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Inventory Management Model for Reducing Stockout rate by Applying Lean Warehousing and DDMRP Tools in a SMEs in the Commercial Sector

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Abstract. This case study addresses the problem of stock-outs and purchase planning, which represent the greatest impact on the economic loss for the company studied. For the analysis of the problem and the proposal approach, a focus was made on the main products sold, the Value Stream Mapping tool was used for the process analysis and the analysis of the main causes by means of Pareto diagrams and the Systematic Interrogation Technique. The implementation of the 5S methodology is proposed hand in hand with the Visual Management to have a better control of the stock and improve the workflow, in addition, the purchase planning is proposed from the application of the DDMRP tool with the objective of being able to meet the demand and have lower losses due to expiration of products. Finally, through the application and simulation of the proposed tools, an average reduction of 28.3% in warehouse ordering times and 25% in order preparation times is evidenced, likewise the DDMRP tool shows a reduction of stock breakage, managing to cover 100% of the demand.

Keywords: Lean Warehousing, DDMRP, 5S, Visual Management, Stockout, Commercial Sector, SMEs.

1. Introduction

The commercial sector is one of the fundamental pillars of the world economy, as it represents the link between production industries and consumers. In Peru, SMEs represent 99.5% of formal companies with up to 5 workers and with an average annual growth of 4.1% for the number of companies in this segment. Likewise, SMEs maintain a good performance of economic activities given that an average growth of 1.9% of the Gross Domestic Product (GDP) was recorded during the years 2016-2021 [24]. At the regional level, a concentration of 60.3% of SMEs are in Lima, Arequipa, La Libertad and Piura. This means that the coastal regions maintain a better economic development due to the facilities they have for accessing markets through ports and greater distribution channels. According to COMEXPERU, 35% of the total number of SMEs were engaged in trade activities such as wholesale and retail businesses, as well as warehouses or pharmacies. Also, the national household survey (ENAHO) shows that the number of SMEs engaged in commerce had a constant average growth rate of 3.3% per year [23]. In July 2022, INEI reported that the wholesale trade sector had an increase of 2.42% over the similar month last year.

The problem identified, according to the diagnosis and the literature reviewed, leads this study of a commercial distribution company that presents a high percentage of stock failures. This represents more than 80% of the company's sales cancellations due to not having the products in stock for dispatch. This is caused by the lack of an inventory management system, which in turn contributes to the expired products. In addition, it was noted that the warehouse is not signposted, and the products sold by the company do not have a fixed space. Likewise, the company does not have a demand planning system, which commonly generates purchase orders empirically, as do several SMEs in the same sector.

Under this scenario, it is essential that commercial SMEs of mass consumption food have implemented an efficient forecasting model to manage the growing and varied demand they present. Given the essence of the case, a study that presents a similar problem within the sector was taken as a reference. The study presented problems of overstocking and understocking, in addition to not having a warehouse control that would allow managing physical inventories. For this, the study proposed an inventory management model under the 5'S

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methodology and DDMRP (Demand Driven Material Requirement Planning). This research is based on an inventory management model under the Lean Warehousing and DDMRP methodologies applied to a mass consumption warehouse of an SME in the commercial sector.

2. State of Art

2.1. Lean warehousing in the commercial sector

Lean warehousing tools are in the set of lean methodologies applied to the logistics operations of a company, including storage processes with the aim of counteracting inefficiencies and waste as activities that do not offer added value in the macro process [4]. [6]. [10]. Several authors confirm that the reduction of muda is the main result of the implementation of lean tools, however, this also has an impact on the causes of muda generation, which are mainly due to poor coordination and integration of logistics activities [5]. [6]. [11]. According to the authors reviewed, it is confirmed that the application of lean tools increases the productivity of the company, especially in storage operations where activities such as procurement, picking, packing and dispatch are involved. Likewise, the most used techniques of the Lean Warehousing methodology are Value Stream Mapping (VSM), 5'S, Pokayoke, Kanban, Jidoka, Hijunka and Standardized Worksheet. With these tools, the aim is to create an optimal process flow. For this, a study commented on the 3 stages for the implementation of lean warehousing being these "create stability", "create flow and "make flow", achieving 26% increase in picking productivity [11]. On the other hand, the implementation of Lean Warehousing in warehouses significantly reduces inventory waste, so this methodology has become a key concept in the Lean field [1].

