empirical work on integrated interventions that treat fill rate as the central KPI. All too often, Lean is implemented as Slotting or SLP as a standalone intervention, or is tested in larger, digitised organisations. It thus remains an open question how exactly low-cost combined approaches will perform under data availability constraints, limited space, and workforce performance variability in SMEs. This paper meets that need by proposing an integrated, context-appropriate approach and testing it quantitatively. In fact, it investigates whether the model can combine Lean Standard Work, multi-criteria ABC slotting, and SLP-based layout redesign to increase fill rate while reducing cycle time, picking travel distance, and space utilisation in a Peruvian SME that imports medical equipment. This paper offers three contributions. First, it lays out a step-by-step integration of Lean, Slotting, and SLP that is aligned with the operational constraints commonly faced by SMEs. Second, it uses two complementary simulation tools-Arena to show how process standardization works and Flex Sim to look at slotting decisions and layout configuration-based on pilot-derived time distributions and 95% confidence intervals. Third, it uses fill rate as the main measure of performance, together with time, distance, and occupancy metrics, to try to make changes that are both cheap and easy to repeat. The rest of this paper is set up as follows: Section 2 is a review of the literature, Section 3 is a description of the methodology and model design, Section 4 is a presentation of the results, Section 5 is a discussion of the findings, and Section 6 is a summary of the main points.

2. Literature Review

For this research, a systematic literature review was conducted with high methodological rigor and scientific validity. Forty academic articles published between 2018 and 2024, selected for their relevance and timeliness, were analysed. The focus of the review was centred on the international trade sector, prioritizing studies on logistics management, operational efficiency, and the application of engineering methodologies in SMEs in emerging economies.

The literature review was carried out mainly by consulting academic articles available in the Scopus and EBSCO databases, selecting publications from the last eight years. Although priority was given to studies applied to the international trade sector and the importing subsector, studies from various sectors were also included, provided that their methodological approach was rigorous and that they could offer transferable contributions to the present study. The methodological procedure was structured in several stages, the characteristics of which are shown in Table 1.

Table 1. Research methodology

Stage	Description
Delimitation of the approach	Search models that implement Lean Manufacturing, Slotting, and SLP tools in warehouse logistics improvements.
Keyword selection	Specific terms such as inventory management, Slotting, productivity, Lean Manufacturing tools, and SLP were used.
Time frame	Only publications from the last 8 years were used to ensure novelty and academic relevance.
Review of academic sources	Only articles whose journals are indexed in Scopus and EBSCO are included, to maintain rigor and scientific quality.
Systematization, synthesis, and analysis	The articles found were classified by tool, benefits, and indicators measured, extracting key evidence to support the proposed model.

Likewise, the articles were classified into four different typologies, thus making it possible to organize the findings in a structured manner and to connect the approaches of other authors to enrich the conceptual development of the proposed model.

2.1. Application of Lean Manufacturing Tools for Standardization

Low warehouse efficiency in SMEs in the international trade sector generates cost overruns, bottlenecks, and makes it difficult to adapt to demand. [10] This problem is quite important since it affects both competitiveness and the ability to fill orders. These kinds of inefficiencies lead to genuine problems, like higher costs from emergency purchases, returns of inventory, physical bottlenecks, lower productivity, and lower quality of service. It is important to highlight that Lean technique implementation provides a distinct solution that focuses on getting rid of waste, improving important procedures, and making logistical operations more consistent. [11]. Many research projects use tools like 5S, Value Stream Mapping (VSM), Kanban, Kaizen, ABC classification, forecasting, Slotting, and the DMAIC tool from Six Sigma. These tools have helped improve Process Efficiency (PCE), Lead Time, Attrition Ratios, and Service Level. [12, 13] It is important to note that Lean Standard Work, which uses standardized procedures, manuals, task cards, and visual controls to make work more efficient, is very important. This tool makes it easy to repeat a procedure, reduce unpredictability, and keep improvements going. [14, 15] The research employs metrics such as inventory turns, stockouts, inventory accuracy (ERI), Service Level, MAPE, and 5S audit, validated by simulation experiments or practical application. [13, 15]

The methodologies used include steps like state analysis (SIPOC, VSM, C&E trees), coming up with lean solutions, and testing them via Arena simulations and pilot tests. [13] In contrast to other research with a more manufacturing-oriented perspective, the success of applying lean solutions in logistics, such as retail warehouses, e-commerce, and import firms, is explicitly highlighted, with a couple of studies proposing a Lean Six Sigma hybrid approach to improve analysis completeness. [10, 13] Despite the positive findings, a significant research gap is that most research remains strongly motivated by a more manufacturing-oriented perspective, with little real evidence on logistics SMEs, especially in Latin American countries. Additionally, a need for further research is identified regarding the intersection of Lean Standard Work with more modern technologies to promote sustainability. [11, 15]

2.2. Application of Slotting to Maximize Warehouse Space

Warehouses, in cases involving a significant product variety, such as a large number of SKUs, storage space allocation is a complex optimisation problem. On one side, there is a need to take into account the real estate capacity, different turn rates, as well as highly varied product properties. The effect of responding to such trade-offs with a trial-and-error solution, which neglects strategic optimisation, would mainly result in inefficient layout topologies, besides raising the cost of operation significantly, thereby resulting in longer picking paths, reduced pallet use, excessive transportation costs, and increased potential for incorrect product placement. [16, 18] In response, research has identified that the use of advanced Slotting techniques can not only optimize the use of space but also improve the performance of the entire logistics system. [17, 19]. Techniques used include models of ABC classification, sorting algorithms, correlation matrices, and penalties for product incompatibility and/or travel distance. [16, 17, 19] Slotting systems that optimize routes, picking zone changes, and logic within the WMS are also used. [18] In order to analyse the results, metrics such as efficient travel distance, use of storage space, receiving efficiency, shipping efficiency, as well as savings in man-hours are used. [18, 19]. The solutions use a method that includes data analysis, classification, assignment, simulation, and validation. This method is employed in real-world situations and in experiments in food, auto parts, and retail industries. [17–18] The proposed methods have been used in both manual warehouses and multi-zone facilities with mezzanine systems. This shows that they can work even in operations with a lot of turnovers and limited physical space. [16–18] The studies report gains of up to 30% in volumetric space utilization, improvements of up to 25% in dispatch efficiency, and savings of more than 800 hours per semester when compared with the baseline layouts. [17, 18] Despite this, a lack persists in the combined consideration of SKU compatibility, ergonomic factors, and maximum height, along with the limited use of artificial intelligence predictive modelling within Adaptive Slotting. [16, 19]

