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Conference Paper

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Design of Self-regulating Planning Model

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Purpose: This research aims to develop a dynamic and self-regulated application that considers demand forecasts, based on linear regression as a basic algorithm for machine learning.

Methodology: This research uses aggregate planning and machine learning along with inventory policies through the solver excel tool to make optimal decisions at the distribution center to reduce costs and guarantee the level of service.

Findings: The findings after this study pertain to planning supply tactics in real time, self-regulation of information in real time and optimization of the frequency of the supply.

Originality: An application capable of being updated in real time by updating data by the planning director, which will show the optimal aggregate planning and the indicators of the costs associated with the picking operation of a company with 12000 SKU's (Stock Keeping Unit), in which a retail trade of 65 stores is carried out.

Keywords: Linear Programming, Linear Regression, Aggregate Planning, Cost Minimization

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1 Introduction

The prognosis is made to be aware of the demand and the future conditions of the market, the companies use planning as a strategic tool, which transforms the prognosis into plans that allow satisfying the consumer's requirements. The aggregate plan is thus an important informative actor along the supply chain which affects the demand of suppliers and customers (Chopra, 2008).

That is why some of the engineering tools that most impact the production processes, are those for programming and planning. These tools are implemented with the aim of reducing process times and associated costs, giving clear guidelines on what to do, how to do it, where to do it and who does what, with the objective of maximizing the efficiency of both operators and the lines of processes (Borissova, 2008).

In Colombia, the mixed market of drugstores has a ratio of one drugstore for every 100,000 inhabitants which is 43.1% in Latin America, followed by Brazil, Mexico and Chile. With a growth of 12.6% between October 2017 and the same month in 2018 of the platform studied, which manages four product categories, these include medicines, personal care, beauty, and baby care and where business is comprised 50% of medicines, and the other 50% is distributed in the other categories mentioned above. The categories that have the best performance are analgesics, cleaning products, personal care, and natural products, the latter of which have a growth of 6.8%, the frequency of purchase for Colombian consumers is every 34 days, of which 52% of buyers plan their purchase (Dinero, 2019).

The current market forces all companies to use technology along the value chain, not only for its internal processes but also external ones, such as

sales through virtual channels, which represent 20% of the platform studied. This generates a logistical-level challenge because it requires satisfying the demand in shorter periods of time, generating high logistical costs.
The percentage of the logistics cost of sales in Colombia, according to the National Logistic Survey of 2018, represents 13.5%, which is composed of the following: cost of storage (46.5%), transport cost (35.2%), cost of administration and customer service (11.1 %) and other costs (7.2%); the cost of storage being an important factor within the total weighting, therefore the need to concentrate their efforts on reducing this type of cost is evident (Alonso, Martínez, Dorado,Páez, Lota, 2018).
This industry has created the need to optimize its planning in accordance with the logistical costs, as is intended with this project, which consists of the preparation of an aggregate planning, whose objective it is to calculate the real time, the optimal quantity to be ordered, and the reorder point - using the information found in the demand history and the support tools for linear programming solutions, such as the extension "Microsoft Excel solver".

2 Machine Learning and Logistics

At present, the advanced analytics, or Big Data, is very important as a support to the planning of an organization, since it is employed to manage large volumes of information and obtaining working data of different sources and formats. All of this is done in order to apply statistical calculations or different mathematical analysis tools that allow one to obtain current data, to identify flaws and to improve operations.

However, advanced analytics is not able to learn or make decisions independently. This is how the concept of artificial intelligence (AI) arises: it is the capacity of a machine to carry out processes without any intervention, having access to the data supplied by the Big data. The machine is able to learn patterns or characteristics provided by the information, and thanks to the acquired learning it creates knowledge, which generates intelligent actions that become more precise over time (Pereira, 2018).

Making use of this technology in the context of the industry 4.0 allows the understanding of data from different sources along the value chain through AI, and to make support decisions in real time, managing to optimize the quality of production, energy-saving, equipment performance (Rüssmann, 2015).

