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Business process analysis and reorganization of the warehouse in Manifattura Berluti

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Summary

INTRODUCTION

The need to respond to the market with more flexibility and in less time, while still guaranteeing multiple customizations in products, has pushed companies to implement increasingly refined management systems that represent a strategic point for being competitive in the market. In recent years, the global market has changed, leading many companies to rethink their products, both in terms of innovation and new product development. This situation has led to increasingly fierce competition on a global level where it is necessary to radically rethink and implement a new approach for analyzing and improving the production flow where the reduction of delivery times, production costs and overall costs is a critical success factor. Around the 1980s, Lean Production was born, a technique that allows companies to achieve a significant reduction in waste (called Muda in the Lean world), favouring the relationship with the customer and increasing customer satisfaction, especially in terms of quality rather than quantity. The thesis is the result of my internship in the special productions department at Manifattura Berluti, Maison of the LVMH group and world leader in the production of luxury shoes. It consists of a project for the improvement and redefinition of supply management aimed at identifying the criticalities present in the production flow, with the objective of evaluating the best supply technique for the present codes. With a view to the future, it is proposed to implement lean warehousing, i.e. the application of Lean principles and techniques to the warehouse, with the aim of streamlining the production flow and increasing the reliability of goods delivery forecasts from the supplier. By analyzing warehouse operations from a Lean perspective, the flow of material and information passing through and interacting within the warehouse can be mapped, in order to identify activities that absorb resources but do not add value for the customer. In order to deliver the 'right product at the right time' to the customer, it is necessary to bring out weaknesses, critical points and inefficiencies so that they can be resolved through a process of continuous improvement.

The first part of the first chapter introduces the principles of the Lean philosophy, introduced by the Japanese with the Toyota Production System. A general overview is given, from the birth and definition of the basic principles to the tools that stem from this thinking. In the second part, the concept of the warehouse is defined, the main activities that take place there are briefly described, and then its function in the supply chain is highlighted with regard to warehouse stock management and its ABC analysis.

The second chapter describes the Berluti maison and in particular the Manifattura, the company behind this work. At the beginning there is a brief general presentation of the Maison describing its growth and evolution over the years with a brief historical overview mentioning some of the most important stages. It then goes on to analyze the organization of the company and the production process, particularly that of special productions, which makes it possible to create such exclusive and sought-after products.

In the third chapter, the project and its results are presented, analyzing in depth all the various operations performed and all the various reasonings made to try to achieve the set objective. The project consists of an in-depth analysis of the warehouse and its supply management. In fact, the work mainly deals with the analysis of the current situation of the company warehouse focusing on the articles in the raw materials warehouse and the subsequent redefinition of the safety stock, reorder point and economic production batch. Finally, the estimation of improvements resulting from the application of Lean techniques is carried out.

The fourth and final chapter contains the conclusions of this work, reflections on the applicability of Lean techniques, the benefits it has brought to the company, its limitations and future research ideas.

1. CHAPTER 1: LEAN PRODUCTION AND WAREHOUSE MANAGEMENT

The first chapter aims to introduce the concept of Lean Production, understood as a philosophy and methodology for managing industrial processes. It will go on to present the techniques and tools generally used to put into practice the concepts that this methodology proposes.

Then the topic of warehousing, on which the paper will concentrate, is discussed.

It will focus on the importance of creating an effective and efficient warehouse through the study of warehouse management models and techniques. In fact, Lean Warehousing will be presented, i.e. the theory that aims to merge the concepts provided by Lean theory with warehouse management logic. In order to get a complete view of the subject, the last paragraph will be devoted to stock management, as optimising stock levels is fundamental to good performance.

1.1 LEAN THINKING

The concept of 'lean' has its roots in mass production, particularly in the automotive industry, and identifies an industrial philosophy inspired by the Toyota Production System (TPS), which aims to minimize waste to the point of zero waste.

The lean philosophy (or lean thinking) was born with the idea of optimizing production by simplifying work and eliminating waste; and to pursue this, it is necessary to follow five key principles (Womack and Jones, 1997). Lean production is thus a generalisation and dissemination in the West of the Toyota production system, capable of overcoming the limitations of mass production developed by Henry Ford and Alfred Sloan, which is still applied in many western companies today.

The foundation of lean production is the understanding that every service realization involves value-added activities (customer requirements) and non-value-added activities (waste). The percentage of non-value-added activities is very high, so it is necessary to attack waste and achieve efficiency.

Lean theory is based on five principles:

1. VALUE: everything that the customer is willing to pay is regarded as value.

The starting point is to define the concept of value, defined exclusively from the customer's point of view. The company must focus only on products or services that can create value and that satisfy customer needs and wants as efficiently and with as little hassle as possible. Accurately defining the value that a product possesses for the customer is the first essential step in lean thinking since providing the wrong product or service in the right way is wasteful.

Value is a set of characteristics of the product or service for which the customer is willing to pay (Graziadei, 2005). It is created by the producer but only takes on meaning when expressed in terms of a specific product or service that can satisfy the customer's needs at a given price and at a given time.

Accurately defining value is very difficult for producers; the person best placed to do so is the one who justifies the existence of the company, the customer, who attributes economic recognition to the perceived value.

The difficulty lies in the fact that, when redefining value, we dwell on the variants of the product or service that is already offered; a lower cost, a greater product variety through customization, and a shorter delivery time, rather than analyzing the concept of value in more depth, questioning the traditional definitions to understand what is really needed.

Once the characteristics that the product offered must have been defined, a target cost must be determined based on the number of resources and labor for manufacture, assuming that all visible Muda (waste) is removed from the process. From a Lean perspective, the cost of the product is determined by asking what it would cost to produce that product without Muda, i.e. once the unnecessary process steps have been removed and the value stream has been made to flow.

2. MAP, identifying the value stream: the stream is the set of activities that are carried out on the inputs to give a product/service to the customer (flow of materials and information);

Mapping the entire value stream for each product is an important step, as it allows one to identify the Muda, and to do so one must consider the entire set of activities involved in the creation of a specific product, such as product conception and design, order management, raw material processing, etc.

