Pilot Implementation of Innovative Proposal for Service Level Improvement in a Spare Parts Trading Company

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Abstract. In the context in which spare parts trading companies are becoming increasingly competitive, the level of service is essential to be able to compete in the market. This indicator is affected by on-time deliveries, which are a key factor in meeting customer demand, as this determines customer satisfaction and thus has an effect on the company's profitability. For a company to deliver its products on time, the warehouse processes must work efficiently, making the picking process one of the most critical of them. It must also run a proper inventory procurement process to have stock on hand to fulfill customer orders. This case study focuses on increasing the level of service in a company that sells spare parts for mining, which was found to have a low service level of 66.1%, in contrast to the recommended level for the sector, which is 85.9%. Therefore, the implementation of the 5S methodology, Systematic layout planning, demand forecasting, and cycle counting are proposed as tools to solve the root causes of the problem. The main results indicated a reduction in picking times of 36.70%, an increase in demand forecast accuracy of 13.45%, and an increase in Inventory Record Accuracy (IRA) of 5.42%.

1. Introduction

Companies in the trade sector contribute significantly to the economy. According to this context, Micro, Small, and Medium Enterprises (MSMEs) represent 99.5% of the business sector, of which 95.2% are microenterprises. According to this, 85.2% direct their activities to the trade and services sector [1]. Likewise, it is important to mention that the trade sector represents 10.2% of the Gross Domestic Product (GDP), and had a growth of 2.9% compared to 2018, in other words, more than 306 thousand dollars [2]. This study uses a medium-sized company dedicated to trading spare parts for the construction and mining sector as a unit of investigation. On-time deliveries are directly related to the service level of the company and are an important factor to measure the proper management of warehouses and inventories. The problem that is evident in this company is late deliveries, which causes the company an economic loss cost of US$42 048 per year, which represents 6.86% of the company's total income. Implementation of a lean manufacturing and SLP-based system for a footwear company is previous work followed by a short paper called service level advancement with 5S, SLP, demand forecasting, and cycle counting in a company, these tools are used as solution techniques to increase the service level of the selected spare parts trading company [3]. This research was carried out in the company NP27, a trading company of spare parts for the construction and mining sector. In addition, the main products sold by the company include down-the-hole hammers, drill bits, and drill rods among others. Being a company dedicated to the import, storage, and distribution of spare parts for the construction and mining sector, it is of the utmost importance to supply these companies in the equipment sector in the agreed time in order not to have low availability of their machinery and the timely delivery of assigned projects. Following the above, the orders arrive on the agreed date, for which, in collaboration with the general management of the case study company, the analysis of the order for the year 2020 was prepared, which indicates that there is a low

level of service due to the delivery of orders outside the date agreed with the client, which is at 66.10%. According to an earlier study in an article, the sector of spare parts trading companies is at 85.90% [4].

1.1 Lean warehousing

In general, a warehouse that functions efficiently allows obtaining an optimal cost of service and an increase in the level of customer service [5]. Likewise, it was indicated that if the warehouse is not properly managed, it will incur higher costs for the company, and consequently, it will harm the delivery of products in the quantity and the period agreed with the customer [6]. Martins et al [7] mentioned that currently, many industries use the lean warehousing methodology to solve warehouse management problems since they do not require an excessive investment for its implementation. The vital objective of industrial companies is to improve efficiency in the warehouse to reduce the amount of inventory and improve the ability to meet customer demand [8]. Similarly, it was indicated that it is necessary to have a competitive advantage and make continuous improvements to product quality and improve safety in the company's environment, so one of the tools that allow to establish a highly efficient, clean, and safe work environment and thus achieve this goal is the 5S methodology [9]. On the other hand, it was pointed out that waste from warehouse processes is eliminated by using various lean tools like 5S [10]. Also, it was revealed that if it is necessary to maximize the use of the warehouse and review the storage locations, the 5S should be considered since this tool allows to obtain better results in conjunction with other lean tools [11]. In the case study, the implementation of the 5S methodology managed to maximize 12% of capacity concerning storage space. In addition, the lean methodology helped classify obsolete materials within the warehouse and the distance traveled by workers was reduced by 23% [12].

On the other hand, the implementation of lean methodologies was carried out with 5S in a case study, which resulted in an estimated annual savings of US$53 726 per year and the picking process was more efficient, achieving a 25% reduction in time. Similarly, it was proposed that the use of techniques, such as Value Stream Mapping (VSM) and the time study, in which matrix tables are applied, layout redesign, and the elimination of activities that do not provide value. The main result of the implementation of this proposal is the improvement of productivity based on the reduction of the total picking time of 22.38%. In addition, by using the VSM technique, unnecessary waste and travel times that do not add value for the customer are eliminated, thus reducing the total picking time, which increases productivity by 23.24%. Likewise, it was proposed the use of the VSM tool in the warehouse of a leading paint manufacturer in India to reduce out-of-stocks and high lead times. The main result was that the lead time for deliveries to remote stations was decreased by 3.2 hours and the lead time for all deliveries was reduced by 58.5 hours [13]. Furthermore, a case study of the application of the 5S methodology for the improvement of the company's productivity was developed. The results indicate that the tool search time in the workplace has been significantly improved and the level of safety is increased. In addition, the 5S audit from its initial to the final stage has improved from 6 to 72 points [14].

