ÓBUDAI EGYETEM

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THESIS

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Title of the thesis: Cost and management optimization of logistic in the work of a private enterprise

Task description:

1. Read the prevalent article and book on this topic
2. Make your hypothesis
3. Collect data and build a database. Analyse the data.
4. Write the conclusions

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1. LITERATURE REVIEW

Historically, the warehouse activity has been seen by the company as just another cost that did not provide extra value. However, delocalization processes and growing demand have meant a change in the conception of warehouse operations and management. (Richards, 2017).

Optimization is a process or a methodology of making something as fully functional as possible, for this purpose we need performance measurement to quantify the efficiency of the activity.

Warehouse management is becoming a necessary activity in the supply chain to generate a competitive advantage over competitors. This is because they are trying to establish improvements to improve customer service, delivery times, and cost reduction. Therefore, it brings extra value that was previously not believed. (Faber, B.M. de Koster, & van de Velde, 2002).

This paper aims to provide a set of tools that can facilitate such management. Performance is measured for a variety of reasons: for improving results, avoiding annoyances until it is too late, keeping track of customer relations, controlling processes and costs, optimal use of storage space, and ensuring quality. Typically for each activity, basic key performance indicators (KPIs) have been developed to have a clear overview of the process and material flow. Whether there are bad results or poor efficiency, the process must be improved.

In our case, studying not only logistic but also economic ratios is the best way to improve the performance, but indicators will not be the only tool to work with, mathematical data analysis could be a perfect help to also obtain conclusions. As a result, logistic costs have become increasingly important in global production costs; indeed, they have become necessary because of the increased product variety and faster demand response imposed by the market. The PILOT manual encourages that supply chain management should be seen as a whole process, and not as a sum of functional areas with different objectives and with a limited view of the impact of certain actions on internal and external customers and suppliers, which is why although the thesis focuses on warehouse management, it will also study the input and output of materials in production and other processes that complement and make the company function. (Price Water house Coopers, 2000).

This resource will help me to optimize one warehouse, the reduction of these logistics costs lowers the overall cost of products sold, allowing businesses to earn a higher profit margin or gain a cost advantage over their rivals.

2. COMPANY IN A FEW WORDS

During the realization of this thesis, I have worked with an enterprise that chooses not to reveal its name and neither the products with which they work. I would like to respect their decision and thank them for their cooperation by providing all the data and information required.

This company has been chosen as the object of study because they have offered to provide the necessary data in exchange for an external view of the behaviour of their work plant, more specifically the warehouse, to learn about the procedures that are carried out within the company, both in terms of purchasing and supplies, as well as transport management, the management of the location of products within the warehouse, and a large part of the decisions that are taken within the warehouse management.

The layout is an adaptation made by AutoCAD by me all the rest information, line orders, state of the silo, errors, and evolution of the families were given in excel format. As a listed company, it is obliged to publish its annual reports annually, which is why the financial information has been found on the internet.

3. METHODOLOGY

The approach is based on a case study and is divided into several stages. A study of the literature, backed up by scientific papers, is presented in the first level. The main objective was to acquire knowledge, look into research case studies in the same context and analyse the methodologies used. In the second stage, one describes the procedure and flows of the materials on the company´s floor. In the third stage, one proceeds with the analysis of storage product types and characteristics, as well as existing locations and the identification of the warehouse process. One also analyses the most adequate Lean tools for the context using key performance indicators, the financial data has been modified with a correction factor between 1,5 and 2. The fourth stage consists of the conclusions and problems detected in the enterprise as well as possible solutions.

4. KPIs SELECTION AND THEORIES BASES

Warehouse management is a key element in achieving the optimal use of warehouse resources and capacities depending on the characteristics and volume of the products to be stored (Poirier and Reiter, 1996).

There are different processes and systems in warehouse management such as reception, storage, order preparation, packing, and dispatch, so before configuring them, it is recommended to analyse the type of product to be stored, the capacity and operability of the warehouse, available information and communication technology, customer demand and location, and the characteristics of the orders to be delivered to satisfy customer needs at minimum cost. (Alexander Alberto Correa Espinal 2010)

The principles for optimal warehouse management include coordination with other logistics processes, balance in the management of inventory levels, customer service, and flexibility to adapt to the changes of a globalised business world.

In this way, Mulcahy (1993), Urzelai (2006), Mauleón (2006), and Harnsberger (1997) indicate that the objectives to be sought with warehouse management are:

Minimise:

- The space used, to increase profitability;
- Investment needs and inventory management costs;
- Risks, including those related to personnel, products and physical plant;
- Losses, caused by theft, breakdowns, and lost inventory;
- Handling, whereby the routes and movements of people, material handling equipment and products must be reduced through the simplification and improvement of processes;
- Logistics costs through economies of scale, reduction of shortages, and delays in the preparation of shipments.

Maximise:

- Product availability to meet customer orders;
- Storage capacity and product rotation;
- Warehouse operability;
- Product protection.

It should be noted that the first two maximisation objectives are partially opposed, so their level of implementation must be balanced, since greater storage capacity tends to reduce the warehouse's operability.

According to the Heineken company, when talking about a warehouse, 7 points must be touched upon. The first is Planning, which is defined as the ability to organise the warehouse resources (personnel, space, and equipment), to manage the costs of operations efficiently, while meeting the service requirements of the internal and external customer. Then there must be excellence in execution by being able to organise and direct the daily workflow of warehouse activities to meet internal and external customer requirements. There must be good asset management by selecting the appropriate equipment

(warehouse space, forklift, racking, loading docks, etc.) to execute cost-efficient warehouse operations and maintain them in good working conditions following applicable regulations (safety, maintenance, etc.). There should also be management reporting to produce timely and accurate data to prepare reports on storage operations and ultimately interpret and explain the figures to relevant stakeholders. Sustainable storage is important as is the ability to maintain the warehouse as a safe environment for both staff and visitors in accordance with regulations, to ensure the quality of stock, and to prevent defective quality products from moving down the supply chain. In addition, there must be inventory management ensuring that all inventory movements are carried out under instructions received and recorded properly and promptly to ensure stock accuracy and finally warehouse service provider management overseeing the execution of warehousing activities outsourced to warehouse service providers to ensure the required level of service and cost.

Rouwenhorst et al. (2000) argue that the logistics costs of warehouse operations are determined to a large degree during the warehouse facility's design. Therefore, the design of the plant studied during the thesis is observed and criticised. As a result, strategic planning of this activity and the actions identified for operational support is critical. The use of Lean Manufacturing tools in logistics has become extremely relevant in this context since their main objective lies in cost reduction, as well as in the elimination of any waste sources within the organisation. To that end, the Lean methodology aims to remove all that does not add value to the final product. These factors, however, are often considered to be of paramount importance in the value chain, as they affect consumer satisfaction and market response performance.

Antonio Iglesias, a logistics and supply chain specialist, defined logistics indicators in an article for the ESAN university as: "Quantifiable performance measures applied to applied to logistics management that make it possible to evaluate the performance and the result in each operational process result in each operative process carried out in the work chain". (Iglesias, 2019)

In this study, the measurements of the indicators related to the warehouse and its management are going to be carried out with the aim of showing how important is the strategic management of the warehouse for a company, and how this management is going to be conditioned and in turn, will have a consequence on the rest of the company.

Following the indications of the PILOT manual, measuring is one of the most important actions a company must take because what cannot be measured cannot be managed. It is therefore vitally important to establish key indicators throughout the supply chain that allow us to systematically and efficiently evaluate the "health" of our chain. But it is not enough just to measure, we must establish objectives and identify the causes that have prevented us from achieving these objectives, otherwise, there will be no learning from mistakes. The indicators or KPIs should be related to the vision, mission, and objectives of the company. In addition, they must be meaningful and focused so that they can be acted upon, and they must be consistent and comparable so that they can be related to each other and compared with measures already taken in the past. Finally, they should be simple and easily understandable, and there should not be a large number of indicators. (Price Water house Coopers, 2000)

Once the set of indicators are extracted from papers, they are classified according to the dimensions of time (Mentzer & Konrad 1991; Neely et al. 1995; Gallmann & Belvedere 2011), quality (Neely et al. 1995; Frazelle 2002; Gallmann & Belvedere 2011), cost (Beamon 1999; Keebler & Plank 2009), and productivity (Frazelle 2002; Keebler & Plank 2009).

KPi selected from the time area:

- **Dock to stock time:** lead time from supply arrival until the product is available for order picking. (Ramaa et al.2012).
- **Shipping time:** lead time to load a truck per total orders loaded. (Campos 2004).

KPi selected from the Productivity area:

- **Inventory utilization:** rate of space occupied by storage. (Rama et al.2012).
- **Warehouse utilization:** rate of warehouse capacity used. (Bowersox et al.2002).
- **Shipping productivity:** total number of products shipped per period. (Mentzer and Novack 1999).

