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Reducing Customer Complaints in Air Conditioning Installation Services through Lean and MRP Tools: A Case Study

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Abstract

In Latin America, the business services sector is constantly searching for continuous improvement to improve the performance of service operations and service quality. However, merchandise availability must be guaranteed to prevent stockouts and preserve high customer satisfaction. Therefore, managing a warehouse inside a service organization is challenging. In this way, a model for improvement was created to address the issues raised above, combining Lean Service tools such as ABC, 5S, and standardization of work with a Material Requirements Plan (MRP) to reduce the claims rate, which is currently 60 percent owing to ineffective management of the tool ordering and installation processes. After implementing the pilot plan and the simulation in the Arena software, a significant variation in the claims rate was evidenced by reducing it to 30%. This study contributes to the validation of lean tools in the air conditioning service industry and will continue to contribute to future managers with similar processes.

Keywords

Warehouse management; claims; Lean Warehousing; 5S; ABC classification; Standardization Work; Material Requirements Planning (MRP); customer satisfaction; air conditioning installation.

1. Introduction

In Peru, the business services sector contributes 1.69 percent of the national GDP, and the services sector, in general, generates the most jobs [1]. Additionally, the subsector of services rendered to businesses increased by 3.4 percent owing to higher activity in advertising and market research (4.9 percent) and administrative and support service activities (3.0 percent) [2]. However, close to May 2020, the business services sector fell by 40.84 percent [3]. This result shows that service companies need help in fulfilling their proposals. In this case, warehouse management is paramount to ensuring a correct service process. This must balance the quantity of stock to offer its clients while keeping the goods and materials in a good shape [4]. This study attempts to lower the volume of claims for services provided to consumers in response to issues created in warehouse management in service businesses. A preventive, corrective, or installation service procedure that needs to be better managed may result in considerable loss of business.

High cycle delivery times, poor service process performance, poor cooperation, and ineffective communication throughout the process are issues noted because of the industry's lack of adaption [5]. This issue was discovered in another study. For instance, lean services and BPM tools can be used in an MSE in the distribution industry to optimize the leading warehouse management indicators. This has led to improvements in inventory record accuracy, location record accuracy, coverage, cycle time, and productivity of 16 percent, 32 percent, 57 percent, 3 percent, and 24 percent, respectively [6]. Previous research has established a multi-method approach to examine how firms might differentiate between value-added and non-value-added activities and methods to reduce waste and enhance warehouse operations. It has been shown that employing many methods improves our comprehension of how longer lead times affect non-value-added distribution warehouse operations [7].

Therefore, it is essential to ensure inventory availability to avoid stock-outs and maintain high customer satisfaction. Therefore, managing a warehouse inside a service organization is challenging. As a result, a case study was selected to represent the industry's issue with a restricted full-service capability brought on by inadequate management of the tool order process and, therefore, of the installation process, which led to a high rate of claims for the services provided. By Combining Lean Service techniques such as ABC, Jidoka, and Work Standardization with a Material Requirement Plan, a model for improvement was developed to solve the problems above (MRP). The introduction, Literature Review, Proposed Model, Validation, Discussion, Conclusions, and Recommendations for Future Research are the sections of this scientific work.

2. Literature Review

2.1 Lean philosophy in material storage processes in the service sector

Previous studies have shown that the Lean Warehouse approach incorporates many lean concept elements to customize them to a company's storage procedures and reduce inefficiencies in logistics operations [8]. To boost the effectiveness and efficiency of business storage systems, Lean Warehouse, which integrates many methods based on lean philosophy, such as 5S, standardization of work, and ABC, was used in our study. By enhancing working conditions to decrease downtime and travel lengths, these warehouse solutions boost the company's overall productivity [9]. Conversely, the effective use of these technologies may result in fewer out-of-stock situations and higher distributor satisfaction owing to shorter wait times [10],[11].