Analyzing the value stream, three types of activities can be identified:

- Activities that create value: e.g. processing of raw material, semi-finished product, etc.
- Activities that do not create value but are unavoidable under current production or management systems: e.g. handling in the processing cycle, transport, etc.
- Activities that do not create value and are eliminable: this category includes all waste.

The objective of lean thinking is the elimination of the latter type of activities, which are considered waste.

In order to learn to distinguish in each activity whether or not it creates value for the customer, one must ask oneself not so much whether such an activity is necessary or not, but whether the customer is willing to pay for it, i.e. whether he would notice the absence of such a process step (Graziadei, 2005). All activities that transform the product by changing its aesthetic, physical, mechanical characteristics are value-added activities.

3. FLOW: anything that stops the flow is waste, so it must be identified and removed;

After having identified the value for the customer and removed all activities that do not create value, it is necessary to redesign business processes and structure in such a way that the new 'lean' flow can flow steadily and continuously bringing the desired benefits to the company. Value-generating activities must take place without interruption, creating a continuous flow. This principle overturns the traditional way of thinking in batches, according to which activities must be grouped by type in order to be performed more efficiently.

The first step in achieving a continuous flow, removing all obstacles, is to focus on the product and never lose sight of it, from start to finish; the focus is on the product and its needs rather than on the process and equipment. The second step is to ignore the traditional boundaries of tasks and functions, structured in departments and offices. Finally, the third step is the rethinking of the practices and tools used in the process in order to eliminate backward flows, waste, and waiting between production steps.

4. PULL, tie everything to the customer: forecasts are always wrong, so instead of aiming to better forecasting, one must focus on greater responsiveness.

The fourth principle of lean thinking is to adopt a pull production logic in order to design, plan and realize exactly what the customer wants when the customer wants it. This means that it is the customers who 'pull' the product from the company rather than the company trying to 'push' often unwanted products to customers through sales forecasts (push logic). Pull logic implies that, upstream, goods or services are produced when the customer, downstream, demands them. Value-added activities, as well as flowing without interruption, must be activated by the customer, otherwise, they risk not generating value and being wasteful. Applying this concept limits excessive stock levels and stabilizes demand, especially avoiding the need to activate discount campaigns and promotions to sell off the excesses of mass production. Adopting the pull logic also allows obstacles to the continuity of the flow to emerge, allowing them to be removed.

5. PERFECTION: a perfect process involves the complete elimination of waste so that every single activity creates value for the customer, therefore continuous improvement systems must be put in place. Once the value stream 'pulled' by the customer is defined, it is necessary to continuously strive for perfection through continuous process and flow improvement (Kaizen).

At this point, we can say that the lean philosophy is based on the reduction/elimination of all activities that do not add value. To do this, it is necessary to bring out weaknesses, defects and inefficiencies so that they can be solved them. In fact, ideal perfection is the complete elimination of waste, so that the production process is composed only of value-generating activities. Perfection is the goal to strive for through the application of continuous improvement, which is a dynamic condition, as the value for the customer continues to change over time.

1.1.1 7 Wastes

Waste is defined (Muda in Japanese) as any activity that absorbs resources without creating any additional value. Applying the definition of waste within the production process, 7 varieties of waste were identified.

1. overproduction: production that exceeds demand is the main source of waste and the most dangerous in a manufacturing company; it causes misuse of resources and saturates inventories with products that in part will not be sold and will become obsolete. On the other hand, production driven by forecasting alone may be insufficient to meet demand and lead to lost sales. Therefore, it would be smart to produce only what is necessary.

2. Waiting: this is found when an operator remains to wait for a part or other necessary item and cannot perform any task. It is calculated by taking into account the difference between the total passage time of the good/service in the production flow (flow time) and the total cycle time required to perform the task (cycle time). The most common causes of this waste are mainly: synchronization errors between production stages, non-arrival of material, plant breakdowns, set-ups, etc. This is why it is important to have an efficient, well-tested and properly maintained structure.

3. stocks: the presence of stocks and materials immobilized in the process generates waste of both space and financial resources. By this waste is meant all materials that are waiting for an event (processing or sale) and thus wasting time during which no value is added for the customer.

4. transportation: these are all operations for the transfer of a good that does not bring any added value; in addition, transport operations also potentially cause damage to the product. Therefore as such, they should be carried out safely and minimized.

5. unnecessary movements: very similar to the previously mentioned waste, but in this case, unnecessary movements or inefficiencies due to the difficult availability of what is needed within the processing cycle (e.g. moving material from one location to another in the same processing, unproductive search for packaging board, etc.) are considered. Keeping this factor under control inevitably leads to an improvement in productivity.

6. quality defects: it is essential to analyze each defective part, whether it is a reject or a rework, and study the causes in depth. A non-conforming product represents a major cost for the company and should never be detected by the customer, as this would entail further costs in terms of complaint handling and image. Added to this is the issue of corporate social ethics, which is summarised in the term 'Compliance'.

7. over- processing: these are waste due to process problems. In general, there may be processes that are inadequate for the flow, such as machinery that is calibrated with a higher or lower capacity than necessary, or that is poorly automated and requires the constant presence of employees. There are also problems related to the mistaken belief that all activities are indispensable, when in fact there are redundant or non-essential activities: in this case, the process should be streamlined.

Just In Time

JIT was first developed within Toyota's manufacturing operations by Taiichi Ohno in the 1970s as a means of meeting customer demands with minimum delay. In its original form, it referred to the production of goods, assemblies, and subassemblies to meet exactly the customer's demand in terms of time, quality, and quantity. With a JIT system, the "buyer" can be the actual end user or another process along the production line (Farahani, et al., 2011).

The American Production and Inventory Control Society (APICS) has the following definition of JIT:

"…a philosophy of manufacturing based on planned elimination of all waste and continuous improvement of productivity. It encompasses the successful execution of all manufacturing activities required to produce a final product, from design engineering to delivery and including all stages of conversion from raw material onward. The primary elements include having only the required inventory when needed; to improve quality to zero defects; to reduce lead time by reducing setup times, queue lengths and lot sizes; to incrementally revise the operations themselves, and to accomplish these things at minimum cost" (Funk, 1989).