The supply chain in the industry 4.0 uses a branch of the AI called machine learning, which allows the discovery of patterns in the data through algorithms; these identify which elements that have greatest influence in the supply network by means of continuous learning. The algorithms find new patterns every day without human intervention or some previously established classification. This allows orienting the search, making use of models based on restrictions they find. A set of x elements with high predictive accuracy identify patterns that influence supplier quality, inventory levels, demand forecasts, purchasing processes, production planning, and transportation management. Through the entire value chain, companies have the freedom to evolve considerably, resulting in them being more competitive thanks to automatic learning skills (Columbus, 2018).

A machine algorithm learning is a linear regression, which is the most rudimentary algorithm of the branch of machine learning. This method models an objective value, which is based on independent predictors, it's main use concentrates on making forecasts and discover cause-and-effect relationships between dependent and independent variables.

In simple linear regression to a linear relationship between the independent variable (x) and dependent (y), were to quantify this relationship an objective function is used, which allows one to find the best possible values by minimizing the sum of used square errors in the set of variables. This is the best fit line of the data involved and the best data found that these problems can minimize the error between the predicted value and the current (Gandhi, 2018).

The linear regression was interpreted through linear programming to project the future supply in an optimal and timely way to the shelves of the picking area for each SKU (Stock Keeping Unit).

3 Linear Programming and Added Planning

Linear programming is the first instance of modeling reality problems at a computational level, however, to solve the problem is only the first step, since the objective of this investigation is to create the basis of a program that solves problems by using new data. In order to accomplish this, it needs to create a relationship between linear programming (as a subset of the convex programming, which has a linear objective function f (x) linked to a set of linear equations and inequalities) and the general principle of optimization applied to artificial intelligence through machine learning (Julian, 2016).

Planning is a tool that allows satisfying the demand by optimizing the resources of the system. An aggregate plan is characterized by considering the time horizon, both in the medium and the short term. The criteria of

decision are based on the maximization of profit, which is understood as the difference between the income and the costs, this is why it can be seen as the criteria decision for the minimization of the total costs.
Given the free modeling features of linear programming which involve a lot of restrictions, the solution of the added plans or problems that seek to minimize not only costs, but also resources, can be achieved thanks to the help of an extension for Microsoft Excel called "Solver", which is suitable for solving these types of problems. This application is very popular in the academic and professional field, because of its versatility and ability to give optimal answers according to the reality of the system (Anon., 2017).
In researching of (Granja, 2014), the object is focused on reducing the waiting time of patients, which has generated a problem in regard to the public sector versus the private sector's inability to withstand the growing demand. The results obtained by the investigation, give to understand the importance of the use of linear programming, showing reductions of 38% in the total waiting time of patients.
In another study, the planning area of the mining industry has made use of classical linear programming based on goal programming systems, using multiple objective functions that reduce variations, reserves, and mixtures, ensuring compliance with the tonnage specifications in short and long term planning, reaching the best operational scenario that respects the cost restrictions present in the situation valued (Souza, 2018).
Another industry shows another example, a mixed linear programming model was designed, which presents a multi-objective function that aims to minimize production costs, employee turnover and, in turn, maximize sales while maintaining or improving quality service (Gholamian, 2015).

4 Impact on the social responsibility of employees

Customer satisfaction is reflected in the response times given by the market. For this, the distribution centers deliver products to the sales channels correctly and quickly. The automation of the processes through the use of new technologies of the industry 4.0 has allowed the logistical activities to achieve greater speed in the answer of the orders. However, not everything is positive, given the improvements in speed of the system, the employees of these distribution centers must intensify their work in order to keep up with the rhythms imposed by the automated areas, generating job insecurity and dissatisfaction, as evidenced by the investigation of (Fernández, 2011) in the distribution center of Inditex (Zara).

Any imbalance between human capacity and technology, creates dissatisfaction, either by internal customers or external customers. Unlike in the previous case, where the dissatisfaction of the employees was due to the excess of technology, in this investigation, the lack of technology has generated dissatisfaction of the employees for their long working hours.

The lack of adequate planning generates not only costs associated with the inventory, but also overtime per employee (€ 1.61 / hour) and a high rate of staff turnover. These two consequences have been recognized, given the increase in work outside of regular shifts, resulting in widespread discontent in the workers, which correlates to the monotony of the work and the high workload of more than 10 hours a day.