2.2 Application of ABC to control inventory in warehouse.

ABC classification is a technique that may be used to group various items into several situations. According to the Pareto analysis principle, this approach divides data into three classes, A, B, and C, to create categories based on the consumption values [12]. By separating inventory items by financial categorization using ABC analysis, efforts may be focused on fewer items while being directed toward things with greater representativeness, and thus, better outcomes [13]. It has been demonstrated that ABC can improve the level of service by correctly classifying and distributing the goods in the warehouse, rationally managing its inventories, and identifying those with higher demand, and therefore, higher turnover [14],[15], [16]. ABC has typically been used to streamline the flow of materials to reduce inventory lead times.

2.3 5S Methodology for Improving Warehouse Efficiency.

The finest firms in the world use 5S, a continuous improvement or kaizen approach or tool, which consists of five acts that must be carried out in a particular order to be successful. Putting the 5S into practice may keep workplaces neat, organized, and clean, creating a pleasant working environment. Although this applies to offices and warehouses, its influence on plants or industrial sectors is the greatest. By shortening lead times, cutting costs, raising quality, and eliminating waste, the company seeks to satisfy customers. In addition, it dramatically aids businesses in earning national or worldwide certifications. [17].

2.4 Work standardization to have established processes within an organization when performing specific tasks

One of the most effective lean techniques, work standardization, is least used in business. It consists of choosing the best practices, what each operator does well, or what is shown to achieve the most remarkable results to create a work methodology that all employees must adhere to. Every organization should utilize it to continually improve its production process. The goal is for all operators to perform their tasks consistently in a single manufacturing process [18]. Research has shown that this tool and its components are crucial for integrating intelligent technologies, developing a better order, and ensuring that the staff have the necessary training to do their jobs [6].

2.5 MRP to calculate the need for materials in the warehouse

The Material Requirement Planning (MRP) system is a record where purchase orders are placed with suppliers to meet the demand on the established date, which involves a simple method to identify the number of components, materials, and parts required to generate a final product [19]. The MRP program is efficient, economical, and easy to use [20]. Owing to the established tracking, it was feasible to integrate the operation of an MRP system based on a material BOM, a master production plan, and inventory record. This immediately affected the decrease in purchase orders caused by materials [21], [22], [23].

3. Proposed Model

The model proposed in this study is based on the application of tools, 5s, ABC classification, standardized work, and MRP. These mixed methodologies were selected to moderate the root causes identified in the problem tree. First, the 5s model was implemented to organize the processes. Then, the ABC classification is used to identify high-impact materials. In addition, standardized work will be executed to improve work performance. Finally, MRP is implemented to control the company's stock breakage. Figure 1 shows the proposed model for the case study.