2.2. DDMRP in the retail sector and/or similar.

Adequate demand planning is essential to allow the availability of products at the right time and place, which has a direct impact on lost sales and above all on customer loyalty and satisfaction [2]. On the other hand, according to the author [3], the variability of demand is uncertain, which generates oversupply or stockouts, consequences that can be prevented with the application of methodologies and by implementing an optimal inventory management system. In this situation, the implementation of a Demand-Driver Material Requirements Planning (DDMRP) system generates an advantage to face demand variability and better manage inventories without incurring unnecessary costs [3]. [8]. [12]. Likewise, the application of DDMRP has been increasing over the years in companies around the world given that while avoiding storage costs or stock outs, it can increase the level of service generating satisfactory results by simplifying the needs of the material and in turn, a better flow of information [8]. [18]. On the other hand, with respect to the objectives proposed by the authors, most of them highlight that the efficient availability of materials represents the greatest challenge in the supply chain. In addition, it is reported that lead-time is reduced and optimizes the planning and scheduling of materials compared to alternative techniques such as MRP II and Kanban regardless of the level of demand variability [8]. [9]. Since demand variability is sensitive and especially in SMEs in the retail and commercial sector face increasing demand, the implementation of an efficient demand management system has a positive and relevant impact on the supply chain [3]. [17]. [19].

2.3. 5s in the commercial sector and/or similar

It is a Lean tool that facilitates the elimination of waste from a process, where 5 phases are applied: Classification, order, cleanliness, standardization, and discipline [10]. This methodology allows improving safety, workflow, stock management and efficiency of work area controls through the organization and standardization of the work area [11]. According to several authors, prior to implementation it is important to perform a diagnosis of the initial state of the area to where the methodology will be implemented [4]. [10]. Similarly other authors indicate that a successful implementation of 5S is mainly based on the management of the company and workers, so its implementation must be preceded by adequate training to employees as they will decide how they will carry out the next steps of the implementation [15]. According to success cases the application of 5S allowed the reduction of distance traveled by pallet movement in the warehouse by 20.22% decreasing the picking process time [10]. However, the authors highlight that the human factor is crucial to ensure the performance of the tool since it is based on organizational culture and standardization of processes.

2.4. Visual management in the logistics sector and/or similar

It is a lean tool that gives visibility of relevant information, through visual tools that make the information more digestible for stakeholders, it must be designed so that it is quickly understood in order to increase efficiency, value and clarity in the exchange of information [16] likewise, they mention that visual management allows the organization to be more transparent by making information more available to all stakeholders, in this way it also gives rise to the autonomy of workers as they can have an effective understanding of all information. In the same way, other authors mention visual management as a tool that allows sharing knowledge openly for all employees of an organization, and in this way empowering them since understanding about the organization has increases their participation in decision making [26]. [27].

According to success cases, authors mention that visual management increases the potential of projects and brings benefits to the organization, since it makes the work easier and help to create stability in order and cleanliness, however, there is a great opportunity about the knowledge of this tool, since its knowledge in the industry could generate great benefits according to the results achieved in the proposed model [16]

3. Contributions

Currently many SMEs in the commercial sector are facing increasing demand without having a forecasting model to manage it. Also, according to the literature reviewed, the implementation of DDMRP increases the sales opportunity by having the required products for customers. This contributes to customer loyalty and satisfaction which is reflected in the company's bottom line. On the other hand, Lean Warehousing tools contribute to the optimal performance of logistics operations in the warehouse, the main place that generates unwanted costs for the company. This methodology seeks to reduce the changes originated in the warehouse and avoid problems such as over-supply or stockout. Under this scenario, it has been possible to identify the most appropriate tools according to several authors for the identified problem. The following double-entry table compares the proposals for the problems of this article.

