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Improvement Model to increase service level by applying clustering k-means and lean warehousing management tools in a pet food company

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Abstract*– This study presents an improvement model to increase the level of service in a wholesale pet food company, which faces a technical gap of 13% with respect to the sector in this indicator, a gap mainly attributed to stock breakage caused by inadequate demand planning and inefficient inventory management. As a solution to this problem, a demand forecasting model is developed based on k-means and RFM clustering techniques, leading into categorizing customers according to their purchase level and geographic location. Identifying 4 customer categories and 31 key products. In addition, an ABC analysis is applied together with Lean 5S and Kanban techniques to reorganize the warehouse, achieving a 23.26% reduction in operating times through a pilot test. To avoid stock-outs, EOQ and ROP parameters are introduced to standardize the purchasing process and thus achieve a timely supply of inventory, resulting in an increase in sales equivalent to 1100 bags of feed. The simulation in Arena validates that the set of these techniques together increase the service level by 13.18% and reduce the average inventory by 22.70%. In this way, the project achieves revenue maximization by increasing the units sold and optimizes storage costs. These improvements have a positive economic impact equivalent to USD 72,750 and consolidate a significant improvement in the company's operating efficiency.

Keywords-- clustering, 5S, standardization, EOQ, ROP.

I. Introduction

In recent years, the pet product sector in Peru has seen significant growth, with imports increasing by 11.2% between 2018 and 2022. This growth has led to rising demand and logistical challenges for companies within the increasingly competitive market, requiring them to adapt and streamline operations.

As the company has expanded its operations, it has faced challenges related to managing the growing demand for premium pet food and veterinary products. The increasing number of customers, each with distinct needs based on their pets characteristics, has made managing customer relationships and tailoring services to each client an essential factor for success. This includes optimizing inventory management, demand planning accuracy, and improving storage and distribution processes to effectively meet diverse market needs.

The purpose of this study is to analyze the company's supply chain performance, focusing on improving service levels, reducing stockouts, and optimizing operational processes. The research aims to identify areas for improvement in logistics and propose solutions to address existing gaps.

This study aims to develop a comprehensive improvement model to enhance service levels within a company in the pet food sector. First, increasing service levels by applying data analysis techniques, particularly Recency-Frequency-Monetary (RFM) analysis and K-Means clustering, to segment customers efficiently and better align inventory strategies with demand patterns. Second, reducing stockouts through the implementation of Economic Order Quantity (EOQ) and Reorder Point (ROP) parameters, ensuring timely replenishment and improved inventory planning. Third, optimizing operational processes by integrating Lean methodologies such as 5S and Kanban, streamlining workflows to enhance efficiency in storage, picking, and order fulfillment.

Key performance indicators (KPIs) include customer service level, warehouse occupancy, delivery time, and inventory management efficiency. These metrics will help to assess the impact of logistics improvements and optimize service delivery to meet market demands.

A. State of art

The Systematic Literature Review (SLR) forms the foundation for this research, aiming to identify and synthesize key studies on supply chain optimization, with a specific focus on inventory management and service level improvement.

This methodology ensured the inclusion of high-quality, credible sources which are align with the study's objectives. The selection process began with a comprehensive search in indexed databases such as Scopus and Web of Science. To ensure relevance, only articles from high-impact journals (Q1 and Q2) and those published within the last five years (2019–2024) were considered. The initial search utilized keywords including *Machine Learning*, *K-Means*, *Reorder Point*, *RFM Analysis*, and *Inventory Optimization*, which were combined in various ways to produce an initial pool of 26,434 documents.

To refine the selection, the PRISMA methodology was applied, filtering studies based on their alignment with research objectives and variables. This process reduced the initial pool to 299 articles. Subsequently, the SCImago Journal and Country Rank portal was consulted to verify the academic credibility of the journals. Further filtering—considering criteria such as the publication year, relevance to the study's variables, and typology—resulted in a final selection of 40 articles.

These articles were categorized based on their focus on key research variables, namely: Inventory Improvement Models (10 articles), Demand Planning Models (4 articles), Customer Segmentation Models (9 articles), Route Modeling Approaches (10 articles), and Digitalization Tools for Enterprises (7 articles). This thematic categorization provided insights into trends in areas such as Machine Learning applications in logistics and Industry 4.0 technologies.