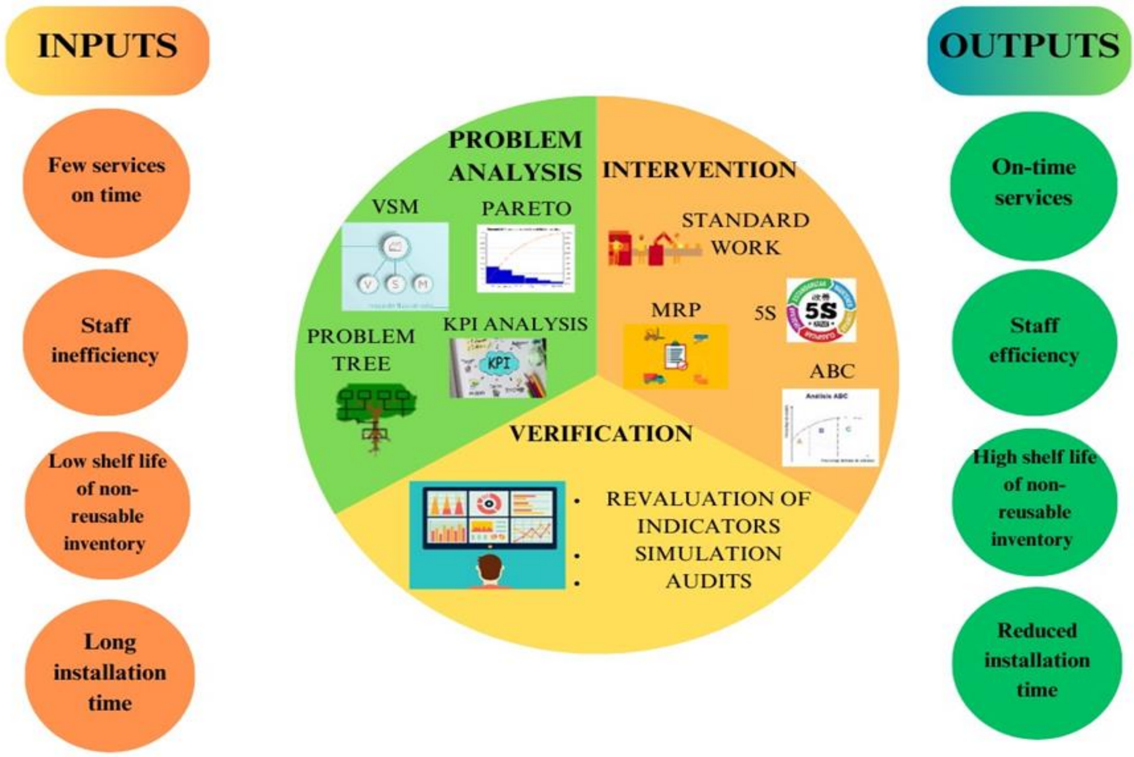

Figure 1: Proposed improvement model

3.1 Model components

The proposed model is divided into three components, as described below.

3.1.1 Component 1: Problem analysis

This component consists of all activities before applying the proposed model. First, data (time) were collected for the construction of the VSM to identify the sequence of the company's activities and the times generated in these activities, as well as to obtain a macro image of the behavior of its operations until dispatches were made. Second, the activities that involve the most time wasted are identified, and the causes are evaluated to determine which has the most significant impact, using Pareto to obtain the most critical root causes. Third, a problem tree is developed to identify the root causes of these problems. After identifying the root causes, Key Performance Indicators (KPIs) were established to measure the root causes of the current situation and find the variation once the model tools were implemented.

3.1.2 Component 2: Intervention

The second part involves implementing technologies, such as 5S, ABC Classification, Standardized Work, and MRP, to improve the quality of services.

a) Application of 5S: In Seiri, unnecessary objects will be eliminated; in Seiton, an ABC classification will be carried out to identify the materials with the most significant impact; in Seiso, elements will be designed to help eliminate sources of dirt inside the warehouse; in Seiketsu, a time study will be carried out on remote tasks inside the warehouse; and finally, in Shitsuke, a checklist will be drawn up to help with the review of important points. Audits will then be performed to ensure these conditions.
b) Application of the ABC Classification: A classification is made to identify high-impact materials according to their cost, level of use, and if they are imported. These three factors will be measured on a scale of importance, which the warehouse operator and air-conditioning technician will determine. In this case, policies will be created to ensure the availability of high-impact materials (CLASS A), such as increasing purchase frequency or dedicating more outstanding care within the warehouse.
c) Standardization of work application: A time study will be carried out to define the standard times of the processes; then, the rules for each procedure will be built, and we will put them into practice. For this, a procedure manual was created to establish the guidelines, requirements, and actions to be carried out by the service operators. Finally, the operation of the strategy is monitored.
d) MRP application: A forecast of the demand for required services will be made with historical information about the company, the materials and tools that are most frequent by date will be determined, and the quantity in stock will be analyzed, after which the amount needed for such a period and the time of anticipation that must be ordered according to the lead time of the suppliers will be determined.

3.1.3 Component 3: Verification

The last component consisted of evaluating the KPIs established before implementation to determine the impact of the changes produced by the model tools used, ensuring the development of the improvement model. In addition, an audit format was used to verify whether the suggested activities were being carried out before and after implementing the tools to ensure their sustainability. The last step was to verify the plan using the outcomes of the pilot test. Finally, the effect of the suggested method is shown using the Arena Software's simulation of the air conditioning installation process in conjunction with the new indications. The suggested model's implementation process is shown in Figure 2

Figure 2: Proposed process

3.2 Indicators

The indicators of the proposed model, which were used to verify and control the improvements proposed in the case study, are presented below. Table 1 lists these indicators and their calculation formulas.