1.2 Inventory management

Conceicao et al [15] pointed out that there are problems in inventory management in companies of different industries, since, to meet customer demand, they must resort to out-of-schedule expenditures so as not to harm the company's service level and deliver the order to the customer at the agreed time. Similarly, it was noticed that companies are forced to stock a large number of items when they do not have a correct interpretation of demand, which generates high inventory costs and lost sales [16]. It is vital to calculate demand forecasts to make the right decisions to meet customer demand without having excessive inventory and achieve greater cash flow. Therefore, it is necessary to use appropriate forecasting models to balance demand and available inventory [17]. In addition, the trade-off of using cycle counting for annual inventory counting significantly affects the performance of the companies, as it does not properly correct the inventory records, thus failing to

meet customer demand on time [18]. In a case study, it was revealed that inventories are properly managed through the use of inventory techniques such as demand forecasting methods and the ABC analysis by 48%, which represents a reduction of US$386 614 of obsolete inventory [19]. A case study was carried out on poor inventory management due to a lack of knowledge for decision-making by owners in the supply process. As a main result, an accurate forecast was obtained that allows for minimizing inventory costs and thus managed to satisfy customer demand, by at least 14% compared to the classic Economic Order Quantity (EOQ) methodology.

On the other hand, cost-based inventory was implemented by minimizing the MSE of the demand forecast. In addition, demand forecasting models based on exponential smoothing are usually optimized when employed as a cost function for parameter optimization. Therefore, high-performance forecasts in terms of bias fall to some extent on how the forecasts are parameterized. As a result, substantial gains of 62% improvement were obtained [20]. The multicriteria ABC analysis to improve the efficiency of inventory management and improve the cost distribution of spare parts was proposed [21]. As the main result, it is obtained that 77.7% of the highest costs that the company's spare parts have been distributed in the first 84 of the 35 677 spare parts. A model was implemented on the low demand review optimization of the management of fast-moving spare parts goods. As a result, the risk of accumulating excess inventories with the new forecasts was minimized by 1.5 million euros over three years. In addition, it was determined that 28% of spare parts with intermittent demand end up as dead stock, while 18% as excess stock [22].

1.3 Improvement of the warehouse layout

Reis et al. [23] pointed out that for a warehouse to have satisfactory productivity, the design, warehouse operations, and material handling systems must be properly executed. Also, it was pointed out that warehouse design involves a large number of interrelated decisions that influence the functionality and processes of a warehouse, technical requirements, equipment space utilization, equipment layout, and others [24]. The industry has an efficient layout, adequate equipment, and the optimal number of people for each activity are key factors in increasing warehouse productivity, as distribution planning allows for reduced distances and order retrieval times [25]. Furthermore, if the warehousing process is not properly managed, this will have an impact on movement, waiting time, and transportation costs, as it can lead to higher time, distance, and internal transportation costs, and also affect the number of employees and transportation devices required for these activities [26].

Different methodologies were developed which consist of the use of the Systematic Layout Planning (SLP), 5S methodologies, and the Analytic Hierarchy Process (AHP) method in different manufacturing companies where the problem focuses on the inadequate use of space and high costs of movement and handling of materials and products. With the execution of the new model, reallocating is probable and increased the processes production by 40%, and also warehouse capacity utilization level of the warehouse is increased to 90% [27-29]. Five plant designs were proposed, of which alternative A5 obtained the highest ranking of 0.454 and is proposed for implementation. A study was conducted in a company supplying raw materials for the automotive sector, in which they found insufficient spaces in the warehouse due to inadequate warehouse management. New layouts were proposed, from which as the main result, it was obtained that when comparing the new proposed layout (warehouse A) with the old one, the proposed layout of warehouse A reduces the total picking distance of the same products from 1068 km to 1034 km, i.e., by 3.18% [30]. On the other hand, a rack system design to improve the warehouse management system was proposed. The main result of this article is the implementation of three types of design, from which they come to obtain the utilization of the storage area up to 40.05% [31]. Additionally, the authors proposed a mathematical model called Integrated Cluster Allocation (ICA) Policy that aims to minimize the retrieval time of picking systems based on product rotation and customer order affinity to solve the problem of high picking process times. The main result is a reduction of the total retrieval time by 40% [32].

This article was developed in five stages. In the first stage, a review of the literature on the proposed solution tools was carried out. In the second stage, the methodology for the implementation of these tools is explained. In the third stage, the validation of the mentioned tools was carried out by

conducting a pilot of the proposal in the company. In the fourth stage, the discussion and comparison of the results were carried out. Finally, the conclusions of the work and recommendations are developed.

2. Methodology

According to the literature review, it was found that, only few executions on demand forecasting, and cycle counting as an integrated model of service level improvement in companies of the same line of business, this is because the research of spare parts trading for the construction and mining sector is very small, so this research work contributes significantly to the increase further research. The development of the model and its components will be carried out in three stages as follows.

2.1 Proposed Model

The proposed model is based on the integration of 5S methodology, systematic layout planning, demand forecasting, and cycle counting, which are supported by lean warehousing, inventory management, and improvement of the warehouse layout typologies. This model was tested and validated through a pilot implementation in the warehouse of spare parts Peruvian company studied. However, these proposed models could be used in another engineering field where there was a warehouse with similar problems. Figure 1 shows the schematic diagram of the proposed model.
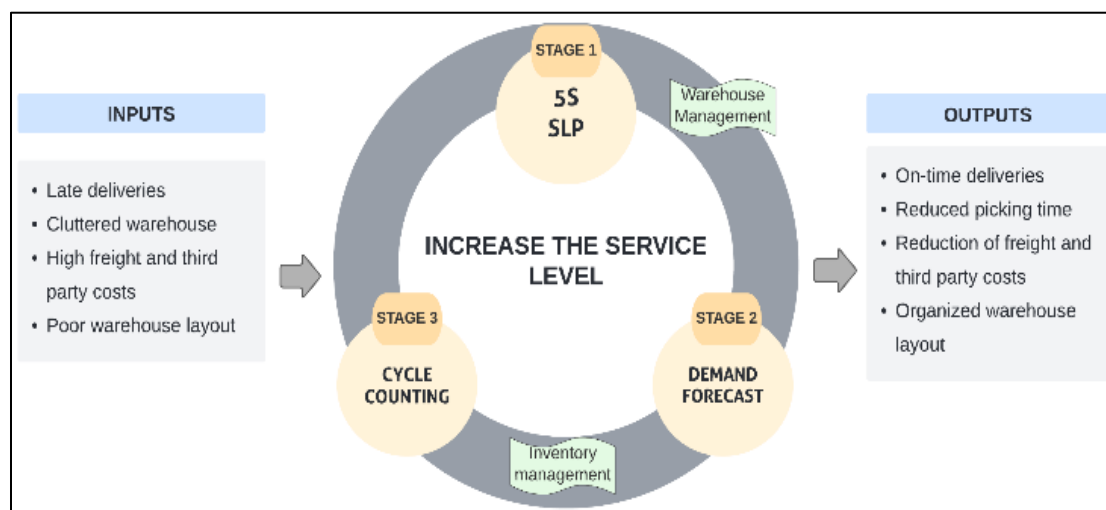