The articles included experimental, theoretical, and applied research, offering a comprehensive perspective on supply chain optimization. Among the tools and methodologies highlighted were RFM (Recency, Frequency, Monetary) analysis - a proven technique that extracts customer value insights from transaction histories (recency of last purchase, purchase frequency, and monetary expenditure) to enable data-driven segmentation. Recent applications in e-commerce demonstrate how RFM clustering combined with machine learning can achieve high-accuracy sales predictions by capturing critical customer behaviour patterns [1].

Complementing RFM, k-means clustering has been shown to enhance demand forecasting and enable personalized service delivery. Lean methodologies, such as 5S and Kanban, emerged as effective approaches for reducing inventory replenishment times and improving warehouse efficiency. Furthermore, simulation tools for evaluating logistical scenarios were identified as essential for better inventory control and minimizing stockouts.

The literature review highlights several relevant findings that support the proposed improvement model. Specifically, standardized work has been shown to enhance timely supply by rubber industry suppliers through three key mechanisms: documentation of detailed procedures, clarification of roles, and ongoing process evaluations [2]. These measures promote consistency, operational efficiency, and continuous improvement.

Building on this foundation, research demonstrates that implementing Economic Order Quantity (EOQ) and Reorder Point (ROP) models significantly improves planning processes [3]. Not only do these methods ensure product availability and better supplier synchronization, but they also facilitate employee alignment through standardized workflows.

Regarding analytical approaches, clustering techniques have proven particularly valuable for analyzing purchasing patterns and predicting product turnover [4].

Most notably, the combination of k-means clustering with RFM methodologies enables effective customer segmentation [5], thereby allowing for precise alignment of purchasing plans with real demand patterns. This integrated approach offers actionable insights for improving both supplier alignment and inventory management

II. Problem

The analysis of the level of service offered to the client by the company under study reveals a clear technical gap with respect to the sector. While the service level of the sector is 98.1%, the company under study achieved only 85% in this indicator during the last period.

This technical gap of 13% on average translates is understood as an unmet demand, which represents a real problem because there are units that are not sold and consequently, unrealized profits for the company under study.

The economic impact of this gap reaches USD 83,500 per year, which shows an opportunity for improvement in the company. The causal factors of this problem are summarized in figure 1. It is determined that 53% of these causes are due to an insufficient stock of products, mainly caused by failures in the demand forecast.

With respect to inventory management, it is observed that the inadequate classification of products in the warehouse together with ineffective communication between the logistics area of the company and the warehouse influenced 29% of the current problem.

The other 18% of the causal factors is made up of the non-utilization of the entire fleet, mainly due to poor planning of the distribution route. However, the first two reasons described above represent 82% of the causal factors of the current low service level of the company under study.

Therefore, following the Pareto principle, the present research will focus on mitigating those causes with demand forecasting tools such as k-means clustering and RFM. While, to improve inventory management, Lean 5S and Kanban engineering techniques will be employed. Thirdly, EOQ and ROP parameters will be introduced to standardize the purchasing process to ensure timely stock supply.

In this way, it is intended to reduce the impact of these causes, which represent more than 80% of the total factors that cause the problem, and thus achieve the main objective of the study, to increase the company's service level. The root cause linkage diagram with the project tools can be visualized in Figure 1.

