Application of the Abc Methodology to Reduce the Delay of Sales Orders in A Company Warehouse in Barranca City

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Abstract

Inventory management becomes more important as companies grow; therefore, it is important to improve its internal processes by seeking efficient storage methods. The processes were analyzed using problem diagnosis tools and it was observed that more than 15% of the total orders are delayed, and more than 80% are due to the fact that there is no specific location of the products in the warehouse. Under this problem, the implementation of the ABC methodology is proposed, which allowed dividing the large number of products that the company sells into families and classifying them into groups A, B and C. Subsequently, the entire company warehouse was divided into zones. Arena software was used to compare the results between the current situation and the improvement implemented. According to the results obtained, it was shown that from a reduction in picking times of 20% or more, the improvements implemented would be significant, and so it was. A reduction in picking time of approximately 33% was achieved, and late orders per day decreased on average from [5.03 ± 1.5] to [1.83 ± 0.56] orders.

Keywords
ABC methodology, warehouse, picking time, backorders, Arena.

1. Introduction
The ABC methodology is a categorization technique based on the Pareto Principle to determine which items should be prioritized in a company's inventory management, allowing the company to separate stock-keeping units (SKUs) into three groups (Jemelka et al. 2016) starting with group A. This is the most important group because it usually occupies 20% of inventories and has the highest turnover; therefore, it is of strategic importance. These are the products in which the company has invested the largest budget and usually generate 80% of revenue, so it is a priority to place them in low areas, with direct and easy access. Secondly, group B, comprises a medium turnover range and usually represents, in quantity, 30% of inventories, so they are located in areas of intermediate height whose access is not as direct as in the positions occupied by products A, and their evolution must be monitored, since they can become type A products. In third and last place, group C, are the most numerous, accounting for 50% of the stored references. However, they are also the least demanded and it is advisable to monitor them so that they do not end up forming an obsolete inventory with no turnover, so they occupy the highest or least accessible areas (Hanafi et al. 2019).
It is also known that minimizing order preparation time leads to a considerable increase in productivity and cost reduction, which is why it must be taken into account, in order to achieve an optimal service system, the uninterrupted delivery of goods in the process of cargo movement. For example, proper bulk inventory management can consume only 50% of the total order preparation time.(Nosko et al. 2020). Because the ABC methodology solves one of the

criteria that most affect micro-enterprises, which is the organization of their products in the warehouse; and it is the commercial companies that buy and sell products who lose control more easily due to the fact of acquiring a great variety of types of products (Jemelka et al. 2016).

This company located in Barranca does not have any specific procedure for storing all its products in the warehouse. What is currently done is the random placement of their items only based on the experience they have developed over time and what they are used to doing. This methodology can be applicable to inventory management for any type of product, be it spare parts, medicines, books, tools, machines, among others, having as a function, in this case, the fulfillment of order requests in terms of quantity and optimum times. (Conceição et al. 2021).

For the diagnosis of the problem, Value Stream Mapping (VSM) was used to show all the processes involved in the final delivery of the product and to detect which ones do not generate value. It was identified that the picking process takes more time than the others. It was observed that there is a delay of between 1h to 3h to prepare a single order during the day. This reflects the deficient response capacity due to the deficiency in picking. The process was analyzed and three main causes of orders delayed were found. A Pareto diagram was developed to determine which of these problems is the most critical to the process. Based on a count record (times per year), it was identified that the non-specific location of products in the warehouse causes that picking time per order increases. Then, an issue tree was developed to identify the root causes involved in the non-specific location of products in the warehouse, where the most determining root causes are the distribution of products based on their experience and order of arrival in their warehouses, which give them a random approach when organizing their warehouse; and the lack of signage for product location. These generate negative effects related to delays, non-compliance and even insecurity.

Companies in the buying and selling business commonly face problems related to the management of their products. Therefore, the ABC classification method will be used to classify items into groups and establish appropriate levels of control over each of them, so that sales orders can be fulfilled. The problem that is reflected is that, of the total orders, more than 15% are delayed, of which more than 80% are due to materials not having a specific location in the warehouse. So, is the ABC methodology an effective model in the warehouse to reduce the delay of sales orders of a company in Barranca?. It is essential to apply a method that can solve this problem, since the performance of companies is considerably influenced by the inventory present; in this way, the existence and availability of finished products must be ensured and avoiding the retention of unnecessary products, which would only generate extra costs (Asana et al. 2020).

1.1 Objectives

The objective of this research is to apply the ABC methodology in a warehouse of a company located in Barranca to reduce the delay of orders. The specific objectives are to reduce the picking time for each family of products in order to minimize delay of orders; in addition, to locate the items of each group of families in the warehouses in a way that contributes to the reduction of the time in which an order is attended.