Table 1: Indicators

Indicator	Formula
Claims Index	$\frac{Number\ of\ claims}{Total\ number\ of\ services}\ 100$
5S Audit	$\sum(5S\ audit\ score)$
Duration of non-reusable inventory	$\frac{Ending\ inventory}{Average\ sales}\ x100$

On-time services	$\frac{Services\ delivered\ on\ time}{Total\ services\ delivered}x100$
Average cycle time	$\frac{Service\ processing\ time}{Completed\ services}x100$

4. Validation

4.1 Initial diagnosis

The proposed model was applied to a company's warehouse that offers air-conditioning installation services. The company did not find a warehouse with a classification of materials according to their level of importance, so it was not possible to identify and distinguish what was needed. It was also observed that it was not kept clean or organized, and the tools did not have a specific location. The tools do not have a specific location. Because there is no classification, there are always problems with the missing materials. There is no service-level agreement with equipment suppliers or a specific material requirement plan. Likewise, the processes must be standardized, resulting in low operator efficiency. All of these factors generate a high rate of customer complaints. Figure 3 shows the problem tree for the case study.

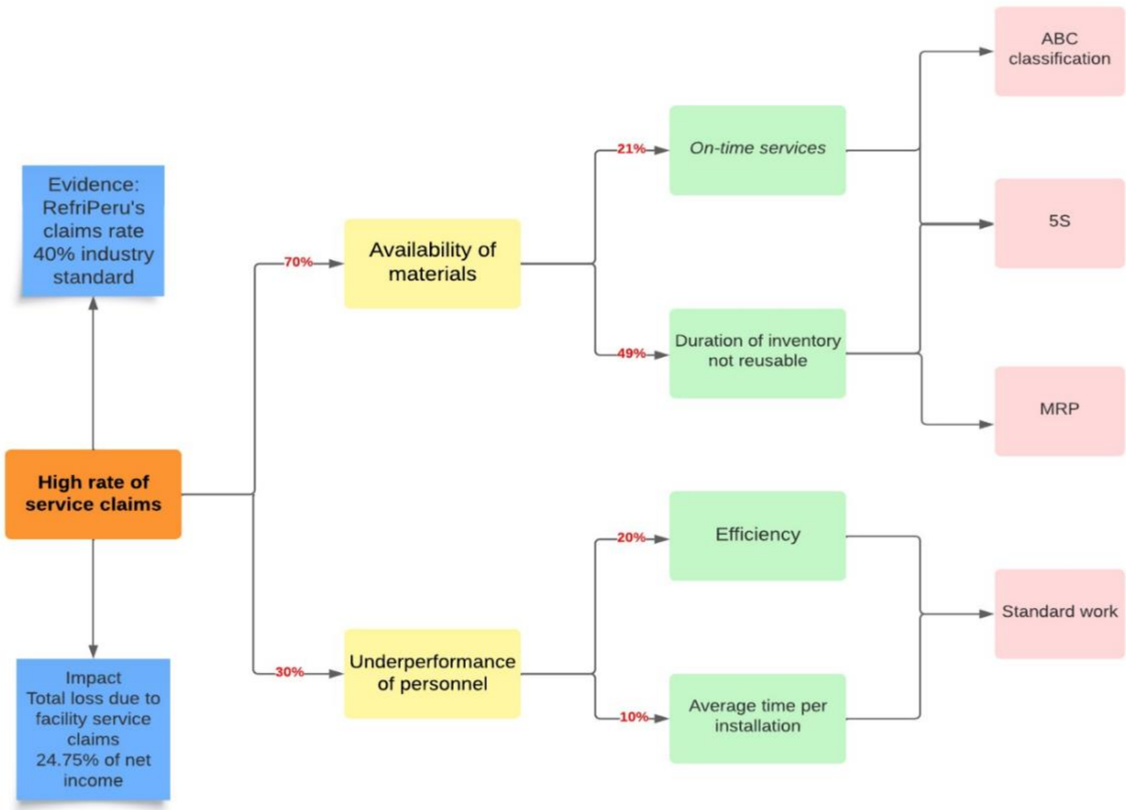

Figure 3: Problem Tree

4.2 Validation of the design and comparison with the initial diagnosis

To execute and assess the changes achieved, a test or pilot plan for the 5S technique was carried out in the warehouse. The MRP and Standardized Work tools were simulated using the Arena program and the indications gained were assessed.

