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Application of SLP, EOQ and Demand Management to Increase Turnover in a Manufacturing Company

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Abstract

Manufacturing companies require careful inventory management to ensure they meet customer demand. The most common problem these companies face is inventory turnover, which impacts the company's total costs. The company's inventory overrun represents 9.3% of sales. Therefore, to streamline inventory turnover and optimize costs, a SLP model is proposed to maximize warehouse utilization, EOQ, find optimal order quantities, and define demand forecasts. To simulate the scenario with these tools, a FlexSim model was created, designing the current and proposed warehouse layout. Implementing the tools shows a decrease in inventory-related overruns of 4.7% of sales, saving S/. 275,260 annually.

Keywords
Manufacturing, inventory management, Economic Order Quantity (EOQ), demand, SLP

1. Introduction
The manufacturing sector represents the second largest productive sector impacting Peruvian GDP, accounting for 12.4% (Banco Central de Reserva del Peru, 2022) ikewise, in 2022, the manufacturing sector in Peru grew by 0.96% year-over-year. This was due to the resumption of economic activities, increased domestic demand, and increased industrial exports (Instituto Nacional de Estadística e Informática, 2023).

In 2021, the BCRP (2022) reported that the plastics sector grew by 18.9% year-over-year. Likewise, the plastics manufacturing industrial sector was found to be constantly growing. According to the Euromonitor platform, Peru produced 4.842 billion soles worth of plastics in 2021, and in 2022, this figure increased to 5.018 billion soles. Therefore, the sector's growth trend reflects (Euromonitor International, 2022). For this reason, this increase also had an impact on the growth of the Economically Active Population (EAP) in the manufacturing sector, increasing from 619,000 people in 2021 to 713,000 in 2022 (Banco Central de Reserva del Peru, 2022). Furthermore, over the last 5 years, it is important to highlight that the installed capacity utilization rate of the plastics manufacturing sector has experienced significant growth. Although it decreased by approximately 5% in 2022 compared to the previous year, the indicators maintain a positive trend.

Manufacturing companies face overstocking. Inadequate inventory valuation causes final products to remain in their facilities for prolonged periods, unnecessarily increasing the company's maintenance costs. According to Angudelo and López, inventory maintenance costs are associated with the amount of stock stored (Angudelo, D. & López, Y, 2018). Inventory costs represent between 30% and 35% of the company's value. Likewise, inventory turnover is also a recurring problem in most companies, as low inventory turnover is often associated with excess inventory, excessive stock maintenance, and the presence of dead stock. Low turnover also leads to liquidity problems, which puts increasing pressure on working capital (Rivera, J. & Verástegui, G., 2019).
The planning strategies addressed in this article are related to inadequate inventory assessment, which causes final products to remain in facilities for prolonged periods of time, unnecessarily increasing the company's maintenance costs.

It also addresses the importance of space organization, order, and cleanliness in the warehouse, since inefficient use of storage space arises from the accumulation of deteriorated and slow-moving products, as companies do not have a waste management process. Therefore, this merchandise is located in the warehouse, occupying space that could be used to house new merchandise.

Finally, strategies related to inventory control methods in the warehouse are also addressed, as there is no classification of materials with a high sales turnover value. According to Milla and Panta, products should be properly located in the warehouse, so that their exit is easy and quick to locate, in addition to having methods, means, spaces, signage and labelling of records that allow establishing the stock of the product, the time of permanence and easy handling by warehouse operators (Milla A. & Panta A., 2019).

1.1 Objectives
The objective of this study is to determine if the application of SLP, EOQ and demand management increases inventory turnover in a manufacturing company.

2. Literature Review
2.1. EOQ
Inventory management must be controlled, and there must be a constant flow of incoming and outgoing products to avoid prolonged storage; based on the economic order quantity, EOQ for its acronym in English, the optimal number of units in an order, total inventory costs such as maintenance costs, ordering costs, and costs due to shortages can be reduced (Kaushik, O. et al, 2019). Therefore, this tool seeks to achieve a balance between the entry of raw materials and finished products, so that there is no excess of the former and the manufacturing of the requested quantity is fulfilled, achieving maximum efficiency at a minimum cost. For example, Olsson, A., & Silver, E. A., 2020, mention that by implementing the EOQ, a manufacturing company achieved a significant reduction in storage costs and an improvement in inventory turnover. In addition, it is noted that the EOQ is most effective when combined with other inventory management techniques, such as ABC analysis and demand forecasting.