2.3. Application of SLP to Reduce Travel Distances and Improve Warehouse Spatial Efficiency

Several studies agree that inefficient layouts generate unnecessary routes, congestion, and high logistics times, affecting operating costs and responsiveness in warehouses and industrial facilities. [17, 18] Spatial disorganization leads to material flow setbacks, increased lead time, and limitations to scale operations, especially in SMEs. [19, 20]. To solve it, Systematic Layout Planning (SLP) is used as a structured methodology that prioritizes functional relationships, identifies incompatibilities, and improves space layout using tools such as ARC/ARD diagrams and from-to analysis. [21, 22] In some cases, it is combined with Lean approaches such as 5S or PQRST analysis to strengthen redesign. [19, 22]. Common metrics include reduced distances travelled, logistics cost savings, increased picking efficiency, and operational order. [20, 21] The process typically involves layout diagnosis, relationship analysis, design of alternatives, and scenario comparison. [22] The applied cases range from warehouses to steel plants, showing improvements such as 34% less material movement, 26% more efficient use of space, and logistics savings of up to 21%. [20-22]

3. Methodology

Despite the proven effectiveness of Lean tools, Slotting strategies, and Systematic Layout Planning methodologies, only a few studies have proposed an integrated model that combines these approaches and applies them in real warehouse environments within SMEs. In Appendix 1, a systematic review of six reference models was conducted, assessing each component on the scope of the literature review, integration of engineering tools, application in case studies, and use of performance indicators. The research fills a known gap in the literature by providing a structured and cost-effective tool specifically for small and medium-scale enterprises (SMEs) within developing economies, grounded on pilot results and simulation findings. The research helps to develop application knowledge by combining such tools in a way that increases efficiency in space, productivity in operation, and process standardization.

3.1. Proposed Model

The proposed model consists of an inventory management framework aimed at addressing common challenges in the sector: inefficient storage planning, inadequate allocation of products and activities within the warehouse, and high variability in packing processes. These problems lead to a low Fill Rate, which is a problem that has not been studied enough in the literature, especially in research that looks at Lean Standardization, Slotting, and SLP together in small and medium-sized businesses. Figure 1 shows the proposed model, which has a low Fill Rate as its main input and an enhanced Fill Rate as its main output. This is done by using three main parts: diagnosis, intervention, and evaluation. The model's primary contribution is that it uses all three of these strategies together to improve the Fill Rate.

3.2. Model Components

3.2.1. Component 0: Analysis of the Current Situation

The first section of the model helps to identify problems that are happening right now with the storage process. This is done by looking at warehouse performance measures, including wasted time, variability, and the way operations are set up in the warehouse layout. With this information, a problem tree is built that shows the issues and their primary causes, as shown in Figure 3. This organized analysis lets you pick the correct technical tools to fix the problems you uncovered.

3.2.2. Component 1: Intervention

In Component 1, there is a proposal for the adjustments that are made to solve the problems detected in the last section, utilizing the correct tools. The first stage is to use Lean Standardization, which begins with producing the initial spaghetti diagram. This chart demonstrates how goods move across the warehouse until they are ready to be shipped. After that, the average work pace (Takt Time) is utilized to find out how long it truly takes to choose and pack things.

After that, a Work Combination Chart is produced to indicate how operators complete their jobs in order. Then, an initial line balancing chart is constructed to indicate how much work each person has to do and how it compares to the established takt time. Besides, an ECRS analysis is used to redesign processes by looking at each step in a methodical approach. Finally, a new line balancing chart is constructed using the new time measurements that were taken after Lean was put in place.

There is also a Standard Work Board that shows the appropriate order in which to do tasks during dispatch operations. This method makes a fresh spaghetti diagram that displays a better flow after Lean changes. Step two uses the Systematic Layout Planning (SLP) method. The design begins by defining the tasks and examining how they are connected. Next, flow data is collected, which includes both the movement of materials and the movement of operators within the warehouse. A study of the space needs for each operation is also done. Next, the FlexSim simulator program is used to come up with other options for redesigning the arrangement.

We look at these options to see which one has the best performance, and then we make changes to get the ideal layout design. The Slotting tool is used in the third step. It starts with an ABC multi-criteria analysis of product demand to find goods in the warehouse that have high and low rotation. Based on this, the current locations of these products are looked at and moved to new places based on the ABC results. Finally, a relationship diagram between the goods is made, the layout is changed to fit, and the suggested adjustments are put into place.