2. Literature Review

The ABC methodology solves one of the criteria that most affect micro-enterprises, which is the organization of their products in the warehouse; and it is the commercial companies that buy and sell products who lose control more easily due to the fact of acquiring a great variety of types of products (Jemelka et al. 2016). This statement perfectly reflects the current situation of the company, where several items are marketed in the various measures that are requested per day and due to lack of time may be pending for the next day as well as can be canceled. For this reason, it was decided to investigate and put forward proposals that could solve this problem, and this is how it was decided to opt for the use of the ABC methodology. There are different ways to develop and apply the ABC analysis. This is based on the consideration of the main categorization criteria; at this point there are the analysis criteria according to sales value, order preparation time, purchase frequency, which are used for a more precise execution of the methodology (Cabrera et al. 2019).

Information was compiled from research by other authors in which they explain how they achieved optimal results in sales, costs, time savings and even positive impacts on health. It is evidenced in a case study conducted for the reduction of picking times in national distribution centers, that by applying this technique combined with integer linear programming, strongly beneficial results were reached demonstrating savings of 3.64 HH/day, cost reductions of 10% per month, quantifiable reductions in order picking errors, efficient warehouse organization and even had a positive impact on the health of workers (Gutierrez et al. 2019). Another research article justifying the effectiveness of the ABC methodology was conducted for a hospital in the city of Medan, where there is an insufficient supply of drug products generating an increase in costs due to unexpected and immediate purchases. For this article, drugs were categorized according to their value and percentage of annual investment, so that it was concluded in a higher inventory control, records verification and supervision for category A with an investment of 70.4% of the total consumption of drugs; category B presented an investment of the total of 20%; and category C, an investment of 9.6% of the total consumption (Rizkya et al. 2020). In addition, Mely et al. (2017) makes use of the ABC methodology to classify raw materials into the three categories, including tools such as inventory policy analysis as periodic review for each of the categories. It found an overstocking that increases the total inventory cost of raw materials, which, thanks to the alignment of methodologies and inventory control tools, it was possible to reduce the total inventory cost by 42%; however, the total cost of ordering rose due to the higher frequency of orders in smaller quantities. This research reflects the effectiveness that the ABC methodology can have if we take advantage of its use in conjunction with a tool. This methodology can also serve as support for other models such as the case of Kusuma and Hakim (2020), who noticed a big problem in a warehouse when they found several materials with low turnover as a consequence of deciding to store large quantities of materials to avoid shortages and interruption of activities. They developed mathematical models using LINGO, in which they determined, thanks to an ABC analysis, the most critical materials and minimized total costs based on the proposed inventory system and adjustments in the quantity and ordering time.

3. Methods

The methodology shows the steps to be followed to improve the distribution of products in a warehouse in the city of Barranca. The type of methodological design used is experimental, since in this article we intervene in both the independent variable (inadequate location of products in the warehouses) and the dependent variable (delay of sales orders) by making changes, determining a relationship between them and directly impacting the causes of the effects. Likewise, the independent variable contains two dimensions which are the two warehouses to be evaluated; and the dependent variable is divided into five dimensions corresponding to the five families of products grouped according to their similar characteristics, these are the family of office, school, electronic, handicrafts and gift items. In this case, it will be measured how the location of the products in the warehouses intervenes in the delay of sales orders.

The causes of the delay of sales orders were analyzed and, based on this study, the analysis of how the dependent and independent variables were related and measured was deepened; therefore, this type of research belongs to a correlational scope. Likewise, it has a quantitative approach which, as pointed out by Falcon et al. and Henríquez et al. (as cited in Henríquez-Fuentes et al. 2018), is based on the search for solutions by quantifiable and operational methods, helping to make decisions based on the reduction of possible risks, guaranteeing the feasibility and certainty to study and relate the variables involved.

First, an analysis of the current state of the warehouse will be performed, these will be measured with the indicators of total time an order remains in the system, which was measured based on the time it takes for an order to be attended from the time it is requested until it is dispatched completely ready, the time in queue of each order family, which is measured by the waiting time an order has to be attended, the number of orders attended during working hours, the number of orders delayed within the working time. Warehouse information such as storage procedures was collected by observation and detailed analysis of the current status and warehouse criteria to identify where and how these products are stored. In addition, a measurement of the picking time of customer orders was performed from the time an order is taken care of until it is finished being prepared. The measured times were recorded using a stopwatch.

The population to be studied will be the warehousing process, of which the sample was determined as the time record of 50 orders that were generated during the course of the week; these are the time between incoming orders, the probability that the order belongs to a certain family of items, how many items are in each order, how long it takes a storekeeper to prepare the complete order and fit it. It should be noted that only 50 orders were recorded due to factors related to time and distance, which prevented the taking of a larger sample.
Secondly, as shown in Figure 2.1, the process starts with the receipt of orders from customers; they will order a certain quantity of orders from the company and, depending on the availability of the warehouse personnel, the company will start preparing the order from the warehouse until it is completely ready.