The Economic Order Quantity (EOQ) model is a widely used inventory management tool that helps determine the optimal order quantity, minimizing the total inventory costs. These costs include the ordering costs and holding (or carrying) costs. The EOQ formula calculates the ideal order size that results in the lowest possible total cost, balancing the frequency of orders with the cost of maintaining inventory.

EOQ is essential for organizations aiming to optimize their supply chain efficiency and reduce excess inventory. By minimizing inventory holding costs while ensuring sufficient stock levels, the EOQ model helps maintain a balance between ordering and inventory holding. This approach is particularly useful in reducing waste and lowering costs associated with overstocking or understocking.

When implemented correctly, the EOQ model can lead to significant improvements in inventory management, such as reductions in order frequency, inventory carrying costs, and stockouts. In practice, EOQ is often integrated with other inventory management strategies, such as the optimal-policy curve, to address specific operational needs and constraints, further enhancing supply chain performance. (Kaushik 2019).

2.2. SLP

SLP is a methodology that improves usability and optimizes the use of existing resources in operations through the redistribution, organization, and relocation of work areas (Potadar & Kadam 2019).

A manufacturing company's warehouse is a fundamental and indispensable part of its operations. Its poor layout has a strong impact on its workflow. A lack of warehouse design planning or lack of space leads to accumulation of merchandise, blockages in spaces, among other things (Torres et al. 2022). Therefore, the Systematic Layout Planning (SLP) method is used for these specific types of problems.

Chen et al. (2021), report that implementing SLP enabled a company to significantly reduce material travel times, decrease warehouse congestion, and improve inventory accuracy. By optimizing warehouse layout, a more efficient flow of materials was achieved, which facilitated product location and reduced inventory counting errors.

Supply Chain Logistics (SLP) is defined as a strategic methodology that focuses on optimizing the flow of goods, information, and resources throughout the supply chain. SLP emphasizes the integration of various logistics processes to enhance efficiency, reduce costs, and improve service levels. The approach aims to streamline operations by aligning logistics activities with overall business goals, ensuring that each component of the supply chain contributes to a seamless and effective order management system. (Torres, C. et at, 2022)
The significance of Supply Chain Logistics (SLP) is emphasized as a critical framework for optimizing plant layouts and enhancing operational efficiency. By employing SLP principles, organizations can create workflows that minimize unnecessary movement and waste, leading to improved productivity. The strategic planning of layouts not only maximizes space utilization but also contributes to substantial cost reductions through decreased transportation time and labor expenses.

Additionally, the implementation of SLP fosters flexibility and scalability in plant operations, allowing for easier adjustments in response to changing production demands. It also promotes better collaboration among various departments, facilitating a more cohesive working environment. Overall, SLP is presented as an essential methodology that supports effective layout planning and drives improvements in manufacturing processes. (Xu 2020).

A study focused on a manufacturing company experiencing congestion issues, long search times, and inventory control errors due to a poor warehouse layout. The SLP methodology was applied to analyze material flow, the relationships between different warehouse areas, and product movement frequency. Based on this analysis, a new layout was proposed that optimized space, reduced travel times, and improved accessibility to materials. The results showed a significant decrease in material search times, a reduction in warehouse congestion, and an improvement in inventory accuracy.

The study also highlights the importance of considering ergonomic and safety factors when designing the warehouse layout, as well as the need to involve warehouse workers in the design process to ensure the new layout is practical and efficient. (García et al. 2019).

2.3. Demand planning

The effective implementation of work standardization requires the participation of all members of the organization, as it ensures the uniformity of all tasks, reducing variations and errors in the results of operations. Additionally, it facilitates the onboarding of new employees by providing clear and properly documented guidelines. The importance of flexibility and adaptability in implementing work standardization, as it allows for rapid responses to market demands and the ability to adjust to unforeseen events that may occur in a changing context, such as agile organizations (Lee et al., 2019). Organizational culture characterized by adaptability promotes a mindset of continuous improvement among employees, as they will be willing to change and progressively enhance standardized processes based on the learning and feedback obtained from their daily work (Singh et al., 2022).