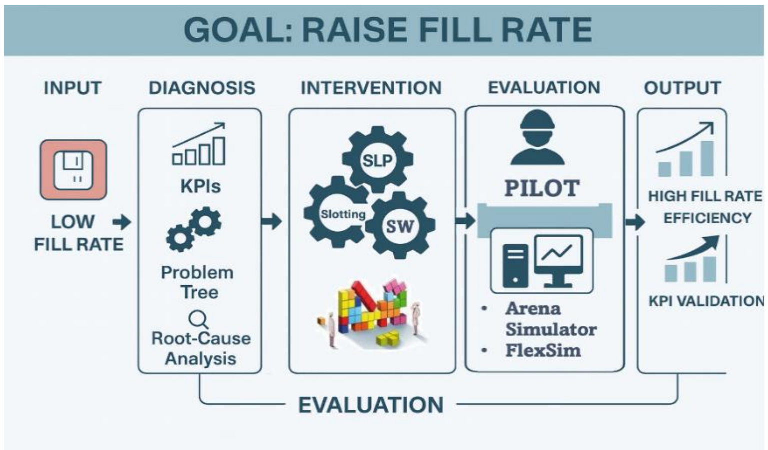


Fig. 1 Proposed model

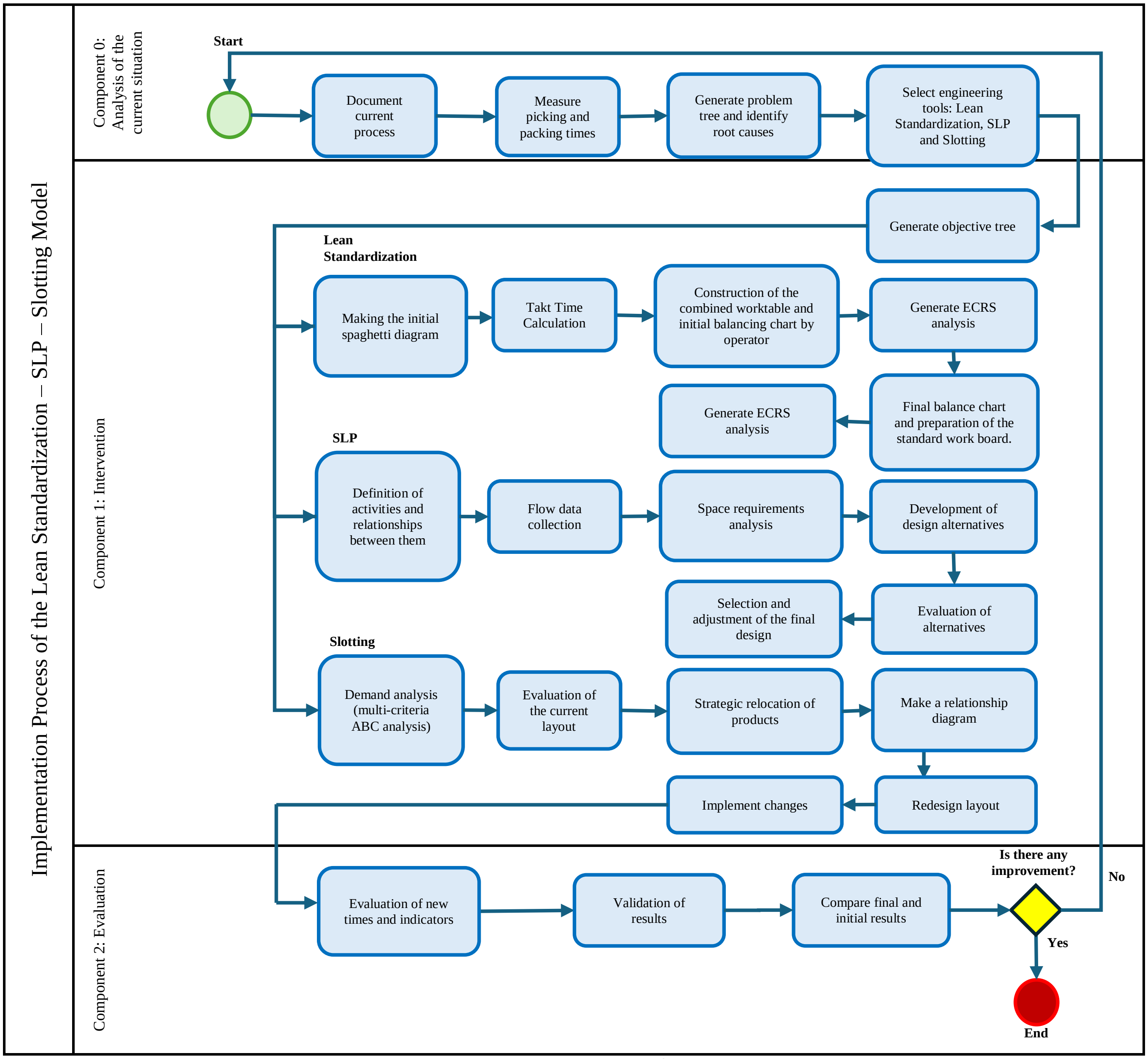


Fig. 2 Proposed method flow

3.2.3. Component 2: Evaluation

Component 2 evaluates the effectiveness of the model by comparing the current state with the post-simulation scenario using key performance indicators. This component determines whether the proposed implementations have led to a significant improvement. The implementation process of the proposed model is illustrated in Figure 2.

3.3. Model Indicators

The simulation results are evaluated using the following performance indicators. This will be evaluated in the following section.

3.3.1. Fill rate

This indicator measures the percentage of customer order units that are immediately dispatched from available inventory, without the need for replenishment or waiting. [23]

$$\text{Fill Rate} = \frac{\text{Total Units Delivered from Inventory}}{\text{Total Units Demanded}} \times 100 \qquad (1)$$

The main objective is to achieve a 3.5% increase in the Fill Rate.

3.3.2. Total Cycle Time

Defined as the total time an operator takes to perform the picking and packing of a sales order. [24]

$$\text{Total Cycle Time} = \text{Picking Time} + \text{Packing Time} \quad (2)$$

The goal is to reduce the total cycle time by 26 minutes through the proposed improvements.

3.3.3. Warehouse Occupancy Percentage

This indicator measures the amount of space used relative to the total available space for storing goods within the warehouse. [25]

$$\text{Warehouse occupancy percentage} = \frac{\text{Space Used By Merchandise}}{\text{Storage Space Available}} \quad (3)$$

This indicator reflects the inventory replenishment level of the company. The goal is to increase the occupancy rate by 4% in order to reduce the risk of stockouts.

3.3.4. Travel Distance during Picking

This indicator measures the distance, in meters, that the operator travels to complete the picking task [24].

$$\text{Travel Distance} = \text{Total Meters Travelled by Operator} \quad (4)$$

This indicator helps identify unnecessary movements made by the operator during the picking task. The objective is to reduce the total travel distance by 3.2 meters.

In addition, order accuracy and labor productivity were monitored qualitatively and are proposed as formal KPIs for future tracking, although they were not included in the simulation results.

4. Results

4.1. Description

The case study was conducted in the storage area of an SME dedicated to importing and marketing medical equipment, located in Lima, Perú. Its main clients are other companies seeking equipment for use in the medical field. Within the warehouse, common sector issues have been identified, such as a low Fill Rate of 89.02%; however, the industry benchmark suggests an acceptable value of 95%. The warehouse team includes three operators.

The first concerns receiving products that enter the warehouse. The second organizes the goods in the warehouse and picks them when a sale order is generated. The third is in charge of packing the products prepared by the second operator. In addition, a supervisor is required to ensure the correct development.

4.2. Diagnosis

We did not just assume the low Fill Rate, but used six months of warehouse information to figure it out. The Fill Rate was 89.02% on average during this time, which is lower than the sector average of 95%. The warehouse used around 75% of its available storage space, which is lower than the reference value of 90%. [9] A Pareto study of non-conformities revealed two primary factors: ineffective product distribution within the warehouse (about 65% of recorded events) and order rejections stemming from packaging problems (approximately 35%). To corroborate these findings, multiple internal databases were examined. A stacking audit was carried out on 30 randomly selected locations in the warehouse and found that only about 76.7% of entries in the system matched, confirming that mismatches were common.

In parallel, a time study was run on 31 completed orders using a basic stopwatch, measuring the time from the start of picking to the end of packing.

The recorded cycle times ranged from roughly 22 to 64 minutes, and the variation between orders was high (coefficient of variation above 25%), which showed that the warehouse did not follow a stable or standardised way of working.

These data sets were consolidated into the problem tree shown in Figure 3, which links the main causes to the low Fill Rate and to an estimated economic impact of approximately PEN 15,165 in lost revenue and rework per product.

4.3. Validation Method

4.3.1. Lean Standardization Pilot Plan

To obtain time data before and after the implementations, a pilot test was conducted with the three warehouse operators under normal operating conditions. Appendix 2 presents the results of the steps carried out during the pilot test: a standard work board outlining, step by step, the procedure to be followed by the operator, along with target times for completing the picking and packing tasks. In this pilot, 30 valid time observations were collected for each of the two main activities: picking and packing. A simple continuous timing approach was used, recording how long each task took while the operators followed the sequence defined on the standard work board. The consolidated results are summarised in Table 2.

Picking times showed moderate variability, with a coefficient of variation of around 20%, whereas packing times were more dispersed, with a coefficient of variation above 28%. This confirmed that the packing stage was less standardised and therefore became the main focus of the Lean Standardization efforts.

The mean times obtained in this pilot were later used both to define the target times on the standard work board and to feed the time distributions applied in the simulation models.