3.1. Proposed model

Figure 1 shows the proposed model for the implementation and execution of the improvement. The flow of information in the model begins with the collection of information from the company where a high rate of stock-outs, a high percentage of sales cancelled due to lack of stock and a high rate of expired products were obtained. This model consists of 5 components, starting with the analysis and identification of the problem, followed by the application of the 5'S pilot plan and visual management. Culminating with the execution and validation of the DDMRP tool through simulation in Arena software. This allows reducing the percentage of stock-outs, the percentage of sales cancelled due to lack of stock, expired products, as well as a better inventory management and demand and supply management.

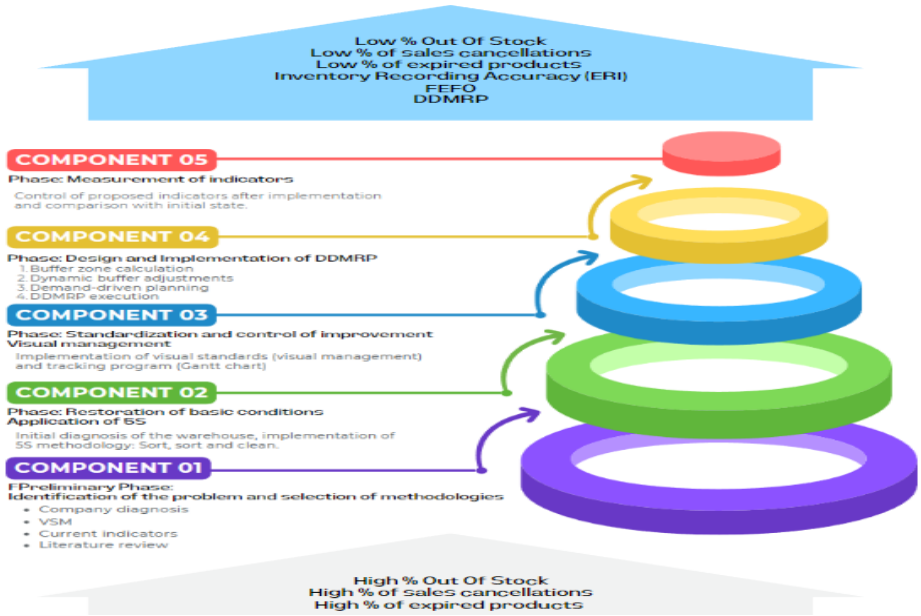

Fig. 1: Proposed model. Adapted from [3] [4] [11]

3.2. Model components

Then, we proceed to describe the components of the model to carry out the improvement. Likewise, the graphical description of the implementation flow is shown in figure 2.

- Component 1

  The model begins with the preliminary phase, which consists of identifying the problem through interviews with managers and analysis of the information provided by the company. At this stage, the information in the databases is standardized and the main causes of persistent problems are identified through Pareto diagrams.

  A Value Stream Mapping (VSM) of the logistic process of the supply, storage and order dispatch processes was also carried out. From the information provided, it was found that the company loses an average of 15% of its sales due to lack of stock, in addition to having a high percentage of overdue orders. The interviews also revealed that the company uses an empirical method for placing purchase orders and does not use an inventory management system. After determining the problems and identifying their causes, a literature review was conducted to guide the research with the best tools for the problems identified.

