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Optimizing Logistics and Inventory Management in SMEs: Integrating Economic Order Quantity and Systematic Layout Planning in a Peruvian Distribution Company

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Abstract

In the context of the Peruvian distribution sector, small and medium-sized enterprises (SMEs) face significant challenges in warehouse and inventory management, impacting their operational efficiency and customer satisfaction. This study addresses these issues by implementing a logistic model that integrates Economic Order Quantity (EOQ) and Systematic Layout Planning (SLP) to optimize operations in a Peruvian plastic distributor. The proposed model aims to enhance warehouse organization, streamline inventory management, and improve delivery performance.
The research contribution involves a detailed application of the SLP methodology, combined with ABC analysis for product categorization and matrix tables for layout optimization. Additionally, the study incorporates EOQ for optimal order quantity determination and demand forecasting techniques to reduce stockouts. Key results demonstrate substantial improvements in operational metrics. Notably, on-time delivery rates increased by 18%, from 76% to 90%. Inventory stockouts decreased dramatically by 85%, reducing from 14% to 2%. The overall cycle time for order processing was shortened by 50%, from 60 minutes to 30 minutes. Furthermore, the effort required for picking and packaging activities was reduced by 33%, from 20,620 kg-mt to 13,820 kg-mt. These results indicate that the integration of SLP and EOQ models significantly mitigates the inefficiencies in warehouse management and inventory control, leading to enhanced operational performance and customer satisfaction in the distribution sector.

Keywords
Warehouse Management, Systematic Layout Planning, On time delivery, Plastic Distributor, EOQ

1. Introduction
Efficient warehouse management is crucial for organizations involved in the selling and storage of various items. Likewise, these organizations necessitate effective inventory management. According to the National Institute of Statistics and Informatics, 98.6% of companies in Peru are classified as small and medium-sized enterprises (SMEs).

Within these establishments, informality prevails, as the proprietors themselves perceive no need for development and believe that as long as the firm remains profitable, there is no necessity for change. Similarly, the trade industry accounts for around 11% of the Gross Domestic Product (GDP), equivalent to 24 billion dollars. The sector experienced a growth rate of 2.6% in 2018, surpassing the growth rate of 1.0% in 2017 (Caridade, R. et al., 2017). In July 2019, the wholesale, retail, and automotive trade industry experienced a 3.19% gain, as reported by the National Institute of Statistics and Informatics (INEI).
Presently, this industry is facing common issues in the transportation and delivery of its goods, which could potentially impact customer loyalty and business sustainability. The company's performance and competitiveness may be diminished by these limitations in delivery operations. The number 17 is represented by the numeral (Flynn, B., S. et al., 1990). The organization being analyzed is facing two distinct issues: inadequate warehouse management and subpar inventory management. The crucial aspect is how a small and medium-sized enterprise (SME) in the industry may minimize these factors and achieve a boost in revenues.

The proposal suggests utilizing the SLP tool to do an ABC analysis. This analysis will help identify the product families that provide the best profit margin for the organization. Additionally, a second level ABC analysis will be performed to identify the goods within each family that have the highest profit margin. This will enable more effective segmentation of warehouse spaces. Additionally, the utilization of matrix tables to assess the effort expended in the existing distribution of the operating yard and to compare it with the results after implementing the proposed changes. To implement the 5s methodology, begin by categorizing the materials or items and assigning them to their respective spaces or locations. Subsequently, individuals who fail to contribute to maintaining a neat and orderly work environment are removed. Ultimately, the organization conducts a verification of the previously established stages in order to ensure traceability and competitiveness, with a specific emphasis on continual improvement. Additionally, the installation of BPM flow diagrams will be incorporated, which were not included in the previous study, in order to provide a more comprehensive solution to the problem at hand. Employee training will be conducted to ensure the standardization of effects and attain the desired outcome. The position design will be carried out based on the data acquired from each tool, together with OWAS. This will be documented in a working procedure, which will outline the appropriate considerations and methods for placing the body and limbs in the correct position for shifting the load. Ultimately, the management of inventories will involve implementing a combination of inventory policies, demand forecasting, optimal procurement quantities, and a purchasing plan.