Fig. 1. Proposal model

2.2 5S and SLP methodologies

This stage allowed to generate a change of culture in the warehouse picking process. Through the execution of 5S audits, it was possible to determine the level of culture that the company has regarding this methodology. This step is common in the 5S methodology since the implementation of this in many scientific studies has had favorable results and is very dynamic to use. In addition, this methodology is properly linked to the SLP methodology, hence it was considered to use both tools. As a first step, we began with the classification of the items in the warehouse and categorized them according to their characteristics using red cards, which were managed through a general register. In the second step, the SLP methodology was implemented through the development of the ABC analysis and the activity relationship diagram. Based on this, the warehouse layout was modified. As a third step, the scheduling of cleaning activities was developed, as well as the verification of their compliance. As a fourth step, the frequency of verification of 5S activities was established. The discipline policies that are the last step of the first stage in the proposed model, their discipline policies and standards were determined, as well as recognition actions for achievements and continuous training. Through the execution of 5S audits, it was possible to determine the level of 5S culture. In the pilot study, a score of 93 points was obtained, which improved the initial of 29.

2.3 Demand forecasting

The data considered for the demand prediction covers the company's customer market, mainly spare parts for mining projects, which are located in Peru. It was based on the historic demand of the previous year. NP27 is the fantasy name (in substitution for the real name) of the company in which the pilot implementation was carried out. On the other hand, QL5, and QL6 are the families of spare parts marketed by the company, as well as DHD340, ROCK66, and drill rods. This stage involved the selection of the most demanded spare parts of the QL5 and QL6 families, from which the 2-month demand forecast was determined using different time series analysis methods. It should be noted that the Holt-Winters method was chosen as the forecasting method with the lowest Mean Absolute Percentage Error (MAPE).

2.4 Cycle counting

In this last stage, the calculation of the products to be counted per day was made employing the ABC analysis of the spare parts, from which 261 working days per year were considered. From this calculation, 2nd category A spare parts, 1st category B spare parts, and 1 category C spare parts were counted. It is worth mentioning that this count was carried out during the working hours of the warehouse personnel and those in charge will carry out the count through an inventory register for which the warehouse manager is responsible for its daily execution.

3. Results and Discussion

3.1 Description of the validation scenario

The case study was carried out in a company that sells spare parts for the construction and mining sector, which is located in the district of Ate, in Lima-Peru. This company has more than 20 years of experience in the sector and works with well-known clients, such as Summa Gold Corporation, Stracon, and Pevoex Contratistas, among others. In addition, among the main products marketed by the company are down-the-hole hammers, drill bits, and drill rods, among others. These products are divided into 5 families, of which the QL5 and QL6 families represent 80.4% of the company's sales. The validation was carried out from January 2022 to April 2022 by performing a 5S audit. A time study of the picking process of 17 through a sample of 17 observations, the execution of a two months demand forecast of the most profitable spare parts, and the daily inventory count for 2 months. The validation was developed as a pilot plan in the company's warehouse since permission was obtained from the general manager and the participation of personnel from the warehouse area of the company under study. It should be emphasized that a previous meeting was held with the general manager in which the company's problems and the benefits of the solution tools to be used were explained, and also the costs and schedule for the implementation of the proposed tools were detailed and explained to the general manager, which led to his acceptance for the implementation of the project.

3.2 5S and SLP methodologies

For the validation of the 5S, the final audit of the 5S was carried out, to evaluate whether this culture was sustained over time. It should be noted that this evaluation is made up of the same questions asked in the initial diagnosis, which are related to each of the 5S. A score of 93 out of 100 points was obtained, which is significantly higher than the initial situation. Figure 2 shows graphically the radar of the 5S audit implemented in the warehouse of the company under study. Similarly, the implementation of the SLP methodology has allowed the boxes of products to be properly located in the reception and dispatch area. It should be noted that these boxes were previously stored according to the worker's criteria and the space available in the area.
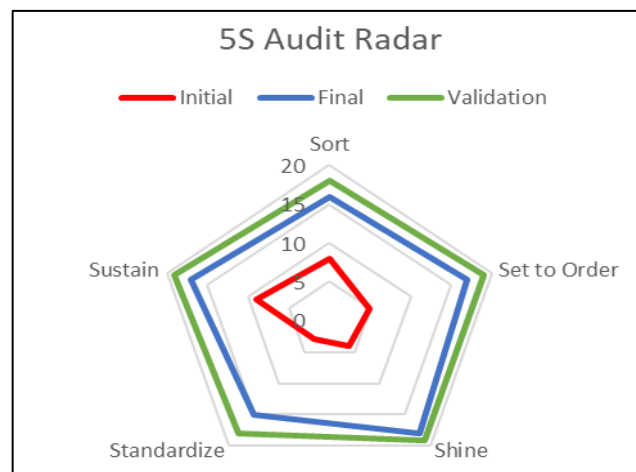
Fig. 2. 5S Audit radar