Just-In-Time (JIT) is a logistical-productive method aimed at eliminating stocks and material inventories in the factory. It is based on the concept of producing only when needed, i.e. when customer demand arises, which is immediately downstream following the process flow. (Ohno et al, 1978). It is the methodology with which the Toyota production system aims to manage the production process with pull logic, in opposition to the management of the Western mass production process era. For Just-in-time, the trigger that moves all business processes is not the demand estimates and forecasts, but the customer's order, and the objective is to deliver what the customer wants, in the required quantities at the required time. As with the customer, one process in the operational flow transfers to the next (downstream) process only the necessary number of parts and only at the time they are required.

This way of organizing the production start-up, together with the adoption of ever-smaller batches enabled by the introduction of rapid set-up techniques (SMED), eliminates or drastically reduces the stationary material waiting to be processed, thus reducing the total lead time from days to hours and minimizing storage costs and defects.

The JIT is based on three core elements (Sugimori et al, 1977):

The JIT consists of three elements:

- Pull System
- One-Piece-Flow System
- Takt Time

JIT is a management philosophy rather than a technique. The many benefits of a JIT system include:

- Reduction of stockouts
- Reduction of inventory levels
- Reduction of need for material handling equipment
- Reduction of timeframes between delivery and production
- Significant quality improvement
- Employee inclusion in continuous quality improvement

1.1.2 Lean Warehousing

Organizations have long strived to adopt effective managerial tools and techniques that would improve the efficiency of their operations. This has largely been achieved building on lean thinking and tools. Lean has been one of the most powerful managerial philosophies in recent history (Womack and Jones, 2003; Holweg, 2007; Villarreal et al., 2016; Shah and Khanzode, 2017). At the heart of successful lean implementation is the concept of "waste," which refers to the non-value adding activities in a particular system. Waste can be defined as anything other than the minimum activities and materials necessary to perform a particular process. Although lean started as a production strategy, the Japanese philosophy is now widely implemented in a wide range of industries. Lean principles have been studied in production, operations and business management literature (Womack and Jones, 2003; Villarreal et al., 2009; Holweg, 2007; Shah and Khanzode, 2017). One research area in which waste reduction has been given considerable attention is within the field of logistics and supply chain management.

Scientific studies on the subject of Lean Warehousing are relatively recent (Bartholomew, 2008). Lean principles, as seen, originated as a manufacturing strategy, but have found application in many different sectors. In parallel, the literature has recognised the central role of warehouse management and its influence on logistics performance, and Lean Thinking is also increasingly finding outlets in supporting warehouse and distribution centre processes (Abushaikha et al., 2018).

The growing need to improve supply chain performance has forced warehouse management to focus on reducing or eliminating non-value-added activities. In recent years, there has been a growing interest by supply chain management scholars in the warehouse function as an area of research in the field of logistics. Some of these have focused on the possibility of using the concepts provided by Lean Thinking for this purpose.

The goal of Lean Warehousing is to serve customers faster, with less storage space, less inventory and greater accuracy. What characterises a Lean Warehouse is the use of all functional and cross-functional people together with technology to seek continuous improvement (Sharma & Shah, 2016).

In the literature, several authors have argued that Lean concepts do not find great applicability in warehouse operations because the latter are simpler than production operations (Gaunt, 2006), and again in comparison to the latter, they do not add value to the finished product because they do not change its characteristics. The objective of Lean Warehousing, however, can be summarised as the identification of activities that are not strictly necessary for logistical purposes, allowing them to be eliminated as 'muda'. Most of these make use of VSM, with the aim of investigating and identifying such activities.

Lean principles are now universally applied, even within warehouses, so much so that we speak of Lean Warehousing. By studying the waste in your warehouse, you can identify all the activities that absorb resources without creating additional value (e.g.: errors in goods receipt or dispatch, unoccupied or poorly occupied space, etc.). Therefore, realising a lean warehouse is not something immediate: it requires transforming classic top-down leadership into bottom-up initiatives. This means that every worker must be an inspector, and everyone is expected to help the company achieve the goal of continuous improvement. On the other hand, managers must be coaches for their employees and finally, employees must be rewarded for proactive behaviour. We can summarise the concept of Lean Warehousing by saying that creating a lean warehouse is an evolution not a revolution. It is observed that many companies have the capacity and skills to embrace the lean approach, but fail to implement it because, very often, the culture is lacking. It is crucial, therefore, that at the root of it all there must be communication from the managers, who must make the new approach and the reasons for the change perceived by all employees. Every person in the organisation must have the ability to problem solve and feel useful to the company in the process of finding and eliminating waste. The goal is to create a warehouse where problems are visible and where they can be solved at the root. If employees fear penalties for their mistakes, then the lean approach cannot work, for it is precisely from the mistakes that it is possible to see where action can be taken to improve the system. Furthermore, every improvement action, no matter how small, must be recognised and celebrated, because the mood of the employees is the most important indicator of progress in the lean perspective: if employees are committed and find pleasure from solving problems and eliminating waste, all possible evaluation metrics will reflect the right reality.

1.1.3 Lean warehousing tools

A series of Lean tools, that are implemented by Toyota in its processes, and subsequently analyzed in academia and researched, are listed and explained below. They are very useful for analyzing critical business issues.

<u>Value stream map</u>

One of the most frequently used methods in the implementation of lean concepts in the warehouse is the value stream map. This is the first tool to be used because it highlights where it is most appropriate to take action to improve, building a solid plan of action.

The VSM is a graphical tool for mapping activity flows and showing the current and future status of processes with a focus on possible opportunities for improvement (Dotoli et al., 2015).

A value stream is a collection of all the actions (whether value or non-value) that are required to move the product or product family through the stream, starting from raw materials to customer contact (Rother and Shook,1999).