Demand planning is a critical component of inventory management, enabling businesses to align their inventory levels with actual consumer demand. By accurately forecasting future demand, companies can optimize stock levels, reduce storage costs, and enhance customer satisfaction. The article "Inventory Management Model in the Commercial Sector to Reduce Inventory Levels Through the Use of Demand Forecasts" underscores the importance of integrating demand forecasts into inventory strategies to achieve these objectives.

Effective demand planning involves analyzing historical sales data, market trends, and other relevant factors to predict future product needs. This process allows businesses to move away from traditional "forecast push" supply chains, which rely heavily on projected demand, toward "demand-driven" supply chains that respond directly to actual customer orders. Implementing demand-driven strategies helps mitigate issues such as excess inventory, stockouts, and the bullwhip effect, leading to more efficient operations and improved profitability
Incorporating demand forecasts into inventory management not only streamlines operations but also provides a competitive advantage in the commercial sector. By accurately predicting and responding to consumer demand, businesses can enhance operational efficiency, reduce costs, and improve overall customer satisfaction. This approach aligns inventory levels with market needs, ensuring that products are available when customers require them, without the burden of overstocking or understocking. (Cornejo et al, 2021)

3. Methods

For the development of this research, three phases were conducted, focusing on a diagnosis to understand the problem, the development of EOQ, SLP, and demand planning tools, and finally, the analysis of the results, as can be seen in Figure 1.

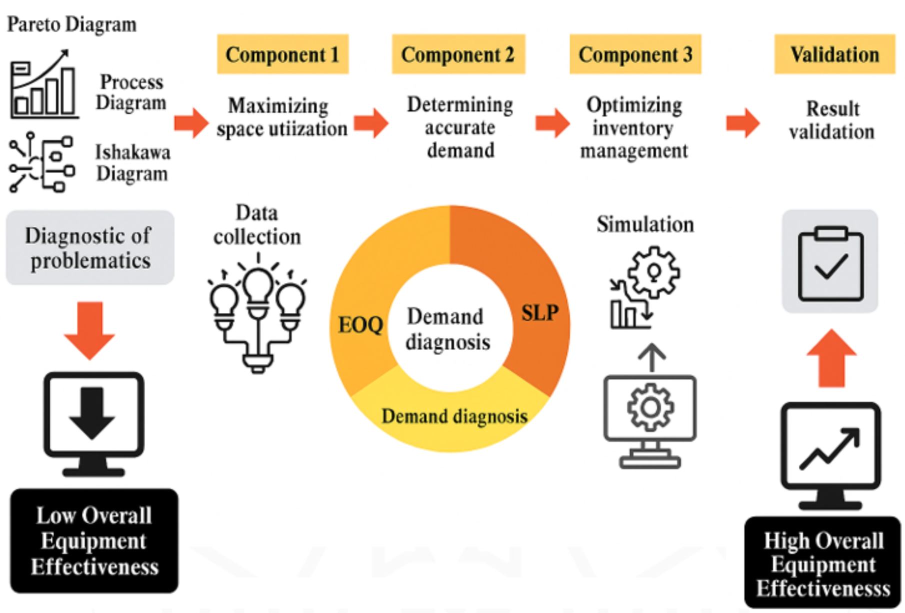

Figure 1. Proposed model

3.1. Model components

3.1.1 Current Analysis

This phase aims to analyze the company's current situation and diagnose its status. It was determined that the company lacks good area distribution and poor space optimization. We applied the SLP tool, which involved analyzing the relationships between areas, both qualitatively (such as safety, ergonomics, and flexibility) and quantitatively (distances and costs). After the SLP, we applied a demand forecast analysis, evaluating different forecasting models and selecting the one with the lowest mean absolute deviation, that is, the smallest error between actual and forecasted quantities. Finally, the demand forecast was used to calculate the optimal number of units per order, considering inventory costs and annual demand.