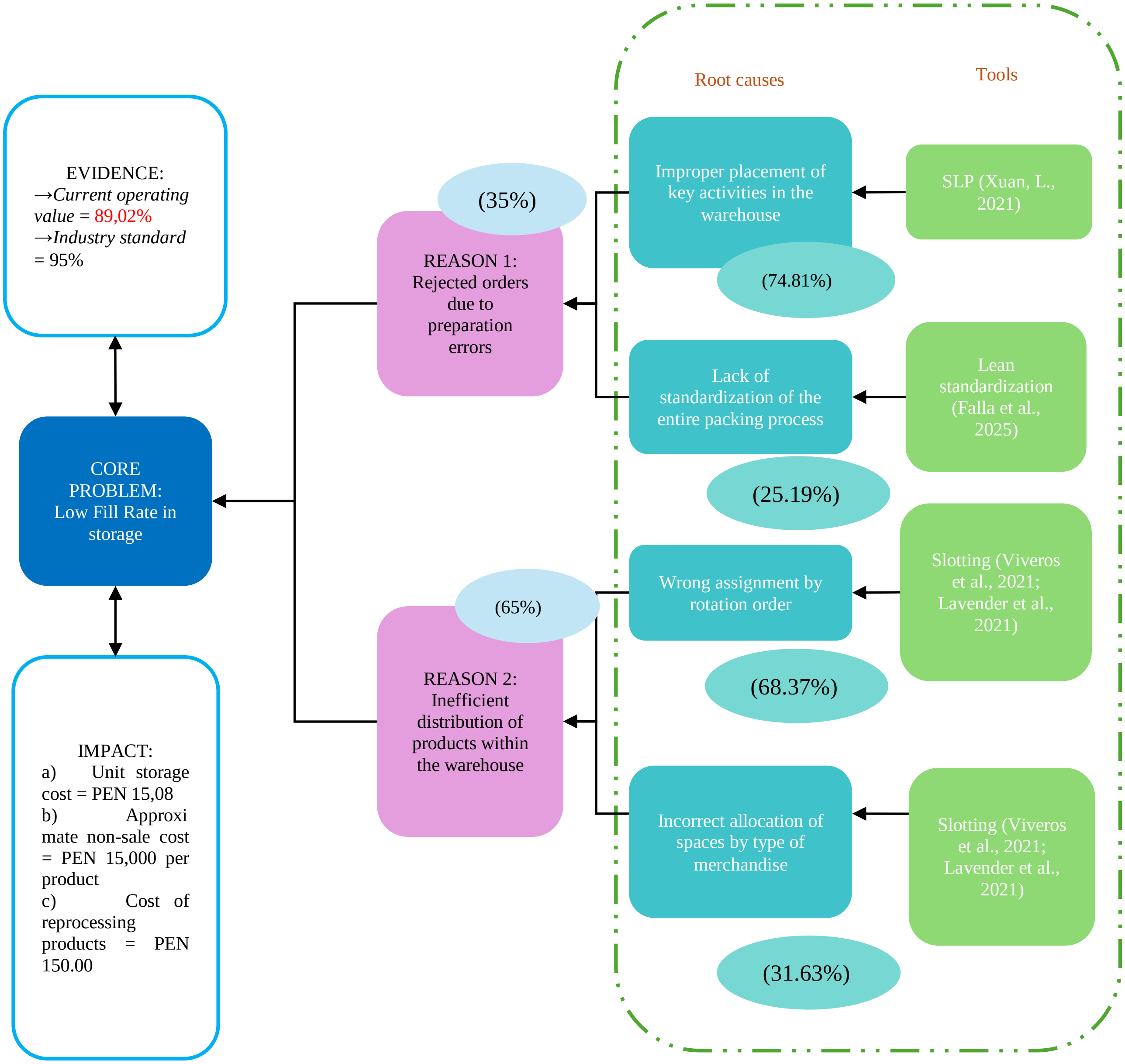


Fig. 3 Problem tree

Table 2. Descriptive statistics of picking and packing times

Activity	Mean time (min)	Standard deviation (min)	Coefficient of variation (%)
Picking	12.59	2.52	20.0
Packing	42.12	11.93	28.3

4.3.2. Lean Standardization Arena Simulator Simulation

To assess the effect of Lean Standard Work on packaging operations, a discrete-event simulation model was built in Arena, reproducing the current and standardized picking-packing flows with empirical cycle times as stochastic inputs. The main performance measures are total order cycle time and Fill Rate, both evaluated with 95% confidence intervals. December 2023 was chosen as a representative month, during which N = 31 orders were processed. Using the finite-population sample size formula (95% confidence, 5% margin of error, maximum variability), we estimated that a minimum of approximately n ≈ 29 orders was required with the following formula:

$$n = \frac{31 * 1.96^2 * 0.5 * 0.5}{0.05^2 * (31-1) + 1.96^2 * 0.5 * 0.5} \cong 28.76 \cong 29 \quad (5)$$

Since the population was small, a census approach was adopted, and time was recorded for 100% of the orders, eliminating sampling error and increasing the robustness of the validation. The empirical time data were imported into Arena's Input Analyzer to identify suitable probability distributions. Several families (Beta, Normal, Lognormal, Gamma, Weibull, Triangular, etc.) were tested using Chi-square and Kolmogorov–Smirnov tests. Picking times were best represented by a bounded Beta distribution (p-values > 0.10), while packing times were modelled with a Normal distribution; although its Chi-square p-value is slightly below 0.10, the K–S p-value (> 0.15) supports its use in the simulation, and the Chi-square test can be sensitive to interval definitions, particularly with limited samples. All fitted parameters, errors, and p-values are summarized in Table 3. In the Arena model, each order moves through the picking and packing stages using these fitted stochastic times. Multiple replications were run for both the "As-Is" and "To-Be" configurations, and 95% confidence intervals were then obtained using the Output Analyzer. These results confirm that the reductions in total cycle time and improvements in Fill Rate achieved through Lean Standardization are statistically significant and not driven by random variability. Based on these considerations, the base model aligned with the company's current indicators is presented along with the model incorporating the proposed implementations and reporting improved indicators. Figure 4 displays the storage process diagram. Figure 5 illustrates the initial Arena model used to obtain baseline indicators prior to implementation, while Figure 6 presents the model after applying Lean Standard Work, already incorporating the fitted task-time distributions. Finally, Figure 7 shows the proposed organization of storage spaces enabled by the Lean tool and the standard work board.