Value Stream Mapping (VSM) is the tool used in the Lean philosophy to apply the second principle, as it allows the mapping of the value stream, i.e. the set of all processes and activities that contribute to the realization of the product.

It is an effective tool because it integrates, through a graphical representation, two fundamental sequences to be analyzed:

- the flow of materials, i.e. the sequence of steps in the production process from raw material to finished product;
- the information flow, i.e. the sequence of information transmitted from the customer down to the individual departments on what, how much and when to produce.

Value Stream Mapping consists of drawing two value maps:

- the Current State Map, which defines the current flow picture and is the starting point for identifying waste;
- the Future State Map, which represents the ideal flow to be had in the future through the improvement actions to be taken.

The objectives of the Value Stream Map are therefore (Considi, 2009):

- See the stream in its entirety;
- Identify where waste lurks and what causes it;
- To provide a common language at all levels of the organization;
- Show the link between the flow of material and the flow of information;
- Visualize the effects of improvements designed to make the flow;

- Build the basis for a couple of actions.

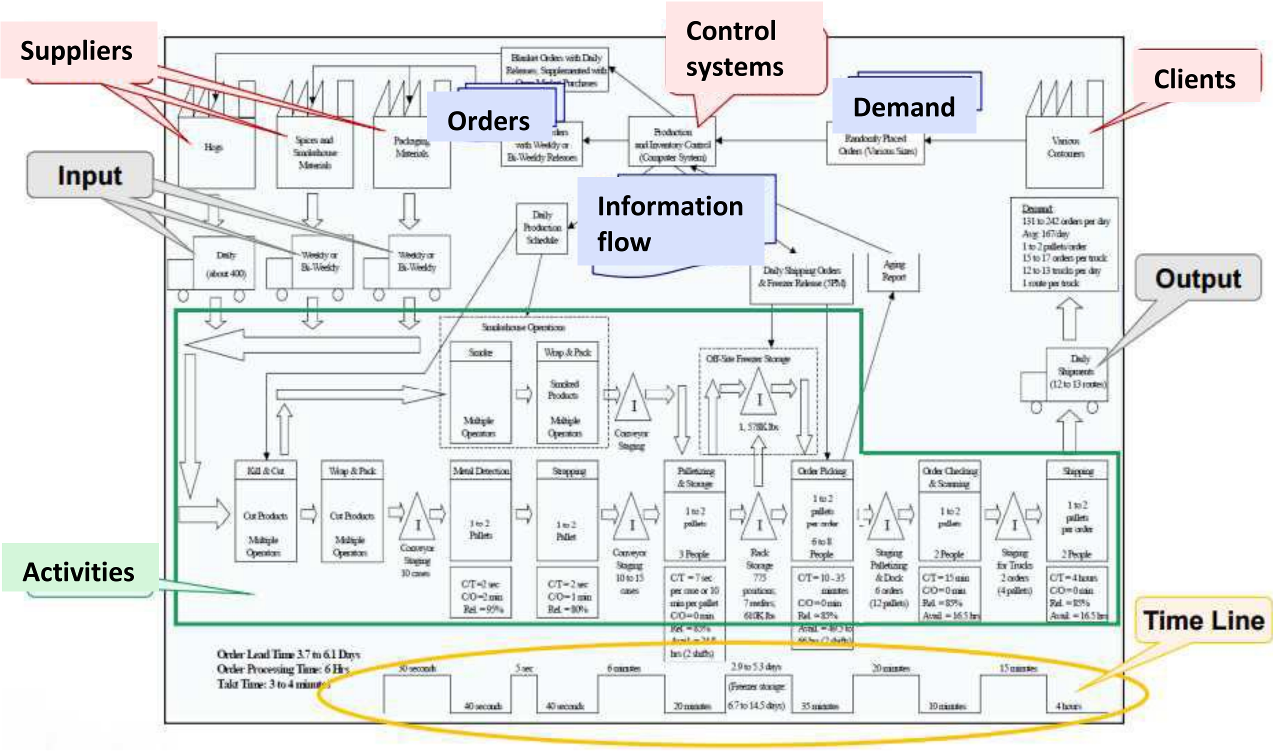

Figure 1: Current State Map

(GarciaF.C., Appygling Lean Concepts in a Warehouse Operation)

<u>Visual Management</u>

The theory behind Visual Management is quite simple and is based on clear, visual clues that assist the operators' actions. This means that all information needed to process a given action is visible and shared in real-time with everyone involved. These accurate representations make it possible to discover potential improvements, also because it is easier to identify problems and align everyone clearly and effectively.

The actions to be taken in order to maximize the positive effects of Visual Management are:

- Create and share Key Performance Indicators (KPIs);
- Adopt illuminated signs to highlight interruptions or waits;
- Making right and wrong samples of the same family visible in dedicated spaces;
- Adopt visual control systems (Kanban);

- Indicate the production flow through recognizable signs.

Examples of visual control systems are the use of colored sheets, coloring floor areas, illuminated indicators, displays indicating performance, standard works...

The correct use of visual management allows operators to perform their work clearly and without doubt.

<u>The 5S methodology</u>

The 5S technique helps to achieve one of the fundamental objectives of the Lean philosophy: to make problems visible. 5S is an acronym for 5 Japanese terms that represent the 5 principles to be applied in order to improve productivity through the introduction of standard procedures that guarantee efficiency, repetitiveness and work safety. Applying this tool to a warehouse means having a clean and organized warehouse so that problems can be identified and resolved quickly by addressing the root causes.

The 5 steps that make up the methodology are:

- Seiri: keep only the fundamental things by eliminating those that are not required. Everything else is put aside or eliminated.
- Seiton: there must be a specific place for each thing and each thing must be put in its proper place. The place each object occupies must be clearly identified and demarcated.
- Seiso: keep the workplace tidy and organized. Workplace cleaning activities should be part of daily activities and not performed as an occasional activity when in fact the situation created does not involve anything else.
- Seiketsu: the workplace and activities should be standardized. Quoting Ohno: 'Where there is no standardization, there is no Kaizen', sums up the concept that improvement is only possible through standardization, which allows activities to be optimized and contributes to quality improvement.
- Shitsuke: maintain and continuously improve acquired standards.