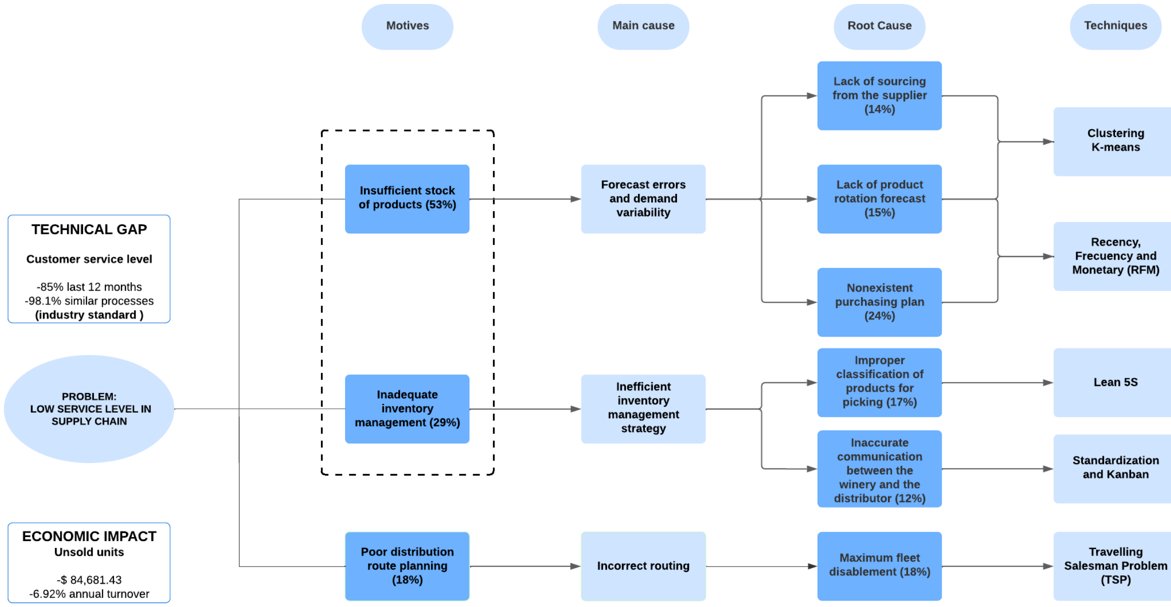

Fig 1. Diagram of the linkage of problems, root causes and techniques.

III. METHODOLOGY

Efficient logistics and storage management are critical for ensuring optimal service levels and reducing operational costs in companies. In this context, a three-component improvement model is proposed: data analysis, warehouse reorganization, and standardization of purchasing processes. This model aims to close the existing technical gap and enhance service levels by optimizing key processes within the supply chain. Figure 2 illustrates the principal inputs, outputs, and the components of the improvement model, providing a clear overview of its structure and objectives.

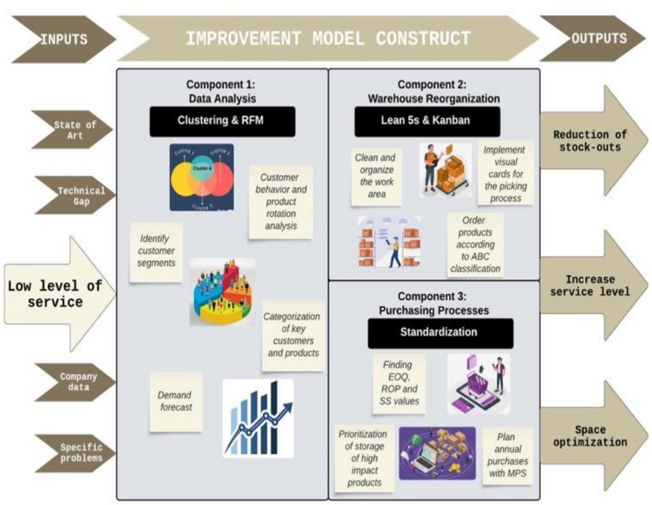

Fig 2. Implementation method of the improvement general model.

A. Data Analysis

The company currently segments its customers using three main variables: geographical location, group type, and sales channel. While this segmentation provides a broad overview, it fails to capture the unique behavior of individual customers, as they are treated in large homogeneous groups. This lack of granularity limits the ability to tailor strategies effectively and address specific needs.

To address this, a more precise segmentation approach is proposed, utilizing a sample size calculation to determine the required data for analysis (1). In the formula (1), Z represents the critical value corresponding to a 95% confidence level (1.96), while p and q are the probabilities of occurrence and non-occurrence, both set at 0.5 for maximum variability. The variable e denotes the permissible error margin, established at 5% (0.05), ensuring a reliable sample size calculation.

$$n = \frac{Z^2 \, x \, p \, x \, q \, x \, N}{e^2 \, x \, (N-1) + Z^2 \, x \, p \, x \, q} \quad (1)$$

Where:

- n: Sample size
- N: Population size

For customers, where N = 493

n = 217

For orders, where N = 3324

n = 345

These samples will be used to optimize segmentation through techniques such as k-means clustering and RFML analysis, enabling the identification of specific behavioral patterns and individual customer needs. For the RFML analysis, the following variables will be considered:

- Recency: Date of the last purchase
- Frequency: Purchase frequency
- Monetary: Purchase value
- Location: Purchase zone

B. Warehouse Reorganization

The company's warehouse faces numerous challenges stemming from disorganization, including difficulty locating products, reduced employee productivity, and safety issues due to inadequate cleaning and maintenance. Additionally, obsolete inventory occupies valuable space, and the lack of a systematic stock control process leads to overstocking or shortages of critical products. Moreover, the absence of standardized procedures results in inconsistencies, as employees perform tasks using their own methods, increasing the likelihood of errors.