KPi selected from Cost area:

- **Labour cost:** cost of personnel involved in warehouse operations (Cagliano et al. 2011).
- **Maintenance cost:** cost of building maintenance and equipment maintenance (Johnson et al. 2010).
  The experience throughout history indicates that machines decrease in performance over time, affecting their useful life. But on the other hand, we also know that by eliminating the degradations that cause these inefficiencies, we can bring production equipment up to acceptable quality levels.

  Thus, maintenance appears as a set of actions aimed at extending the useful life of any equipment and installation, reducing costs, avoiding unnecessary stoppages, contributing to the unnecessary stoppages, contributing to the quality of manufacturing, the useful life of any equipment and installation and serving as a support to the production process and the company. There are two types of maintenance: corrective maintenance is the one performed after failure and preventive maintenance is the one performed with the intention of reducing the probability of failure of an asset. (Jesús A. Royo Sánchez 2004)

KPi selected from Quality area:

- **Storage accuracy:** storing products in proper locations. (Vos et al. 2005).
- **Storage quality:** storing products without errors. (my definition).
- **Receiving accuracy:** pallets unload without incidents. (my definition).

Financial ratios are statistical comparisons of accounts or categories in financial statements. Internal company management may use these relationships between financial statement accounts to determine how well a corporation is doing and what areas need to be improved.

Ratios allow us to compare companies from various industries, both large and small, in order to determine their strengths and weaknesses.

-Activity ratios are used to evaluate a company's operational performance.

- **Stock turnover:** is an efficiency/activity ratio that calculates how much a company sells and substitutes the entire batch of inventory in a given timeframe. (Irfanullah Jan 2019).
- **Days inventory:** The number of days it takes for inventory to be converted into sales. (U.S security and exchange commission 2014).
- **Collection period (days):** it refers to the time it takes, on average, for the company to receive payments it is owed from clients or customers. (Corporate Finance Institute).
- **Credit period (days):** is the time frame between when a customer purchases a product and when the customer's payment is due. In other words, this is the amount of time a customer has to pay for the product. (Corporate Finance Institute).
- **Working capital turnover:** is a metric that calculates the amount of revenue produced per dollar invested in working capital. (Obaidullah Jan 2013).
- **Fixed assets turnover ratio:** is an activity ratio that measures how efficiently a company is generating revenues using its fixed assets. (Obaidullah Jan 2013).

-Liquidity ratios assess a business's liquidity, i.e. its ability to convert its assets to cash and pay off its obligations without any significant difficulty, delay, or loss of value. As a supplier, these ratios are very interesting.

- **Current ratio:** with this ratio the capacity of a corporation to cover its current liabilities with cash obtained from its current assets is calculated. (Obaidullah Jan 2013).
- **Cash ratio:** this ratio considers only a company's most liquid assets for example cash and marketable securities. They are the assets that a business can use to pay short-term debts the quickest. (Obaidullah Jan 2013).

-A solvency ratio is a crucial criterion for determining whether or not a company can satisfy its long-term debt obligations.

- **Return on assets:** (ROA) is a profitability ratio that calculates how efficiently a company's assets have been used to produce a profit. It is determined by multiplying the period's net income by the average total assets. (Obaidullah Jan 2013).

5. THE DESIGN OF THE WAREHOUSE

Warehouse layout is a basis in the industry, it determines the efficiency and in some cases the survival of an enterprise, however, it could vary a lot depending on the structure of the business.

The internal distribution aims of the warehouse, are to hasten the speed of order´s preparation, the precision of these, and the efficiency of the placement of the stocks.
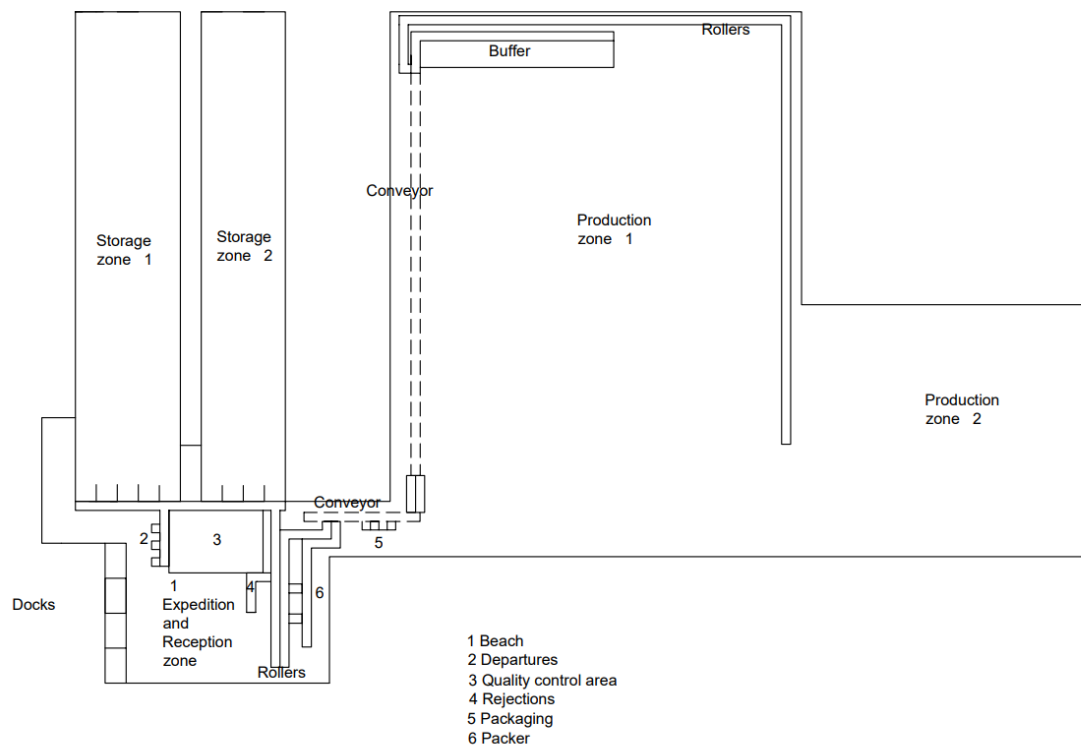
1. Figure: Layout of the Enterprise

Source: own elaboration

This layout corresponds with the production and storage floor of the enterprise, the products come and go through the 4 docks located on the left bottom side. There we can find the beach rack-free area, located in front of the docks, where merchandise is temporarily deposited on the ground waiting to be transported to another location.

All the products are transported in euro pallets of 800 x 1.200 mm and the movement inside the building is made up of rollers or conveyors. The product storage is fully automatic, once the pallets are in the roller, the tag is read, and the height and the weight are measured. Knowing these characteristics, the system decides in which corridor and in which position it should be. If an error is produced during the lecture there is a reduced zone with capacity for the rejected pallets.

They use a barcoding system which is widely used in the industrial world. It is used to identify products, keep an exhaustive inventory control, and control the loading and unloading of goods in warehouses. First of all, this system requires the implementation of label printers and electronic barcode readers. In addition, the system can be easily integrated with management software to optimize warehouse processes.

2. Figure: Label used by the company.

Source: the company

On the right bottom side, the number corresponds with the pallet, and on the top left side with the container.

The storage has 9 corridors with a left and a right side to each of them, 13 levels, and 65 channels, so in total it has a capacity of 13.176 pallets.

3. Figure: Right side corridor 9 occupation.

Source: SGA system

As I previously mentioned, the storage is divided into different zones regarding how tall it is, how heavy it is and how much refrigeration the product needs.

<250 kg	Super light
250-500 kg	Light
500-850 kg	Heavy
>850 kg	Error → reconfiguration

1. Table: Weight criterion

Source: own elaboration

< 0,5 m	Super low
0,5-1 m	low
1-1,5 m	Tall
>1,5	Error → reconfiguration

2. Table: Height criterion

Source: own elaboration

Room T°	Tempered
12-24°C	Cold
2-6°C	fridge

3. Table: Temperature criterion .

Source: own elaboration

Even though the warehouse is divided into zones, it follows a chaotic method. It is worth mentioning that there are no pre-assigned locations. Products are stored according to space availability, optimizing the time. The idea is that we can find one reference in two completely different locations and only the system knows where they are.Each type of pallet has a preference zone but also other possible zones where it could be located in case the first one was full.

In addition, they also have two different production zones and to ensure the quality of the products, they have a zone to test them. The conveyors are unidirectional, so if the raw materials are going to production, finished products can not go to storage at the same time. To minimize this problem, they have used buffers.

When the finished product arrives at the packaging area, they introduce them in their proper wrapper and consequently put the articles into different boxes. Finally, to wrap all the pallets in plastic they have a specific machine called a packer.