Spaghetti Chart

The Spaghetti chart is a tool used in production flow mapping to check how wasteful layouts and flows are. This tool is useful for highlighting waste resulting from the distance traveled by operators to move from one part of a warehouse to another.

The Spaghetti Chart is generally presented as a set of curved lines drawn on the layout of the analysis area. The lines will represent the flow of people, materials or information step by step.

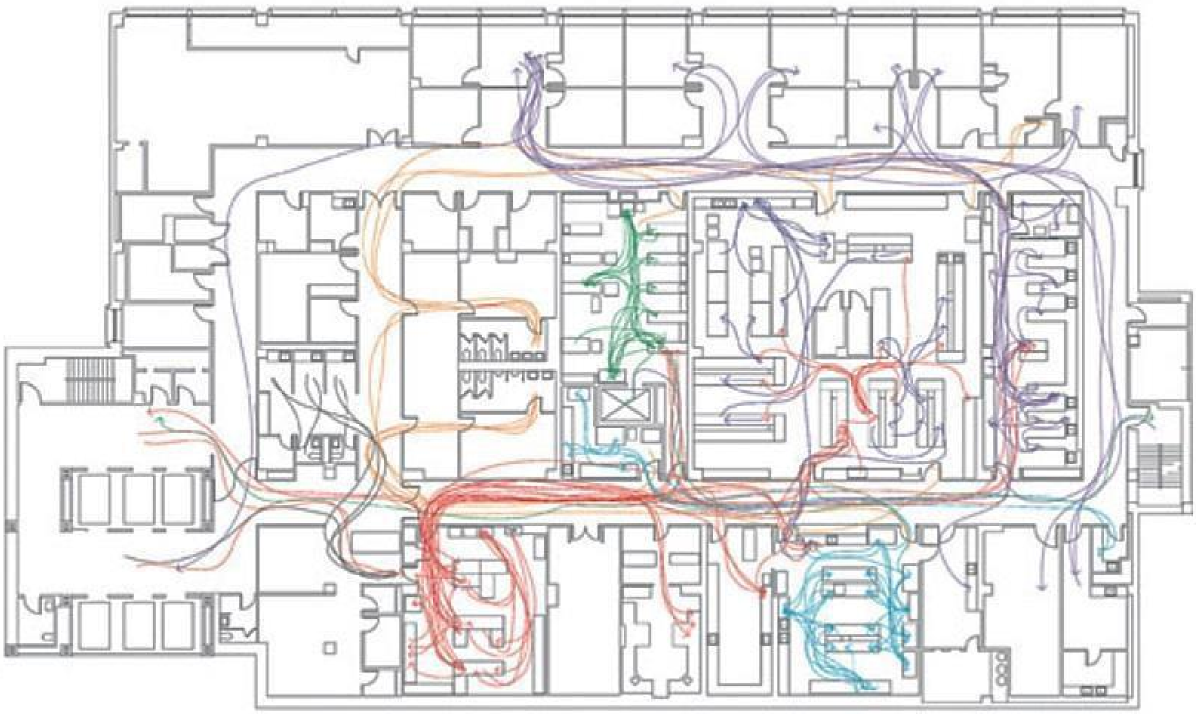

Figure 2: example of Spaghetti Chart tool

The first step in the layout review is the physical mapping of manufacturing processes. It starts by tracing within the process a set of products taken as a reference for volumes realized, turnover or characteristics representative of the order fulfilment cycle. One traces the overall production flow within the plant, identifying not only the stages but also all intermediate movements, buffer or warehouse waits.

This produces a spaghetti chart, i.e. a complex web of flows in which it is possible to highlight the inefficiency of the layout under consideration due to continuous movements, cross flows and dispersive backflows, which represent worthless costs and slowdowns in the order fulfilment process. It is called a spaghetti chart because it resembles a plate of spaghetti.

Kaizen and people involvement

"Kaizen" comes from Japanese and literally means "improvement" or "change for the better", referring to the philosophy or practice that focuses on continuous improvement in processes, engineering and management.

According to Deming (1986), Kaizen activities are related to the PDCA (plan-do-check-act) cycle:

- PLAN: establish the objectives and processes required to achieve the desired results.
- DO: implement the new processes, preferably on a small scale.
- CHECK: Measure the new processes by comparing the results obtained with those expected, evaluating the differences.
- ACT: Analyzing the differences in order to understand the reasons for them. Each cause will be part of one or more PDCA steps.

The process is carried out over and over again so as to achieve small improvements day by day, giving people time to get used to it. Kaizen activities must be carried out by the people and therefore they are at the center of the company's transformation and continuous improvement. Employees must know and share the company's objectives and know how their contribution contributes to the achievement of these objectives. The presence of communication channels that enable an effective exchange between operators, management and top management is the key to business success.

The Gemba (Production) must be the place where all improvements are born.

The Gemba and management share an equally important position: the former provides the products or services, while the latter sets the strategy and shows the way to achieve certain goals. With this view, responsibilities are shared and everyone feels important to the goal. People are the first and most important asset of the company; they must be motivated and empowered to contribute to the good of the company.

1.2 THE WAREHOUSE

In supply chain management storage is described as a buffer of collected goods to ensure the amounts required in the shortest amount of time. The warehouse is a key junction of the supply chain and logistics and plays a crucial strategic function to meet the challenges arising from such factors as reduced delivery times, a higher number of orders, and fewer items per order; when managed optimally, it offers significant benefits for efficiency, supply chain organization, and competitiveness. Its reliability and accuracy of it is the first guarantee of a logistics organization's success.

Warehousing is a common term, and many people have a picture of what it is, but the field is far more complicated than most observers would think (Jenkins 1990.)

Warehouses are seen as an opportunity to improve operation optimization and information flows, reduce inventory levels, and to enable more agile distribution (Vrijhoef et Koselka, 2000). The successful performance of a warehouse depends on appropriate strategy, layout, warehouse operations and material handling systems (Lehrer et al., 2010).