To address these issues, the implementation of the Lean 5S methodology is proposed. A checklist was developed based on the principles of this tool to quantify the problems and determine which standards are most and least adhered to, thereby providing a concrete basis for improvement.

In addition, to reorganize the inventory, an ABC classification will be used, categorizing products based on their contribution to total sales. The classification is shown in the following table I:

TABLE I
ABC PRODUCT CLASSIFICATION

Participation	**Classification**	**Number of Products**	**Sales per Class (USD Currency)**	**% of Sales per Class**
0–80%	A	31	1,839,777.70	79.40%
80.01–95%	B	49	360,367.47	15.60%
95.01–100%	C	124	116,639.60	5.00%

This classification will guide the physical reorganization of the warehouse, ensuring that products contributing most to sales (Class A) are located closer to the exit for faster picking and dispatch.

C. Standardization of Purchasing Processes

Currently, the company's procurement methodology is not standardized, relying on the sales volume of the previous month to determine the quantity of stock ordered. This short-term approach does not consider inventory levels, leading to inefficiencies such as overstocking or shortages. Furthermore, the supplier's lead time of 100 days exacerbates these challenges, highlighting the need for a more effective ordering strategy.

To address this, the implementation of the Economic Order Quantity (EOQ) model and Reorder Point (ROP) technique is proposed, enabling better alignment between supply and demand. The EOQ model will determine the optimal order quantity to minimize inventory holding and ordering costs, as represented by the following formula (2):

$$EOQ=(\sqrt{2DS/H}) \qquad (2)$$

Where:

- D: Annual demand
- S: Ordering cost per order
- H: Holding cost per unit per year

Additionally, the ROP technique will be used to ensure timely replenishment. The formula for the reorder point is (3):

$$ROP = d.\ L + SS \qquad (3)$$

Where:

- d: Daily demand
- L: Lead time

These models will standardize inventory management, reducing inefficiencies and ensuring the timely availability of products to meet customer demands.

IV. INNOVATIVE PROPOSAL

The aforementioned technical gap highlights an opportunity for improvement for the company. Therefore, this project will focus on proposing the use of the engineering techniques described above in the company in order to achieve an improvement in the service level indicator.

Next, the contribution of each component, its level of application (implementation or simulation) and its solution area are described with the aim of evaluate its effectiveness.

A. Data Analysis

The improvement model proposed in this first component consists of adding the k-means clustering technique and RFML analysis to the current customer segmentation strategy. Unlike other segmentation methods, K-means and RFML enable categorizing customers based on their purchasing behavior and geographic location, making it possible to forecast demand for each specific customer group according to their particular needs and location, as determined by the RFML variables. This strategy gives the company the advantage of offering personalized products to customers by sales region.

Considering the data of these variables for a sample of 217 customers, 4 clusters were obtained, which are presented in Figure 3.

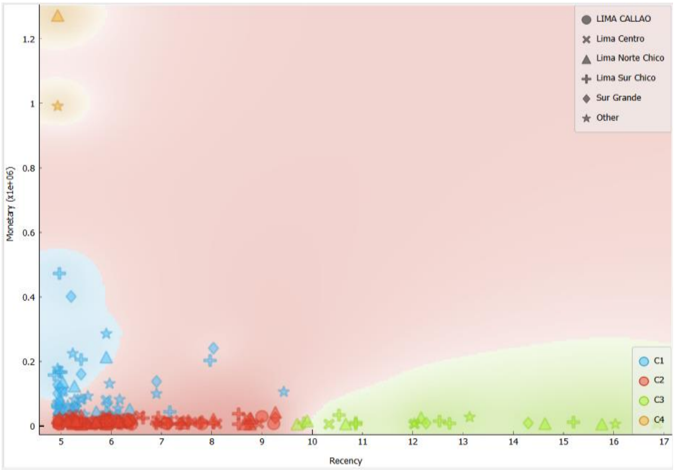

Fig 3. Clustering k-means and RFM model

For example, it is noted that "C4" has a higher level of turnover and purchase intensity than the other 3 clusters, so the 2 customers that make up "C4" would be the star customers. Based on this customer hierarchy, the 20 products preferred by the "C4" and "C1" clusters were found, which allows the company to focus its marketing strategies, promotions and efforts on the customer groups and products with the highest purchase levels. This gives the company a greater chance of obtaining a higher return on investment.