6. ANALYSIS

6.1. Silo analysis

As it is known, the silo is divided into different parts attending different characteristics, for example, Z01 corresponds with pallets heavy tall and with no need of refrigeration.
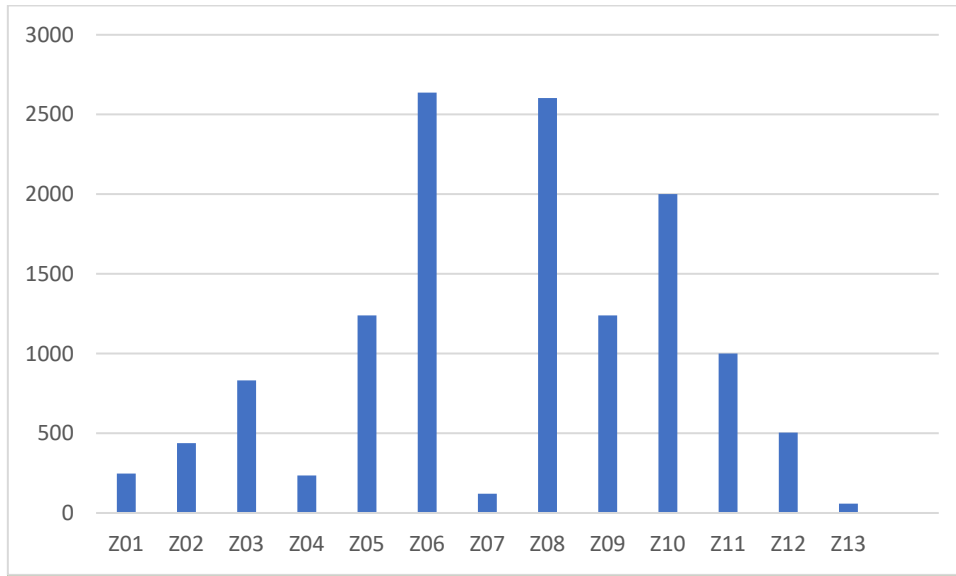
4. Figure: Holes of the Silo .

Source: own elaboration

This first figure shows how the silo has holes distributed in 13 different zones. The silo has a capacity of 2637 for the Z06 zone, usually for final products which need refrigeration and are low. There is also another zone with huge capacity, known as Z08, it is majorly destined for raw materials at room temperature. There is no criteria that says finish products must be in certain places and the rest of products in the remaining ones, it is the temperature itself that manages it. Usually, it is the final product that needs a lower temperature than the rest, but this is not always the case, which is why the use of this type of storage is very effective.

I have received an excel from the enterprise showing how was the silo on a particular day. The idea is to see how many products were in their preference zones, how many were in a non-preference zone and to know if the distribution of holes in the silo is correct.
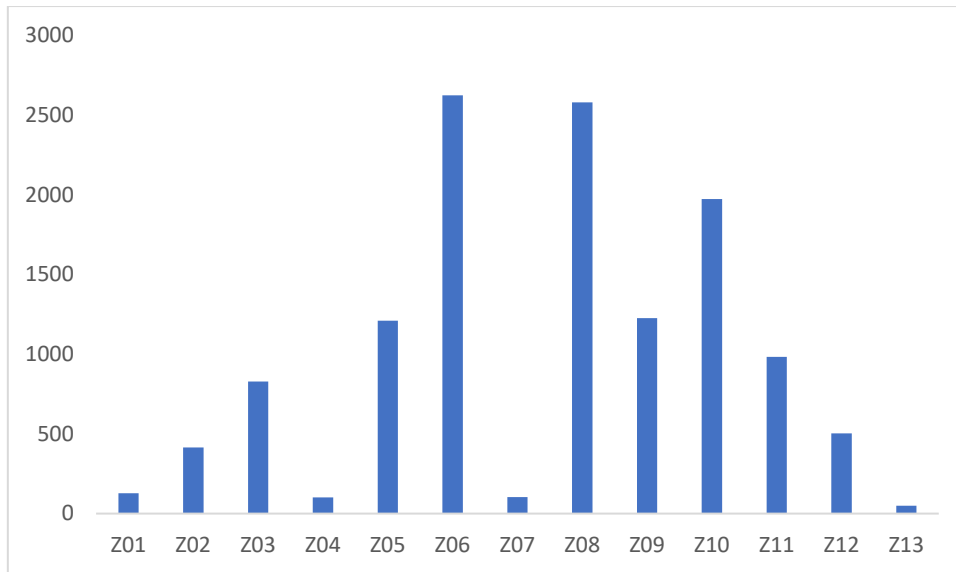
5. Figure: state of the silo 2/10/2019 .

Source: own elaboration

The figure above shows the state of the silo as of October 2, 2019. The figure below shows the assumed state of the silo if the products were in their preferred state without taking into account the silo capacity.
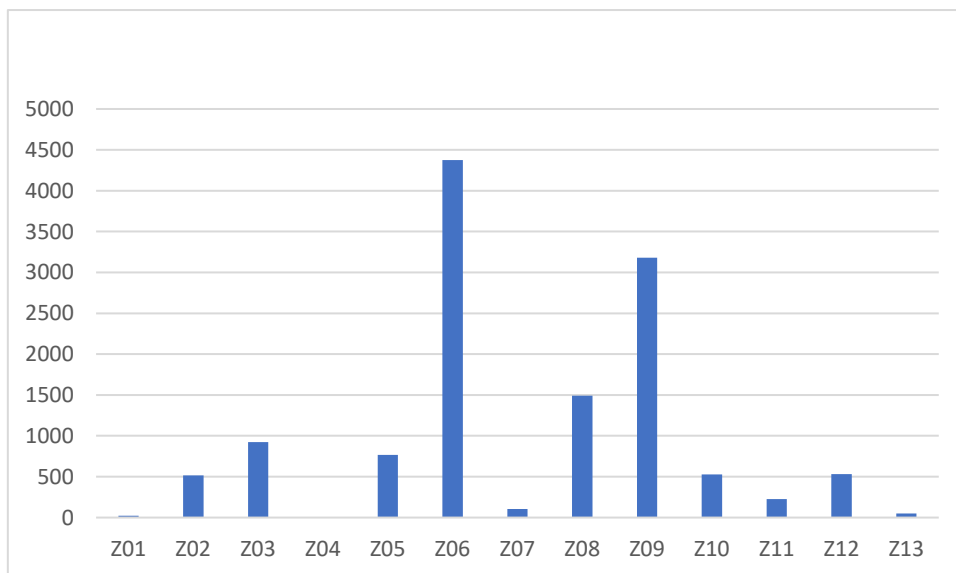
6. Figure: state of the silo with preference places 2/10/2019 .

Source: own elaboration

According to the preferences zones Z06 and Z09 should consist of many more holes, the consequence is that the system is locating short pallets in zones that are specifically for high pallets but with the same temperature. Specifically, the hole Z10 is facing this overload of pallets.

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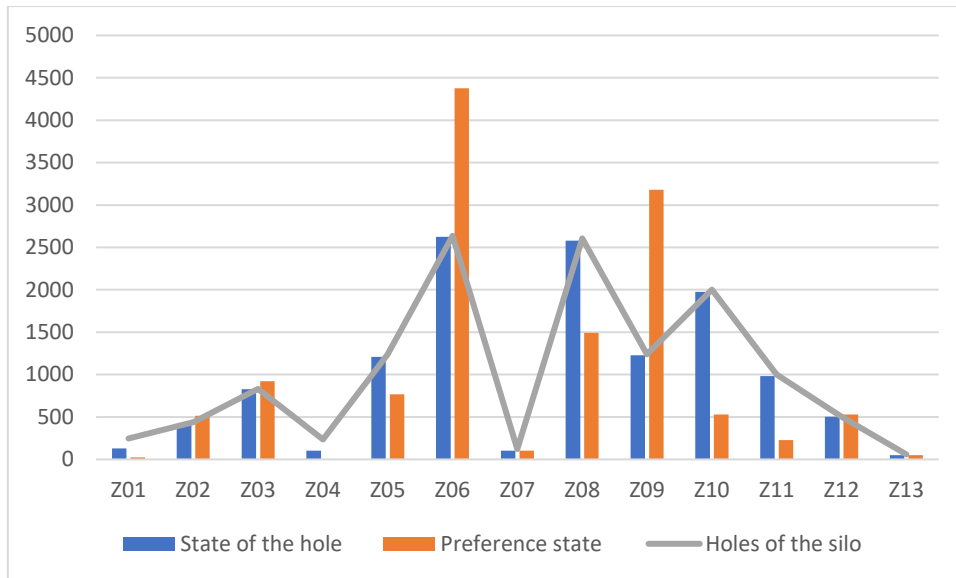
7. Figure: Comparison states   2/10/2019 .