Keeping in mind the new planning in the process of shelf assortment, the workforce will not intervene in the supply of the products, which contributes to the elimination of delays caused by reprocessing, which is represented in an increase of overtime, of up to 4 hours daily. This will allow the daily work to be accomplished within the established schedule, avoiding additional costs for overtime.

5 Case Study

5.1 Company and Process Background

The regulations on health, the arrival of foreign competition with new sales formats has forced the traditional drugstore chains to reinvent themselves. They sell €1,537 million approximately each year, according to Euromonitor data.

Its new business plan is to strengthen medicine sales, representing 50% of the total sales and the inclusion of OTC (over the counter) or over-the-air products.

In the case of large areas, as is the case with the drugstore platform involved in this research, their annual sales represent €135 million approximately in 2018, according to Euromonitor data.

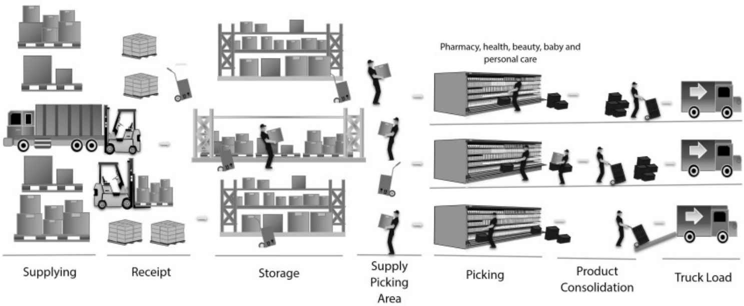
However, according to ASOCOLDRO (Asociación Colombiana de droguistas y detallistas), there are adverse factors in the market such as smuggling, counterfeiting, and unfair competition, currently affecting market prices. Despite this, the sector has grown between 5% and 8% per annum, regarding employability, ASOCOLDRO issued figures show that 52% of the workforce was female and 48% was male (Dinero, 2015).

The competition in Colombia of the large areas in 2016 is comprised of, according to ASOCOLDRO, 3000 small commercial establishments, of which

98% belong to urban areas and 2% to rural areas, 25% of these establishments are single family and 75% belong to pharmaceutical chemists (Espectador, 2016).

5.2 The Process

The process of supplying is carried out in a frequent way but not for the same reference, the moment a product is about to go out of stock or has been completely out of stock, it proceeds to request the transport of the storage using a forklift from the corresponding rack to be supplied with the



shelves of picking

Figure 1: Distribution center process

Once any of the points of a sale send the record of the sales made of any product, a request of supply of that specific SKU (Stock Keeping Unit) arrives, as well as the quantity. This data is registered in the technology platform of the pickers indicating this information to supply this product at the specific point of sale; by using a container which will have the products requested by a store, the operator proceeds to collect these items.

When the container is ready, the process of labeling is carried out with the supplied information about the products, as well as the destination, they are then taken to the loading area, where they will be waiting to be transported to the different points distributed in different cities of the country. See “Figure 1”.

Table 1: Times of process

Process	**Time (s)**
Storage per box	37,5
Supply picking area per product	63,4
Picking per product	25,92
Order consolidation	37.68

The times of the processes are evidenced in Table 1, these times have direct implications associated with operation costs.

6 Methodology

6.1 Data Gathering

The products chosen for this research are OTC (Over the counter), within this group are medicines that do not require a medical prescription, personal care products, beauty, and baby care products. The data obtained was the result of the collection of information during fieldwork in January

2019. Additionally, classified products of the 3 reference types were taken (A, B and C), and because the mode of operation is cross docking, none of the references have storage. This indicates that the least amount of time a product takes to leave the distribution center is 3 days, and the most are 7 days; for this reason, all products were considered as having a high turnover (Aldana, 2014).

6.2 Forecast of Demand

To make the demand forecast, the linear regression method was used, which consists of finding the relationship between one variable with another, in the case of this study, the existing relationship is between the demand and the days, generating, as a result, the following mathematical formula:

$$y = ax+b \tag{1}$$

$$a = \frac{n\sum_1^6 xy - \sum_1^6 xy}{n\sum x^2 - (\sum x)^2} \tag{2}$$

$$b = \frac{\sum_1^6 y - a\sum_1^6 x}{n} \tag{3}$$

Where,

X= The number of days from Monday to Saturday (1 and 6).
Y= The daily demand that was presented in the company's database.
n= The number of demand history data that was used to find the linear regression. See Table 2.