Table 1. Picking process activities

ID	Activity
A	Review purchase order
B	Moves to order location
C	Remove boxes
D	Open the box
E	Check order quantity
F	Places ordered parts in a box
G	Checks the condition of the spare parts
H	Takes a photo of the condition of the spare parts
I	Close the box
J	The box is transported to the dispatch area.
K	The boxes are placed back in the initial location

To validate the implementation of this tool, a time study of the picking process was carried out, in which an initial sample of 10 observations was taken to calculate the necessary number of samples to be taken for the calculation of standardized times. Likewise, this calculation is made with a confidence level of 95% and a margin of error of ± 5%. Table 1 reveals the activities of the picking process for which the length will be timed and Table 2 shows the initial time study of the picking process. Through the time recording of 10 observations, the calculation of the minimum size of observations was performed according to the activity with the highest Coefficient of Variability (CV), which corresponds to activity 'I'. It should be noted that the atypical times present in the time recording were omitted for the calculation of the average time $\overline{X}$. Subsequently, the calculation was performed as shown in Equation 1.

$$N = \left(\frac{t \times s}{e \times \overline{X}}\right)^2 = \left(\frac{2.262 \times 0.9312}{0.05 \times 10.413}\right)^2 = 16.37 \cong 17 \text{ observations} \tag{1}$$

Therefore, it is concluded that the minimum sample size will be 17 observations. Likewise, for the calculation of the observed time, the lower and upper limits must be considered, which will be calculated as shown in Equation 2.

$$CL = \overline{X} \pm (\overline{X} * k) \tag{2}$$

Where k= precision level of 18%.

Table 2. Initial time study

ID	Average Time [min]	S	CV	g	t
A	10.984	0.8762	0.0798	9	2.262
B	19.397	1.2437	0.0641	7	2.365
C	36.133	1.0296	0.0285	7	2.365
D	17.318	0.9461	0.0546	9	2.262
E	12.500	1.0820	0.0866	9	2.262
F	19.673	1.3007	0.0661	9	2.262
G	16.354	0.9395	0.0574	9	2.262
H	3.418	0.2840	0.0831	9	2.262
I	10.413	0.9312	0.0894	9	2.262
J	16.713	1.4909	0.0892	9	2.262
K	23.486	1.3696	0.0583	9	2.262

It is important to emphasize that the average time was found without considering the outlier times within the observations, being those times that are notoriously far from the mean of the times. Table 3 indicates the calculation of lower and upper limits to find the observed time.

Table 3. Observed time calculation

ID	Average Time [min]	LCL	UCL	Observed Time [min]
A	11.333	9.293	13.373	11.333
B	19.465	15.961	22.968	19.465
C	36.303	29.769	42.838	36.303
D	10.853	8.900	12.807	10.853
E	8.879	7.281	10.477	8.879
F	19.980	16.383	23.576	19.980
G	16.442	13.482	19.401	16.442
H	3.433	2.815	4.051	3.433
I	10.405	8.532	12.278	10.405
J	16.081	13.186	18.976	16.081
K	23.198	19.022	27.374	23.198

Table 4. Standard time calculation

ID	Observed Time [min]	V.F.	Normal Time [min]	Allowances [%]	Standard Time [min]
A	11.333	1.00	11.333	9	12.353
B	19.465	1.00	19.465	9	21.216
C	36.303	1.00	36.303	9	39.570
D	10.853	1.03	11.179	9	12.185
E	8.879	1.03	9.145	9	9.968
F	19.980	1.03	20.579	12	23.049
G	16.442	1.03	16.935	9	18.459
H	3.433	1.00	3.433	9	3.742
I	10.405	1.03	10.717	9	11.682
J	16.081	1.03	16.563	12	18.551
K	23.198	1.00	23.198	9	25.286
Total time [min]					196.062
Total time [h]					3.268

Since there are no times outside the lower or upper limits, the average time is equal to the observed time for all activities. On the other hand, to calculate the Normal Time, the Valuation Factor (VF) is calculated using the wasting house method for each activity. In addition, to calculate the Standard Time, the percentage of allowances is calculated for each activity. Table 4 shows the calculation of the Standard Time of the picking process. According to Table 4, the total standard time was 196.062 minutes, i.e. 3.268 hours for the picking process. Figure 3 shows graphically the comparison between the result of the picking process time and the target value [8].

Fig. 3. Comparison of results of picking process time and target value

3.3   Forecasting demand

For this proposal, the pilot plan was considered as a validation method. The percentage of MAPE obtained in the results enabled the Holt-Winters method to be chosen as the appropriate method for demand forecasting (<10%), so this allows the forecasts to be more accurate and give a better result for the implementation of demand forecasting. In the development of this tool validation, the forecast of the 6 most representative products of the QL5 and QL6 families was carried out, according to the ABC analysis, with the Holt-Winters method being the forecast with the lowest MAPE. In this validation, the forecast for March and April 2022 was developed. Table 5 shows the comparison of demand and forecast for the 6 spare parts in March and April 2022. In addition, Table 6 shows the percentage accuracy of the Holt-Winters forecast for March and April for the 6 spare parts. On the other hand, Figure 4 shows graphically the comparison between the forecast accuracy obtained and the target value for this study, which was 85% [16].