Source: own elaboration

In this figure are represented the three previous figures, in such a way that the blue bars correspond to the real state of the silo, the orange ones the supposed preferential state, and the gray line represents the holes that the silo has destined for each zone.

We see that there is no much space in the silo so they are carrying a heavy load of stock at the moment. Therefore, there had to be relocations and the only zones with visible space are Z01 and Z04 corresponding with heavy zones, these areas are intended for very specific pallets, so this underutilization is acceptable. The Z07 and Z13 zones have been designed with few holes, but in the right way, as very few products have them as preferred zones, Z08 and Z10 are housing pallets that should not be there.

This type of logistics buildings are installations where the racks not only fulfil the function of storing the goods but also support the structure of the building. A change in the design of this would not be easy as the racks not only support the weight of the load, the roof, and the enclosures, but also other essential elements such as cabling and communication, and security systems.

6.2. Family analysis

Within the warehouse the products can be classified by families, the analysis of these groups over five months can give us an idea of which products have a higher turnover or which products are being overstocked. Furthermore, knowing the evolution of the occupation of the family permits us to identify what is the correct strategy of storage, in this case, the strategy comes determined by the temperature that each family needs.

The brown line called ZFP corresponds with the final products, what I can see, is that in august there is a stop in the production coinciding with the worker's vacations.
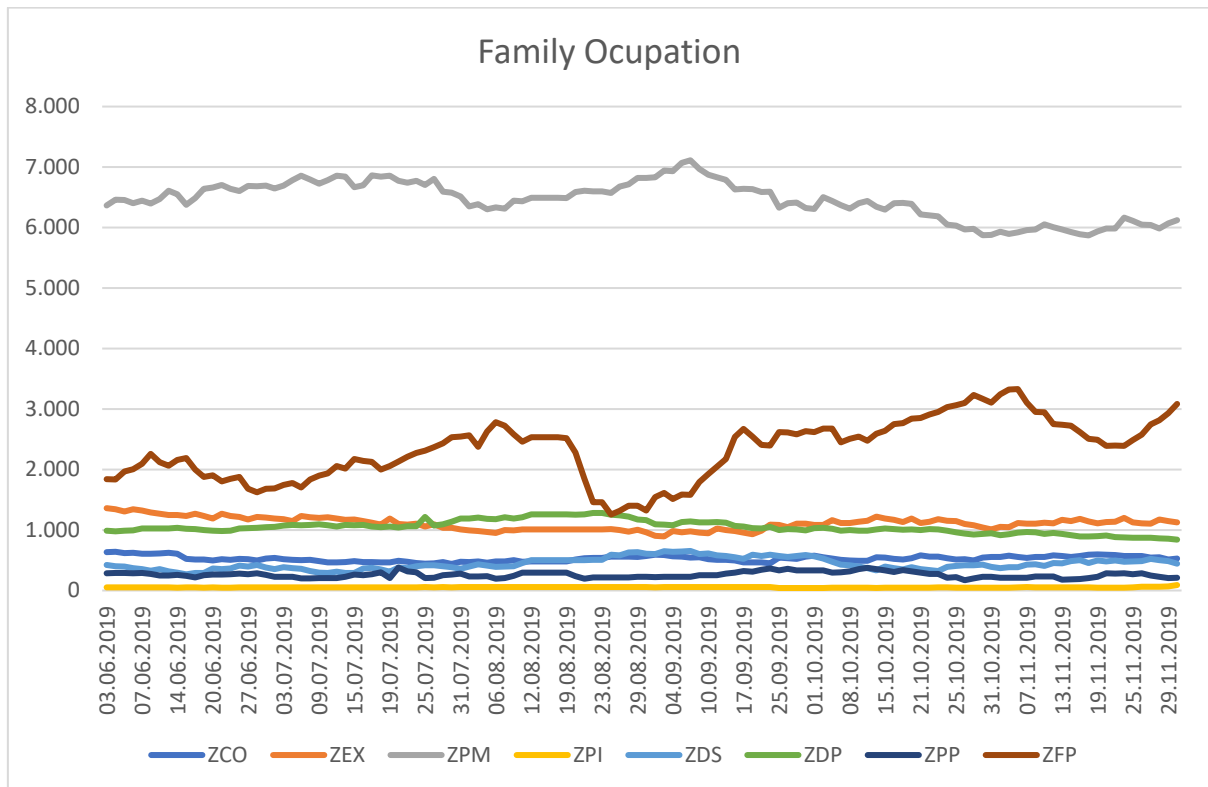
8. Figure : Evolution family stock .

Source : own elaboration

In this way we can take the average per family for the whole year and calculate the average silo capacity, thus correcting the low storage peaks at Christmas and in August when production is already reduced and the high production peaks due to sudden demand.

	Max	**Min**
ZCO	640	439
ZEX	1.361	894
ZPM	7.112	5.870
ZPI	90	42
ZDS	654	267
ZDP	1.282	841
ZPP	379	170
ZFP	3.330	1.256

Average occupation	12.216 holes occupied

4. Table: Evolution family stock .

Source: own elaboration

So, the silo would have a capacity of about 1.000 pallets more than the average to withstand unexpected variations.

In addition, raw materials ZPM occupy a large part of the silo's capacity, as expected, and do not vary greatly throughout the year.

5.3. Bottlenecks

The meaning of bottleneck in a company refers to that activity or phase of production that is usually slower or more costly and, therefore, generates downtime and delays in the rest of the production line. This also implies that some of the production phases and the resources involved in each of these phases, work below their capacity, which directly causes inefficiency in the production chain and an accumulation of stocks of unfinished products. This analysis improves throughput by strengthening the weakest link in the manufacturing process.

The possible bottlenecks in the enterprise analysed are:

- It is only possible to reject four pallets in the reading position, because it is the capacity of the rejected zone, if a fifth pallet is rejected it would provoke a collapse in the roller.

  I have received the different errors that the reading machine has had over 6 months during 2019. There are 6 different types of error. In the first place, the galibo error when the machine detects that the pallet is overflowing in some area and measurements are no longer exactly 800 x 1.200 mm. There is also, a lecture error when it is not possible to read the code, and other error when there is no space in the silo, if the machine accepts the pallets as valid but its place was occupied then it will return. Finally, there are also type pallet errors when there are new materials

with new heights and specifics temperatures and the system is not configured yet and the last is an error in the hole when the photocells detect an empty space and the system command to pick up that specific pallet.

system errors

- error galibo
- error lecture
- error type pallet
- error no hole
- error in hole
- error occupied hole
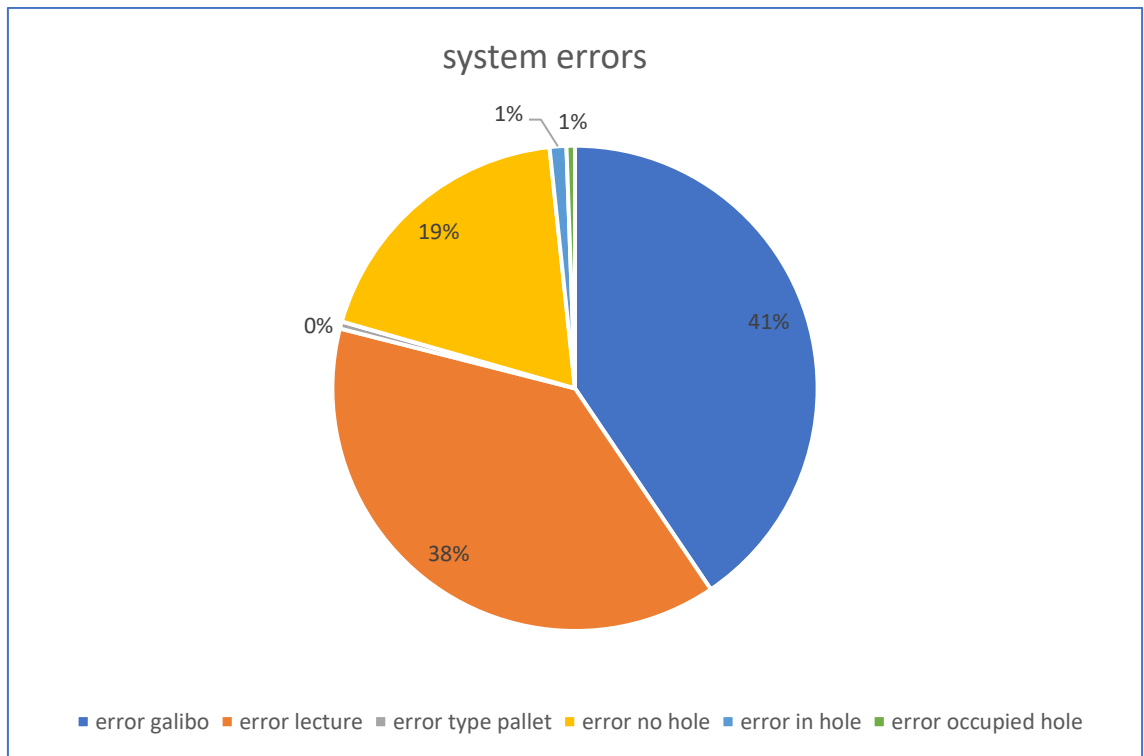
9. Figure: Percentage and type of errors

Source : own elaboration

The average error in one day is 78,28, knowing that the storage works 16 hours of the day, there are around 4,89 pallets rejected each hour, therefore a space with 4 seats for this area may seem a bit tight.