Secondly, 4 demand forecasts were made with 4 different methods in order to compare each of them and find the most accurate one using MAE and RMSE performance metrics. Figure 4 shows the comparison between the estimated units to be sold with the linear regression method, which yielded the lowest error levels (MAE = 245 & RMSE = 279 sacks), and the actual units sold by the company, over a period of 24 months.

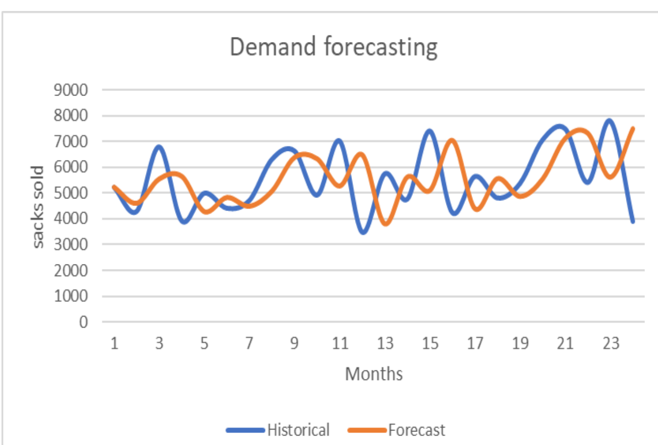

Fig 4. Demand forecasting

These forecasted units to be sold will be used in the Arena simulation to evaluate the company's service capacity and calculate the level of service offered to the customer.

B. *Warehouse Reorganization*

In the second component, the total reorganization of the warehouse is proposed.

First, an ABC analysis of all products was performed, where it was found that 31 products represent 80% of the turnover. The objective of the ABC analysis is to redesign the layout of products in the warehouse to one that prioritizes the proximity of class "A" products to the exits. The proposed layout is shown in figure 5.

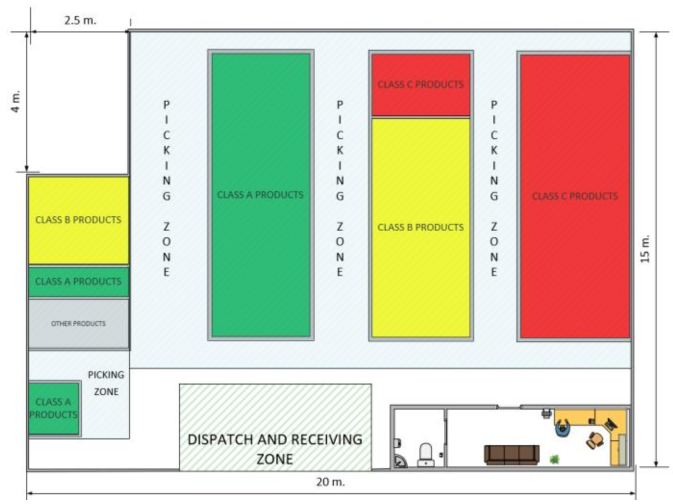

Fig 5. Layout proposal

Second, two key tools were implemented: the 5S methodology and the Kanban system. The 5S technique was used to improve order and cleanliness in the warehouse, solving organizational problems, eliminating unnecessary products and facilitating inventory management.

On the other hand, the Kanban system was implemented to improve coordination between the warehouse and the company, optimizing the order picking and dispatch process, addressing the current poor communication.

Both techniques were implemented in the company through a pilot test carried out in the warehouse, where it was possible to reduce the execution times of the picking activity and improve the evaluation of the warehouse, which was verified through different 5S audits, as shown in table II.

TABLE II
5S AUDITS

Audit	Category	Rating	Score	Standardized score
INITIAL	Seiri (Classification)	/15	5	6.67%
	Seiton (Order)	/15	7	9.33%
	Seiso (Cleaning)	/15	7	9.33%
	Seiketsu (Standardization)	/15	0	0%
	Shitsuke (Discipline)	/15	0	0%
TOTAL		**75**	**19**	**25.33%**
FINAL	Seiri (Classification)	/15	14	18.67%
	Seiton (Order)	/15	14	18.67%
	Seiso (Cleaning)	/15	11	14.67%
	Seiketsu (Standardization)	/15	13	17.33%
	Shitsuke (Discipline)	/15	6	8.00%
TOTAL		**75**	**58**	**77.33%**

C. Standardization of Purchasing Processes

The improvement proposal in this third component is the implementation of the EOQ and ROP parameters in the process of purchasing from the supplier, for each of the 31 class "A" products found in the previous component of the study. These parameters establish rules that facilitate the decision of the units per SKU to order from the supplier and the right time to place the order. Considering the extensive lead time of the supplier, it is key to find the stock level at which to repurchase since the purchase plan must be prepared in time. In this way, the introduction of these parameters seeks to standardize the purchasing process and cancel stock breakage by always having sufficient stock.