Frazelle et al. (2007) identifies the main challenges for storage: small transactions, more articles, complex and perishable products, international orders and returns, value-added services, less margin of error, and less time to satisfy the customer. Warehouse operations systems are configured through the following sequential processes: reception, storage, order picking, and dispatch. These processes imply resource allocation decisions that affect system performance.

A few notable roles of warehouses include: consolidating products, pushing for economies of scale in large batches, and value-added processing (Bartholdi & Hankman, 2011; David, 2018).

In the past, warehouses are frequently thought of as merely functional spaces for handling and storing items; they are seen as surfaces devoid of additional value where products must stay for the shortest amount of time possible. Performance was primarily measured by the absence of issues, and as products handlers made up the majority of the workforce in the warehouse, they were both unskilled and unaccountable. Today, the warehouse is an essential component of the supply chain since it regulates the flow of goods and the length of lead times, even decreeing the success or failure of the company. This is true because Warehouse Management (WM) is becoming a critical activity in the supply chain to outperform competitors on the level of service provided to the customer in terms of delivery time and cost (Faber et al.,2002).

In spite of the high expense of holding inventory, warehouses act as a buffer between the variability of supply and demand, making them a necessary element in today's supply chain.

Due to e-commerce, supply chain integration, globalization, and just in time methods, warehousing has grown increasingly complicated and expensive in recent years. Main target is to increase productivity and accuracy, reduce cost and inventory whilst improving customer service (Richards 2011).

Every company, whether it engages in industrial or commercial activity, needs a warehouse. Managing your warehouse effectively gives your company a competitive advantage both in terms of customer service and financial performance. Operations-wise, there is no difference between warehouses used for manufacturing and distribution because the internal operations are the same. The scale of the volumes handled, the markets served, and the logistics network all varied.

A manufacturing company needs three different types of warehouses—one for raw materials, one for semi-finished goods, and one for finished goods—whereas a business only needs one warehouse, which is primarily used to store finished goods. This is a significant difference between the two types of businesses.

A warehouse can be defined as a materials handling station dedicated to receiving, storing, order picking, accumulating, sorting and shipping goods (Van Den Berg & Zijm, 1999). This definition covers a wide variety of systems, which can be further characterized according to industrial application.

In this sense, three general types of warehouses can be identified:

- Distribution warehouses: products are collected and/or assembled from different suppliers and redirected to the customer.
- Production warehouses: within a production process, we have warehouses for semi-finished raw materials and finished products.
- Contract warehouses: warehouses used on behalf of one or more customers.

A further classification can be made according to the function the warehouse performs, in particular, we distinguish:

- Raw material warehouses, where the goal is to maintain a reserve against unanticipated supply shortfalls and so guarantee production continuity;
- Semi-finished goods warehouses, where the function is to provide a buffer between manufacturing processes with the same function as the raw materials warehouse;
- Finished goods warehouses, where the warehouse acts as a buffer for variations in demand. Typically, it is a distribution warehouse whose job it is to gather products from a single or multiple suppliers, categorize them, and then distribute them to numerous clients.

What all types of warehouses have in common, however, are the main operations that take place within them. Warehouse processes begin with goods receiving, which includes unloading, unpacking and dividing goods, and proceed to storage, picking, packing and shipping.

1.2.1 Objectives and issues

The main objective of warehouse management is to satisfy its customers. Customer service consists of the ability to make products available with respect to customer needs, so the role of the warehouse is to get products through as quickly as possible.

In order to respect the commercial or customer service lead time, i.e. the waiting time between order issue and product delivery, it is necessary for each of the links in the logistics chain to respect partial lead times, as delays lead to the establishment of safety stocks and emergency management. A warehouse must also be able to achieve this without losing control of its costs. This is the second management objective that a warehouse manager must follow over time. Costs can be divided into three classes (Mocellin, 2017):

- costs concerning the storage area;
- product handling costs;
- transport costs.

The creation of a warehouse can be due to different reasons (Mocellin, 2017):

- reasons of a technological nature, since products need a waiting time before moving to the next stage of the production process or before being shipped to the end customer;
- reasons of a commercial nature, in order not to risk going out of stock (stock out, i.e. when demand cannot be met due to lack of product), it is necessary to maintain stock levels sized to cope with sudden demands;
- economic and strategic reasons, such as buying large quantities of goods to take advantage of cheaper prices.

The choice of whether or not to create a stockpile depends on the industrial strategy and the compatibility between the commercial or customer service lead time and the lead time of the company's production processes. Stockpiles are a direct consequence of the lead time that is considered tolerable in customer service as they mask the production and procurement lead time so as not to lengthen the customer service lead time.

Optimal warehouse management is the key to success for any business, as it means making sure that a product is immediately available to satisfy the customer. Organizing a warehouse in a structured manner is a priority not only for companies with a high flow of goods, but for any company that needs storage space. The warehouse must not be regarded as a low-value space, intended only for temporary storage of products. Achieving an efficient warehouse also depends on considering all possible problems right from the design phase of this space.

The main warehouse problems can be classified into three categories (Vignati, 2002): physical, operational and managerial.

The physical problems are:

- the determination of the necessary surfaces and volumes
- the definition of the layout;
- the selection of positioning structures;
- the choice of handling equipment.

From an operational point of view, the main topics to be addressed are:

- the means and procedures for receiving materials;
- the positioning of materials;
- picking systems;
- the use of packaging for shipping;
- the formation of loading units.

Management issues include:

- the determination of stock levels;
- inventory management;
- human resources management;
- cost management;
- controlling warehouse productivity.

1.1.2 Warehouse operations

In warehousing, the flow of activities can typically follow these steps:

• *Receiving*: offloading and inspection of goods to ensure correct quality and quantity of delivered orders (Frazelle, 2002).

• *Put-away*: moving goods from the receiving area and storing them in the suitable location for future picking orders (Frazelle, 2002; Faber et al., 2013).

• *Picking*: once a customer has placed an order, the relevant goods are picked and prepared for dispatch in an efficient and effective manner (Frazelle, 2002; Faber et al., 2013).