I also want to remark the huge quantity of galibo errors and lecture errors which account for 79% of all errors in the system. These errors could be probably fixed. Firstly, by informing the operators to change the way the labels are placed as the attempt to do it quickly may be causing the operation to be poorly executed, and secondly, by looking at the way pallets are being wrapped and packed, because the plastic may not be fitting as tightly as it should, causing this type of error.

The following figure shows the different types of errors during the six months of the period.
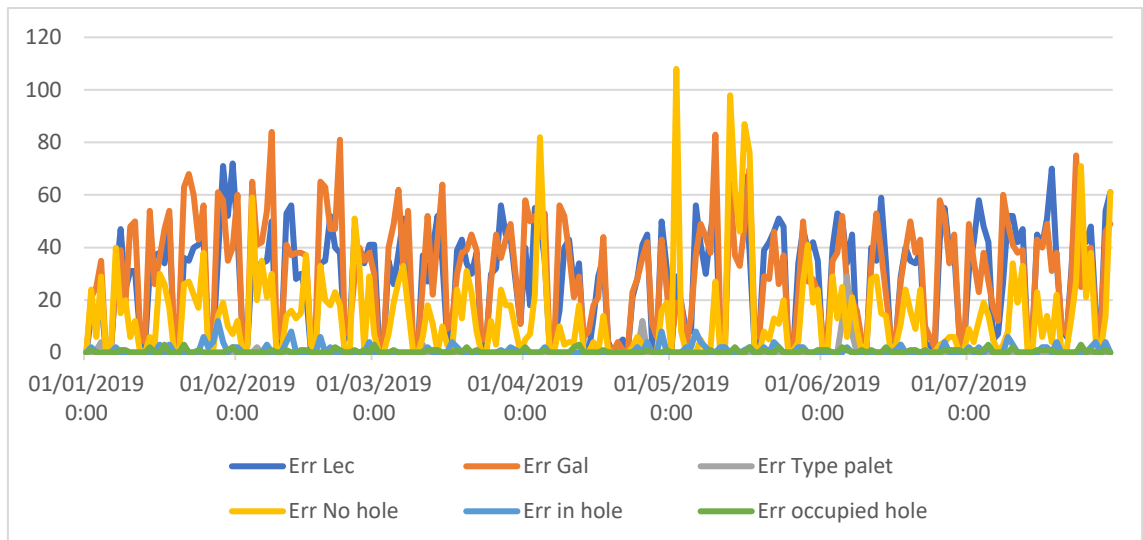
10. Figure: Evolution of errors

Source: own elaboration

In this figure, I can identify 3 periods of time when there was overstock in the storage: one in April and two in May. It is important to say that this pattern is just as harmful to the company as the lack of stock as it can lead to stock deterioration, increased storage costs and difficulty in movement flows. Therefore, in August there are hardly any errors in the number of occupied holes due to the holiday break. In general, errors are very irregular and inconsistent, with large peaks on specific days.

- In the silo, the products are introduced from the top and are extracted from the bottom. The connexion between both levels is a lift, so the volume and the flow of products will depend on the capacity and speed of this lift. From the data collected, we can see that there are around 1.397 extractions from the silo in a day, so the elevator must be able to handle a load of 59 pallets per hour, almost one pallet per minute.

- There are four packaging stations that limit the capacity of storage, taking into account the two different production zones, the demand for packaging has to be high. Knowing the locations produced in a day, it is possible to calculate the amount of load to be carried by each packaging workstation. A total of 10 pallets should be organised and packed at the time, with four positions.

- In relation to the previous point, there is only one machine packer that plasticizes the pallets before introducing them to the silo, which is about 40 pallets per hour, perhaps too much of a burden given the number of galibo failures that have occurred.

- The conveyor is unidirectional that produces the stop of some products making longer the time of movements.

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5.4. Inactive holes analysis

The inactivity of the products is one of the great problems that arise in the warehouses since it supposes a great expense that increases the final price of these. This is due to the fact that it is not only taking up space, but it does not allow new products to be incorporated and even increases the number of failures of the reading machine, which is why a study like this could be very useful.

Thanks to the information provided by the company, we can extract some interesting data:

Maximum days in the storage	1.055
Minimum days in the storage	0
Average days in the storage	40,93
Number of products storage more than 1 year	24
Number of product storage between 6 months and 1 year	376
Number of products with 0 days in the storage	404

5. Table : Inactivity data.

Source : Company information

- The products stored for more than one year are all from the same family ZCO .
- There are 157 products of raw material and 1 final product that have been stored for more than 6 months and it would need a justification.
- There are 54 raw materials that have been stored the day when information was captured and 5 final products.

The reason why the company has decided to store goods for a long period of time could be due to cyclical business situations. For example, it may be for a price advantage, if it is known that there will be a rise in product prices in the near future. In such cases, companies stock up on the necessary product or merchandise to profit from the increase in the price of the product by purchasing it before the increase. Another reason for stockpiling products is to cope with variations in demand so that when demand increases, it can then be replenished from inventory (Arrieta, 2002).

5.5 Using performance indicators

The goal of using these indicators is to find out the poor performance inside the warehouse in addition to have a good understanding of the events and the movement of materials. In this section, I would like to divide the ratios between financial and logistics ratios.

5.5.1. Financial ratios

Recent research carried out by CSCO (Chief Supply Chain Officer) just shows that there is a direct link between effective inventory management and corporate cash flow generation.

Activity ratios

- Stock turnover: For this indicator, it is necessary to know the revenue that a company generates from its primary business activity, in this case, the sale of its products and the money equivalent to the stock in storage.

Operating revenue/turnover	1.931.595.600
Stock	255.709.537

6. Table: Stock turnover data .

Source: Company information

$$\frac{\text{operating revenue/turnover}}{\text{stock}}$$

$$\frac{1.931.595.600}{255.709.537} = 7,55$$

- Days inventory: This rate is the inverse of stock turnover.

$$\frac{1}{\text{Stock turnover}} * 365 = \frac{\text{stock}}{\text{operating revenue/turnover}} * 365$$

$$\frac{255.709.537}{1.931.595.600} * 365 = 47,68 \ days$$

- Collection period (days): For this indicator, it is also necessary to know the amount of money that is due.

Debtors	263.523.078
Operating revenue/turnover	1.931.595.600

7. Table: Collection period data .

Source: Company information

$$\frac{\text{Debtors}}{\text{operating revenue/turnover}} * 360$$

$$\frac{263.523.078}{1.931.595.600} * 360 = 49,11 \ days$$

- Credit period days (days): For this ratio instead, we need the money owed to suppliers.

Creditors	142.679.112
Operating revenue/turnover	1.931.595.600

8. Table: Credit period days data .

Source: Company information

$$\frac{\text{Creditors}}{\text{Operating revenue/turnover}} * 360$$

$$\frac{142.679.112}{1.931.595.600} * 360 = 26,59 \ days$$

- Working capital turnover: For this indicator, it is necessary to know the difference between the current assets and the current liabilities, which is the same as the working capital.

Operating Revenue	1..931.595.627
Working capital	376.553.503

9. Table: Working capital data .

Source: Company information

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$$\frac{\text{Operating revenue}}{\text{Average working capital}}$$

$$\frac{1.931.595.627}{376.553.503} = 5,12$$

- Fixed Assets turnover ratio: For this indicator, it is necessary to know the average of the long-term assets

Operating Revenue	1.931.595.627
Average fixed assets	628.758.694,5

10. Table: Working capital data .

Source: Company information

$$\frac{\text{Operating Revenue}}{\text{Average fixed assets}}$$

$$\frac{1.931.595.627}{628.758.694,5} = 3,07$$

Liquidity ratios

- Current ratio : For this indicator, it is necessary to know the assets of a company that are expected to be sold or used as a result of standard business operations over the next year and also the short-term liabilities.