This article suggests implementing the SLP tool (Baby, Bibinetal., 2018) in conjunction with inventory policies to minimize untimely deliveries in a marketing context. The improvement proposal has four stages: diagnostic, preparation and design, execution, and validation.

2. Literature Review

Several models are associated with the issues encountered by ABC. Unfortunately, there is currently no model that simultaneously uses the selected methods to enhance the efficiency of logistics management. Naqvi, et al. (2016) propose applying the SLP technique to decrease production costs and enhance material flow by restructuring the facility. The outcomes of his research were favorable as it eradicated delays and reduced transit between the different sections of the manufacturing facility. The redesign alternatives demonstrated substantial annual cost savings. In a similar vein, Freitas, et al. (2019) successfully identified logistical shortcomings stemming from communication breakdowns among employees by implementing the 5s methodology. This resulted in a substantial profit of €43,285.69 by the end of the initial year. Furthermore, Haddad, et al (2016) enhanced process management and standardized activities in the field by implementing Business Process Management (BPM). The outcome led to a significant enhancement of 108 percent in achieving its overall objective and a decrease in the number of grievances. In terms of finances, profits rose in three out of four business operations. The level of satisfaction among internal customers rose from 81% to 96%. The study conducted by Calzavara et al (2017) aimed to assess the efficiency and ergonomics of the hand picking process. The study focused on evaluating the time required for the procedure as well as considering factors such as the size, position, and angle of inclination of the gathered packages. The findings indicated that picking up an inclined box is more advantageous in terms of activity time compared to picking a package in a horizontal position. Additionally, selecting a smaller package is more helpful than choosing larger packages (Calzavara et al., 2016). Finally, Brunaud, et al. (2018) incorporates the integration of inventory policies into their research. This amalgamation of inventory planning and policy effectively integrates tactical and operational decisions. The aim of this study was to reduce inventory expenses by identifying the most efficient inventory levels to satisfy demand predictions. The outcomes included enhanced seasonal stock control, decreased losses, streamlined purchasing, and reduced obsolete stocks, among other benefits (Brunaud et al., 2018).

In the document by Ali Naqvi et al. (2016), they identify a decrease in productivity caused by the way plants are distributed. Similarly, Baby et al. (2018) highlight the issue of long routes from the warehouse to the yard, while Ogasawara et al. (2019) report extended processing times for lengthy journeys. These three research publications exhibit a deficient distribution of plants. The writers concur that the arrangement of the facilities significantly impacts the output of the facility. The objective of distribution design is to determine the optimal arrangement of facilities and reduce the amount of material handling required. In order to address these issues, the authors of the three cases analyzed employ the systematic plant planning technique to assess the needs of various areas and streamline the movement of goods and staff, thereby optimizing efficiency and minimizing exertion. However, this technique could be enhanced by doing an ergonomic analysis of the energy expended by operators. Furthermore, the text does not specify if the procedures are appropriately developed to prevent operators from experiencing delays caused by the inefficient layout of the facility, as well as to ensure standardization of their activities.

This paper suggests examining an EOQ inventory management model and its replenishment policies by analyzing the outcomes achieved in various types of companies, including a manufacturing company (Haddad et al., 2016), a service network company (INEI, 2016), and a pharmaceutical company (Nemtajela et al., 2017). The authors advocate for the implementation of this model to enhance the management of the production system and inventory. They aim to improve the precision of demand prediction by reducing errors and enhancing the performance of inventory simulation (INEI, 2016). Additionally, they propose a synchronized production and delivery schedule to minimize the combined costs of delivery and inventory (Nemtajela et al., 2017). Furthermore, they suggest reducing inventory levels by utilizing demand forecasts (Ogasawara et al., 2019).

3. Methods

3.1 Proposed basis and model

The improvement proposal is designed utilizing industrial engineering processes and tools to resolve the challenge faced by the organization being analyzed. Initially, the root causes are connected to the most suitable technical approaches to effectively tackle them, with the objective of minimizing the delay in order delivery. Subsequently, the improvement suggestion is designed, taking into account five distinct stages: Diagnosis, Design, Implementation, Validation, and Dissemination.