Table 2: Forecast of Demand – Linear Regression

	Demand data						**Forecast**					
Description	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Acetaminofen adultos 500mg tabletas caja	8	0	0	0	0	0	5	4	2	1	-1	-2
Atiban 2mg tabletas caja x30tab. pfi	0	6	6	0	0	0	4	4	3	2	1	1
Epítasis 3g sobres caja x6sob.	2	8	8	2	2	2	6	6	5	4	3	3
Esparadrapo leukoplast 7.5x4.57cm. x1und.	0	1	1	0	0	0	1	1	1	1	1	1
Aspan 50Mg Tabletas Caja x30Tab. Siegfried	0	1	1	0	0	0	1	1	1	1	1	1

Demand data: shows the BUO (Basic order unit) daily demand of each reference per day, in some cases, the demand is equal to zero given that at the points of sale there has been no sale of the product.

Forecast: shows the BUO (Basic order unit) daily forecast of each reference per day, taking into account the database of the demand of the company, through linear regression, in some cases the forecasts are negative numbers, this is due to the fact that the demand is zero units, which means that for that day it is not necessary to make an order.

6.3 Model formulation

The construction of the model went through several stages; these are described in detail below.

Stage 1: Gathering the necessary information for the implementation of the model correctly as historical demand, in-place inventory for each reference, storage capacity in picking and distance from the stock storage area to the corresponding picking storage area.

Stage 2: Based on the data found, we proceed to determine the costs of maintaining the units in inventory, of making an order and the waiting time to supply, and the lead time of the product, with which we proceeded to calculate the minimum security stock to have a 95% service level.

Stage 3: Through linear programming a supply planning model is built with the Solver tool in which the decision variables are established such as the optimal quantity of inventory, order size, restrictions of maximum inventory capacity, productivity and minimum level of inventory whose objective is to minimize the costs of the operation of supply and storage in picking. See Table 3.

Table 3: Solver supply planning model

Reference	I_i	Q_i	ss_i	L_i	Restriction on Inventory	Restriction on Capacity	Restriction on Productivity
Acetaminofen adultos 500mg tabletas caja.	*	*	12	4,9	8	72	94
Atiban 2mg tabletas caja x30tab. pfi	*	*	4	0,7	51	360	686
Epítasis 3g sobres caja x6sob.	*	*	4	0,7	60	370	686
Esparadrapo leukoplast 7.5x4.57cm. x1und.	*	*	2	4,6	28	60	105
Aspan 50Mg Tabletas Caja x30Tab. Siegfried	*	*	1	0,7	23	96	686

* Take into account that, to solve the model in the solver, these spaces are left, since, in these, the optimal solution appears

Description of Solver supply planning model:

Ii: Optimal units in the inventory of each reference.

Qi: Optimal order size for each reference.

SSi: Security stock is the minimum level of inventory that allows meeting the customer's demand with a service level of 95%, a value of k and d of 1.64 for a normal distribution corresponds to this percentage.

$$SS_i = k \cdot \sigma_d \cdot \sqrt{L} \tag{4}$$

Li: Lead time is the time that elapses between the order being placed and the delivery of the order.

Restriction Inventory: This restriction guarantees that the customer's demand is 100% satisfied.

Restriction Capacity: This restriction ensures that the units in the inventory do not exceed the maximum capacity of the distribution center.

Restriction productivity: With this restriction, it is ensured that the productivity goals will be met within the available times of the working day. Later in this document, section 6.3.3 explains the formulation of each of the restrictions.

Stage 4: The model of the horizon is constructed that will show the programming of the assortment for the following week, in this the references are related to the corresponding data that allow me to find the variables that will allow the operation of the model as they are; available per hours of inventory, daily demand and its deviation, and basic unit of order, among others. Behind it, the planning model that will provide the data for the column of the size of the order is linked, and the reorder point is calculated from the inventory given by the solver. See Table 4, 5 and 6.