Current assets	546.905.821.5
Current liabilities	399.188.232

11. Table: Current ratio data .

Source: Company information

$$\frac{\text{Current assets}}{\text{Current liabilities}}$$

$$\frac{546.905.821,5}{399.188.232} = 1,37$$

- Cash ratio:

Current assets	546.905.821,5
Current liabilities	399.188.232
Stocks	255.709.537,5

12. Table: Liquidity ratio data .

Source: Company information

$$\frac{\text{Current assets} - \text{stocks}}{\text{Current liabilities}}$$

$$\frac{546.905.821,5 - 255.709.537,5}{399.188.232} = 0,73$$

Profitability ratio

- Return on assets (ROA): For this indicator, it is necessary to know the amount of money that the company earns after certain deductions have been removed from the gross income.

Annual net income	179.328.555
Average total assets	1.175.664.516

13. Table: Return on assets data .

Source: Company information

$$\frac{\text{Annual net income}}{\text{Average total assets}}$$

$$\frac{179.328.555}{1.175.664.516} = 0,1525$$

5.5.2. Logistic ratios

Time indicators :

- Dock to stock time : For this indicator, it is necessary to know how much time does the product stays on the beach, and how long does it take for the machine to reach the desired location.

Number of pallets stored from trucks	537
Total time	634:26:42

14. Table: Dock to stock data .

Source: Company information

$$DS_t = \frac{\sum \Delta t \, (DS)}{Pal \, Sto} = \frac{Time \; between \; the \; supply \; arrival \; up \; to \; product \; storage \; (hour)}{number \; of \; pallets \; stored \; (nb)}$$

$$DS_t = \frac{634:26:42}{537} = 1:10:43 \; hour/pallet$$

- Shipping time : For this indicator, it is necessary to know how long does it take for the machine to take a product and take it to the departures area in addition to the stay on the beach.

Number of exit corridors	3
The time between order and truck complete (min)	100
Number of pallets in the truck	42

15. Table: Shipping time data .

Source: Company information

$$Ship_t = \frac{\sum \Delta t \, (Ship)}{OrdLi \, Ship} = \frac{time \; between \; the \; order \; picking \; finishes \; and \; the \; truck \; is \; complete}{numbers \; of \; order \; lines \; shipped \; (nb)}$$

$$Ship_t = \frac{\sum \Delta t \, (Ship)}{OrdLi \, Ship} = \frac{90}{42} * 3 = 7,14$$

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Productivity indicators

- **Inventory utilization** For this indicator it is necessary to know the total space the silo has intended for storage, and which part of this is busy.

Number of holes of the silo	13.408
Number of holes occupied	12.725

16. Table: Inventory utilization data .

Source: Company information

$$Inv_{Utp} = \frac{Inv\ CapUsed}{Inv\ Cap\ =} = \frac{average\ space\ occupied\ by\ inventory}{total\ warehouse\ inventory\ capacity}$$

$$Inv_{Utp} = \frac{12.725}{13.408} = 0,949$$

- **Warehouse utilization** For this indicator it is necessary to know the measurements of the corridors of the silo, the space needed for the lift, and the dead zones that are useless in the silo.

Number of corridors	9
Area of the corridors	62,4 m2
Height of the corridor	15 m
Area of the lift	8,4 m2
Height of the lift	15 m

17. Table: warehouse utilization data .

Source: Company information

$$War_{Utp} = \frac{War\ CapUsed}{War\ Cap\ =} = \frac{average\ space\ occupied\ in\ the\ warehouse\ (m3)}{total\ warehouse\ \ capacity\ (m3)}$$

$$War_{Utp} = \frac{181.353}{189.907,5} = 0,954$$

- **Shipping productivity** For this indicator it is necessary to know, the numbers of workers and the hours worked of the shipping employees, and the total lines shipped.

Number of workers	2
Work shifts	2
Hours per shift	8
Days of the month work	20
Pallets in a truck	42
Trucks per day	4

18. Table: Shipping data .

Source: Company information

$$Ship_p = \frac{OrdLi\ Ship}{WH\ Ship} = \frac{number\ of\ order\ lines\ shipped\ (nb/month)}{sum\ of\ employee\ labor\ hours\ working\ in\ shipping\ activity\ (h/m)}$$

$$Ship_p = \frac{42 * 4 * 20}{2 * 2 * 8 * 20} = \frac{3.360}{640} = 5,25$$

Cost indicators

Thanks to this rate we will know more clearly where the money of the enterprise is going.

- Labour cost: For this indicator, it is necessary to know, the salary paid to the employees and the charges paid for all employees. There are 2 workers in charge of the outgoing products and 2 in charge of the reception of these, in addition, there is a morning shift and an afternoon shift.

Number of workers	4
Work shifts	2
Salary with charges per year	25.000

19. Table: labor cost data .

Source: Company information

$$Lab_c = Salary + charges + others\ (\frac{Euros}{year})$$

$$Lab_c = \ 4 * 2 * 25000 = 200.000\frac{Euros}{year}$$

- Maintenance cost: For this indicator, it is necessary to know what equipment is used to maintain the correct working of the machines.

They used preventive maintenance of each corridor that suppose the stop of the movements of these corridors during 3 days, the approximate cost that it causes is around 7000 euros per corridor, that includes not only the measurements and care of machinery but also the stagnation of stored stock. As all the companies it will also have a variable cost of corrective maintenance, it would be around 10.000 per year.

$$Maint_c = BuildC + EqMaintC + others \ (\frac{Euros}{year})$$

$$Maint_c = 7.000 * 9 + 10.000 = 73.000 \ \frac{Euros}{year}$$

Quality indicators

- Storage accurary : For this indicator, it is necessary to know where the pallets are located , their preferences and the total amount of pallets stored.

Number of pallets stored	924
Number of pallets in preference zone	599

20. Table: Storage accurary data .

Source: Compay information

$$Sto.a_q = \frac{Cor \ Sto}{Pal \ Sto =} = \frac{number \ of \ pallets \ stored \ in \ proper \ location \ (\frac{nb}{day})}{number \ of \ pallets \ stored \ (\frac{nb}{day})}$$

$$Sto.a_q = \frac{599}{924} = 0,6$$

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- Storage quality: For this indicator, it is necessary to know the number of errors produced by the storage system and the total pallets stored in one day .

Number of pallets stored	924
Number of pallets rejected	78,28

21. Table: Storage quality data .

Source: Compay information

$$Sto.q_q = \frac{Error\ Sto}{Pal\ Sto} = \frac{number\ of\ errors\ stored\ \left(\frac{nb}{day}\right)}{number\ of\ pallets\ stored\ \left(\frac{nb}{day}\right)}$$

$$Sto.q_q = \frac{78,28}{924} = 0,084$$

- Receiving accuracy: For this indicator it is necessary to know the number of pallets unloads without any kind of incident and the total pallets unload for production or shipment of final products .

Number of pallets unload	1.023
Number of pallets unload without incidents	980

21. Table: Storage quality data .

Source: Compay information

$$Rec_q = \frac{Pal\ corrects}{Pal\ unload} = \frac{number\ of\ pallets\ unload\ without\ incident\ \left(\frac{nb}{day}\right)}{number\ of\ pallets\ unload\ \left(\frac{nb}{day}\right)}$$

$$Rec_q = \frac{980}{1.023} = 0,9579$$

5. INTERPRETATION

The stock turnover ratio is a useful indicator of a company's ability to convert inventory into revenue. To determine whether a business is efficiently managing its inventory, the inventory turnover ratio should be compared to the industry benchmark. If sales are down or the economy is struggling, a lower inventory turnover ratio could be the result. A higher inventory turnover ratio is usually preferred because it means that a given amount of inventory generates more sales.

Comparison with other companies in the sector :

	Stock turnover
Company 1	5,26
Company 2	17,11
Company 3	5,79
Company 4	7,88
Average	9,01

21. Table: Comparison sotck turnover   .

Source: sabibvdinfo

The company has lower ratio than the average of its competitors which could mean they may overestimate demand for their products and buy an excessive amount of inventory.

A 47,68-day inventory ratio means that the company has the possibility to sell out of its entire inventory in 48 days. When the company considers that this ratio is higher than the preferred one they introduce discounts, product bundles, or other incentives to encourage customers to purchase more frequently. It is also important to understand how the ratio fluctuates over the course of the year due to seasonal sales periods peaks and troughs can help the enterpirse create an accurate inventory forecast for the future of your business.

The collection period represents the number of days between when a credit sale is made and when the buyer pays for it so the company will receive the money from their sales in about 50 days. A short average collection time means that the company receives payments quickly but on the other hand there is a downside to this, there is a possibility of losing clients due to the credit terms which are too stringent since customers might look for suppliers or service providers that provide more flexible payment terms.