- Component 2

  In the second stage, we started with an initial 5S diagnosis by running an audit with the basic points that the warehouse must comply with to ensure order, cleanliness, and safety. Once this is done, the implementation plan is divided into 2 stages, the first one: Implementation of tools to restore basic conditions and the second one: standardization and improvement assurance; the whole implementation will last 4 weeks and will be preceded by 2 days of training for the personnel involved. In the first stage corresponding to the second component, firstly, we proceed to the classification of materials and tools in the workplace, where we separate the necessary from the unnecessary for the development of daily tasks, this with the help of red labeling that will allow us to make a better classification. Secondly, the sorting stage takes place, where specific places are arranged within the facilities for each item, based on the frequency of use and to ensure stability, labels and signage are applied to floors and shelves. Finally, we proceed with the cleaning phase, where we mainly identify the sources of dirt and proceed in the first instance to eliminate them; if this is not possible, we work on mitigating them, and we also extend a cleaning routine according to the needs of the area. To measure the progress of the implementation, weekly audits will be carried out.

- Component 3

  In the third stage of the model, once the basic operating conditions have been reestablished, we proceed to ensure the improvement through visual standards that will allow us to expose the best way of working for the model of all the personnel involved in the warehouse processes. In the same way, in order to ensure awareness of the application of the methodology, a presentation of the change (before and after) is made for everyone's knowledge and understanding of the best way of working. At the same time, an implementation control program is maintained where dates are specified for 5S audits, which will allow us to quantify the state of the area with respect to the ideal conditions of order and cleanliness.

- Component 4

  In this stage, the DDMRP is developed and executed. For this, it is necessary to calculate the parameters and calculate the buffer zones of the products that are in critical points and are categorized by zones with green, yellow, and red color codes. Then the necessary adjustments of the buffers are made according to the forecasted future demand. Subsequently, the DDMRP execution consists of applying the net flow equation to determine the appropriate time to place the purchase orders for the necessary products, considering the results of the buffers.

- Component 5

  In the final stage of the model, the control of the implemented methodologies is carried out through the measurement of the proposed indicators, where data on sales performance and inventory control will be used. First, this information will be taken to a dashboard to make the analysis and decision-making

spaces more efficient meetings where most of the time is used to analyze the performance of the warehouse operations. In the case of finding deviations in the indicators, an "action" instance will be used to propose solution plans to reestablish the conditions already standardized in the previous stages.