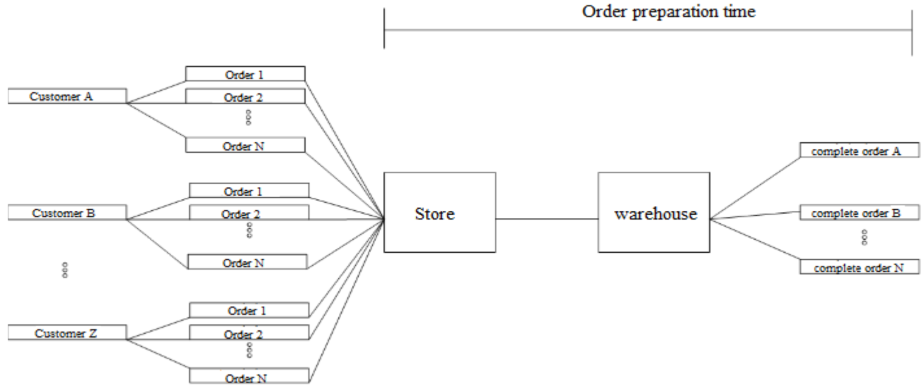


Figure 1. Order reception and preparation process

By analyzing the product location system, problems were identified, such as the non-fulfillment of orders at the end of the day, measuring the time taken from the time the customer places the sales order until it is ready for delivery. To determine the indicators before and after the application of the ABC methodology, it was decided to use the Arena software (version 16.1) as a tool to simulate the current process maintained by the company, and compare it with the scenario after the application of the improvement. This was to show the impact of the methodology and if it was significant for the process.

The data used in the software was collected thanks to the reports provided by the company. They were analyzed and validated using Minitab to determine which distribution most closely resembles the data series collected for the simulation. Then, for the application of the ABC methodology, groups were established for each family of items. In Group A, there are two families, office and school supplies; in Group B, electronics and handicrafts; and in Group C, only gift items. In this way, the warehouse products were grouped according to their rotation and income in the two warehouses, and were reorganized in order to reduce the distance and travel time. Finally, once the methodology has been applied, the optimized simulation will be run again with the data from the improvements, and the results of both scenarios will be compared.

4. Data Collection

For this simulation, the order handling process was analyzed and the following scheme was proposed for the simulation, which contemplates the entry of orders through a create, to subsequently perform an assign that is responsible for assigning the attribute of the type of article and the number contained in the order. Then a decide is performed, which identifies whether the order contains the corresponding article type, and if so, it is passed to the process and is attended with a given delay time. The process is repeated five times per entity due to the five product families it has to go through.

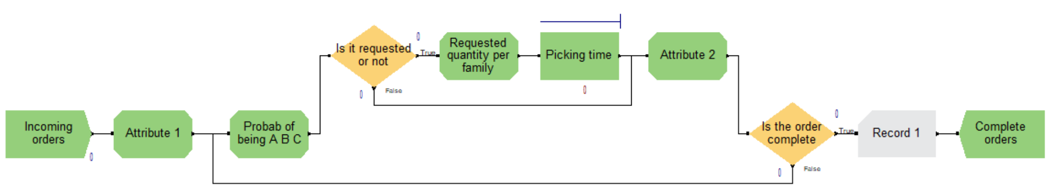


Figure 2. Simulation model in Arena

To simulate the complete process in Arena, we started by validating the order arrival time using a sample of 50 orders which were analyzed by Minitab software, resulting in a data distribution that resembles a normal distribution as shown in the following graph.

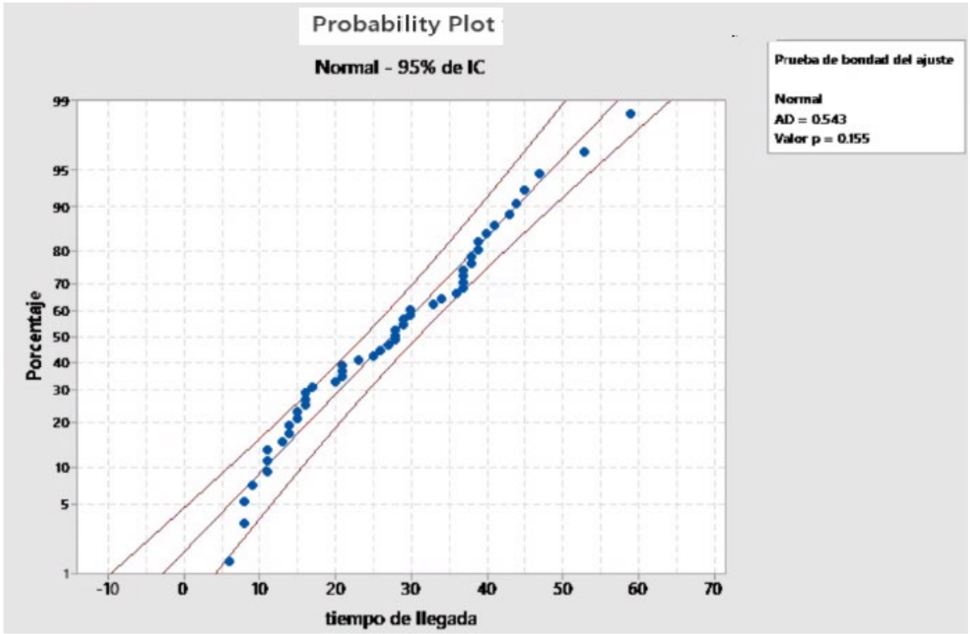


Figure 3 Arrival time validation

Descriptive Statistics

N	N*	Mean	StDev	Median	Minimum	Maximum	Skewness	Kurtosis
50	0	27.26	12.9154	28	6	59	0.251410	-0.679079

Figure 4. Mean and Standard Deviation of arrival time

Subsequently, the rest of the data required for the simulation were validated, such as the probability that each family is ordered by the customer, the number of items ordered from each product family and the order preparation time.