Table 5. Forecast accuracy by SKU

SKU	Demand		Forecast	
	March	April	March	April
1541 - QL6 - 6EVD 156	48	34	41	27
4011 - QL6 - 12 153	30	30	25	24
4011 - QL6K	26	18	18	14
1540 - QL5 - 5HVMR	45	32	36	25
4011 - QL5 - 13 - W	22	24	16	22
4011 - QL5E - W	28	25	20	21

Table 6. Forecast accuracy by SKU

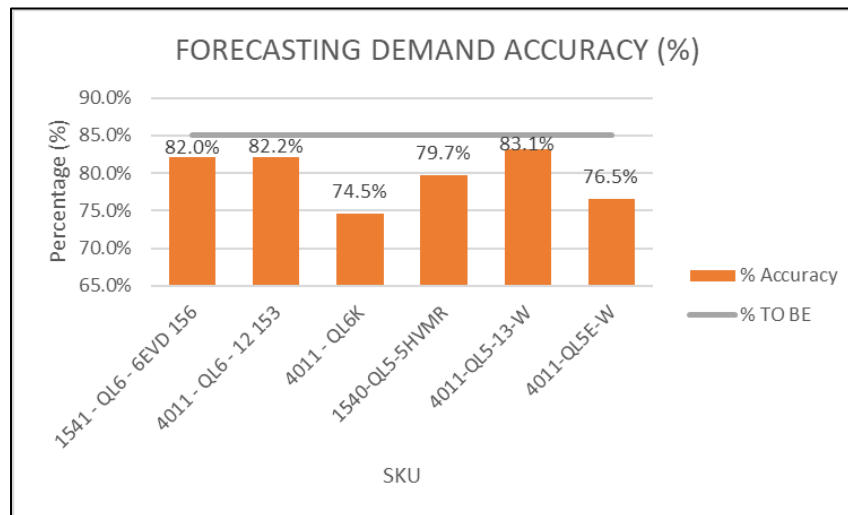| SKU	Forecast Accuracy [%]
1541 - QL6 - 6EVD 156	82.0
4011 - QL6 - 12 153	82.2
4011 - QL6K	74.5
1540 - QL5 - 5HVMR	79.7
4011 - QL5 - 13 - W	83.1
4011 - QL5E - W	76.5

Fig. 4. Comparison of forecast accuracy and target value

3.4 Cycle counting

For the validation of this tool, it was proposed to carry it out through the pilot plan, in which a sample of 4 SKUs per day will be chosen like 2 of category A, 1 of category B, and 1 of category C. Given that there is a total of 61 SKUs, the inventory will be turned in a total of approximately 15 days, so that every 2 weeks a change in the IRA indicator will be reflected through the use of the cycle count. It should be noted that the implementation of this tool began in the period from March to April, where the first count was performed on March 1. After turning the inventory, the first IRA indicator of the current situation was obtained on March 17. Table 7 shows the percentage of IRAs over this period. As can be seen, the IRA indicator showed a positive trend with an increase of 88.47% on the last date of April. Figure 5 shows graphically the comparison between the performance of the IRA during March and April and the target value for this study, which was 91% [18].

Table 7. Inventory record accuracy by each count date

Spare Part Family	Inventory Record Accuracy [%]		
	17th March	4th April	25th April
QL5	80.34	89.40	83.70
QL6	81.68	83.23	86.88
DHD340	82.15	83.22	90.56
ROCK66	72.87	83.70	94.12
Drill rods	80.20	86.38	87.08
Average	79.45	85.19	88.47

After developing the validation of the tools, a comparison of the situations before and after the implementation of the proposed tools with the target values will be carried out to verify the success of this study. Table 8 presents the comparison results of the indicators obtained from the

implementation of the proposed tools. It can be seen that the result obtained in the picking time exceeded the expectations of the target value. On the other hand, the results of the service level indicator and the IRA indicate that a considerable improvement was obtained. However, it does not reach the expected value of the project.
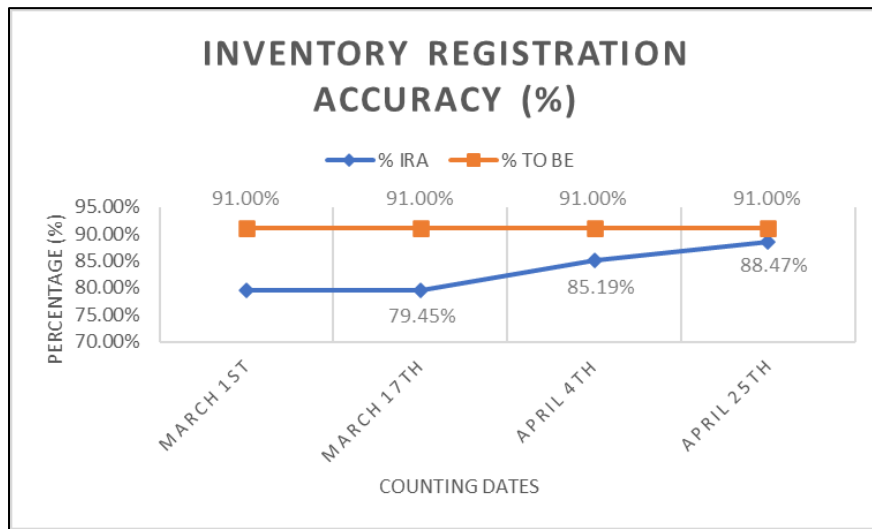

Fig. 5. Comparison of IRA according to each count date and target value

Table 8. Comparative indicators

Solution Technique	Indicator	Unit	As-Is Value	To-Be Value	Result Value
5S and SLP	Picking time	(h)	5.16	4.13	3.27
Forecasting demand	Service level	%	66.10	85.00	79.68
Cycle counting	IRA	%	83.05	91.00	88.45

3.5 Picking time

In the case of picking time, the result was a reduction from 5.16 to 3.27 hours, i.e. 36.71%. This was possible because there was no major resistance to change on the part of the warehouse personnel, since they were aware of the problems of delay in the picking process and the consequences that it entailed, such as delays in the delivery of orders to the customer. In addition, the layout redesign through the relocation of racks and furniture within the warehouse was advantageous, since it was possible to relocate the spare parts appropriately in the corresponding racks through the ABC analysis and this allowed the excess of boxes within the warehouse aisles to decrease considerably, which facilitates the forklift to move through the warehouse fluidly and, consequently, to reduce the picking time.