The Design phase involves outlining the development of instruments to be utilized, mostly by identifying and detailing the procedures to be executed via Systematic Layout Planning, 5s, Business Process Management, Working Study, and Inventory Policies. Additionally, indicators are suggested to quantify the existing and projected disparity.
Lastly, we include the estimated expenses associated with this plan, which have been evaluated based on their current definition. In addition, the Gantt diagram facilitates the scheduling of the time required for each step of the project.
The proposed model is based on Deming's continuous improvement cycle, which consists of four primary stages: Plan, Do, Check, and Act. These steps are visually represented in Figure 1.

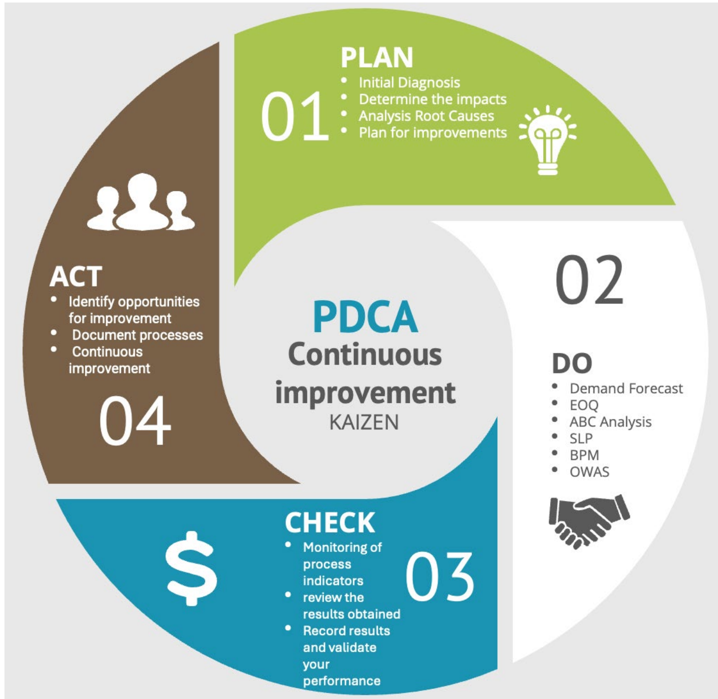

Figure 1. Proposed Model

3.2 Description of the model components

The steps mentioned previously are succinctly explained below:
As a further phase, the current study presents two primary goals to enhance the efficacy of warehouse and inventory management, wherein the implementation of the following tools is proposed:
In the context of Supply Chain and Logistics Planning (SLP), the company intends to employ ABC analysis to identify the product families that yield the largest profit margin. Additionally, a second level ABC analysis will be conducted to identify the goods within each family that create the best margins. This will enable more effective segmentation of warehouse spaces. Additionally, the utilization of matrix tables to assess the effort expended in the existing distribution of the operating yard and to create a comparative analysis following the implementation of the proposed changes.
Furthermore, inventory management will encompass the collaborative execution of inventory and demand forecasting strategies, appropriate procurement quantities, and a purchasing schedule.

Finally, the analysis of the data should be conducted, utilizing a traffic light table to display the comparison between the initial results and the outcomes acquired from the simulation. In addition, it is categorized based on whether the results are deemed acceptable or not acceptable.

Evaluation of the present state:
In order to gain insight into the current state of the distribution company, regular visits and meetings were conducted with the Operations Manager and staff responsible for operational processes. These interactions aimed to establish a connection and understand the sequence of activities, as well as identify any existing issues that may be affecting employee performance. Afterwards, a compilation of existing issues was made, and a priority matrix was created to identify the primary concern. The matrix analysis revealed that the company faced challenges in managing warehouses, inventory, and purchasing. Specifically, it was found that the company had an inefficient logistic management system, which was evident in the low level of service as assessed by the index of on-time deliveries. Subsequently, the causes were examined by means of an issue tree analysis. The primary reason was recognized as the inappropriate distribution of areas in the yard and non-standard operations in the warehouse area. In the field of procurement and inventory, they had weak technical capacity.

After doing the quantitative studies, the indicators to be measured in the proposal are determined. Due to the significant impact of inadequate warehouse management, employee travel will be measured using time and distance indicators during the picking and packaging process. Similarly, the index of stockouts, which measures the frequency of products being out of stock due to poor inventory and purchasing management, serves as an indicator (Table 1).