4.3 Improvement

4.3.1 5S Pilot

For the 5S methodology, an initial audit was performed to evaluate the level of implementation of the 5S, and areas requiring improvement were identified. In addition, an ABC classification of the materials and tools in the service warehouse was performed. To help manage and prioritize inventory items effectively, focusing on those with the most significant impacts and costs. As a result, there was a considerable reduction in the tool search time from 15 to 5 min. Additionally, the average 5S audit indicator score increased significantly from 1.86 to 4.1 points. Figure 4 shows the results of the 5S audits before and after the implementation of the pilot.

In this way, the aim is to encourage workers to perform the task with awareness and commitment. As they become part of their daily routine, habits of cleanliness and order are generated, which will positively impact all their actions. This gradual and consistent approach will help establish a more efficient and organized work culture in which everyone is committed to maintaining a clean and orderly environment. Figures 5 and 6 show the warehouse before the implementation of the 5S pilot and Figure 7 shows the same warehouse after the implementation of the 5S pilot.

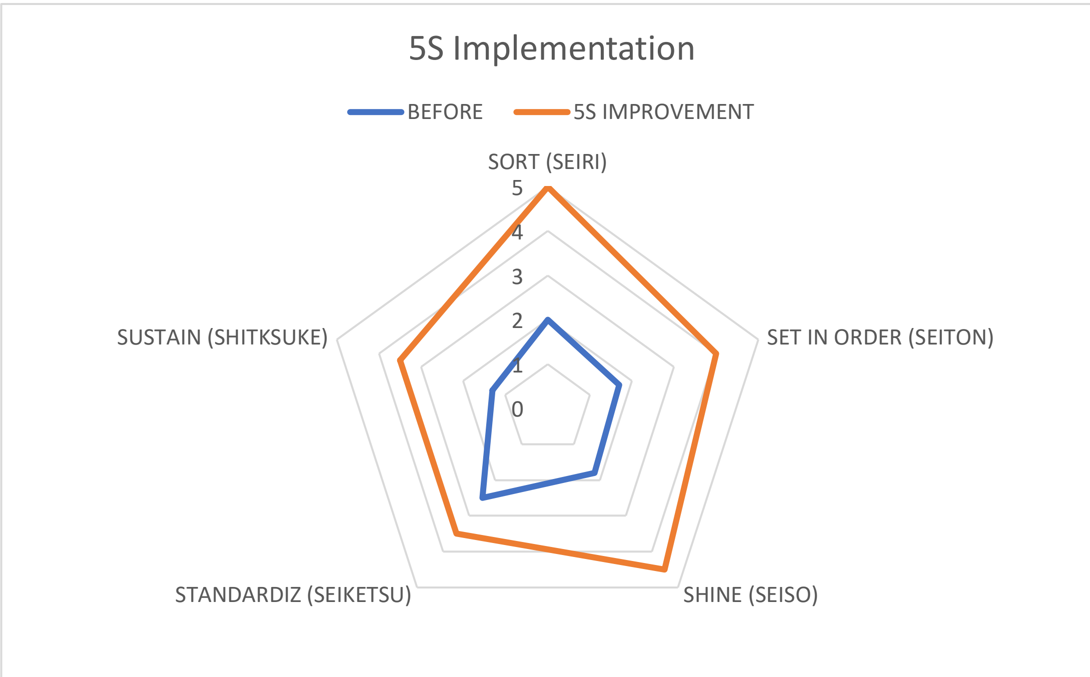

Figure 4: 5S Audit chart before and after implementation