3.1.2 Implementation of the tools

The first tool implemented was the SLP (Scale-based Planning and Design) to perform a plant redistribution. For this analysis, the distances between operations and reprocessing were considered. This was done to improve plant layout, reduce the distance of incoming and outgoing material flows, and reduce operating times. The second tool applied was demand forecasting, which evaluated different forecasting models. Double exponential smoothing was the one with the lowest mean absolute deviation. This helped achieve greater accuracy in annual demand and facilitate the anticipation and/or planning of monthly orders. The EOQ (Order-to-Order Quality) approach was then applied to manage inventory and find the optimal balance between ordering and holding costs. This helped reduce warehouse inventory and avoid the need to rent a second warehouse to maintain slow-moving products.

3.1.3 Verify the results

To validate the desired results, in Table 1, we have proposed the following indicators:

Table 1. Indicators

Indicators	**Formula**	**Unit**
Storage space used	$\frac{Number\ of\ boxes\ per\ order}{Maximum\ warehouse\ capacity}\ x\ 100\%$	Units
Distance traveled	$\sum Distance\ traveled\ to\ store\ boxes$	Meters
Storage time	$\frac{Distance\ for\ storage}{Average\ travel\ time\ per\ meter}\ x\ 100\%$	Hours
Inventory cost	$Unit\ cost\ x\ demand\ +\ maintenance\ rate$	Dolars
Days of inventory	$\frac{Annual\ demand}{Economic\ Order\ Quantity}$	Days

4. Validation

The manufacturing sector represents the second largest productive sector, impacting Peru's GDP with 12.4% (BCRP, 2023), and a manufacturing company's warehouse is a fundamental part of this. Based on data collected from the company, an increase in the inventory turnover period has been observed, reaching an average real value of 200 days. However, based on information collected from the Superintendency of the Securities Market, the average inventory turnover for industrial companies in similar sectors is 72 days (Superintendencia de Mercado de Valores, sf), so there is a large gap in the analyzed company. Therefore, the economic impact of the low inventory turnover is seen in the inventory overcost that the company had of 560 thousand soles per year, which represents 9.3% of net sales. Among the main causes that cause this problem are a) deficient stock control, b) inefficient use of storage space, c) inefficiency in forecasting demand. Below, Figure 2 presents the results of the application of the proposed model and the evaluation of the indicators.