	Collection period(days)
Company 1	110
Company 2	48
Company 3	97
Company 4	72
Average	81,75

22. Table: comparison collection period   .

Source: sabibvdinfo

The ratio from the company is more demanding than the others companies' ratio but they need to ensure that they have sufficient funds to fulfill their financial obligations on time.

The credit period determines the rate at which creditors are paid off during the year. It aids management in determining the efficiency with which accounts payables are managed. In this case, it takes an average of 27 days to pay.

	Credit period(days)
Company 1	39
Company 2	2
Company 3	13
Company 4	24
Average	19,5

23. Table: comparison credit period .

Source: sabibvdinfo

The company needs around 7 days more than its competitors to pay to their suppliers.

The working capital turnover ratio of the company is 5,12, a high ratio indicates that working capital is being used very effectively. A low ratio, on the other hand, could indicate that there are too many debtors or inefficient use of resources.

	Working capital turnover
Company 1	2,58
Company 2	5,37
Company 3	2,46
Company 4	3,841
Average	3,56

24. Table: comparison working capital turnover .

Source: sabibvdinfo

As a result of good asset management, the company has a higher ratio than the other selected companies in its sector.

Fixed assets turnover measures how well a company's property, factory, and equipment produce sales, the company has a 3,07 ratio and as I have stated before, it is really important to compare with the other companies of the sector .

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|	Fixed assets turnover
Company 1	2,25
Company 2	0,25
Company 3	29,.9
Company 4	0,29
Average	8.17

25. Table: comparison fixed assets turnover .

Source: sabibvdinfo

Leaving the result of the third company that may distort the average somewhat, the company studied uses effectively its assets to generate revenues.

As the company has a current ratio greater than one, 1,37, I can say that they have the financial resources to remain solvent in short term, otherwise with less ratio than 1 they would not have had enough capital to afford its short term obligations. Another way to see the liquidity of the company is the cash ratio. In this case, the short debt would only be paid with cash or near cash resources as it has a 0,73 ratio. This means that if the company is forced to pay all current liabilities immediately they would not be able to do it with the cash alone.

The ROA is an estimate of the efficiency in which the corporation converts its investments into net income. A higher Roa implies that the company is earning more money on less investment. As we can see in the graphic the company has been improving in the last 4 years
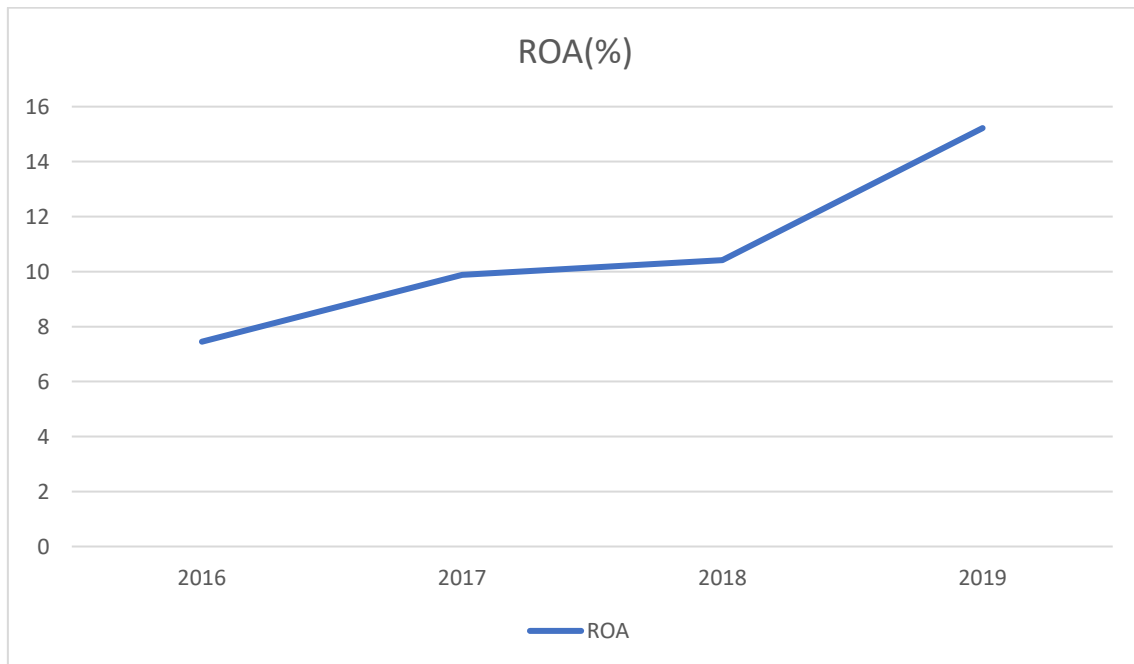


11. Figure: Roa Evolution.

Source: own elaboration

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The average time that a pallet needs to go from the dock to the correct hole of the silo and be prepared to supply the production is 1 hour 10 minutes and 43 seconds. Each truck has its unloading area on the beach, so this is the time it takes to place it there, put the corresponding labels, introduce it into the rollers and reach the corresponding site. The average time it takes for a pallet to be deposited at the exit area is 7.14 minutes. Thanks to the provision of three outfeed rollers, the loading of the complete truck are carried out more quickly.

The 94,9% of the hole is full which means that we have a large stockpile load and this trend is repeated throughout the year, except for August and Christmas, when the percentage can drop to around 80%. When we talk about the use of the warehouse we refer to the percentage of it that is dedicated only to storage, i.e. we want to minimize aisles and dead zones to the maximum and for this, an automatic silo as the one used by this company is one of the best solutions reaching a percentage of 95.4%.

The shipping productivity ratio defines how many pallets are being prepared by the operators in an hour of work, so taking into account that 4 trucks are filled every day and they have a capacity of 42 pallets they are preparing an average of 5,25 pallets per hour.

Storage accuracy provides us with the percentage of pallets that are actually in their preferred zone and not in an alternative zone due to lack of capacity reasons, so only the 60% percent are being colocated correctly .We also know that 8 out of every 100 pallets are rejected due to some type of error. The extraction of pallets from the silo is more efficient as 96% of the pallets are extracted without incident.

The cost of maintenance is a major investment for the company, as we see in the graph below, the company have to reach a balance between predictive and corrective maintenance. We know that preventive maintenance is necessary but there comes a point where this only increases costs and does not produce improvements. We also know that we will always have residual corrective maintenance due to the planned obsolescence of the machines.
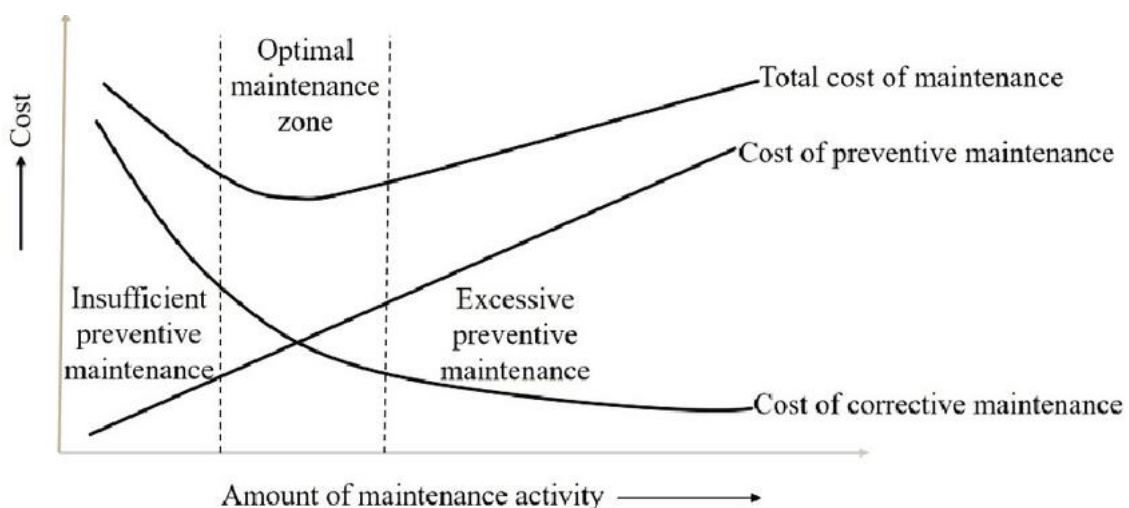