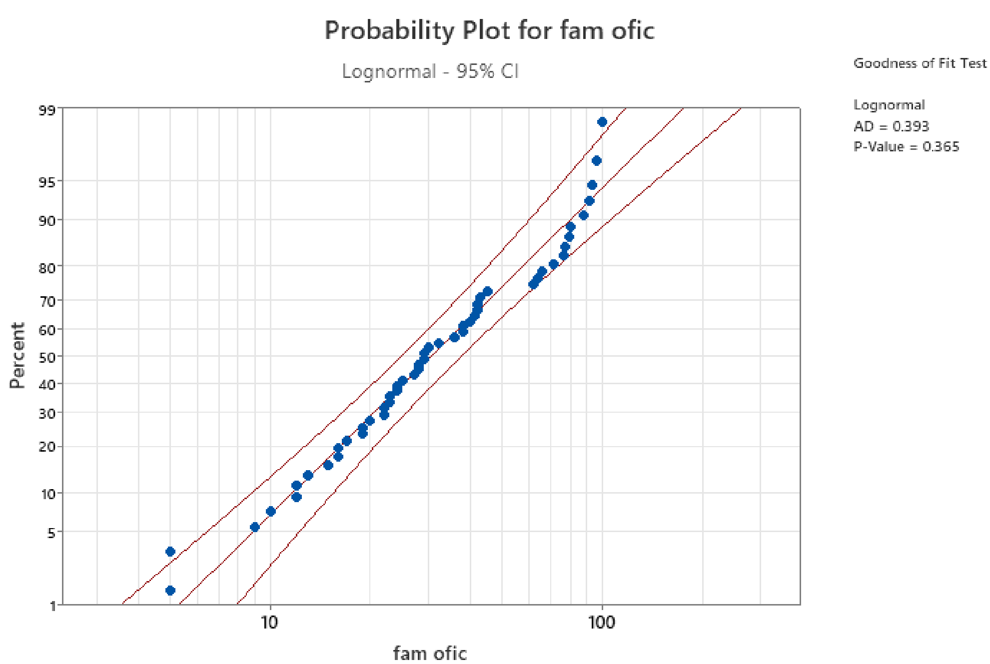


Figure 5. Probability validation for office supplies

Descriptive Statistics

N	N*	Mean	StDev	Median	Minimum	Maximum	Skewness	Kurtosis
50	0	39.24	27.1026	29	5	100	0.883518	-0.432118

Figure 6. Mean and Standard Deviation of the probability for office supplies

And so on with the other records until all the necessary data for the simulation is completed.

5. Results and Discussion

The indicators of the company's current situation were obtained after simulating the process, which are detailed in the following table.

Table 1. Main current KPI's of the company

KPI	Average
Total time an order remains in the system	[93.18 ± 19.68] min
Total queue time for each order in the picking process	[33.01 ± 12.47] min
Number of orders handled within 8h	[14.97 ± 1.59] orders
Number of orders delayed due to closing of the store during the day	[5.03 ± 1.5] orders
Maximum number of orders handled per day	21 orders
% Delayed orders due to store closing during the day	[28.28 ± 8.41] %
% Utilization of the storekeepers	[86.14 ± 4.84] %

The indicator shows that it currently takes [93.18 ± 19.68] minutes on average to fulfill a single order and this generates [5.03 ± 1.5] orders on average to be delayed during the day. Secondly, all the company's historical sales data was collected for 3 months and grouped according to the number of times they are ordered in order to know which ones have a higher turnover in the warehouse. As can be seen in the following table, office supplies have the highest turnover along with school supplies; therefore, these items have the highest turnover in the warehouse.

Table 2. ABC analysis by rotation of each product family

FAMILIAS DE PRODUCTOS	Nº PEDIDOS	PORCENTAJE	GRUPO	
Artículos de oficina	6754	65.62%	80.56%	A
Artículos escolares	1537	14.93%		
Artículos eléctricos	1151	11.18%	14.47%	B
Articulos de manualidades	338	3.28%		
Artículos de regalo	512	4.97%	4.97%	C
TOTAL	**10292**	**100%**	**100%**	

Thirdly, a redistribution was made by locating the points closest to the picking area, eliminating the shelves and using the shelves that the company has. This resulted in the following organized plan with specific locations for each product, so that those with higher turnover, belonging to group A, can be removed more quickly; therefore, these are located on the second floor. In addition, types B and C were located on the second floor of the company. Group B at the entrance to the second-floor stairs and group C at the farthest part of the second floor.