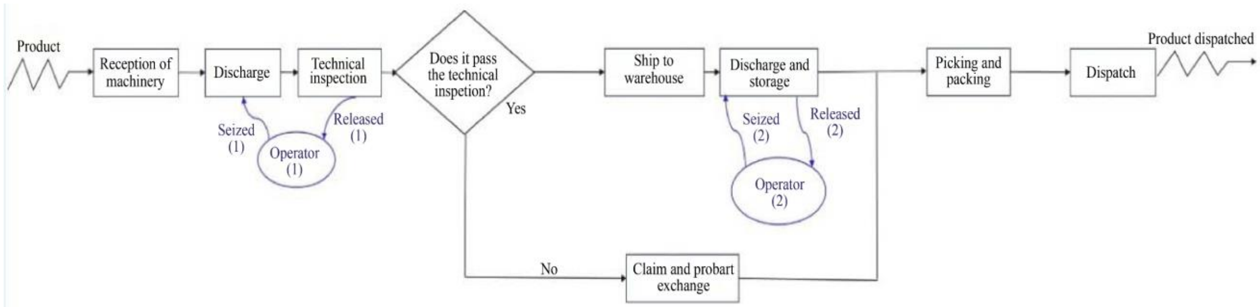


Fig. 4 Representation of the current model of storage

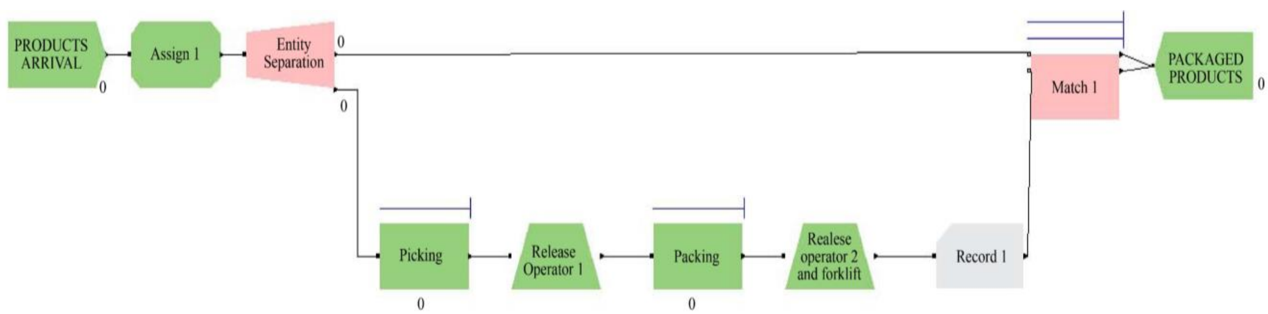


Fig. 5 Original model before implementation of the lean standardization tool in arena software

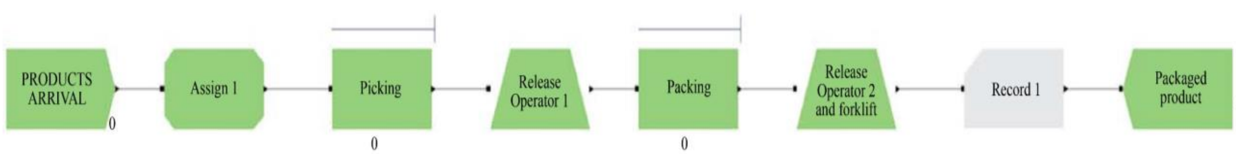
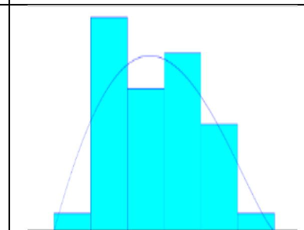
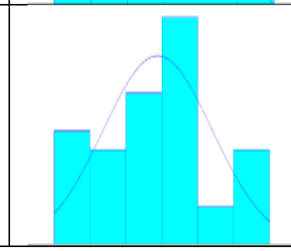


Fig. 6 Proposed model in arena software

Before	After
	

Fig. 7 Before and after pilot plan

Table 3. Statistical evidence of the time distributions of picking and packing processes

Process	Distribution Type	Interval	Unit	Kolmogorov-Smirnov test	Chi-square test (p-value)	Accepted / Not accepted	Graph
Picking	Bounded Beta Distribution	(7, 19)	min/order	> 0.15	0.414	Yes	
Packing	Normal Distribution	(41.1, 11.7)	min/order	> 0.15	0.0478	Yes	

4.3.3. Slotting and SLP FlexSim Simulation

For the validation model developed in FlexSim, the first step for Slotting involves performing a multi-criteria ABC analysis using Python programming, as shown in Figure 8. The time data used to construct the probability distributions in the simulation were obtained from a pilot plan that collected 30 observations for each of the analyzed processes. This first step made it possible to gather data that was both representative and in line with how things actually worked, which made it possible for the simulation to show the inherent fluctuation that happens in real life. This analysis finds the products with the most rotation and moves them closer to the location where they will be packed and sent. In the SLP section, a relationship diagram is also made to show how operations in the warehouse connect with each other. Figure 9 shows this. Based on this, Figure 10 presents the original model used to obtain the initial indicators, while Figure 11 shows the model with the implemented improvements, which enables the assessment of the enhanced performance indicators. To ensure data reliability, statistical representativeness criteria were applied before their use in the model. Additionally, the records underwent data cleaning and normalization to eliminate inconsistencies and preserve the dataset's integrity. Sampling procedures were conducted at the 95% confidence level, providing a solid basis for estimating the model parameters. Consequently, the values incorporated into the simulation reflect real operating conditions with only minimal variability.

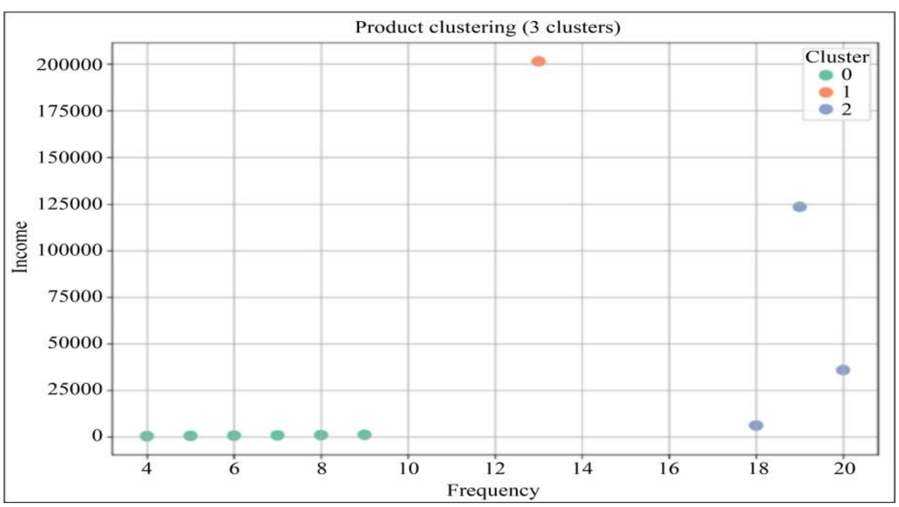


Fig. 8 Product clustering using the ABC multi-criteria method using the Python language