Table 1. Initial Results

Indicator	Unit	Actual value
On-time delivery	%	76%
Cycle time	Minute	59.74
Effort	Kg-mt	20,620
Stock Out	%	14%

The proposed process involves the integration of the SLP application with EOQ to enhance operational productivity and planning management efficiency. It also aims to ensure the safety of goods and operators within the organization during working hours. Figure 2 outlines the sequential steps to be taken in order to implement the recommended technologies collectively.

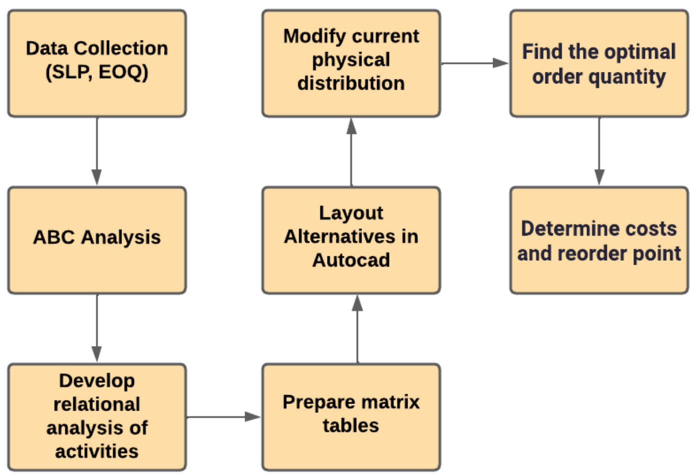

Figure 2. Phases of Systematic Layout Planning and Economic Order Quantity

Step 1: In this phase, we established the measurements of the area to be altered, specifically, the operational patio. Subsequently, the measurement of each specific location within the operations yard and the subsequent calculation of the distances between them were conducted. Furthermore, data was gathered to formulate the ABC analysis for the company's most profitable and high-turnover items in the subsequent stages.
Step 2: In the second phase, we assess the product families based on their contribution to the company's income in 2019 using the ABC Analysis. Presented below is the ABC Diagram (Figure 3):

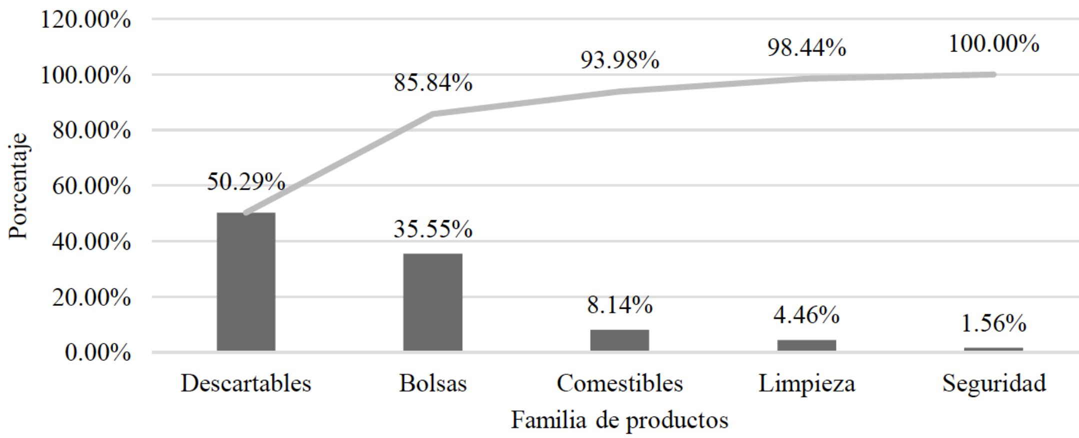

Figure 3. ABC Analysis

According to the ABC analysis, it is determined that the category of products that should be given priority in the redistribution of yard areas is the family of discards and bags. This is because these products create 85.84% of the total money collected by the company. By implementing this approach, it is anticipated that the time and effort required by the operators will be reduced.

Step 3: In the third phase, we assess the existing endeavor and contrast it with the effort required for executing the redistribution of areas based on the prior study. This assessment was conducted using matrix tables, which establish a relationship between the weight of the load that needs to be moved (Figure 4 and 5).