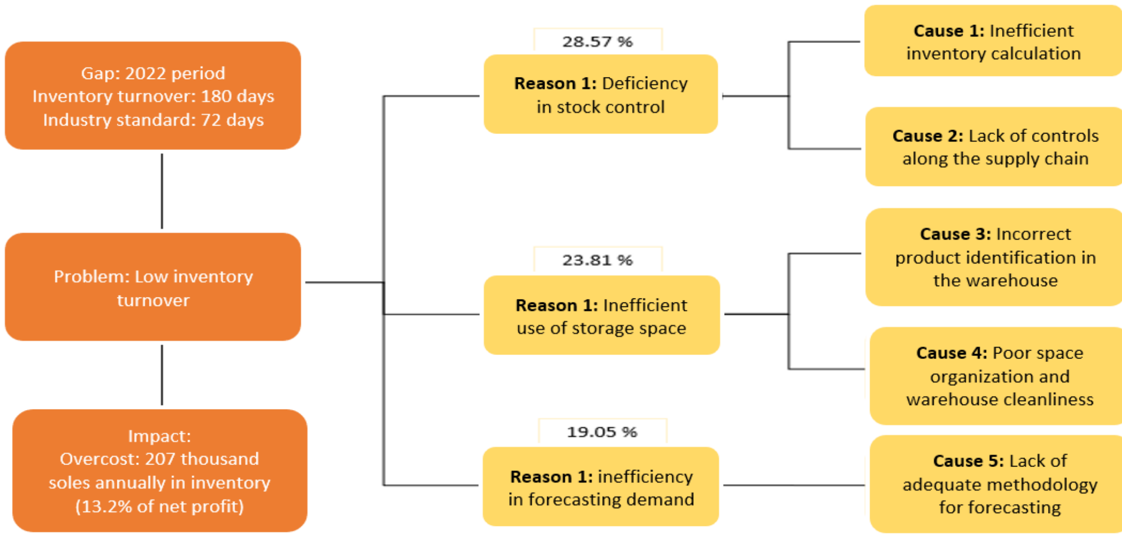

Figure 2. Problem Tree

4.1. SLP Validation

In this phase, the results of the simulation of the improvement tools were evaluated. This phase was crucial to determining the success of the proposed model. The variation in the indicators was assessed and compared with the initial state. For the evaluation of the SLP, the new route was considered, measured from the arrival of the order, through production, and shipment to the storage area. The new space layout shown in Figure 3 reduces the time spent locating and storing the finished product.

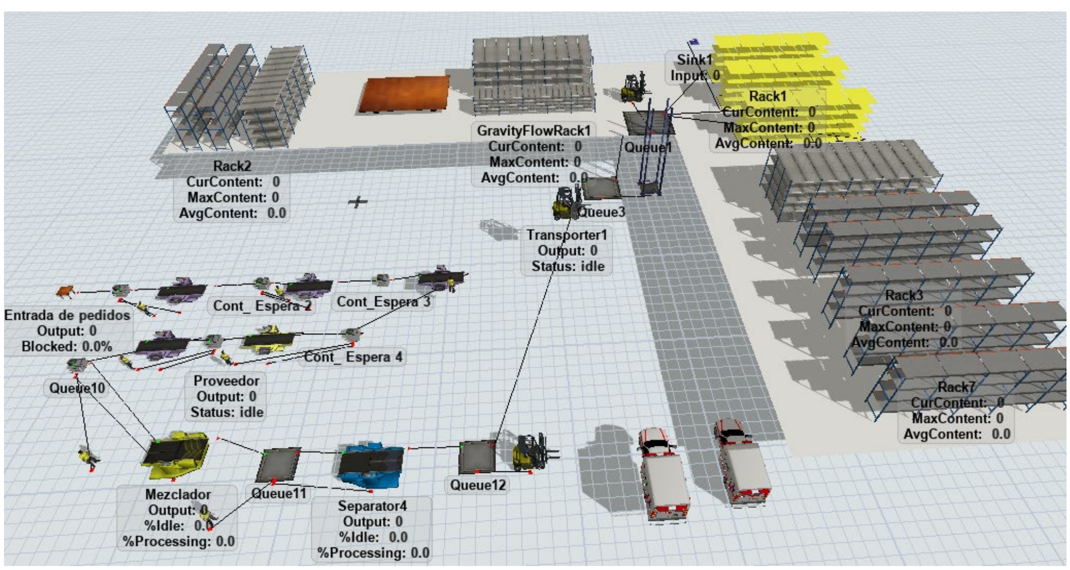

Figure 3. Process path simulation in FlexSim

Below, in Table 2, the results obtained in the simulation will be shown.

Table 2: SLP Implementation

Indicators	**As Is**	**To Be**	**%**
Storage time	2,77 hrs	1,70 hrs	- 38.6%
Distance travelled	8,465.8 m	5,202.4 m	-38.5%

4.2 Demand planning Validation

After the plant redistribution and route simulation, the best demand forecasting model was evaluated to determine the quantity of products to be produced to meet the period's requirements and avoid unnecessary resource consumption. Therefore, the following methods were calculated to determine the company's demand forecasting model based on sales history from 2021 to 2022.

In Figure 4, the behavior of the projected demand with each model and the given history is observed to evaluate, in Table 3, the difference between the two; the one with the smallest gap is the ideal for this type of company."