In addition, through the application of the 5S and SLP tools, picking times in the warehouse were considerably reduced, and as a result, deliveries were made to customers on time. Table 9 shows the comparison of the initial situation and the implementation of the 5S and SLP methodology. According to Table 9, the total picking process time was reduced from 5.16 hours to 3.27 hours or 36.71%. In addition, it can be observed that 3 activities managed to reduce more than half of their time, which are the removal of boxes, transportation of boxes to the dispatch area, and placing the boxes in the initial location. This is because by implementing the SLP methodology and the ABC analysis it was possible to locate the spare parts according to their rotation, which reduced the number of boxes in the aisles of the warehouse. After all, there was no space to store them due to the lack of a storage policy. Similarly, some activities increased in percentage terms by up to 23%. However, this does not represent more than 3 minutes of variation, unlike the activities mentioned above, which had a reduction of up to 54 minutes. Figure 6 shows graphically the comparison between the picking time

before and after the implementation of the SLP methodology and the target value, which was a reduction of 20%, that is, to 4.13 hours [8].

Table 9. Before and after time evaluation

| Activities	Time [min]		
	Before	After	Variation [%]
Review purchase order	10.978	12.353	12.53
Moves to order location	35.128	21.216	-39.60
Remove boxes	93.416	39.570	-57.64
Open the box	16.495	12.185	-26.13
Check order quantity	12.191	9.968	-18.23
Places ordered parts in a box	19.584	23.049	17.69
Checks the condition of the spare parts	15.732	18.459	17.34
Takes a photo of the condition of the spare parts	3.054	3.742	22.54
Close the box	9.923	11.682	17.72
The box is transported to the dispatch area	41.086	18.551	-54.85
The boxes are placed back in the initial location.	52.179	25.286	-51.54
Total time [min]	309.766	196.062	-36.71
Total time [h]	5.163	3.268	
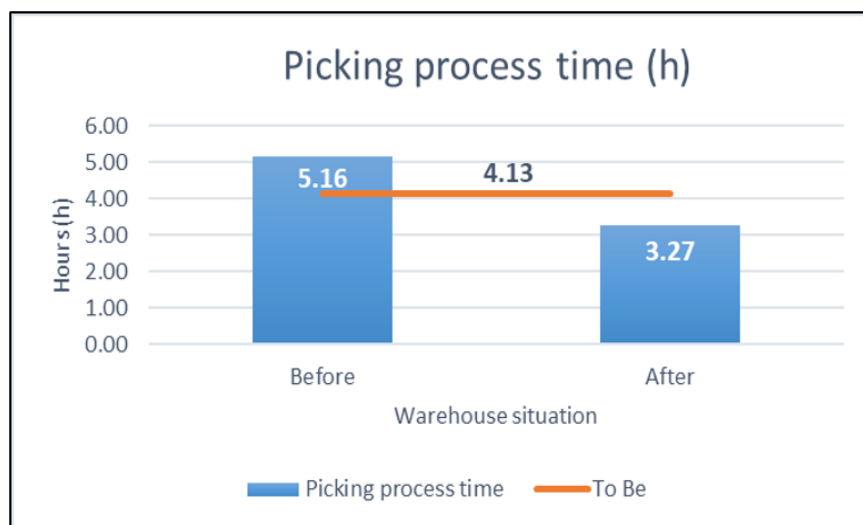
Fig. 6. Comparison of picking process time before and after 5S with SLP implementation and target value

3.6 Forecast accuracy

In the case of the demand forecast result, it was not possible to achieve the target value because there is high variability in the demand of customers who are not subject to contract so adapting a forecast with efficient accuracy is complicated. In addition, it should be considered that the execution of the demand forecast using MINITAB software is a new method of forecasting customer orders since the company carries out the supply of products through the review of historical sales (moving average method) according to the manager's criteria. Consequently, there was resistance to the implementation of this tool, hence, despite obtaining an improvement in the accuracy of the demand forecast, the expected result was not achieved. However, a considerable improvement in service level of 13.58% was obtained through the use of Holt-Winters forecasting, which allows us to meet customer demand efficiently. Figure 7 shows graphically the comparison between the service level before and after the implementation of the demand forecast and the target value.
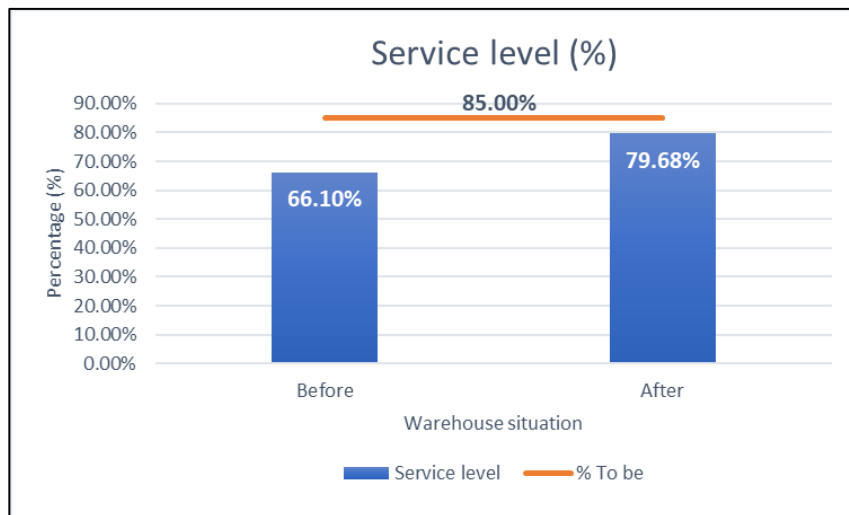
Fig. 7. Comparison of service level and target value