Table 4: Horizon Model part 1 –Product Characteristics

Product Characteristics									
		Product Location							
ABC	**Reference**	Sector	**Hall**	**Rack**	**Level**	**Position**	**BUO**	**Available. (Und.)**	**Demand (Und.)**
C	Acetaminofen adultos 500mg tabletas caja	1	13	11	4	4	9	21	1
A	Atiban 2mg tabletas caja x30tab. pfi	4	2	1	1	5	70	57	2
C	Epítasis 3g sobres caja x6sob.	4	1	1	2	7	74	68	4
C	Esparadrapo leukoplast 7.5x4.57cm. x1und	1	4	14	1	3	50	29	0
B	Aspan 50Mg Tabletas Caja x30Tab. Siegfried	1	7	16	3	10	12	24	0

* Take into account that, to solve the model in the solver, these spaces are left, since, in these, the optimal solution appears.

Table 5: Horizon model part 1 – Inventory Policy Configuration

Inventory policy configuration										
			Reorder		Order					
ABC	Daily Demand+	Daily demand	Hours	Days	Days	Hours	Q_i	Shelving	Available/Hour in-	Demand / Hours
C	5	1.0	*	*	7	93	*	27	72	1
A	5	1.0	*	*	3	187	*	70	152	1
C	7	1.0	*	*	7	118	*	74	109	1
C	1	1.0	*	*	7	300	*	50	174	1
B	1	1.0	*	*	5	144	*	24	144	1

* Take into account that, to solve the model in the solver, these spaces are left, since, in these, the optimal solution appears.

To develop the aggregate planning model, the planning horizon is established for a day and the demand to be supplied is identified, based on the demand histories given by the organization.

Supply Program								Horizon								inventory at the end of the week (Days)
								Friday				Saturday				
Reference	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Cartons	8	11	14	15	8	11	14	15	
Acetaminofen adultos 500mg tabletas caja	Supply						1	174	171	168	166	166	163	160	158	16
Atiban 2mg tabletas caja x30tab. pfi							5	72	69	66	64	64	61	5	56	3
Epítasis 3g sobres caja x6sob.							1	152	149	146	144	144	141	138	136	13
Esparadrapo leukoplast 7.5x4.57cm. x1und							2	109	106	103	101	101	98	95	93	8
Aspan 50Mg Tabletas Caja x30Tab. Siegfried							1	144	141	138	136	136	133	130	128	12

Table 6 : Horizon model part 2

To make a better description of the model, each column will be described:
Horizon model part 1:

ABC: Classification of products in categories ABC according to the rotation of the said reference.

Code: «Article code» or «Reference number».

Product Location: Coordinates of the product location in the distribution center as its respective one; sector, hall, level, rack, and position.

Sector: Zone of the winery to which it belongs.

Hall: Hall in which the shelf is located.

Level: Level of the rack in which it is found numbered from 1 which is the closest to the ground.

Rack: Subdivision of the shelf where it is located

Position: Specific position of the product inside the cubicle

BUO: Basic ordering unit.

Available: Units of the product in the storage area.

Demand: Units demanded by the client; information of its historical data granted by the company.

Daily demand +desviation: It is equivalent to the daily demand summation of said reference plus the deviation of that demand.

Daily demand destivation: It is the deviation of the daily demand for that product.

Reorder: This point indicates when the order must be placed either in hours or days of optimal inventory using the tool Solver

$$ROP_i = \frac{I_i}{D_i} \quad (5)$$

Order: Q Is the optimal order size for each reference, this value is extracted from running the optimal supply model by means of the solver tool.

$$Q = Q_i \quad (6)$$

To this item belong the following four columns: Hour, Days, Q, and shelving.

Hour: Duration of my inventory in stock in hours.

$$\text{Duration inventory}=\frac{\text{Inventory in shelving(units)}}{\frac{\text{Demand+desvaition(units)}}{\text{8 (hour)}}} \tag{7}$$

Days: Duration of the inventory in stock in days

Q: Corresponds to the optimal order size for each reference. This value is extracted from the execution of the optimal supply model by means of the Solver tool.