• *Despatch*: as orders fulfilled, they are packed and made ready for delivery to the customer (Frazelle, 2002; Shah and Khanzode, 2017).

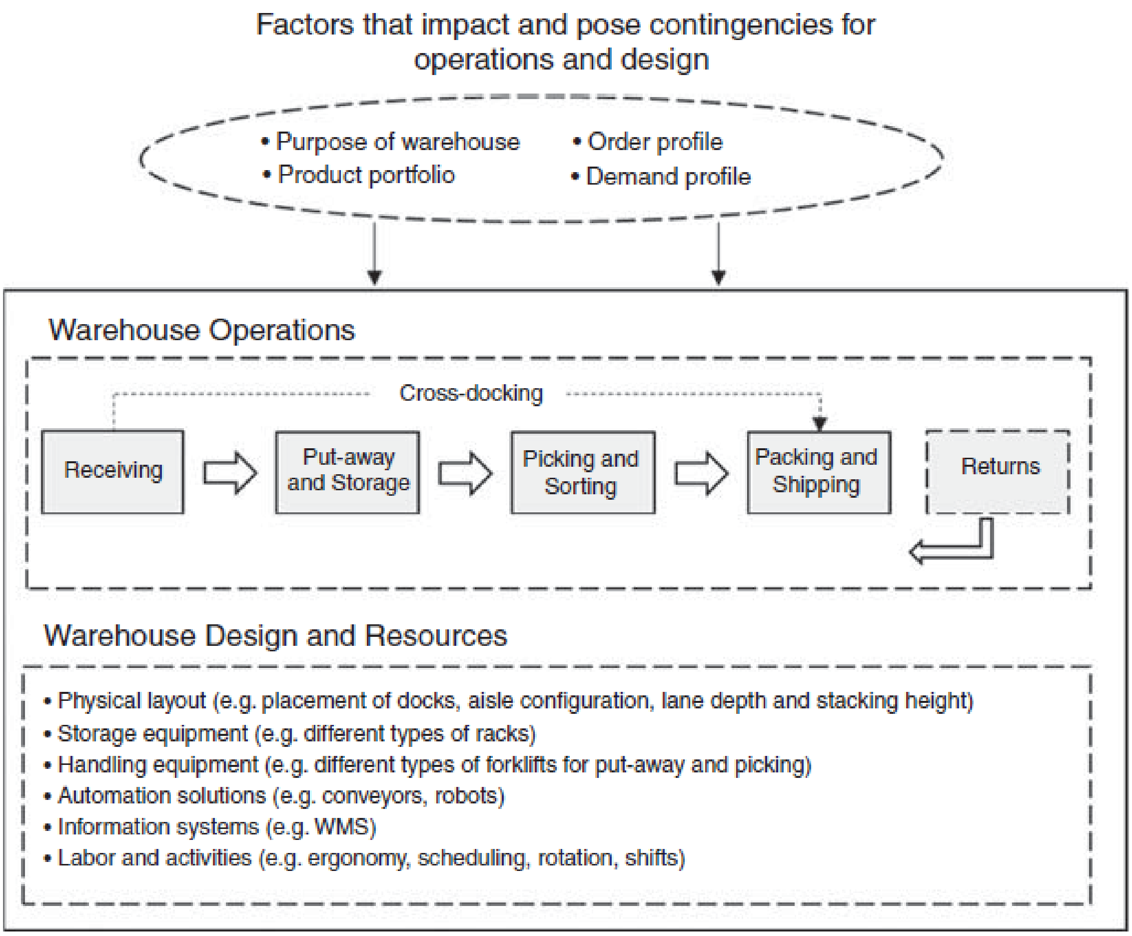

Figure 3: Overview of warehouse operations and design

(Adapting warehouse operations and design to omni-channel logistics)

Receiving

Receiving, unloading, and inspecting arriving items is the initial step that establishes the beginning of the process of managing the incoming flow of goods and information within the warehouse area. When a vehicle pulls up to the reception area, the process of receipt begins with the unloading of the units that need to be handled for later inspection. To avoid discrepancies in the inventory of goods in the warehouse and to ensure that there is no subsequent incorrect invoicing in the case of sales transfers of goods between two parties, the goods are compared with the order that triggered the delivery and with what was declared by the transporter during this phase.

In order to keep a stable average stock level at this point, it is crucial to manage the number of items entering the warehouse, which must first be commensurate with the outflow. In this phase, it is, therefore, necessary to schedule deliveries, and to ensure that these are met by suppliers. This phase also includes all the operations of subdivision (prepackaging) of the goods according to the allocation logic for storage (Frazelle, 2002). In particular, when a supplier delivers goods in bulk, they are then broken up to make selection easier and faster, or to combine different products to build kits or assortments of goods that must be handled together.

Put-away e storage

This refers to all operations to transport the goods from the receiving area to the place where the products will be physically stored. Hence, it includes material handling, position verification and placement of the handling unit.

As far as the goods allocation strategy is concerned, this depends on the size and quantity as well as the handling characteristics and containers of the goods (Frazelle, 2002).

Operational management and maximizing warehouse space utilization are both considered in the optimization objectives of warehouse operations. Both factors are significantly influenced by the storage policy (Confessore et al., 2003). A collection of guidelines for allocating the warehouse location where incoming commodities are to be stored is known as a storage policy.

Three types of warehousing policy can be distinguished:

- Dedicated storage policy, in which storage areas are permanently allocated to certain products. This policy is used to simplify control, as each storage space can be identified by a permanent label. The disadvantage of this policy is the rigidity of the spaces, especially in the case of seasonal products.
- Random policy, the position of a certain product within the warehouse is not uniquely determined, and is chosen, often by special software, from all the positions available at that time. The advantage of this policy is the maximum utilisation of the warehouse surface area, at the expense of optimising picking routes. By indicating with Ipt the inventory of the SKU (p) at time (t), the required warehouse size (MSHA) is equal to the maximum of the sum of the inventories of each SKU in the time period under consideration.
- Class storage policy for which the warehouse assortment is divided into classes, i.e. into groups of related products. Classes can be formed by SKUs that have their individual inventory levels negatively correlated, which implies that SKUs are dedicated to a certain zone, but within each zone, the SKUs are randomly placed. This approach draws on benefits of both dedicated and random storage, enabling reduced travel while avoiding congestion (Gu et al., 2007).