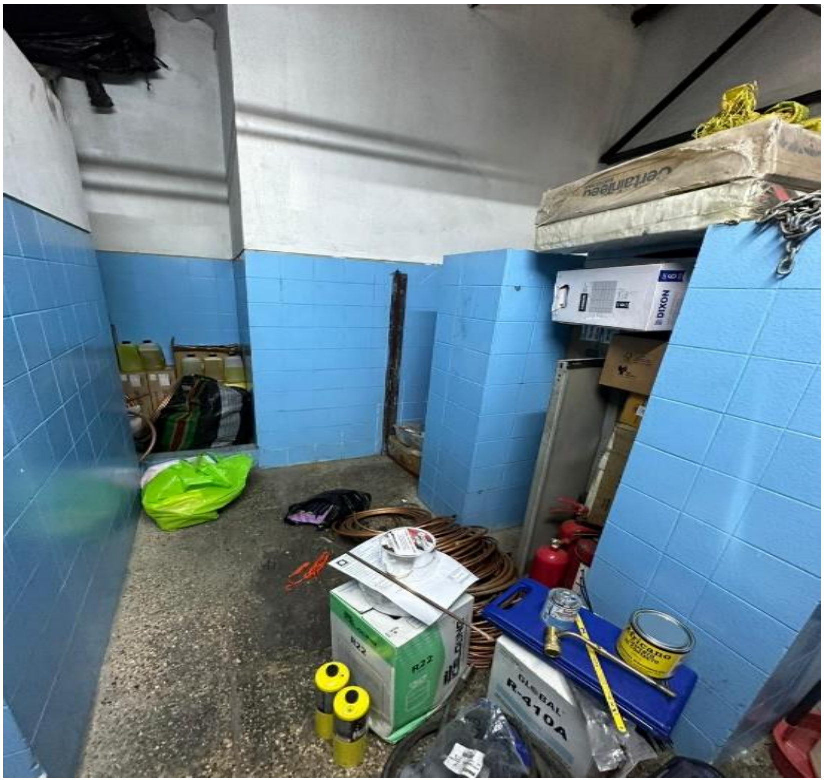

Figure 5: Warehouse before implementation

Figure 6: Warehouse before implementation

Figure 7: Warehouse with 5S Philosophy

Figure 8: Fully sorted warehouse

4.3.2 Simulation proposal

For the simulation, the entire process of an air conditioning installation service was considered, from the arrival of requests to the verification and confirmation of the service. Among the activities that occupied most of the time were the search for tools and review of the stock of materials in the warehouse. It was also observed that the time taken by the operators to install the air conditioning was very high, and many operators needed clear instructions on how to handle specific tools and materials. Therefore, it was decided to implement MRP to determine how much is needed for a certain period and the time in advance that should be ordered according to the lead time of the suppliers. With this, there is no shortage of materials in the warehouse. In addition, purchasing third parties due to a lack of inventory will be avoided.

Additionally, Standardized Work was chosen to be implemented to reduce downtime in the facilities and decrease customer complaints. The simulation was performed using the Arena software version 16.1. Figure 8 shows the simulation of the situation before the improvement.