Shelving: Round the order size Q, according to the multiple of the BUO.

$$\frac{Q}{BUO} = \text{Enterer} \tag{8}$$

$$\frac{Q}{BUO} * BOU \tag{9}$$

$$\text{Available /hour inventory} := \frac{\text{Available(units)*Hour}}{\text{Gondola(units)}} \tag{10}$$

$$\frac{\text{Demand}}{\text{hour inventory}} := \frac{\text{Demand+desviation(units)*Hour}}{\frac{\text{Shelving(units)}}{\text{8(hours)}}} \tag{11}$$

Available/Hour inventory: Equivalent to the product among the reference units on the shelf for the hours of inventory on shelving.

$$\text{Available/Hour inventory} = \frac{\text{Available*Hour}}{\text{Shelving}} \tag{12}$$

Demand/Hour inventory: It is equivalent to the product between the daily demand and the deviation from the reference for the hours of duration of the inventory on shelving, all the above about 8 hours a day of the working day.

$$\text{Demand/Hour inventory} = \frac{\frac{\text{Daily demand +desviation*Hour}}{\text{Shelving}}}{8} \tag{13}$$

Horizon model part 2:

Supply program: This section of the Table, the planner calculates the day to provisioning on the shelf. This allows the process of preparation of all references to be carried out in an automatic way with the ability to exercise greater control of the workforce. Likewise, the units to be supplied in the form of corrugated boxes are shown.

Horizon: In this, the working days of the week are divided into 4-time slots of three hours each, and the units in stock are calculated with the following conditional equation.

$$\frac{\text{AV}}{\text{Hours}} \leq \text{Reorder(Hours); Order(hours)} + \frac{\text{AV}}{\text{Hours-(Demand*3)}} \tag{14}$$

$$\frac{\text{AV}}{\text{Hours}} \geq \text{Reorder(Hours);} \ \frac{\text{AV}}{\text{Hours-(Demand*3)}} \tag{15}$$

The column inventory at the end of the week shows the equivalent of the units in inventory in days, for how many days this inventory reaches me to meet the demand of the customers.

Furthermore, it is possible to observe the items that were used to find the costs associated with the supply plan. See Table 7.

Table 7: Costs associated with the supply plan

Item	Price	Unit
Inventory maintenance cost	0,001	€ /unit/day
Logistic operator direct	0,02	€ /hour
Forklift cost	0,04	€ / hour
Ordering cost	0,01	€ / unit/ chance
Lead time	0,07	minutes

Inventory maintenance cost:

$$\text{Inventory maintenance} = 33{,}6\left(\frac{\text{Cm}^3}{\text{unit}}\right)*0{,}008 = 0{,}001\,\frac{€}{\frac{\text{unit}}{\text{day}}} \tag{16}$$

Logistic operator direct workforce cost: It has one operator.

$$\text{Logistic operator direct workforce} = 1\text{hour}*1{,}22\,\frac{€}{\text{hour}} = 1{,}22\left(\frac{€}{\text{hour}}\right) \tag{17}$$

Forklift cost: It has one machine.

$$\text{Forklift cost} = 1\text{hour}*2{,}49\,\frac{€}{\text{hour}} = 2{,}49\left(\frac{€}{\text{hour}}\right) \tag{18}$$

Ordering cost: It has one machine and one operator.

$$\text{Forklift \& logistics operator cost} = 1\text{hour}*3{,}71\,\frac{€}{\text{hour}} = 3{,}71\left(\frac{€}{\text{hour}}\right) \tag{19}$$

Total costs: It is equivalent to the sum of the product between units in inventory by the cost of keeping the inventory plus order size by cost make an order.

$$\sum_{i=1}^{12.000} I_i \cdot C_{si} + Q_i \cdot C_{Pi} \tag{20}$$

Initially, the company established an ABC classification for its products, the ABC analysis consists of applying the Pareto 80/20 principle to segment the products. In this case, the inventory is classified according to its importance, based on the inventory value of each reference, the inventory value is calculated by multiplying the annual demand by the unit cost. Then, the results are sorted and grouped according to the percentage they represent with respect to the total; this percentage is accumulated until completing the approximate for each category as follows:

- Category A: It is estimated that 20% of the references are equivalent to approximately 80% of the value of the inventory.
- Category B: 30% of the references are equivalent to approximately 15% of the inventory value.
- Category C: 50% of the references are equivalent to approximately 5% of the inventory value.