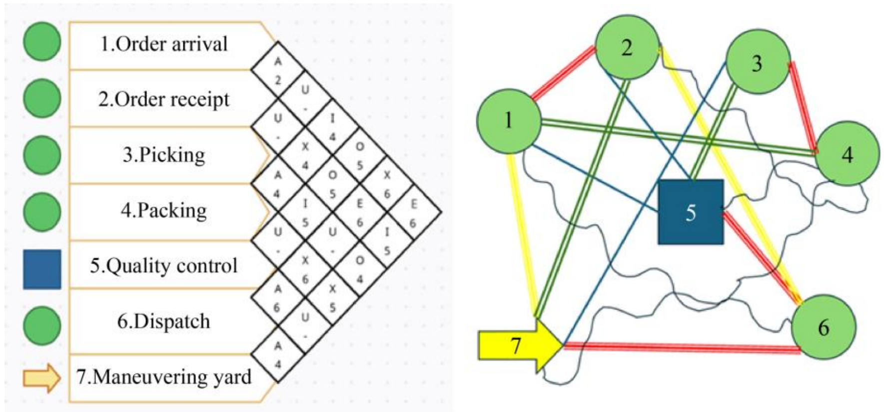


Fig. 9 Activity relationship diagram and space relationship diagram

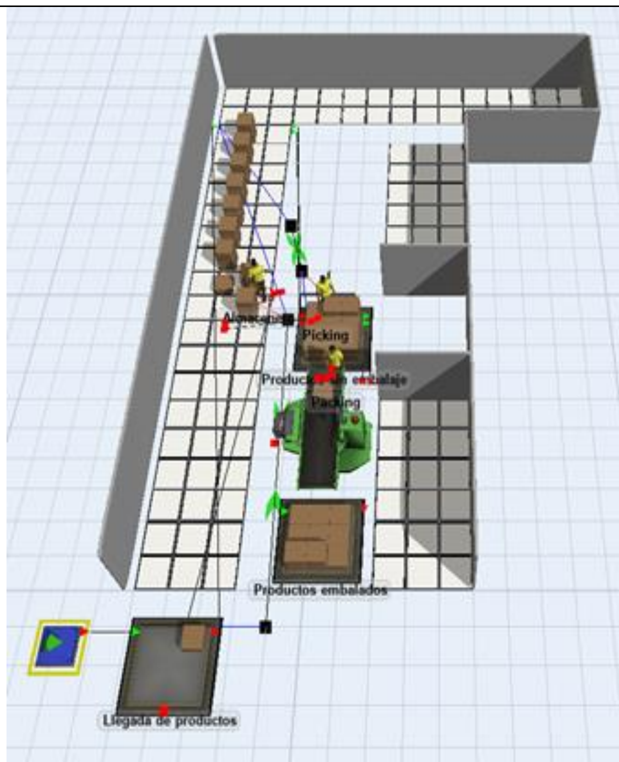


Fig. 10 FlexSim simulation of the original warehouse layout

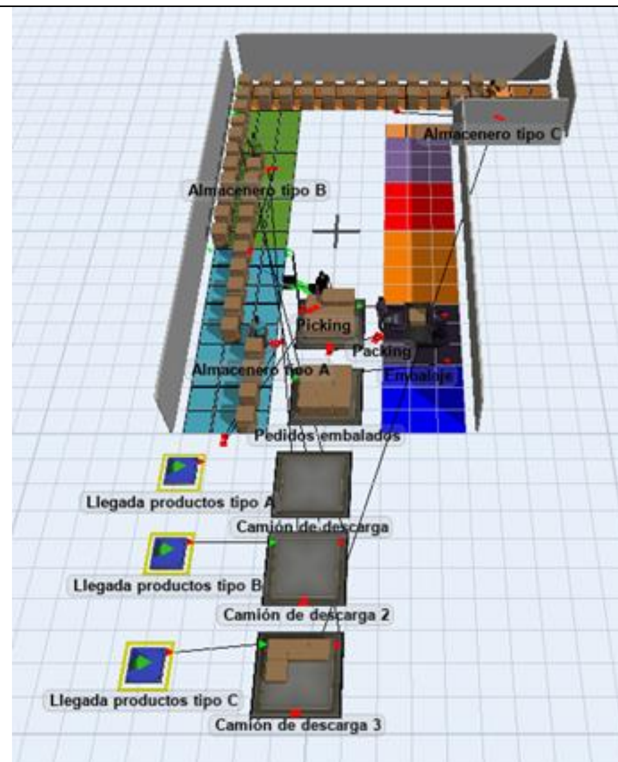


Fig. 11 FlexSim simulation of the proposed warehouse layout after Slotting and SLP optimizations

4.3.4. Simulation Results

Table 4 presents the values of the indicators for both the original model and the model after implementation. Following the application of the model's three tools, a 3.68 pp increase was observed in the main indicator, Fill Rate. Additionally, a 25.43% reduction in total cycle time was achieved. The warehouse occupancy rate improved by 14.67%, and the travel distance was reduced by 17.81%. As can be seen in Figure 12, in an illustrative manner, the main KPIs have improved with the new proposed model.

Table 4. Validation process results

Indicator	Original Model	Proposed Model	Improvement	Tool
Fill Rate	89.02%	92.70%	3.68 pp	Proposed model
Total Cycle Time	57.72 minutes/order	43.04 minutes/order	25.43%	Lean Standardization
Warehouse Occupancy Percentage	75%	86%	14.67%	Slotting
Travel Distance	16.28 meters/order	13.38 meters/order	17.81%	SLP

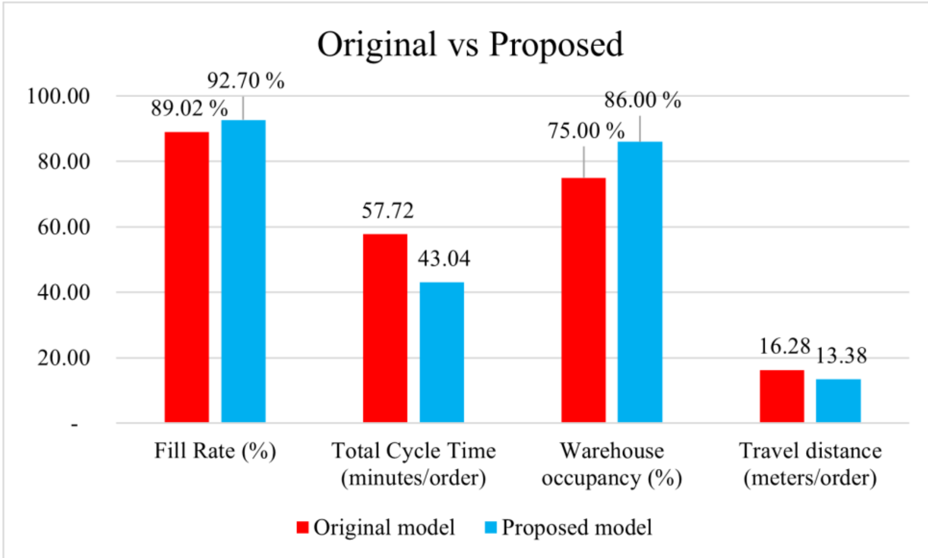


Fig. 12 KPIs comparison between original and proposed model

4.3.5. Economic Validation

A 3-year financial cash flow projection was conducted, considering an investment of PEN 9,623 for the implementation of the improvement model. The project yielded a Net Present Value (NPV) of PEN 71,905, confirming its viability. Additionally, an Internal Rate of Return (IRR) of 327.98% was obtained, significantly exceeding the Cost of Capital (COK) of 11.41%, which further supports the project's profitability. Moreover, a Benefit-Cost (B/C) ratio of 10.53 was achieved, indicating that the benefits are 10.53 times greater than the costs. The Payback Period was calculated at 4 months, meaning that the project's net gain will be realized starting from the fourth month after implementation. The economic indicators are detailed in Table 5.