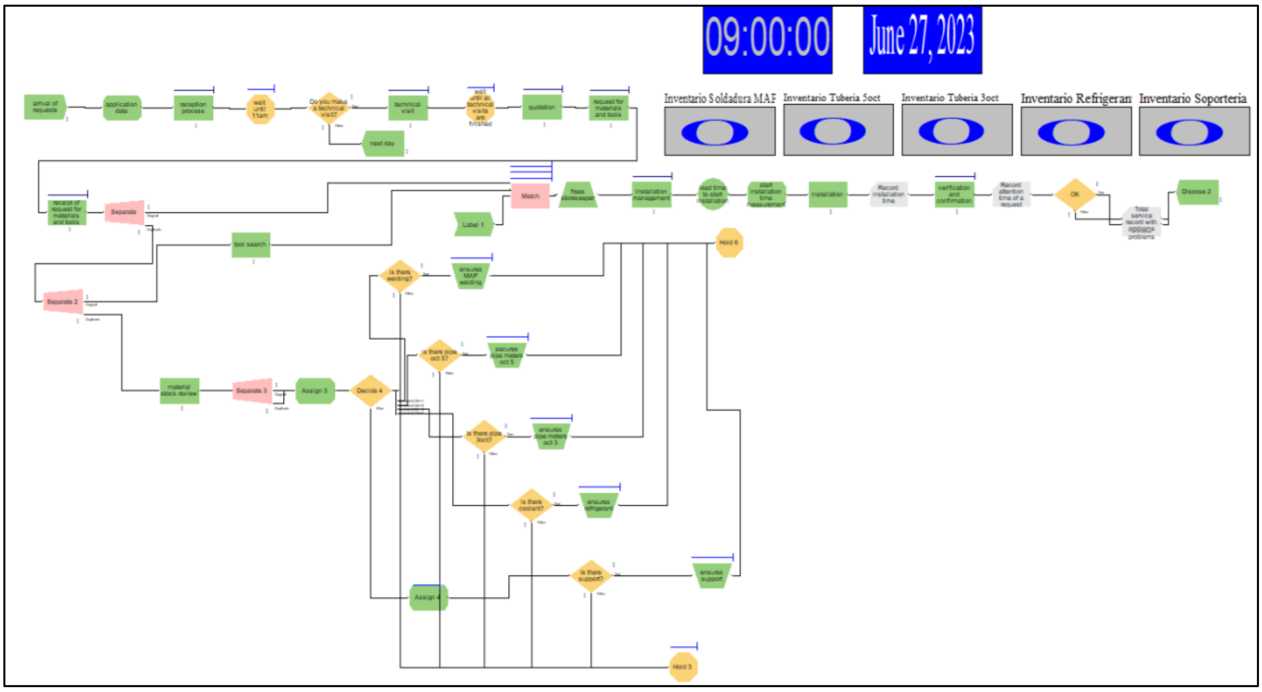

Figure 9: Simulation in Arena Simulator software of the situation before improvement

The Input Analyzer program received data collected from 30 observations to create a proper distribution in the model. An initial sample of 30 duplicates was collected to determine the required number of repetitions in the simulation. Three runs, with a mean width of 0.795, were performed. The last one produced 154 replicas. Along with the introduction of the MRP and the decrease in installation time per service made possible by using Standardized Work, the rearrangement and cleanliness of the warehouse were also considered for the enhanced model. An Output Analyzer program was used to extract and analyze the model indications, and 500 random variables were created for each variable. A better simulation scenario is shown in Figure 9.