For this situation, a reorder point of 6 hours is applied, and the size of the order Q depends on the ABC classification. That is, the order represents 3 days of inventory for category A products, 5 days of inventory for category B, and 7 days of inventory for category C. Using the maintenance costs of the inventory and its supply in the current planning model, the associated costs were calculated, resulting in € 17,907.48 per day.

Table 8: ABC Cost Classification

Classification	Inventory	Q_i	ROP (hour)	Cost keep inventory	Cost order	Total
C	203	9	6	0,0021	0,0000 082	0,0021 082
A	4	73	6	0,00036	0,0000 027	0,0003 627
C	94	36	6	0,00078	0,0000 027	0,0078 27
C	61	21 9	6	0,0056	0,0000 087	0,0056 087
B	94	18	6	0,00024	0,0000 027	0,0002 427

Applying the self-regulating planning model, optimal amounts of maintenance and supply were determined, obtaining a cost of € 14.852.17 per day, showing a savings of 17%, annually represented in € 1.07 million. See Table 8.

6.3.1 Decision variables and vectors

Variables

I_i The number of units in stock in picking area for the reference i.

Q_i The number of units to be ordered from the storage area for the reference i.

Vectors

C_i Maximum capacity in units of reference i.

Cs_i Cost of maintaining a unit in stock of reference i.

Cp_i Cost of ordering a storage unit of reference i.

L_i Lead time of the reference i.

Ii_i The initial invention in the picking area of reference i.

D_i Daily demand per reference i.

SS_i Security stock of reference i.

The next step in the construction of the model is establishing the objective functions.

6.3.2 Objective function:

Minimize the total cost of the organization during the time of the planning, in this case, it is one day.

$$\text{Min Z} = \sum_{t=1}^{8311} I_i \cdot Cs_i + \sum_{t=1}^{8311} Q_i \cdot Cp_i \qquad (21)$$

6.3.3 Subject to:

The productivity of the workforce: The productivity of the workforce is defined as the relationship between time, work time, delivery time, and the number of units ordered. The working day is 8 hours daily.

$$\frac{(8 \cdot 60)}{L_i} - Q_i \geq 0 \tag{22}$$

Inventory: The inventory of the reference I must be equal to the inventory in the immediately previous period, plus the order size made in that period, minus the required amount, and minus the inventory that must remain in stock, in order to guarantee the production flow.

$$Ii_i + Q_i - D_i - I_i = 0 \tag{23}$$

Picking capacity: The number of daily units in inventory cannot exceed the capacity of the picking area.

$$I_i \leq C_i \tag{24}$$

Security stock: The daily units in the inventory of reference, cannot be less than the security stock.

$$I_i \leq SS_i \tag{25}$$

Constrain positive: Ensure that the variables take positive values.

$$I_i, Q_i \geq 0 \tag{26}$$

7 Results

The quantity obtained with the solver model of the supply plan of the inventory units and order size for the first six SKU's (Stock Keeping Unit), is detailed in Table 8 and the reorder point is detailed in Table 9, from these data the costs of maintaining and ordering were calculated. The cost for the first six SKU's (Stock Keeping Unit). with the proposed model is detailed in Table 11.

Table 9: Available inventory and quantity to order

Reference	I_i	Q_i	**Units**
Acetaminofén adultos 500mg tabletas caja.	12	4	Units
Atiban 2mg tabletas caja x30tab. pfi	51	0	Units
Epítasis 3g sobres caja x6sob.	60	0	Units
Esparadrapo leukoplast 7.5x4.57cm. x1und.	28	0	Units
Aspan 50Mg Tabletas Caja x30Tab. Siegfried	23	0	Units

Table 10: Reorder point by product

Reference	ROP	Units
Acetaminofén adultos 500mg tabletas caja.	0	Days
Atiban 2mg tabletas caja x30tab. pfi	8	Days
Epítasis 3g sobres caja x6sob.	7	Days
Esparadrapo leukoplast 7.5x4.57cm. x1und.	28	Days
Aspan 50Mg Tabletas Caja x30Tab. Siegfried	23	Days

Table 11: Inventory costs

Reference	Inventory maintenance cost	Ordering cost
Acetaminofén adultos 500mg tabletas caja.	€ 0.024	€ 0.33
Atiban 2mg tabletas caja x30tab. pfi	€ 0.018	€ *
Epítasis 3g sobres caja x6sob.	€ 0.046	€ *
Esparadrapo leukoplast 7.5x4.57cm. x1und.	€ 0.016	€ *
Aspan 50Mg Tabletas Caja x30Tab. Siegfried	€ 0.0054	€ *

*Cost equal to zero since there is no requirement for that product, this scenario is possible because there is an inventory available.