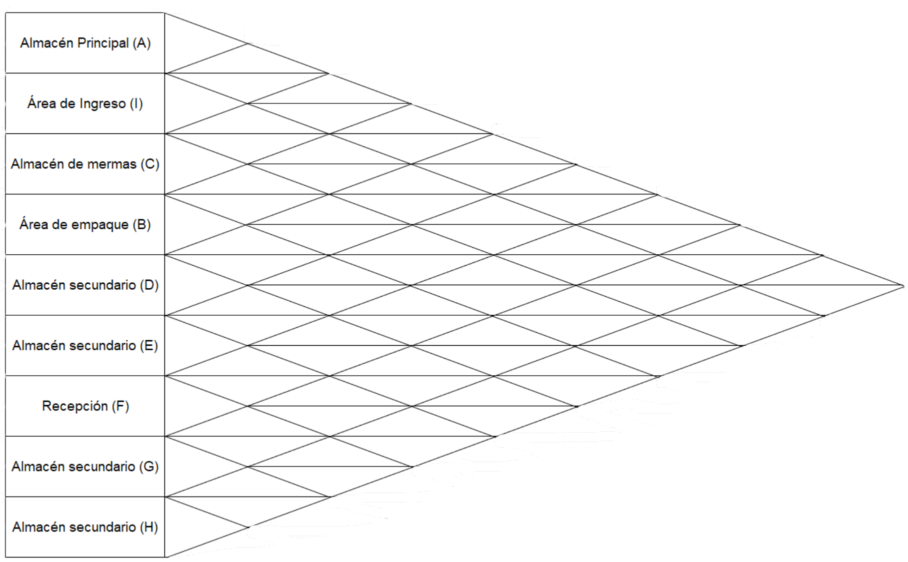

Figure 4. Relational table of activities

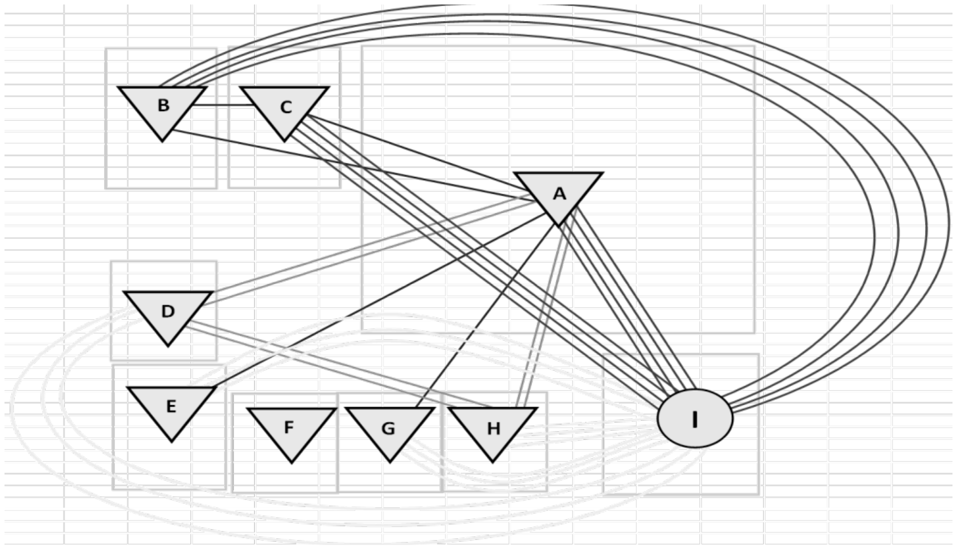

Figure 5. Relational Diagram of Activities

Step 4: The fourth stage involved doing a Relational Analysis of Activities utilizing both the Table and the Relational Diagram of Activities. Based on the analysis, it was determined that it is crucial to have close proximity between the income area (I) and the packing area (B), as well as between the income area (I) and the waste warehouse (C), and also between the main warehouse (A) and the income area (I).

However, it was particularly crucial to have close closeness between the entrance area (I) and the subsequent areas: secondary storage (D, E, G, and H). The proximity between the main warehouse (A) and the secondary warehouses (D and H), as well as the secondary warehouses (D) and (H), is also significant.

Step 5: After completing the analysis of prioritizing of regions, their proximity, and the efforts made to carry out operational activities, we then start to create the new layout, taking into account the conclusions from each previous evaluation. In this revised distribution, the main focus was on the close proximity between the main warehouse locations, the entrance area, and the secondary warehouses, taking into consideration the specific family of products assigned to each store (Figure 6 and 7).