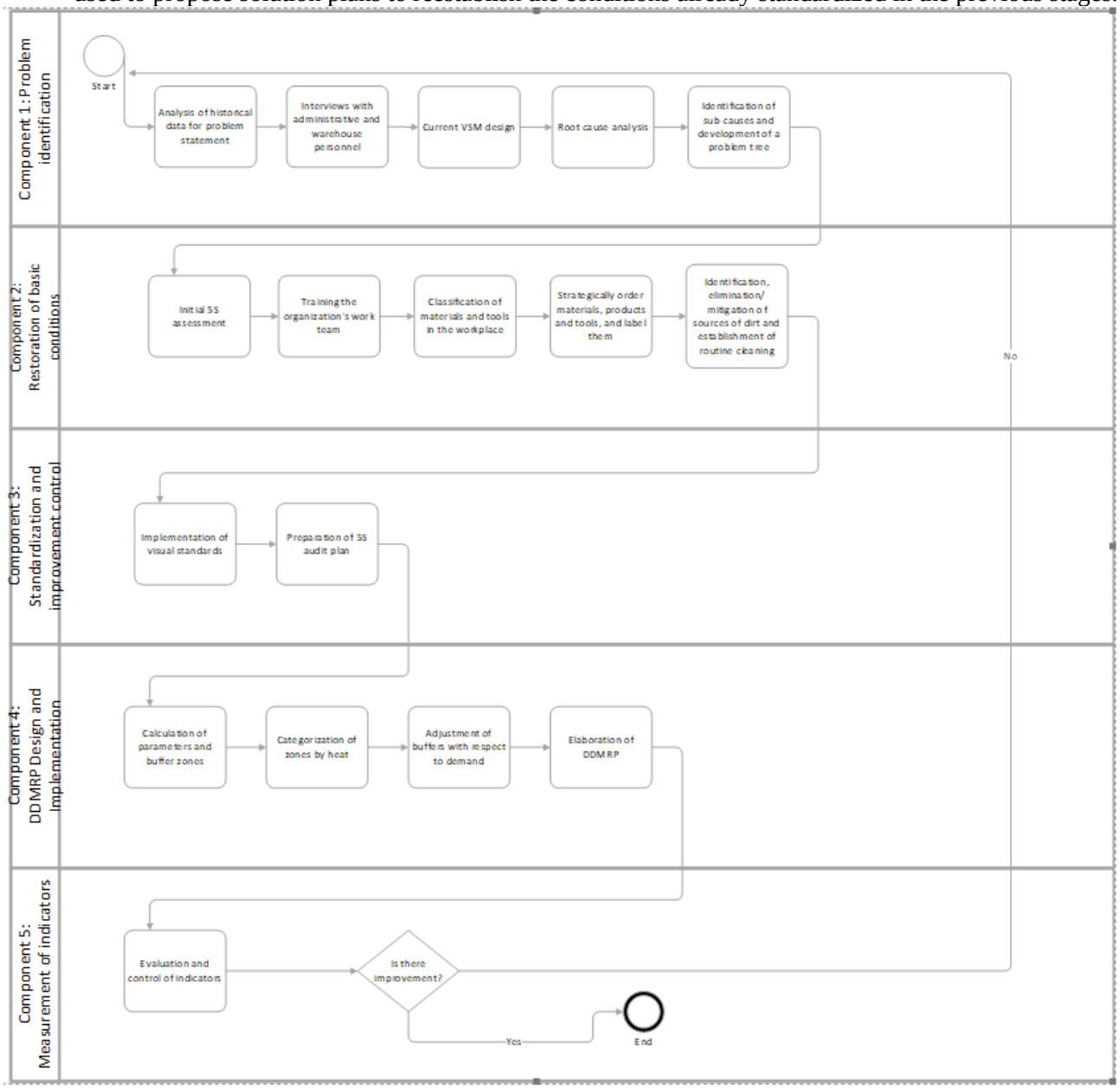

Fig. 2: Proposal flowchart

3.3. Model indicators

- Percentage of stock breakage: This is the percentage of products not supplied in relation to demand. The objective is to reduce the indicator to less than 7%. [2].

$$\alpha = \frac{\text{Quantity of products not supplied}}{\text{Total quantity required}} * 100$$

- Inventory obsolescenc: Percentage of damaged, obsolete and/or expired units of inventory. The objective is to keep the indicator below 1% [17].

$$OBS = \frac{UO + UV}{UD} * 100$$

- Inventory turnover: Number of times stock is rotated in a period. The objective is to achieve an indicator between [7-9] times for a period of 10 months that the analysis will be carried out [7].

$$ROT = \frac{CV}{IP}$$

4. Validation and Discussion

4.1. Initial diagnosis

After identifying the root causes using tools such as Ishikawa, Pareto charts and the systematic questioning technique, a problem tree was drawn up, where the main problem was the high rate of stock outs (15.78%), which was caused by 2 reasons, firstly, disorder in the warehouse and secondly, expired products.

The root cause of the first reason was found to be that the work area did not meet the basic storage conditions, so according to the literature reviewed, the implementation of the 5s methodology was chosen [3]. Likewise, the warehouse does not present a layout to define the zoning and a visible workflow and information for the collaborators, so the visual management methodology was applied, according to the literature reviewed [16]. On the other hand, for the second reason, it was identified that the organization does not have a forecasting model to manage demand, so, according to the literature, it was decided to apply the DDMRP methodology [3] [9].