The product “Acetaminofén” in Table 8 has an inventory (Ii) of 12 units and to order (Qi) of 4 units. In Table 9 the reorder point is equal to 0 since the order is the same day. This reorder point is calculated from the units in the inventory of the solver and the associated daily demand. The cost associated with an inventory of this reference in Table 10, shows an inventory maintenance cost of € 0.024 per reference per day and a cost of the ordering of € 0.33 per reference.
The total costs of maintaining inventory and the total cost of orders was € 14.852.17 per day for all SKUs.

8 Improvements

The development of such applications is characterized by economic and standardized, such as Excel, it makes the operation of the company faster and more effective through planning and an autonomous system that automatically updates, having information current in the cloud. and building a competitive advantage over the supply chain. However, Industry 4.0 talks about cutting-edge practices with software and advanced robots, creating a paradigm that is almost impossible for medium and small companies. This publication is intended to convey the opposite message. Industry 4.0 is also knowledge, regardless of the medium or the tool, as long as a practice determined by this fourth generation is guaranteed, in the particular case, through an approach to artificial intelligence. For companies that do not have the necessary resources to invest in an ERP (enterprise resource planning), this application can guarantee the planning of a high number of SKU’s (Stock Keeping Unit), with an attractive cost-benefit ratio for the small companies.

The aggregate planning has an important role in the economic field since it allows to meet the requirements of the clients and to save resources. The optimization achieved through fields of artificial intelligence as it is the machine learning which uses multiple algorithms such as linear regression based on the principle of minimization of linear programming allows companies to:

- Determine the optimal level of inventory in real time without any intervention.
- Reduce storage costs based on demand data in real time.
- Adapt inventory policies autonomously depending on the market situation.
- Improve productivity at levels that surpass the best possible case without the use of 4.0 technology
- Assertive management of demand variability.

9 Relevance in the Sector

In Colombia, logistics costs are equivalent to 13.5% of the final price paid for the product, keeping this in mind, a reduction in the percentage directly and positively impacts the acquired profit; i.e. the lower the production costs, the higher the profit. This allows their prices to be more competitive compared to the drugstore and retailer sector, which creates a healthier competition that benefits consumers and the whole drugstore market economy. This also encourages the growth of better planned supplying systems, propelling this sector to be at the forefront of the logistics field.

Taking into account that technology in distribution centers is very expensive for small and medium enterprises, this application shows through the guild, that tools and technology 4.0 are available to organizations for free or economic. For example, Excel, cloud, QR readers, etc. With this development, the intention is based on stimulating innovation in the planning of complex operations, which have a high cost in their processes, and generating creativity with low-cost technological tools, breaking the paradigm that technology and revolution 4.0 are a high-cost fashion.

10 Conclusions

This autonomous system, with clear policies in the optimal management of inventories, especially in the picking areas, pulls the operators to be more continuous in their operation, in such a way that they can finish their processes at the end of the shift, without needing to generate over time.

The implementation of the proposed plan is expected to achieve a service level of 95%, as well as an optimal minimization of costs at 6.28 % associated with the logistics process of storage.

The indirect cross docking process seeks to reduce the inventory at the minimum or to an almost non-existent point, with the quantity of inventory and the size of the order indicated in the plan, it is reduced to the quantity of inventory that best allows to carry out the operation of supply.

The decrease in the costs associated with the logistics process will generate greater profitability in the sector due to the impulse of a much better-structured supply. By applying the proposed model, a saving of € 1 million is evidenced by year, representing a 17% decrease in costs associated with the process, generating a strong competitive advantage in the market.

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