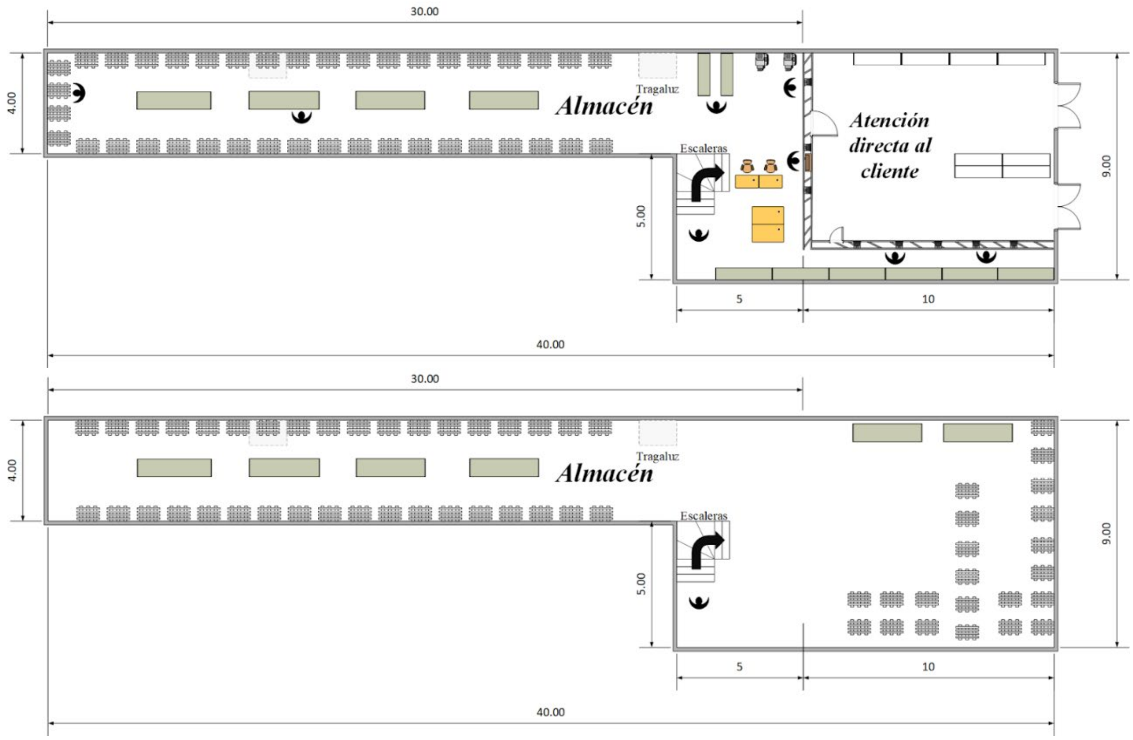


Figure 7. Current plan of the two warehouses

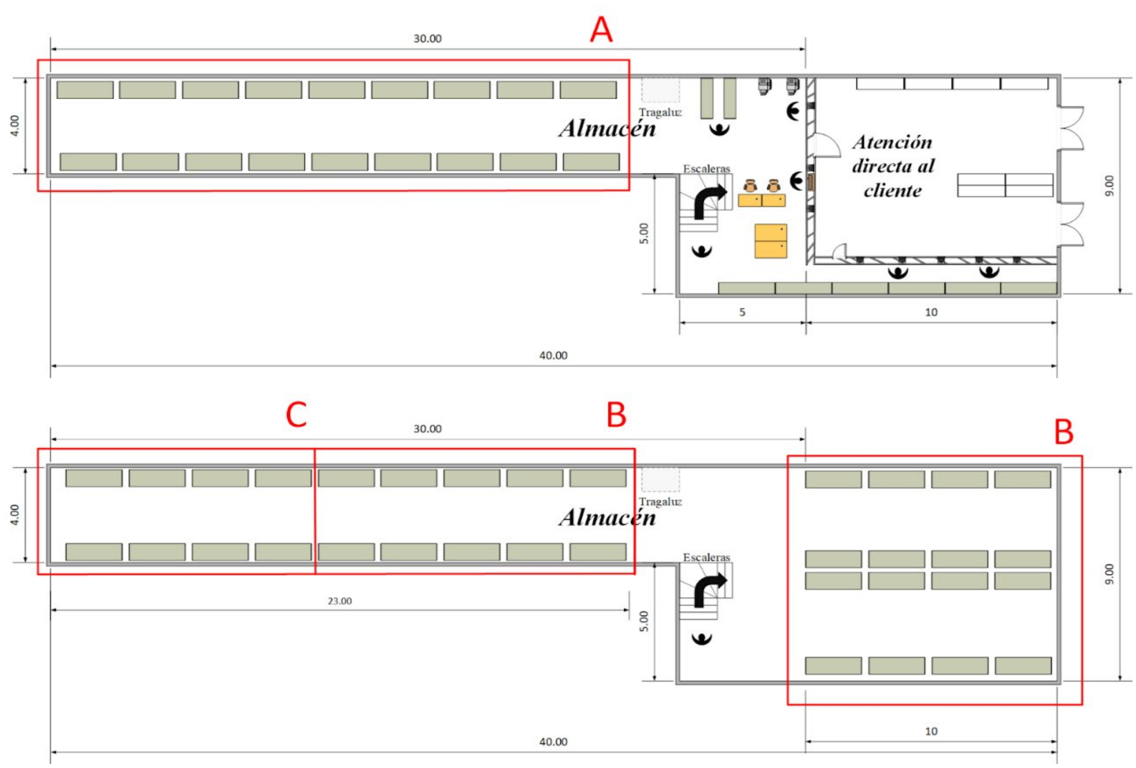
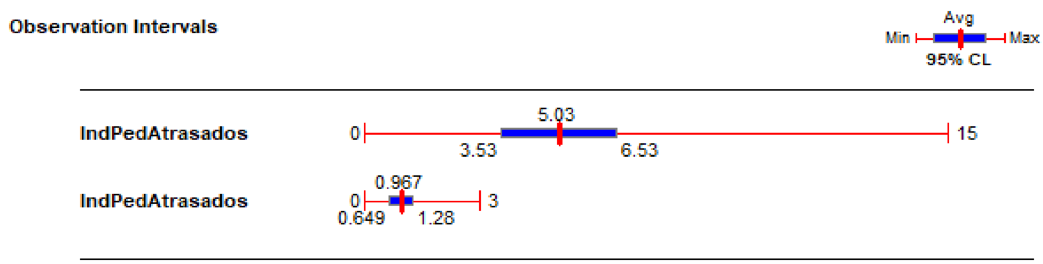