M	A	B	C	D	E	F	G	H
A		16	9	12	8	7	4	6
B	16		4	7	10	12	13	23
C	9	4		5	9	7	11	21
D	12	7	5		5	10	10	17
E	8	10	9	5		4	7	10
F	7	12	7	10	4		3	10
G	4	13	11	10	7	3		6
H	6	23	21	17	10	10	6	

Figure 6. Relational Table of Activities

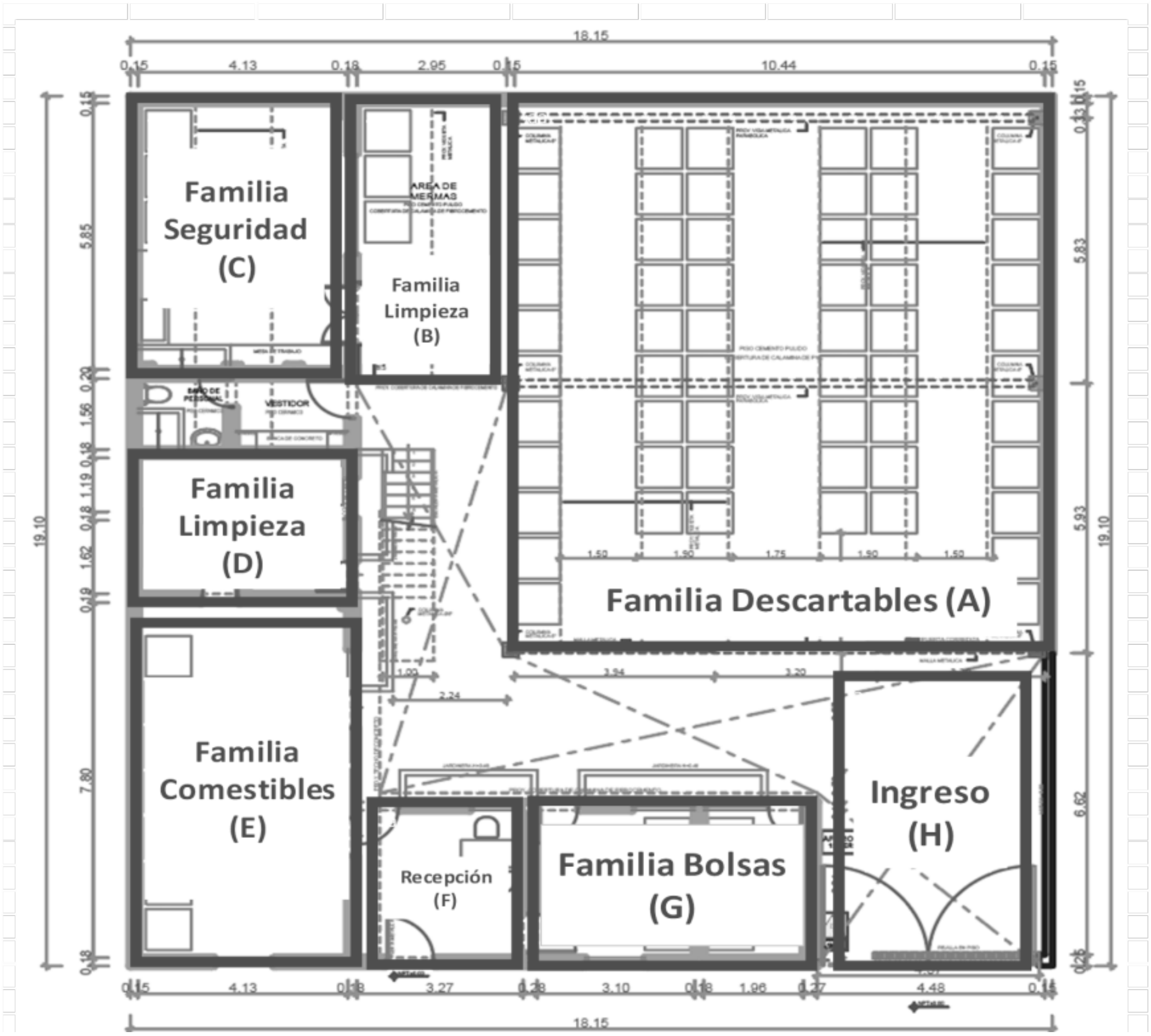

Figure 7. Proposal Layout

Step 6: In the seventh phase, we determined the ideal order amount by examining the past and projected demand for each product in the bag and throwaway category.