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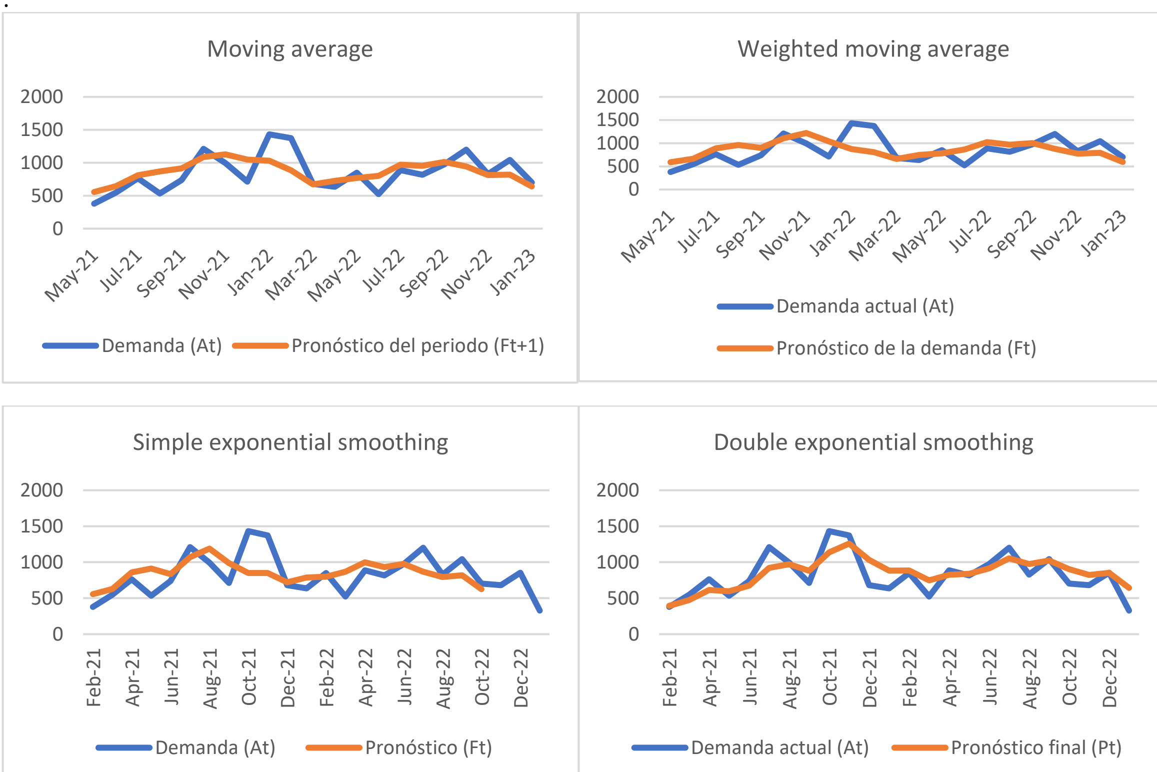

Figure 4. Representation of demand forecasting model

Table 3. Result of demand forecast models.

	Moving average	Weighted moving average	Simple exponential smoothing	Double exponential smoothing
Mean absolute deviation (MAD)	277	262	249	246

Thus, using the double exponential method, the projected demand for 2023 is 8,610 boxes (Table 4).

Table 4. Demand forecast of double exponential

Period	Projected demand
Jan-23	644
Feb-23	657
Mar-23	670
Apr-23	684
May-23	697
Jun-23	711
Jul-23	724
Agu-23	738
Set-23	751
Oct-23	765
Nov-23	778
Dic-23	792
TOTAL	8610

4.3 EOQ validation

To develop this component, in Table 5 analyzes the order cost per unit, the annual demand in units, and the annual inventory cost, with the goal of finding the most economically viable order quantity, which can strike a balance between the factors described to optimize costs.

Table 5. Distributions adjusted for each activity

Description	Variable	Total
Cost to order per unit in soles	S	10.3
Annual demand (units)	D	9690
Annual inventory cost (soles)	H	26.8
Optimal quantity of units per order	Q	86

After finding the balance between the factors to optimize costs, the new inventory turnover days are calculated in Table 6, as the company manages an average of 200 inventory turnover days.

Table 6. Variables of inventory turnover days

Description	Variable	Total
Annual demand (units)	D	9690
Optimal quantity of units per order (EOQ)	Q	96
Inventory turnover	I	113

The use of the simulation made it possible to identify the results of the plant redistribution with the SLP. For example, the total route a purchase order would take to dispatch was reduced by 38.6%, and the route from the production area to the specific warehouse was reduced by 30%.
Likewise, the evaluation of the different demand forecasting models leads us to choose double exponential, which is the model that differs the least from the historical projection. This will allow the company to better plan demand for production. Subsequently, Table 7 presents the key indicators associated with the tools implemented to reduce the company's inventory turnover days.