Once the EOQ and ROP values for class "A" SKUs were found, a macro-excel was made combining the sales forecast found in the first component and the EOQ and ROP values. This integration of components allowed the development of an automated "MPS" template for the 31 class "A" products, which standardizes the purchasing process and greatly facilitates the scheduling of goods receipts. In addition, the macro-excel includes the 4 forecasting methods used so that the company can change the demand estimation method if required. This adds even more dynamism to the process. The results of this homologation of the purchasing process are presented in the following figures.

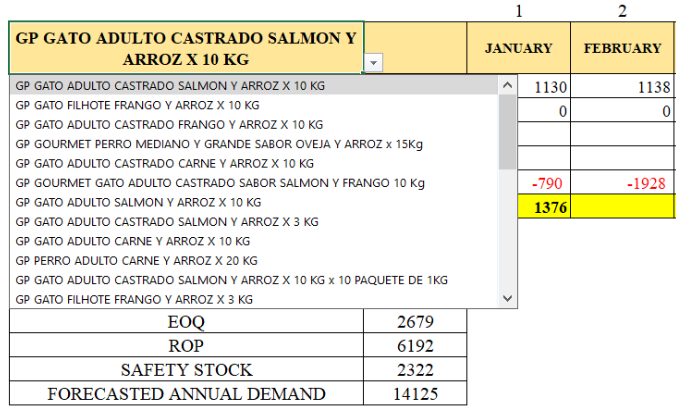

Fig 6. MPS templates for class "A" products

GP GATO FILHOTE FRANGO Y ARROZ X 10 KG		1 JANUARY	2 FEBRUARY	3 MARCH	4 APRIL
FORECAST	4991	399	402	405	408
SCHEDULED RECEPTION		0	0	0	0
SCHEDULED DATE OF RECEIPT					
APPROXIMATE ORDER DATE					
ROP	340	-59	-462	-867	-1275
EOQ		**1376**		**0**	**1376**

GP GATO FILHOTE FRANGO Y ARROZ X 10 KG	Value
EOQ	1624
ROP	2188
SAFETY STOCK	821
FORECASTED ANNUAL DEMAND	4991

Fig 7. Annual MPS templates

Additionally, a simulation model of the company's logistic processes was carried out in Arena. This model contributed to validate the effectiveness of the proposed improvement tools, helped to better understand the company's processes and served to measure the warehouse times in real time.

The model in Arena consists of 3 main parts and it is fully displayed in Figure 8.

1. Simulation of the capacity to meet the forecasted demand (top branch)
- Objective: To measure the level of service achieved and the number of units sold.

2. Simulation of the new inventory policy including EOQ and ROP parameters (middle part)
- Objective: Estimate the average stock level and determine if there is stock out.

3. Simulation of receiving, storage and picking activities in the warehouse (lower branch)
- Objective: Calculate the execution time of logistics activities.