11.Figure: Maintenance cost

Source: Douglas, 2017

6. SOLUTIONS

-"Dock to Stock Time" can be reduced by introducing RFID a sophisticated system called Radio Frequency Identification Technology, which is a form of wireless communication between a reader and a transmitter. In this case between the system that organizes the storage and the pallets. In this way, they reduce operating costs and scanning operations because identifying products that have this technology is not necessary. The number of errors in lecture will be much lower because we are avoiding human error correctly putting the label.So this measure could provide us not only with an improvement in time but also in the long term in costs.
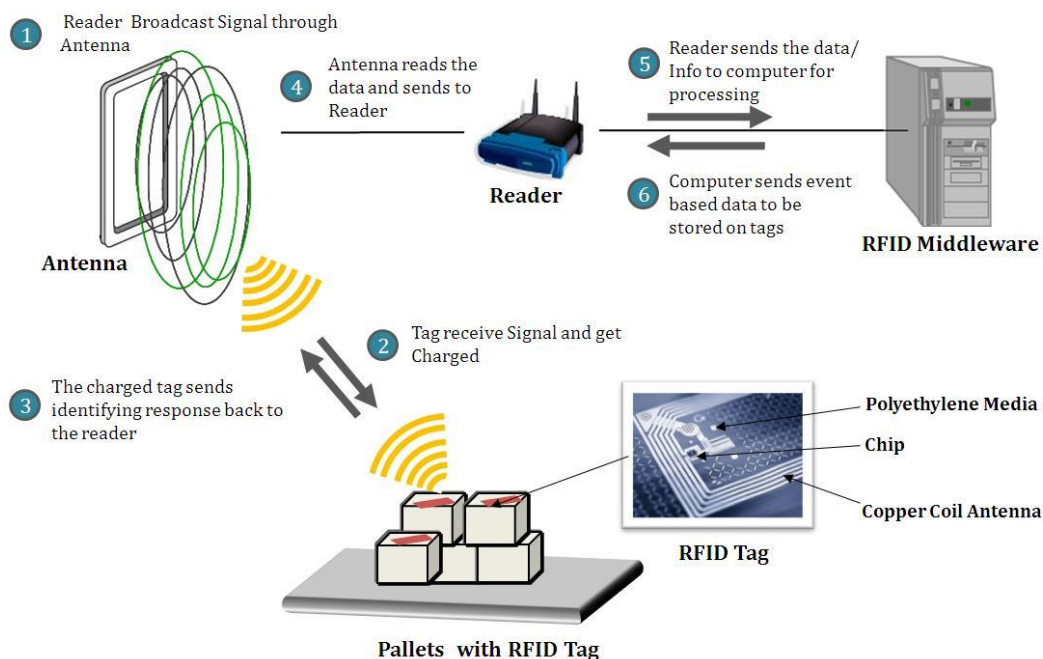
13.Figure: Data transmission process RFID

Source: DATENPEI 2015

Thanks to the logistical cost ratios we have been able to see the amount of money spent to pay for the picking and shipping workers, in the latter, they scan one by one the barcodes of the pallets, so a measure like the one proposed could reduce the number of workers and with them the cost. All this would be solved with an arch reader that would inform the system of the pallet being selected.

-Another cost-saving measure could be to incorporate AGV (Automatic Guided Vehicle) forklifts that can manage movements within the warehouse in a fully automated, accurate, and reliable way. In this way, the workers in charge of moving the pallets with the pallet trucks could be replaced by these vehicles connected to the warehouse management system.

14.Figure: AGV forklift truck

Source: Direct industry

The prices of these vehicles vary between 50.000 and 100.000 making the investment profitable in less than a year.

-Total productive maintenance is a strategy that emphasizes proactive and preventative maintenance in order to extend the life of the equipment. The strategy blurs the line between maintenance and production by emphasizing the importance of encouraging operators to assist in the maintenance of their equipment. It also creates a mutual responsibility for machinery that inspires plant floor employees to participate more. This can be very useful in enhancing the workings of the company's floor in the right environment (increasing time, reducing cycle times, and eliminating errors). Implementing this strategy could provoke a reduction of the corrective maintenance as well as a reduction of the number of employees dedicated solely to maintenance.

-Other possible measures that would help the company is the fact of continuous monitoring, i.e. receiving data on how each machine is performing in real-time to prevent possible failures or simply to have information on performance. This could also help to reduce the days on the hands of the products of the silo, as we have seen some products have not been moved for more than 3 years and lots of them for more than one year. This unnecessary cost produces an increase in the final price of the products. With accurate information, if a product stays more than a specific time established by the company, an alert must be shown and the product must look for a way out. Another way of looking at it is that by having a high occupancy rate we are considerably reducing the possibility of stock-outs. A stockout occurs when the company receives an order for a certain product from the customer and the product is not available in the warehouse in the quantities and conditions demanded. This incident generates very negative consequences, since not only the sale is lost, but also the image of the company itself is damaged. To avoid this situation

it is necessary to foresee the peaks of activity on key days and to take into account the seasonality of the sector, it is also helpful to calculate the forecasts for periods of time as close as possible since the distant future is more uncertain than the near future.

-OEE is a very wide measure in installations such as the company. Overall Equipment Effectiveness is an indicator that is widely used in companies with automated production processes as they are able to determine the overall effectiveness of their work teams. Effectiveness is a technical indicator that encompasses three fundamental factors: availability, yield, and quality rate. By means of the availability factor, we are taking into account the losses due to machine inactivity and system start-up, the performance factor takes into account the speed losses and the quality factor takes into account the errors and rejections.

$$Effectiveness = disponibility * yield * quality$$

Each company depends on the field that they are working and each will have different acceptable values, but the good ones for this company would be: more or equal than 90% in disponibility, more than 95% in performance, and 99% in quality. These values correspond with effectiveness of around 85%. The use of this indicator has led to the improvement of many companies, knowing in which aspects they should focus their improvement.

-One of the most important wastes in this enterprise is the physical flows of materials, as the area is too big and it is all automated they are currently using a mechanism of rollers and conveyors to transport the products. A simple change that would speed up the movement would change those unidirectional conveyor belts for others that could move the goods in both directions at the same time. Value Stream Mapping (VSM) is a methodology to improve physical flows by removing non-value added activities. This method is used to identify problems of this type, in this case, we would like to eliminate unnecessary waiting times.

- The storage accuracy indicator tells us that out of every 100 products we are placing only 60 in their preferred areas. The silo has been designed to establish super low, low, or high pallets, and in the end, in many cases, a super low pallet can be placed in a high area, so a reorganization of the silo could be of great help and could even increase the capacity of the silo or otherwise be able to reduce the number of channels or height reducing movement times.

-Despite being in a chaotic warehouse, where the products are randomly placed following criteria of height, weight, and temperature, we still have products with high, medium, and low rotation and immobilised products. If we were able to place the most used products closer to the exit lift and the less used ones further away, we would find another way to reduce the transport time. An efficient way to achieve this would be to carry out an ABC analysis where the volume of activity is weighted by the annual demand in units and multiplied by the frequency of use. In this way, we would find products with a high volume of movements which would be called A products. B products would be those of average activity and finally the C products in which the majority of articles would be found but which would only represent 10% of the total movements.

7. CONCLUSION

Warehouse performance measurement, in my view, entails identifying and resolving warehouse issues before it's too late. It is a method of lowering costs by enhancing warehouse operations, and getting low costs is a key feature of differentiating companies.

I used a very basic approach to solve the problems. I identified the causes of the problems and then attempted to reduce or remove their effects. It's a cause-and-effect approach that any boss should use.

Waste is what we see - loss is what we measure, a loss is the difference between the current state and the ideal state. The ideal state is when everything happens with zero losses so this must be the purpose of the company. Losses are broken down until there is enough detail to start improvement activities therefore the mission of this and any company must be continuous monitoring of its machinery, production, and warehouse.

It has been seen that the efficiency of the logistics operator will be affected as long as reprocesses and unnecessary activities, among others, are originated. In addition, it has been observed that, even though the company has been operating for years in the line of business and is one of the leading companies in the field, there will always be aspects to improve. For example, and as one of the most surprising data of the analysis, the amount of immobilized time that some of the objects in the silo have. Another very revealing fact is that 40% are in non-preferred areas, which is a design problem. Thanks to different ratios such as the stock turnover ratio or inventory utilization we have realized that the company supports a large amount of stock which minimizes risks in stock breakage but provokes a great cost of storage. We have also seen the different bottlenecks that are preventing the correct flow of materials through the plant, such as the unidirectional conveyors or the few packing stations that we find.

Owing to the complexities of various companies, generalization to a single inventory management model for all enterprises is nearly impossible. However, this study can be used as a guide for every company's potential studies, allowing them to see the shortcomings and advancements of the study and learn from them. It's also worthwhile to experiment with various analysis or different cases to compare with this study, break down barriers and discover new weaknesses. Some of the proposed solutions could help other companies as well, as process automation should be the future to reduce costs and errors, ideas like Automatic Guided Vehicle or RFID technology can make a difference in the medium term. ABC analysis is a very wide measure in companies, especially in those with manual picking, and implementing it in some way in the automated warehouse could make a big difference against competitors. That said, I believe that continuous monitoring and total productive maintenance are a must in all companies for the correct development of the floor of the company.

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