Table 7. Results of the indicators

Tools	Indicator	As Is	To be	Improvement
SLP	Distance traveled	30 m	21 m	-30%
	Storage time	3.10 hrs	1.47 hrs	-52.5%
Demand planning	Inventory cost	S/. 1’697,577	S/. 1’328,740	-21.7%
EOQ	Storage space used	76%	95.5%	+ 19.2%
	Inventory turnover	200 days	113 days	-43.5%

5. Discussion

Based on the diagnosis and validation of the tools, it is evident that their implementation had a positive impact, with some having a greater effect than others. The SLP (Systematic Layout Planning) tool helped optimize the storage travel distance of operators during the day from 8,465.8 meters to 5,202.41 meters. This was achieved by redistributing the warehouse, which in turn reduced the distances operators had to travel to store each line in its respective location. Furthermore, by decreasing the travel distance, the operator's travel time during the day was also reduced, from 2.77 hours to 1.7 hours. Therefore, when compared to the study by Luyo, A. & Sánchez, K. (2021), where they proposed a redistribution of the area to minimize congestion in the flow of materials and personnel—which resulted in a 55.44% reduction in the distance traveled by operators compared to the current layout and a 55.19% reduction in travel time—it is evident that similar results can be found in both time and distance indicators when applying SLP in the storage area.

Similarly, demand forecasting helped achieve a more accurate figure, thereby reducing inventory costs. The inventory holding rate was reduced from 14.1% to 11% with the new demand forecast due to the reduced space required for storage, insurance, and service costs. Additionally, considering that inventory costs in 2022 represented 18.9% of net sales, with the new demand forecast this figure dropped to 15.5% of 2022 net sales, reflecting a 3.4% reduction in its impact on sales. Therefore, when compared to the study by Cornejo, P. et al. (2021), where the same types of demand were evaluated and the one with the lowest Mean Absolute Deviation (MAD) was selected, a 4.66% savings over 2018 sales was achieved. This shows very similar results in the same indicator when using demand forecasts, resulting in a lower impact on sales.

Additionally, calculating the EOQ (Economic Order Quantity) can optimize warehouse usage. As previously mentioned, with an optimal order quantity of 86 boxes, in a controlled and consistent ordering environment, the warehouse can be utilized at 95.5%. This helps ensure that, with the newly calculated quantity, inventory can maintain a more consistent flow and avoid prolonged storage. When comparing these results to those of Ali Yudhanto, N. et al. (2019), similar outcomes were found, with a warehouse utilization rate of 96.7%. However, it should be noted that in their study, only one shift per day was considered in the factory, compared to two shifts in the company in question. Furthermore, electrical service costs were not considered, as the machinery used requires a negligible amount of electricity and operations are conducted using daylight only.

6. Conclusions

It was possible to demonstrate an improvement in inventory turnover, which, through the correct determination of demand, led to greater production accuracy. Additionally, by implementing SLP (Systematic Layout Planning) and EOQ (Economic Order Quantity), the storage area was reorganized, allowing for better inventory control and reduced costs. The proposed combined model showed improvements in the studied company, increasing inventory turnover from 200 days to 105 days. This also resulted in a reduction of inventory-related overhead costs, which accounted for 4.7% of sales, saving S/. 275,260 annually. Moreover, it was possible to accurately determine the exact demand for production. By applying demand forecasting, more precise data was obtained, which led to a reduction in production volume and, in turn, a 23.9% decrease in inventory costs.

On the other hand, the SLP analysis validated a reduction in both the distance traveled (in meters) and the time spent by operational staff moving from the production area to the warehouse, achieving over a 38% improvement in both indicators compared to the current layout.

Finally, with the implementation of EOQ and SLP in the warehouse area, it was possible to reorganize the space allocated to each production line in an orderly manner and based on their respective demand levels. This allowed for better inventory control and optimized space usage, enabling storage of the entire production. Through simulation, a new warehouse layout was obtained, representing a 19.7% improvement in available free space.

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