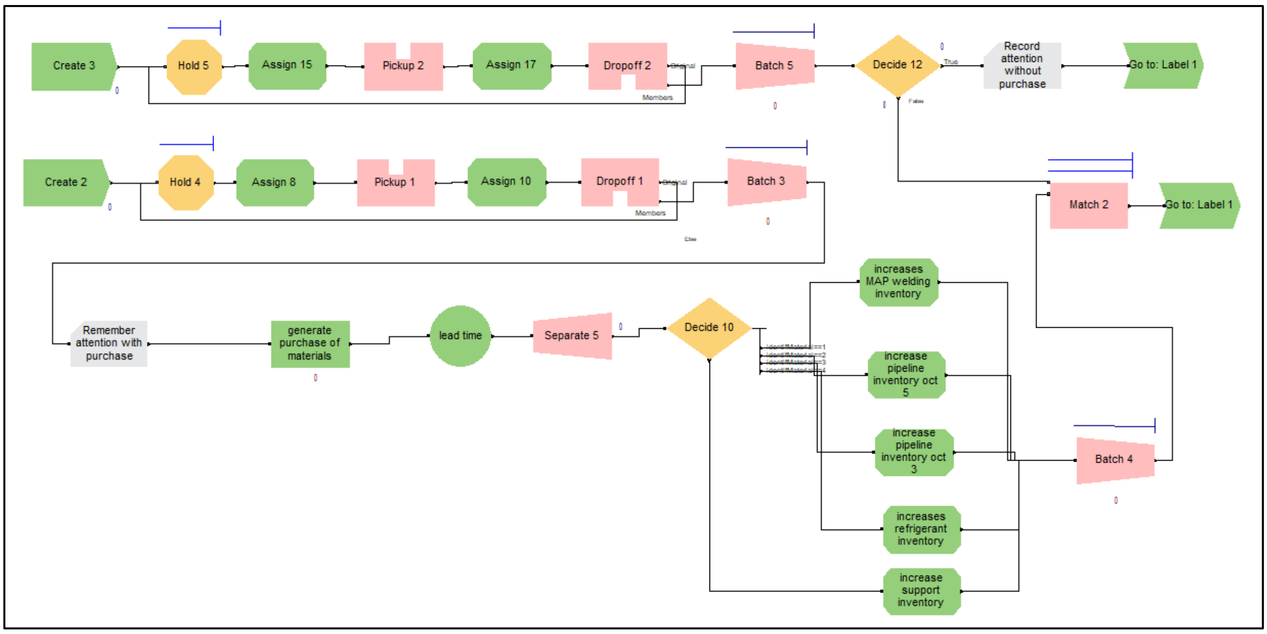

Figure 10: Simulation in Arena Simulator software of the improved situation

In the observations within the warehouse, a total cycle time of 75.15 hours per request was handled, and an average time of 5.49 hours per installation was obtained. In addition, the tool search time was reduced from 15 to 5 min per request. In the current simulation, a cycle time of 72.92 hours and an average time of 4.25 hours were obtained, as well as a near-perfect service with no third-party purchases with four out of five services serviced daily. With the improved scenario, significant variation was obtained in the claims index, which was reduced from 60% to 30%. Similarly, the efficiency percentage of the installation service process increased from 75% to 90%. Table 2 presents the dashboards of the research results.

Table 2: Results Comparison

	Indicators	Current	Target	Improved
General	Efficiency (%)	75%	95%	90%
	Claims Rate (%)	60%	30%	35%
	On-time services in one day (max. 4)	2	4	3
5S	Time to search for tools (min)	15	4	5
	Audit 5 "S	1.86	4.5	4.1
Standardized Work	Average time per installation (hrs)	5.49	4.5	4.25
	Application cycle time (hrs)	75.15	70	72.92
MRP	Duration of Reusable Inventory (days)	8	5	6
	Attention of a service without Purchases (5 services per day)	3	5	4

5. Discussion

The proposed model, based on reducing the rate of similar claims in an installation services company using Lean Warehousing and MRP tools, can be adapted to other companies in the same sector that present problems related to the low availability of materials and low performance of personnel. Causing problems with customers and therefore, their claims The claims rate was reduced by an average of 28%, achieving the research objective of keeping its claims rate below 30%. Another objective is to reduce the average time per installation, which decreases to almost two hours for each installation. In addition, the entire process was reduced to 5.15 hours, thereby optimizing a specific current situation. Finally, we increase the number of services without purchases to five, which is the maximum possible number per day. This means that the company's objective of not resorting to any purchase for any installation service is yet to be reached.

It is essential to note that the validation and scenarios have certain restrictions owing to their execution with the Arena software. This implies that results may vary depending on the particularities of each company. To correct the model implementation with different scenarios, changes must be made to the engineering tools implemented as a solution. In this case, the 5S, work standardization, and MRP. This is because the results were obtained using these tools. When implementing engineering tools, it is crucial to consider the different areas related to the primary process. This is because these problems relate to different areas.

6. Conclusions

This study shows that implementing lean warehousing can substantially improve the productivity of companies in the refrigeration sector. The results are encouraging, showing remarkable improvements in all indicators established for the company's current situation. In particular, the claims index was reduced by more than 50%, a significant achievement that positively impacted a company's financial health, correcting the economic impact of 87,300 soles, as foreseen in the study's objectives. In addition, this implementation increases the net profit generated.

Implementing MRP and standardizing the work proved fundamental for optimizing the primary process.

These actions made it possible to carry out services without resorting to external purchases, a long-standing obstacle that generated significant loss of time and resources. The efficiency in this area has reached 90%. A substantial reduction in installation time was also achieved, decreasing by almost 2 h compared to the usual duration, and reaching a total of more than 5 h for the primary case study process. Additionally, implementing 5S proved critical to the company's service warehouse, improving efficiency and productivity through organization, cleanliness, and standard setting. Consequently, search times were reduced by more than 67%, which minimized waste, contributed to improved workplace safety, and promoted a culture of continuous improvement. The results of these scenarios were positive, indicating that the project is viable in the business context.

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