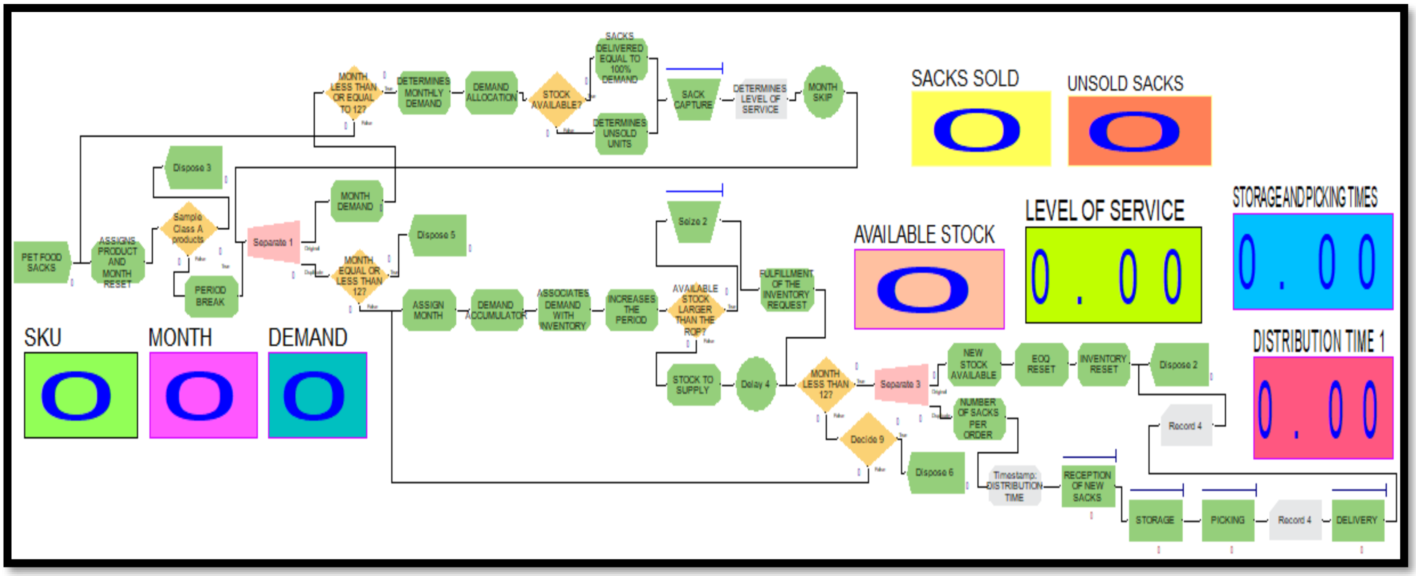

Fig 8. Arena simulation model with proposal components

V. RESULTS

To evaluate the economic sustainability of the project, the various revenues and costs were analyzed between two scenarios. The first scenario considered the initial situation of the company without improvements and the second scenario evaluated the proposed improvement situation, considering of course the investment required for the implementation of the components of this project, which amounts to USD 14,154. It should be noted that the project will use 100% of the company's shareholders' own capital and will not require external financing.

The objective of performing the economic evaluation of the initial and improved situation separately is to find the incremental economic cash flows of the project and from them calculate economic indicators that clearly reflect the impact of the proposed improvements. To find these indicators, a Shareholder Opportunity Cost (COK) equivalent to 12.46% per year and 0.98% per month must also be determined.
The economic indicators of the incremental economic cash flows of the project are as follows:

TABLE III
INDICATORS OF THE INCREMENTAL ECONOMIC CASH FLOW

Indicator	Outcome
Economic Net Present Value (NPV)	USD 72,750
Internal Rate of Return (IRR)	53.42%
Benefit-Cost Ratio (B/C R)	USD 1.28
Payback Period (PP)	2.09 months

The joint application of the 3 project components achieves indicators that highlight the robustness and potential of the project.

The improvement is mainly justified by the 12.90% increase in the level of service offered to the customer, caused by the lower incidence of stock breakage, which was achieved through the standardization of the purchasing process with the EOQ and ROP parameters. This increased responsiveness to customer orders generated more than a thousand new sales, which increased the company's revenues. In addition, this increase in the level of service has closed the technical gap with the sector in this indicator and positions the company at a more competitive service standard.

On the other hand, the reorganization of the warehouse, together with the correct planning of the demand, managed to reduce the number of storage positions needed, which resulted in savings in the cost of storage for the company. Table IV shows a summary of the As Is, To Be and actual values of the project.

TABLE IV
PROJECT RESULTS

Indicator	As Is	To Be	Achieved	Improvement
Level of service	85%	95%	97.90%	+12.90%
Average inventory	450	420	400	-50
Storage times (hours)	3.31	3	2.54	-0.77
Units sold (sacks)	44,900	47,000	46,000	+1,100
5S Audits	25.33%	70.00%	77.33%	+52.00%

The time required for the company's logistics activities, such as receiving, storing and picking sacks, was also reduced by 23.26%. This time reduction was largely due to the implemented Kanban cards and the new warehouse layout. In addition, the 5S philosophy contributed to the establishment of good practices in the warehouse, which is demonstrated in the audits performed, where a 52% improvement in the warehouse score was recorded.