Table 5. Economic indicators

Indicators	Value
Net Present Value (NPV)	PEN 71,905
Internal Rate of Return (IRR)	327.98%
B/C	10.53
Payback Period (Months)	4

4.3.6. Economic Sensitivity and Risk Analysis

Beyond the deterministic economic indicators reported in Table 6 (NPV of PEN 71,905, IRR of 327.98%, B/C of 10.53, and a four-month payback period), a sensitivity and risk analysis was conducted to assess the project's robustness under uncertainty. A Monte Carlo simulation with 3,000 iterations and a 90% confidence level was performed using a specialized risk analysis add-in. The economic Net Present Value (NPV) was defined as the output variable, while three key drivers were treated as uncertain inputs: (i) the initial implementation cost (training, consulting and slotting/SLP adjustments), (ii) the improvement in fill rate achieved by the integrated Lean–Slotting–SLP model, and (iii) the cost of capital (COK) around the base value of 11.4%. Each input was modeled as a triangular distribution (minimum, most likely, and maximum values) based on engineering judgment and pilot results, which is appropriate for SME projects with limited historical data. The simulation results are summarized in Table 6. The mean simulated NPV is PEN 87,617, with a median of PEN 88,606 and a mode of PEN 89,521. In practical terms, most of the simulated outcomes are clearly favorable. About 90% of the runs give an NPV between PEN 72,161 (5th percentile) and PEN 100,771 (95th percentile), so the bulk of the distribution is comfortably positive. Even the worst case observed in the simulation, PEN 64,382, is still above zero. None of the 3,000 iterations produced a negative NPV, which suggests that, within the tested ranges, the project consistently generates economic value.

Table 6. Monte Carlo NPV results

Indicators	Value
Mean NPV	PEN 87,617
Median NPV	PEN 88,606
Mode NPV	PEN 89,521
5th percentile (P5)	PEN 72,161
95th percentile (P95)	PEN 100,771
Minimum simulated NPV	PEN 64,382
Probability of NPV > 0	100%

5. Discussion

5.1. New Scenarios

To check the results, simulations were run on two platforms: Arena software for Lean Standardization and FlexSim software for Slotting and SLP. The original setting was duplicated for simulation on both platforms to facilitate a comparison with the enhanced setting.

In the first scenario, which was specifically the picking and packaging process, Lean Standardization was used with real data from a pilot test. The order of jobs was made the same, and the times were changed to match takt time. Besides, a standard work board was added. The validation in Arena showed that the overall cycle time per order went down from 57.72 minutes to 43.04 minutes, which is a 25.43% improvement. The Fill Rate indicator also went up by 3.68%, from 89.02% to 92.70%.

In the second scenario, the warehouse layout was changed using the Slotting and SLP methodologies. Also, a multi-criteria ABC analysis was used: there were products that needed to be moved. In addition, there were found rearrangement options by looking at how the areas worked together and the limitations of the space. The simulation showed that the overall picking distance went down by 17.81%, from 16.28 meters to 13.38 meters per order. The use of available storage space went up by 14.67%, from 75% to 86%.

These examples demonstrate that the progressive integration of Lean, Slotting, and SLP enhances individual metrics while simultaneously synergistically improving the total efficiency of the warehouse system in the assessed SME.

5.2. Analysis of Results

5.2.1. Performance Improvements Achieved

The implementation of the integrated model led to measurable improvements in all of the most important performance indicators. The Fill Rate went up by 3.68 percentage points, from 89.02% to 92.70%. This is similar to what has been seen in other uses of the Lean models in logistics SMES. [13, 14] This improvement shows that the number of order rejections is going down, which means that the process is more stable and efficient. [10] However, it is still a little short of the industry standard of 95%. One of the main advantages of using Lean Standard Work is that it reduces the overall cycle time by 25.43%, from 57.72 to 43.04 minutes per order. This conclusion is in line with earlier studies that said the total cycle time could reach a 40% improvement regarding the total cycle time. [14, 15]

After slotting based on ABC classification, the warehouse's occupancy rate rose from 75% to 86%, which is a 14.67% rise. According to the literature, other research has indicated that warehouses with a number of distinct SKUs might have their volumetric capacity increased by 30%. [17] This supports the idea that putting things in the appropriate places will help you make the most of your space and cut down on traffic [16].

In parallel, when the layout was updated with SLP, the pickup distance per order fell by 17.81%, from 16.28 to 13.38 meters. This result reflects the functional logic of spatial reorganization using from-to analysis and ARC/ARD tools, as recommended in comparable SLP-based studies. [20, 22]

Together, these results demonstrate the synergistic effect of Lean, Slotting, and SLP in improving warehouse operations. Each tool contributed to a different dimension: time, space, and flow. Their sequential integration enabled simultaneous gains in productivity, order quality, and spatial efficiency, reaffirming the findings reported by recent literature on hybrid logistics models. [13, 16, 20]

5.2.2. Contextualisation of Results within Existing Literature

The proposed model improved all operational dimensions of the warehouse: the Fill Rate rose from 89.02% to 92.70%, total cycle time decreased by 25.43%, picking distance decreased by 17.81%, and effective warehouse occupancy increased by 14.67%. These gains were achieved under real conditions at a small importing SME with informal routines, limited digital records, and a layout that had evolved without structured planning. These simultaneous improvements in service level, processing time, flow, and space, obtained with relatively simple, low-cost analytical tools, show both how large the initial gaps in the warehouse were and how the three interventions, Lean Standard Work, SLP, and multi-criteria Slotting, reinforced one another when applied together.

In the hardware-store SME analysed by Massoni-Gonzales et al., Lean warehousing and Lean logistics improved service levels and reduced stock-outs, as validated through Arena simulation, but did not jointly optimise layout and travel distance. [15] The present model achieves comparable service-level gains while simultaneously cutting cycle time and operator movement, which are critical for labour-intensive SMEs that cannot rely on automation.

Similarly, a system-integration study that combines Slotting and ABC in an automotive-parts warehouse reports average efficiency gains of around 20% in receiving, 25% in shipping, and 30% in shelf capacity utilization. [18] Those results were obtained in a third-party logistics company with its own R&D department and strong information systems. By contrast, the case analysed here is a small importing SME, with informal day-to-day routines and very limited IT support. Even so, it achieves a 14.67% increase in space utilisation and an almost 18% reduction in travel distance, relying only on low-cost tools and straightforward stopwatch-based time studies.

Other Lean and value-stream-mapping applications in retail and e-commerce focus mainly on out-of-stock rates and flow redesign, without explicitly targeting fill rate or combining Slotting and SLP in the validation phase. [12] By bringing these tools together and validating them with two simulation models and an economic analysis showing a positive, robust NPV, the study offers a more complete and rigorous option for SMEs in the international trade sector seeking to improve their warehouses with limited resources.

5.3. Limitations

This study has several operational and methodological limitations that shape its scope. The improvement effort focuses only on the storage and packing stages of the logistics area; upstream and downstream processes, such as purchasing, external transport, and after-sales service, were not analysed, even though they also influence the overall service level. The proposal was validated mainly through computer simulation, using Arena for Lean Standard Work, FlexSim for Slotting, and Excel-based tools for the SLP redesign. These tools were selected based on availability and their fit with the study objectives, but other software or optimisation approaches could lead to different solutions.