4.2. Validation design and verification with the initial diagnosis

According to the results of the analysis of the problem, it was found that the gold category products have the highest rate of stock breakage with an average of 15.78%. On the other hand, a statistical analysis of actual sales and purchases was carried out, where an average absolute percentage error of 11.86% was determined. The economic impact on the company is S/. 601,498, which represents 19.26% of sales for one year, due to stock breakage and expired products.

4.3. Simulation of improvement proposal

The current system contemplates the processes of product supply, inventory control and management, where the sales process takes place in parallel, as shown in figure 3. The supply process begins with the monthly inventory count, which corroborates the number of units of each product to generate the purchase order; the arrival of the products has a waiting time of 5 days. Once the trucks arrive to unload the products, they are unloaded and inspected and then stored. At the same time, orders are received daily, which arrive at the distribution center through the system and are consolidated for packaging the following day by the two warehouse operators.

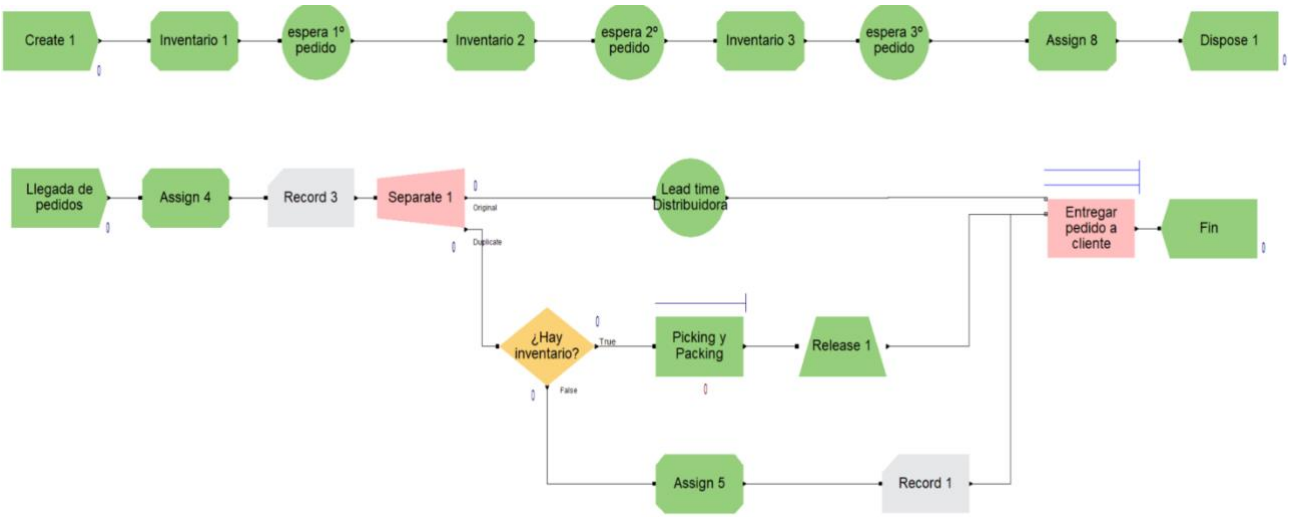

Fig. 3: Improved system in Arena

To initiate the improvement, the 5S tool was implemented hand in hand with Visual Management over a period of 6 weeks, improving the order in the warehouse and favoring safety in the performance of activities. This had a positive impact on the workflow, reducing storage and product reordering time by 28.3%. On the other hand, through the delimitation of work areas, by implementing the stretch wrapping and packaging zone, it was possible to reduce order preparation time by 25% on average.

Secondly, with the simulation of the DDMRP replenishment planning tool, favorable results were obtained, with the loss of sales due to stock breakage going from 15.78% to 0%. If the proposed purchasing plan were implemented in accordance with historical demand, the company would not experience stock breakage problems and would be able to meet all demand. On the other hand, the results of the simulation showed an improvement in inventory turnover, which can be seen in Table 1.