The equation is given by $Q = \sqrt{\frac{2DS}{H}}$, where:

Q: What is the quantity of units included in each order?
D: The total number of units of a product that are requested by customers on a yearly basis.
S: Price associated with each individual order
H: The expense associated with keeping a product in storage for a specific duration

Step 7: In the last phase, we identified the reorder point, the ideal quantity to order, and the ordering cost to prevent stock shortages (Table 2).

Table 2. Purchase Lot

Cod.	Products	Optimal purchase lot
P1	Plate laid biodegradable 22cm x th.	1060
P2	Biodegradable bowl dish 12 oz	1473
P3	Polypaper cup 8 oz c x thousand	1737
B1	Transparent triple barrier bag grad.	3597
B2	Trash bag 220 lt. Negra x thousand	11200
B3	Resealable bag x 50 unt.	2398

4. Validation

4.1 Results Analysis

Arena program is utilized to validate the stock depletion in the current condition of the project. The following diagram depicts the modeled system based on the Supply Chain simulation type. Furthermore, the examination of entities, attributes, activities, as well as controlled and uncontrollable inputs (Table 3).

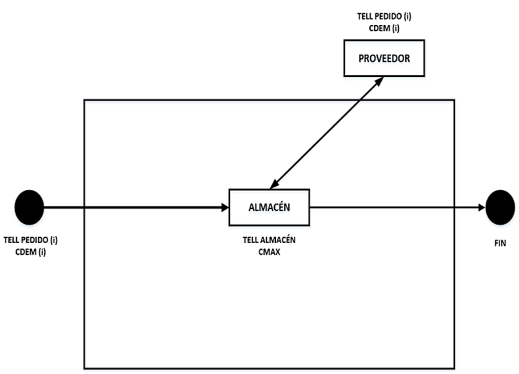

Figure 8. System representation

Table 3. Processing of input data

Entities	Attributes	Activities
Warehouse	Stock (i) Back order (i)	Meet the demand (i) Review the position of inventories Order by product (i) Receiving orders for the product (i) Lose product sale (i)
Provider (i=1,2,3,4,5,6)	Time to wait (i)	Satisfy product order (i)
Demand (i=1,2,3,4,5,6)	Pattern of demand (i) TEMAXP (i)	Sue for products (i) Cancel product order (i)

The following outcomes have been attained by the implementation of the representative product denotation system. In the category of disposable products, P1 achieved a 93.20% reduction in its stock break rate, P2 achieved a 94.61% reduction, and P3 achieved a 93.31% reduction. In the category of bags, B1 successfully decreased its supply shortage by 72.04%, B2 by 87.77%, and B3 by 90.47% (Figure 8).

Conversely, there has been a rise in the number of units sold. P1 experienced a sales growth of 21.97%, P2 saw a sales increase of 49.74%, and P3 achieved a sales growth of 48.50%. B1 experienced a 2.16% increase, B2 saw a 5.93% increase, and B3 had an 8.68% increase.
The results shown in Table 4 demonstrate that implementing this inventory management solution in the organization being analyzed would lead to positive outcomes. The fines resulting from stock shortages were decreased by 93.53% using this method.

Table 4. Control Indicators

Indicators	Simulation	Improvement	Percentage
Units sold P1	3550	4330	21.97%
Units sold P2	1890	2830	49.74%
Units sold P3	2000	2970	48.50%
Stock Out P1	832	57	93.20%
Stock Out P2	991	53	94.61%
Stock Out P3	1040	70	93.31%
Units sold B1	23200	23700	2.16%
Units sold B2	11800	12500	5.93%
Units Sold B3	4840	5260	8.68%
Stock Out B1	794	222	72.04%
Stock Out B2	749	92	87.77%
Stock Out B3	464	44	90.47%