Figure 8. Optimized plan of the two warehouses according to ABC groups

Fourth and finally, the simulation was run again, but focusing on the possible improvement scenarios that the application of the ABC methodology would provide. According to Nosko et al. (2020), the application of this methodology can increase productivity in the picking process by 50% by rationally organizing product groups in an automated storage system (p. 6). Taking into account the previously mentioned value, the complete process of the company will be simulated under different scenarios starting with a possible 50% reduction in picking time, and thus identify to what extent the optimization can become significant. The results will be evaluated with the indicator of the number of backorders per day as shown in the following table.

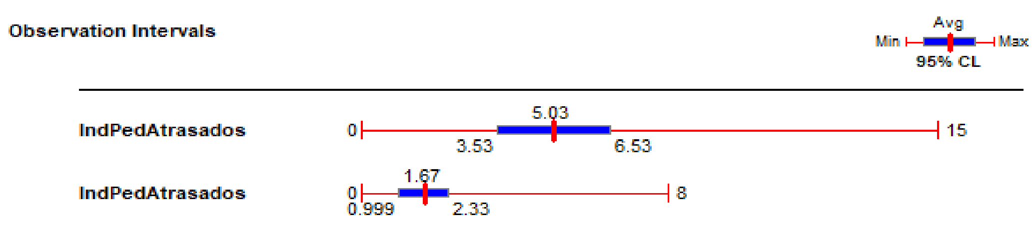


Classical C.I. Intervals Summary

IDENTIFIER	AVERAGE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS.
IndPedAtrasados	5.03	4.01	1.5	0	15	30
IndPedAtrasados	0.967	0.85	0.318	0	3	30

Figure 9. Comparison between current scenario and 50% reduction of picking time

Since there is no overlap between the two confidence intervals, it can be said that the 50% reduction in picking time has generated a significant decrease for the indicator of orders delayed during the day, for a confidence level of 95%.

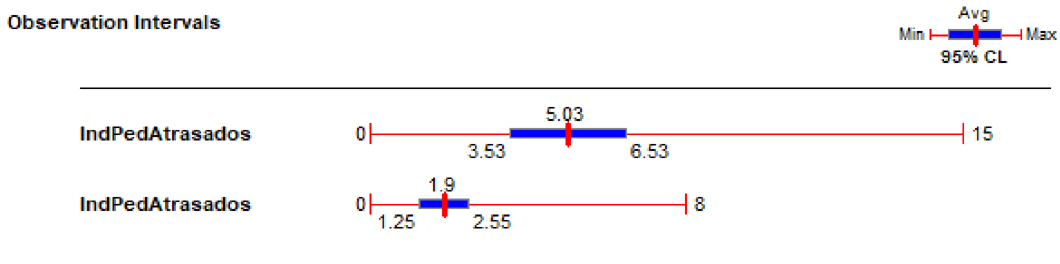


Classical C.I. Intervals Summary

IDENTIFIER	AVERAGE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS.
IndPedAtrasados	5.03	4.01	1.5	0	15	30
IndPedAtrasados	1.67	1.79	0.667	0	8	30

Figure 10. Comparison between current scenario and 40% reduction of picking time

Since there is no overlap between the two confidence intervals, it can be said that the 40% reduction in picking time has generated a significant decrease for the indicator of orders delayed during the day, for a confidence level of 95%.