Table 1: Inventory Turnover Indicator Evolution

Inventory turnover after DDMRP implementation			
Pi	Current	Expected value	Simulated value
P1	4.60	8.28	8.76
P2	6.58	7.62	7.53
P3	3.08	7.30	5.68
P4	6.85	8.52	6.94

5. Discussion

5.1. New potential scenarios

The simulation yielded satisfactory results that support the effectiveness of the methodology. However, to demonstrate the reliability of the tools implemented, their effectiveness in other product categories will be analysed. For the first simulation, we worked with four gold category products, so we will simulate two scenarios with silver and bronze category products. With this, the methodology would be developed for these products and later validated with the Arena software.

For this scenario, the selected products represent the highest quantity demanded with respect to other products in their category.

Table 2: Potential scenarios

Escenario 1	Escenario 2
Lays Ondas Picante 36G	Los Cuates Picante 56G
Lays Pollo A La Brasa 38G	Los Cuates Twist 56G
Piqueo Snax 55G	Los Cuates Picante 26G
Lays Clasicas 38G	Free Papa Sal Base Plana

5.2. Results in potential scenarios

Based on the analysis of the proposed scenarios, the results obtained are presented.

Table 3: Potential results in other scenarios

Scenario	KPI	Current Value	Result
Silver Category	Percentage of Stock Breakage	13.4%	0%
	Inventory obsolescence	4.2%	0%
	Inventory turnover	4.38	7.38
Bronze category	Percentage of Stock Breakage	9.56%	0%
	Inventory obsolescence	5.6%	0%
	Inventory turnover	5.24	8.64

5.3. Analysis of results

According to the results, it was possible to validate the effectiveness of the proposed tools such as DDMRP and Lean Warehousing, which met the objectives set out in terms of stock-outs and warehouse organization. The application of DDMRP validates the improvement in inventory and purchasing management, allowing the company to reduce its costs and avoid stock-outs or overstocking.

5.4. Economic analysis

The economic evaluation of the implementation was calculated based on the behavior of the last four months of the company's sales, considering the profit expected to be obtained from the reduction of stock

breakage and the total fulfillment of demand. With the projected cash flow, the Net Present Value and Internal Rate of Return indicators were calculated, from these it can be interpreted that in the first place, the NPV is positive with a value of 47,994.66 soles, that is, it reflects that the project is viable. On the other hand, the IRR shows a value of 42.05%, which is higher than the opportunity cost (COK) of 20%, which reflects the profitability of the implementation.

6. Conclusions

The present investigation was able to determine that stock out of stock is the main problem of the company in question. These stock-outs generate lost sales opportunities amounting to 601,498 soles, which have a negative impact on the organization. This figure represents 19.26% of sales for the year 2021.

Based on the diagnosis determined, this research has been able to validate and support the 5'S and visual management tools of the Lean Warehousing methodology, in addition to the DDMRP methodology for purchasing and inventory management. With respect to the application of 5'S and visual management it was necessary to have the support of management to express their commitment to the operational staff and all employees of the organization to be part of the change and to develop the methodology successfully. This generated a reduction of time in the most challenging operations of the warehouse, product reordering, picking, and packing. According to the reordering of products in the warehouse, the time required for this activity was reduced by 28.3% on average, while for picking and packing, the operation times were reduced by 25% on average, which generated that the company reduced expenses in extra man hours and the warehouse is conditioned to maximize the efficiency of the area operations.

Meanwhile, to address the main problem, stock-outs, it was proposed to implement the DDMRP methodology to manage purchases and avoid stock-outs or over-supply. For this methodology, we worked with 4 products that are most sold by the company. The methodology was carried out manually and then validated through a simulation in Arena. This resulted in an increase of 64.8% on average in the inventory turnover of these products for a one-year horizon. Likewise, with the simulation it was observed that the application of the methodology achieves a reduction in the cost of sales while covering 100% of the demand for the products, reducing the inventory levels without falling into stockouts.

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