Table 5. Control Indicators

Indicador	Unit	Semáforo			Actual Value	Value obtained
		Red	Yelow	Green		
Timely deliveries	%	>10%	10%-5%	<5%	24%	10%
Cycle time	Min	>60	60-30	<30	59.74	30
Effort	Kg.m	>20k	20k-15k	<15k	20,620	13,820
Stock Out	%	>10%	10%-5%	<5%	14%	

After implementing the SLP (Single-Period Inventory Model) and EOQ (Economic Order Quantity) techniques, we then evaluate the outcomes by examining the suggested metrics. Table 5 presents a traffic light table that displays cycle times, effort, and stock out indicators for important products. Additionally, it displays the present value, the anticipated theoretical value, and the value achieved through successful validation scenarios.

The primary metric for this project is the punctuality rate of deliveries, as it is the primary issue faced by the company. As depicted in the preceding illustration, it was projected to decrease to 10%. In addition, the operators' effort was predicted to decrease to 13,820 kg.m. Ultimately, the intention is to decrease the stock out index from 14% to a figure determined during the ongoing simulation.

6. Conclusions

The main findings of the developed study indicate that the implementation of industrial engineering tools, such as Systematic Layout Planning (SLP), the 5S methodology, Business Process Management (BPM), Work Study, and Inventory Policies, have significantly improved operational efficiency and inventory management in a distribution company in Peru. The results show a notable reduction in cycle times, handling efforts, and stockouts. Specifically, a 93.53% reduction in stockout fines and an increase in units sold of priority products were observed, reflecting improved logistical performance and customer satisfaction.

he importance of this research lies in its contribution to the optimization of warehouse and inventory management in small and medium-sized enterprises (SMEs) in the distribution sector. By addressing common issues in inventory management and goods distribution, the research offers practical and adaptable solutions that can be implemented by other SMEs to enhance their competitiveness and sustainability in the market. The application of methodologies such as SLP and EOQ not only improves operational efficiency but also contributes to cost reduction and improved demand forecasting accuracy, which is crucial for financial stability and business growth.

Contributions to the field of study include the development and validation of an integrated model that combines industrial engineering tools for improving logistics management in SMEs. This model provides a structured approach to diagnosing and solving operational problems, offering a replicable framework for other companies facing similar challenges. Additionally, the research highlights the relevance of ergonomics and process standardization in improving efficiency and workplace safety, which is a significant contribution to the existing literature on operations and logistics management.

Finally, some final observations and suggestions for further study are offered. It is essential to continue investigating the implementation of these methodologies in different contexts and industrial sectors to validate and refine the obtained results. Additionally, it is suggested to explore the integration of advanced technologies, such as automation and artificial intelligence, to further enhance efficiency in inventory management and goods distribution. Continuous staff training in continuous improvement practices and process management is also essential to maintain and increase the benefits achieved through these interventions. This study establishes a solid foundation for future research aiming to innovate and optimize logistics operations in SMEs and other business environments.

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Biographies

Jose Luis Adrianzén-Nuñez holds a bachelor's degree in industrial engineering from the Universidad de Lima with experience in Supply Chain Management and the retail sector. He is currently working at a major company in the retail sector with a presence in five Latin American countries, focused on efficiency, quality, and customer satisfaction.

Gabriel Berrospi-Gálvez is a graduate in Industrial Engineering from the University of Lima with 3 years of experience in the e-commerce business model. Currently I work as a UX Analyst in one of the largest companies in the retail sector with presence in Chile and Peru, providing quality, speed and above all a fascinating experience to its customers.

Martín Fidel Collao-Díaz at ESAN University and Industrial Engineer from the University of Lima specialized in supply. chain management and operations. Leader with more than 25 years in local and international experience in national and multinational companies at industrial, hydrocarbon and mass consumption sectors. Broad experience in supply chain management (purchasing, inventory, suppliers and supply sources management, logistics: transport,

distribution and warehouse management), operations (planning and control of production and maintenance) and integrated system management (ISO 9001, ISO 14001 and OHSAS 18001). Business alignment based on sales and operations planning (S&OP). Besides, continuous search for improvements in profitability based on process optimization and saving projects using tools such as Six Sigma methodology among others, focused to be a High-performance Organization (HPO). Development of high-performance team. Member of IEEE and CIP (College of Engineers of Peru).