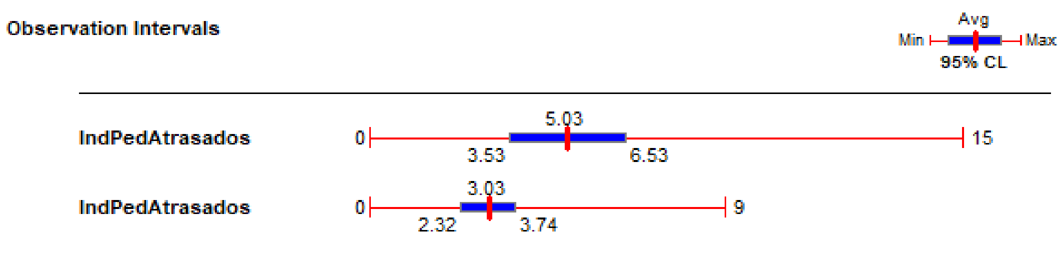


Classical C.I. Intervals Summary

IDENTIFIER	AVERAGE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS.
IndPedAtrasados	5.03	4.01	1.5	0	15	30
IndPedAtrasados	1.9	1.73	0.646	0	8	30

Figure 11. Comparison between current scenario and 30% reduction of picking time

Since there is no overlap between the two confidence intervals, it can be said that the 30% reduction in picking time has generated a significant decrease for the indicator of orders delayed during the day, for a confidence level of 95%.



Classical C.I. Intervals Summary

IDENTIFIER	AVERAGE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS.
IndPedAtrasados	5.03	4.01	1.5	0	15	30
IndPedAtrasados	3.03	1.9	0.71	0	9	30

Figure 12. Comparison between current scenario and 20% reduction of picking time

From the comparison of scenarios between the current situation and the 20% reduction in picking times by implementing the ABC methodology, it is observed that there is an overlap between the confidence intervals; therefore, a more accurate test called "common sequence" will be performed.

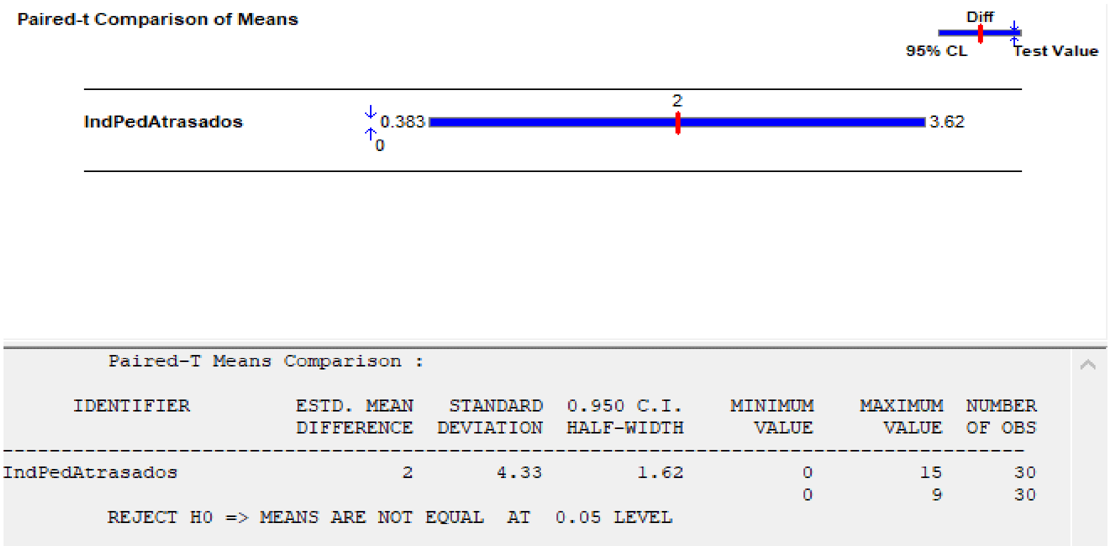


Figure 13. Common sequence test between current scenario and 20% reduction of picking time

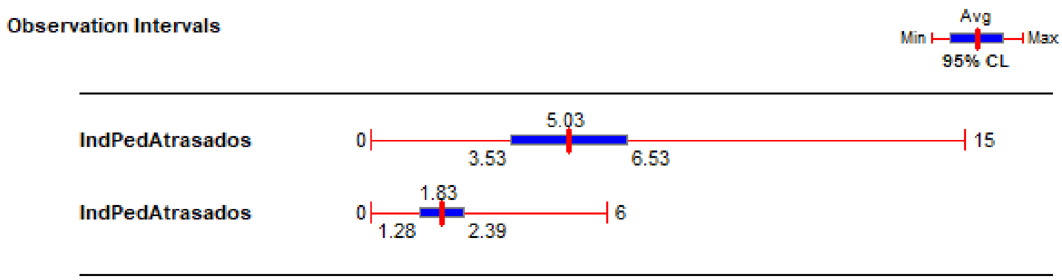
As can be seen in the figure, when comparing the mean between the two scenarios, significant differences could be found between them. Therefore, it can be concluded that reducing the picking time by approximately 20% or more, the indicator of orders delayed during the day has a positive impact.