The good performance of the proposed improvement model is proven, since in four of the five indicators, the "real" result exceeds the "To Be" value estimated before the implementation of the project.

VI. DISCUSSION

The literature review highlights the positive impact of management tools in improving inventory and logistics processes. Evidence shows that implementing dynamic EOQ models can adjust replenishment policies to address unforeseen circumstances, reducing the risk of stockouts and enhancing customer satisfaction [6]. This aligns with the current study, which improved the service level from 86.50% to 97.90%. Research confirms that ABC classification allows for an average 39% reduction in excess inventory [7]. In this project, a 22.70% reduction in average inventory was achieved while maintaining service levels and optimizing logistics costs.

Regarding clustering tools, combining K-means and RFM with demographic data enables personalized strategies to increase sales and improve customer segmentation [8]. This approach was also adopted in the current model, resulting in 1,100 additional units sold while enhancing the potential for targeted marketing strategies.

For operational efficiency, a 37% reduction in activity times through Lean 5S implementation has been documented [9]. Similarly, the present study recorded a 23.26% improvement in logistics activities such as reception, storage, and picking, integrating Lean 5S and ABC classification to optimize processes. Furthermore, Kanban systems prove effective in standardizing logistical processes [10], contributing to faster picking activities in this case.

Finally, predictive models based on Machine Learning demonstrate dual benefits: improving forecast accuracy while achieving a 49.77% reduction in inventory with lower economic losses [11]. In the current study, the implementation of ROP parameters led to a reduction in the average inventory from 450 to 400 units. While this reduction is quantitatively smaller than the 49.77% reported in the literature, it represents significant improvement without compromising service levels, highlighting the tailored application of ROP parameters to balance cost efficiency and customer satisfaction.

VII. CONCLUSIONS

This research confirms that the application of advanced methodologies and tools in the supply chain can significantly enhance the operational efficiency and competitiveness of a pet food company. By aligning with the defined objectives, the study demonstrates the following:

First, customer segmentation using RFM analysis and K-Means clustering proved effective in identifying distinct customer groups, enabling the company to tailor its inventory strategies to better meet demand patterns and improve overall service levels. This segmentation approach supports more informed decision-making in inventory planning and allocation, ensuring that resources are optimally distributed.

Second, the implementation of EOQ and ROP parameters successfully addressed the issue of stockouts by establishing systematic replenishment processes. These tools enhanced inventory control by automating the calculation of optimal order quantities and reorder points, reducing the risk of disruptions in the supply chain and ensuring consistent product availability for customers.

Third, operational processes were streamlined through the integration of Lean Warehousing Management techniques, including 5S and Kanban. These methodologies facilitated the organization of storage areas, improved picking efficiency, and reduced waste, contributing to a more agile and cost-effective operational framework.

Additionally, the study underscores the importance of continuous improvement in demand forecasting to further reduce variability and enhance the benefits of process standardization. Accurate demand predictions will allow the company to maximize the impact of its management strategies and respond proactively to market fluctuations.

From a financial perspective, the findings highlight the robustness of the proposed improvements, demonstrating their alignment with the company's long-term sustainability goals. The integration of these strategies strengthens the company's capacity for efficient, automated, and forward-looking management practices.

The model's effectiveness remains fundamentally dependent on data quality and transparency, with several interconnected limitations requiring careful consideration. At the core lies the challenge of data granularity - successful RFM clustering demands meticulously maintained transaction histories capturing not just basic sales figures but precise timestamps (down to hour/minute for high-volume periods), detailed SKU-level information (including product variants and packaging sizes), and complete customer identifiers. Many organizations struggle with fragmented data ecosystems where this information may be scattered across legacy POS systems, e-commerce platforms, and manual record-keeping methods, creating integration hurdles.

Equally critical is the need for rigorous data standardization across all implementation scenarios. The very definition of key metrics like "recency" must be operationally standardized - whether measured in days, weeks, or business days since last purchase - and consistently applied across all customer segments. Similarly, "frequency" calculations require clear rules about counting periods (weekly, monthly) and treatment of returns/cancellations. Without such standardization, attempts to replicate or scale the model may yield inconsistent results.

In conclusion, this comprehensive improvement model not only addresses existing logistical challenges but also positions the company to sustain growth and competitiveness in a dynamic industry. Continued exploration and adoption of innovative practices are recommended to maintain momentum and achieve ongoing success.

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