The models were built on the following simplifying assumptions: a relatively stable flow of orders, typical product rotation, and a layout that did not change during the period analysed. The time data came from pilot measurements repeated several times on the shop floor, and the simulations were run with a limited number of replications due to available computing capacity and time. In addition, only historical, anonymised data from a single, partially informal SME were used, which limits data granularity and the direct generalisability of the results to larger or more digitised warehouses. Even so, these conditions reflect the reality of many resource-constrained firms and help to position the findings in a realistic context.

5.4. Sustainability and Workforce Implications

From a sustainability perspective, the goal of the model is to become a normal part of the way things are done, not just a one-time improvement initiative. Standard Work makes the process more stable by using basic visual boards and explicit stages for picking and packing. This makes it easier for supervisors to see when something starts to go wrong.

The time results showed that shorter routes, clearer task sequences, and a more uniform workload usually mean less physical work and fewer last-minute corrections for the workers. Training is also easier because operators may learn the work faster, and new employees can get to an appropriate level by practicing on the floor with supervision. In larger or more structured firms, where there are already basic rules, better data, and closer supervision, these same features would probably make the Lean–Slotting–SLP model even easier to maintain, because the organization has more ways to reinforce standards and avoid slipping back into old practices.

5.5. Scalability and Transferability

The model can also be scaled, besides its short-term benefits. It can be used in warehouses with more SKUs or more shifts because its three parts (Standard Work, Slotting, and SLP) can be added one at a time without modifying the core logic. The SME in this case study didn't have a lot of formalization or strong internal controls; thus, problems like missing documents and a messy structure were very clear. These problems could potentially be smaller, and the concept would be easier to roll out in bigger and more organized companies, where governance and data quality are usually stronger. The same approach applies to warehouses in retail, pharmaceutical, or hardware businesses, where organizations have to deal with a lot of different SKUs, not much storage space, and the need to keep selecting and packaging routines simple and clear to avoid mistakes. [9]

5.6. Future Work

Future research may evaluate the proposed model in larger warehouses featuring many SKUs, automated picking systems, and multi-shift operations. Another option is to use technology that helps with SLP and slotting decisions, which would allow for layout changes and performance monitoring in real time. Also, AI-based demand forecasting and Lean standards could help make better judgments upstream and keep the flow constant. Finally, longitudinal research tracking post-implementation KPIs in real operating settings would help confirm the model’s impact beyond simulation and pilot tests. Furthermore, digital assets are increasing their importance for the store's management. In practical terms, this means that investing in a Warehouse Management System (WMS) that shares data with purchasing, production, and sales is vital. With this kind of system, employees can observe the stock levels, locations, and movements in real time. This makes it easier to avoid running out of inventory and to find small problems that may potentially become significant.

The company should also define a framework for monitoring key KPIs after implementation. In practical terms, this could be done by having the three warehouse operators and the supervisor record basic daily information (orders prepared, errors detected, travel distances, stockouts) on the warehouse control laptop at the end of each shift. Those entries can then be collected in a shared Excel file or Google Sheet that administrative staff can access, where simple formulas keep track of indicators such as fill rate, picking and packing cycle time, order accuracy, and how much of the available storage space is actually being used. This type of low-cost dashboard would give the team a clear view of whether the Lean–Slotting–SLP model is being sustained over time and would make it easier to react when performance starts to deteriorate.

6. Conclusion

This research shows that a phased application of Lean Standard Work, Slotting, and Systematic Layout Planning delivers quantifiable improvements in the performance of a medical equipment SME's warehousing operation in Peru. The proven model gives a 3.68 percentage-point improvement in fill rate, from 89.02% to 92.70%, with a 25.43% reduction in overall cycle time, a 17.81% reduction in picking travel, and a

14.67% increase in inventory usage. The authors assert that reduced variability in process execution, SKU rotation and resizing, and a modified layout that increases functional association are reasons for these performance changes. Regarding efficiency, the solution has been proven transferable to other small businesses with a high SKU variety, assuming they have data availability and the capability to perform a basic time study. The economic feasibility, which has a positive NPV, a high IRR, and a short payback period, confirms that the solution is transferable to small businesses.

Further research should apply the model in real operating settings and test how well it scales under different demand patterns. Overall, these results add empirical evidence to a still limited body of work on fill-rate improvement practices among importing SMEs in emerging economies.

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Appendix 1: Comparative table of the components of the proposal model vs. the literature review

		Management Model Based on Lean Warehousing & Lean Logistics to Increase the Level of Service in SMEs in a Hardware Store.	Implementation of standard work in the construction industry.	Using Lean to improve operational performance in a retail store and E-Commerce service: a Portuguese case study.	System integration with Slotting and ABC analysis.	Warehouse Management Optimization Using A Sorting-Based Slotting Approach.	Design of an improved layout for a steel processing facility using SLP and lean Manufacturing techniques.	Lean-Driven Warehouse Model Integrating Slotting and SLP.
		Massoni-Gonzales, Alzamora-Pachacama & Taquía-Gutiérrez (2023)	Fazinga, Saffaro, Isatto & Lantelme (2019)	Marques, Jorge & Reis (2022)	Doğan, Karataş & Bulduk (2024)	Duque-Jaramillo, Cogollo-Flórez, Gómez-Marín & Correa-Espinal (2024)	Salins, Zaidi, Deepak, & Sachidananda (2024)	Proposal of this research
Component 0: Analysis of the Current Situation	Literature review	✓	✓	✓	✓	✓	✓	✓
	Engineering tools: Ishikawa Diagram, Pareto Diagram, and Problem Tree Analysis.	✓	✗	✓	✗	✓	✗	✓
	Case Study: Medical Equipment SME (International Trade Sector).	✓	✓	✓	✓	✓	✓	✓
	Metrics: Fill Rate, Cycle Time, Warehouse Occupancy (%), Travel Distance, Location Record Accuracy.	✓	✗	✓	✓	✓	✓	✓
Component 1: Intervention	Literature review	✓	✓	✓	✓	✓	✓	✓
	Engineering tools: Lean Standard Work, Slotting, and SLP.	✓	✓	✓	✓	✓	✓	✓
	Case Study: Lean pilot implementation + SLP redesign and ABC multi-criteria Slotting.	✓	✓	✓	✓	✓	✓	✓
	Metrics: Fill Rate, Cycle Time, Warehouse Occupancy (%), Travel Distance.	✗	✗	✗	✗	✗	✓	✓

Component 2: Validation	Literature review	✓	✓	✓	✓	✓	✗	✓
	Engineering tools: Simulation (Arena Sim + FlexSim) + Python language.	✓	✗	✓	✓	✓	✗	✓
	Case Study: Analysis of Arena (Lean) + FlexSim (Slotting & SLP) + Economic evaluation.	✓	✗	✗	✓	✓	✗	✓
	Metrics: Fill Rate, Cycle Time, Warehouse Occupancy (%), Travel Distance.	✗	✗	✓	✓	✗	✗	✓
	Total	10	6	10	10	10	7	12

Appendix 2: Standard Work Diagram for the Packaging Process in the Medical Supply Chain