Based on the comparison between the possible scenarios with the objective of evaluating the positive impact limit of applying the ABC methodology, a pilot test was done by recording the time it takes an operator to reach a location in the warehouse, obtain the product, complete the picking of a box and return. By knowing the specific location of each products groups, the distance traveled and the time it takes the operator to complete a box can be measured. Once the time was recorded, it was entered into the Arena software to obtain the new results.

Table 3. KPI's after improvement

KPI	Average
Total time an order remains in the system	[46.98 ± 6.15] min
Total queue time for each order in the picking process	[6.39 ± 2.87] min
Number of orders handled within 8h	[16.17 ± 0.83] orders
Number of orders delayed due to closing of the store during the day	[1.83 ± 0.56] orders
Maximum number of orders handled per day	21 orders
% Delayed orders due to store closing during the day	[10.81 ± 3.05] %
% Utilization of the storekeepers	[65.44 ± 4.15] %

The system permanence indicator shows that, after the relocation of the item families, on average it takes [46.98 ± 6.15] minutes to attend a single order and this means that now only [1.83 ± 0.56] orders on average are delayed during the day.



Classical C.I. Intervals Summary

IDENTIFIER	AVERAGE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS.
IndPedAtrasados	5.03	4.01	1.5	0	15	30
IndPedAtrasados	1.83	1.49	0.555	0	6	30

Figure 14. Comparison between current and improvement scenario

When comparing the scenarios, it is observed that, after the improvement, the indicator of orders delayed during the day is within 30% and 40%; therefore, the proposed improvement has had significant results. The percentage of picking time reduction that the improvement had was determined and it is close to 33%.

The proposed location of the items of each family group in the warehouses reduced the time in which an order is attended Before the improvement, operators took approximately 30 to 140 seconds to prepare a box; now, by applying the improvement and assigning a specific location to each family group, it is easier and faster to find them. Regarding the time an order remains from the time it enters to the time it leaves, before, a single order could be handled in [93.18 ± 19.68] minutes; after the relocation of the families of items, this indicator decreased to [46.98 ± 6.15] minutes. As for the time in queue per order, before several orders were accumulated because of the time it took to attend one, it was between [33.01 ± 12.47] minutes; after the proposal this improves considerably to [6.39 ± 2.87] minutes approximately. About the percentage utilization of storekeepers, this used to be [86.14 ± 4.84] %, but by reducing the order picking time, they even have periods in which they do not have orders to attend to, so their utilization has been reduced to [65.44 ± 4.15] %.

In addition, the indicator for the number of orders in backlog per day decreased from [5.03 ± 1.5] orders to [1.83 ± 0.56] orders. As evaluated, it is from a reduction of 20% to more that the application of the ABC methodology was relevant to the research; and with the result obtained by the implementation, it was possible to reach a reduction of approximately 33%. The achievement of this results can be also supported in the study conducted by the authors Gutiérrez et. al. (2019) who reduced order preparation times in a national distribution center, where they propose a mathematical model of linear programming for the relocation of SKUs in the warehouse and, therefore, reduce picking times. As a result, they obtained time savings for the three types of orders they handle, being 10.33% for type 3, 8.81% for type 4 and 6.69% for type 2. Other benefits obtained were savings in operating costs, organization in the warehouse, reduction of staff movements and impact on workers' health.

6. Conclusion

The results obtained after simulating the order preparation process in the warehouse of a company located in the province of Barranca, show that it is possible to obtain reductions in the delay of orders by relocating the family groups according to criteria based on the ABC methodology. In addition, the reduction in the time in which an order is attended from [93.18 ± 19.68] minutes to [46.98 ± 6.15] minutes increases the productivity of the work performed in the warehouse, which allows a greater number of orders to be covered. This was achieved thanks to the fact that each family of items was analyzed and placed, according to rotation criteria, in groups A, B and C; of which the first group was assigned to warehouse 1 and the rest to warehouse 2, with the objective of minimizing distances by optimizing routes and thus reducing the picking time taken by the storekeepers. Finally, the picking time indicator was reduced by approximately 33% with respect to the initial warehouse scenario. This value is considered significant because it exceeded the 20% that was determined as the minimum value in the statistical tests, and managed to reduce the average number of late orders per day from [5.03 ± 1.5] orders to [1.83 ± 0.56] orders.

In this research article, the current scenario of the picking process has been compared with different possible scenarios to determine if the impact of the proposed improvement would be relevant or not. The application of the ABC methodology has a positive impact on the reduction of picking times; and, therefore, also on other indicators. In this case, the increase in productivity in the picking process has had a positive impact on the reduction of the main indicator of this scientific article, which is the number of orders delayed during the day.

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