3.7 Inventory record accuracy

In this case, it is important to mention that the company carries out its inventories once a year, so the implementation of cycle counting was a new change in the company. Consequently, the warehouse personnel did not manage to adapt adequately to this new work task incorporated into their work, given that the implementation period for this tool was two months (March and April), so the expected value was not achieved in that period. Notwithstanding, a considerable improvement in the level of service of 7.95% was obtained through the implementation of cycle counting. Eventually, this indicator will increase until it exceeds the target value. Figure 8 shows the comparison between the inventory record accuracy before and after cycle counting and the target value.
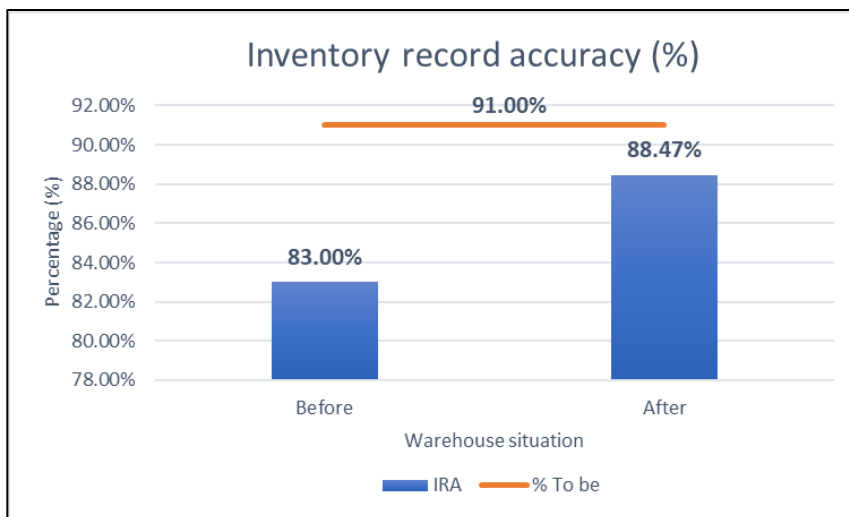

Fig. 8. Comparison of IRA before and after cycle counting and target value

4. Conclusions

The case study company NP27 presents a problem of low service level, which was determined through the analysis of the orders dispatched on time, in which the company is at 66.1%, being the level of the spare parts trading sector of 85.9%. The low service level was caused by unproductive times and stock-outs; the main root causes were inadequate physical layout distribution, disorder and disorganization, inadequate demand forecasting, and inadequate inventory counting. However, according to the characteristics of the case study, such as implementation time, investment, suitability, and difficulty, the research team determined its solution an improvement focused on the 5S methodology, the SLP methodology, demand forecasting, and cycle counting.

The 5S and SLP methodologies were developed as an integrated model, initially obtaining a score of 29 out of 100 points through the implementation of a 5S audit, and then applying the layout redesign with the component of ABC analysis by families, relational diagram of activities, and relational table of activities. Once the tools were implemented, a final audit was carried out, obtaining 93 out of 100 points, and a time study was also carried out for the picking process, reduced from 5.16 hours to 3.27 hours. Regarding demand forecasting, after analyzing the different types of forecasting, it was determined that the Holt-Winters method, due to its lower MAPE, was the most representative of the sample considered. An improvement in the demand forecast was obtained from 66.10% to 79.55% using this method. In the case of cycle counting, the number of products to be counted per day was calculated using ABC analysis. It was determined that every 15 days the entire inventory is turned and in the validation, the IRA indicator was increased to 88.47% through the use of this tool.

Finally, this study has considered the implementation of 5S, SLP, demand forecasting, and cycle counting tools to raise the overall service level of the company. In the case of demand forecasting, the 6 spare parts with the highest representation, i.e., the highest turnover and revenue, have been chosen. From these spare parts, the Holt-Winters method was applied for the development of the 2-month demand forecast. Based on this, for future research, it is suggested to apply this forecasting method to the entire inventory. This will further increase the service level and effectively meet customer demand. In addition, it is important to emphasize that the SLP methodology was implemented in the main warehouse of the company, but there are 2 other warehouses, which are smaller in size. For future work, the application of this technique in these warehouses should be considered, since they have the same problems of disorder and disorganization, as well as poor physical layout distribution.

References

[1] Information on Produce, Estadística Mipyme, https://ogeiee.produce.gob.pe/index.php/en/shortcode/estadistica-oee/estadisticas-manufactura

[2] Information on COMEXPERU, ComexPerU-Sociedad de Comercio Exterior Del PerU, https://www.comexperu.org.pe/articulo/el-sector-comercio-un-mercado-atractivo-en-medio-de-la-incertidumbre.

[3] Silvestre, Chaicha, Merino, and Nallusamy, S., Implementation of a Lean Manufacturing and SLP-based system for a footwear company, Production, 32 (2022) e20210072.

[4] V. Saravanan, S. Nallusamy, and Abraham George, Efficiency enhancement in a medium scale gearbox manufacturing company through different lean tools - A case study, International Journal of Engineering Research in Africa, 34 (2018) 128-138.

[5] E. Oey, and M. Nofrimurti, Lean implementation in traditional distributor warehouse-A case study in an FMCG company in Indonesia, International Journal of Process Management and Benchmarking, 8(1) (2018) 1-15.

[6] C. Udomraksasakul, Songserm, Cherdchoongam, and Udomraksasakul, The bringing of the ABC analysis technique for using to increase the efficiency of placing products in the warehouse, International journal of mechanical Engineering and Tech., 9(13) (2018) 9-13.

[7] R. Martins, M. T. Pereira, L. P. Ferreira, Sa, and F. J. G. Silva, Warehouse operations logistics improvement in a cork stopper factory, Procedia Manufacturing, 51 (2020) 1723-1729.

[8] M. Freitas, F. J. G. Silva, L. P. Ferreira, J. C. Sa, M. T. Pereira, and J. Pereira, Improving efficiency in a hybrid warehouse: A case study, Procedia Manufacturing, 38 (2019) 1074-1084.

[9] N. Sukdeo, K. Ramdass, and G. Petja, Application of 7S methodology: A systematic approach in a bucket manufacturing organization, South African Journal of Industrial Engg., 31(4) (2020) 178-193.

[10] B. Baby, N. Prasanth, and S. S. Jebadurai, Implementation of lean principles to improve the operations of a sales warehouse in the manufacturing industry, International Journal of Technology, 9(1) (2018) 46-54.

[11] Srisuk and Tippayawong, Improvement of raw material picking process in sewing machine factory using lean techniques, Management and Production Engg.Review, 11(1) (2020) 79-85.

[12] S. Nallusamy, Vijay Kumar, Vivek Yadav, U. Kumar Prasad, and S.K. Suman, Implementation of total productive maintenance to enhance the overall equipment effectiveness in medium scale industries, International Journal of Mechanical and Production Engineering Research and Development, 8(1) (2018) 1027-1038.

[13] P. G. Abhishek and M. Pratap, Achieving lean warehousing through value stream mapping, South Asian Research Journal of Business and Management Cases, 9(3) (2020) 1–15.

[14] G V P Rao, S. Nallusamy, and M. Rajaram Narayanan, Augmentation of production level using different lean approaches in medium scale manufacturing industries, International Journal of Mechanical Engineering and Technology, 8(12), (2017) 360-372.

[15] J. Conceicao, J. de Souza, E. Gimenez-Rossini, A. Risso, and A. Beluco, Implementation of inventory management in a footwear industry, Journal of Industrial Engineering and Management, 14(2) (2021) 360-375.

[16] E. Ramos, T. J. Pettit, M. Flanigan, L. Romero, and K. Huayta, Inventory management model based on lean supply chain to increase the service level in a distributor of automotive sector, International Journal of Supply Chain Management, 45(2) (2020) 125-136.

[17] H. Briseno, L. A. Guzmán, P. Cano, and D. Sanchez, Forecasting demand improvement for replenishment in a retail painting company, Acta Logistics, 6(4) (2019) 155-164.

[18] R. Ishfaq and U. Raja, Empirical evaluation of IRI mitigation strategies in retail stores, Journal of the Operational Research Society, 71(12) (2020) 1972-1985.

[19] Nallusamy, S., Balaji, and Sundar, S., Proposed model for inventory review policy through ABC analysis in an automotive manufacturing industry, International Journal of Engineering Research in Africa, 29 (2017) 165-174.

[20] Kourentzes, J. R. Trapero and D. K. Barrow, Optimising forecasting models for inventory planning, International Journal of Production Economics, 225 (2019) 197-206.

[21] C. Teixeira, I. Lopes, and M. Figueiredo, Classification methodology for spare parts management combining maintenance and logistics perspectives, Journal of Management Research and Analysis, 5(2) (2018) 116-135.

[22] O. Nnamdi, Strategies for managing excess and dead inventories: A case study of spare parts inventories in the elevator equipment industry, Operational Supply Chain Management, 11(3) (2018) 128-139.

[23] Augusto da Cunha Reis, Cristina Gomes de Souza, Nayara Nogueira da Costa, Gustavo Henrique Cordeiro Stender, Pedro Senna Vieira, and Nelio Domingues Pizzolato, Warehouse design: A systematic literature review, Brazilian Journal of Operations & Production Management, 14(4) (2017) 542-555.

[24] J. Saderova, A. Rosova, M. Sofranko, and P. Kacmary, Example of warehouse system design based on the principle of logistics, Sustainability, 13(8) (2021) 4492-4499.

[25] P. Raghuram and A. Singh, Warehouse optimisation using demand data analytics - A case study-based approach, International Journal of Business Information Systems, 35(4) (2020) 519-538.

[26] Lorenc and T. Lerher, Effectiveness of product storage policy according to classification criteria and warehouse size, FME Transactions, 47(1) (2019) 142-150.

[27] M. Qamar, O. T. Meanazel, A. H. Alalawin, and H. A. Almomani, Optimization of plant layout in Jordan light vehicle manufacturing company, Journal of The Institution of Engineers (India): Series C, 101(4) (2020) 721-728.

[28] Edith Leon-Enrique, Valeria Torres-Calvo, Martin Collao-Diaz, and Alberto Flores-Perez, Improvement model applying SLP and 5S to increase productivity of storaging process in a SME automotive sector in Peru, International Conference on Industrial Engineering and Industrial Management, (2022) 219-225.

[29] Diaz, D. E. A., Garcia, Y. S., Santivanez, G. Q., and Castaneda, E., Optimization model to increase the productive flow, applying SLP, 5S, and Kanban-Conwip Hybrid System in companies of the metalworking sector, International Conference on Information Management, (2022) 186-190.

[30] N. Phumchusri and P. Kitpipit, Warehouse layout design for an automotive raw material supplier, Engineering Journal, 21(7) (2017) 361-387.

[31] J. Saderova, L. Poplawski, M. Balog, S. Michalkova, and M. Cvoliga, Layout design options for warehouse management, Polish Journal of Management Studies, 22(2) (2020) 443-455.

[32] M. Mirzaei, N. Zaerpour, and R. de Koster, The impact of integrated cluster-based storage allocation on parts-to-picker warehouse performance, Transportation Research Part E: Logistics and Transportation Review, 146 (2021) 102-109.