<u>Picking and sorting</u>

The picking process, which is the procedure for gathering handling units from their storage locations for later distribution to the customer, can start after an order has been received at the warehouse. This is the basic service that a warehouse must be able to provide, and it is the process around which many warehouses are designed (Frazelle, 2002).

Among warehouse processes, picking is the one that absorbs the most human resources, and it is the one that directly affects the level of service if it is manual (de Koster et al., 2007). Furthermore, picking is the most cost-intensive activity in a typical warehouse. A study conducted in the United Kingdom (Frazelle, 1988) shows that about 50% of the operating costs of a typical warehouse can be attributed to picking operations (figure 1.1). An initial distinction can be made within the picking process according to whether it is manual or automated.

Consistent with the type of goods handled in the warehouse, there are different logics for picking. By handling policy, we mean the guidelines that specify which quantity of a certain product must be taken out of the storage area first.

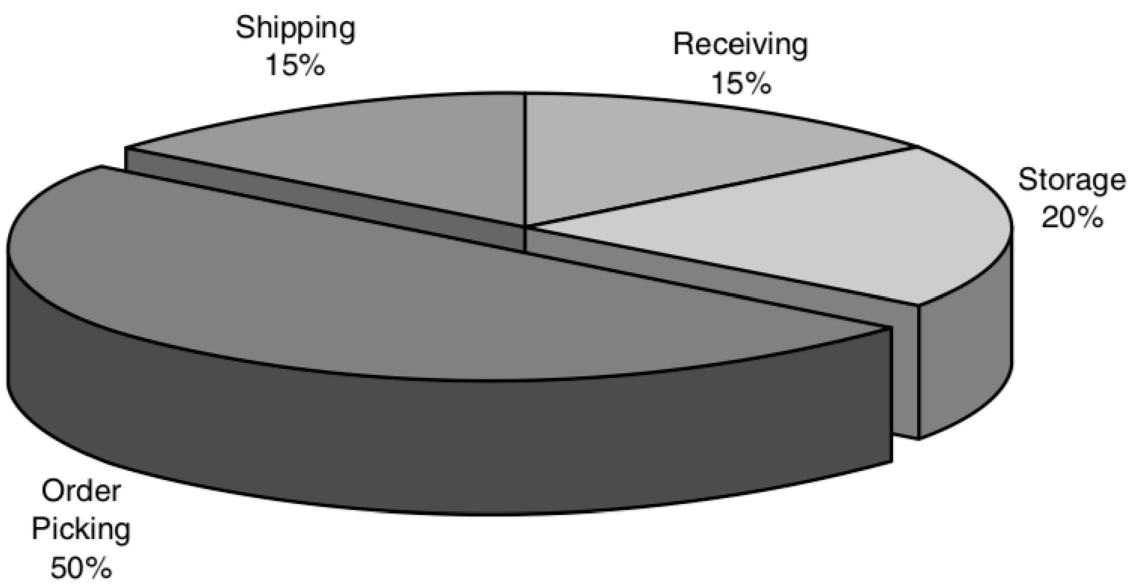

Figure 4: Distribution of operating costs in a warehouse

Source: (Frazelle , 2002)

Two logics are distinguished:

- FIFO (first-in, first-out). This logic is used when the product is subject to high rotation and high perishability. In this case, the quantities of a certain article that have entered the warehouse first must be immediately accessible for picking. In this case, multilayer should not be allowed and a spot check of the articles is necessary to ensure that the oldest article can be identified.

The main advantage is that it is an excellent method of ensuring that goods do not lose all or part of their value when they expire. To facilitate its use, there are devices such as dynamic pallet racking for gravity movement. The drawbacks only arise if moving goods, for example, incurs a higher resource cost than the value that stock lots lose while waiting.

- LIFO (last-in, first- out). In this case, there are no problems of the perishability of the goods, so the item that has most recently entered the warehouse can be picked first. In some cases, stocks - or certain types of products - cannot wait long for everything that arrived earlier to be disposed of.

In fact, the LIFO method is also used for the organisation of stocks and goods in stock on a speculative basis, to keep goods in stock and only use them when prices are favourable and not when the time comes according to a simple logic of consumption.

A further distinction regarding picking activities is the order processing mode. The four common picking methods include single, batch, zone and wave (see, e.g. Hassan, 2002; Bartholdi and Hackman, 2016). One mainly distinguishes order picking from batch picking.

Order picking is the picking mode for which the picking quantities to be processed by the operator refers to a single order or a fraction thereof. The main advantage of this technique is the simplicity of order management, as only one bill relating to the order to be filled needs to be managed. The disadvantage is the heterogeneity of the order, which can lead to many picker stops and long pick routes.

Batch picking, on the other hand, consists of filling a batch of orders or a batch of fractions of orders. This logic allows the same articles belonging to different orders to be grouped together, thus optimizing picking routes. A further potential advantage lies in the subsequent sorting operations, which implicitly lead to further control. The main disadvantages are, on the one hand, the complexity of order management, as two or more bills will be handled simultaneously with one picker, and on the other hand, sorting operations will require dedicated space, which implies that space is taken away from the stock.

Finally, the picking process can also be associated with the activities of packing the goods, once they have been picked, and the activities of sorting the distribution units to staging areas or shipping areas.

Packing and shipping

It is the last of the warehouse operations and includes first of all the control of the outgoing goods, to ensure the correctness and completeness of the withdrawals previously made.

The goods must then be loaded into appropriate containers for shipment and in parallel all accompanying documentation must be prepared.

The documentation that generally has to be drawn up contains at least:

- The packing list.
- The address labels.
- The transport document (DDT).

In some cases, the products must be weighed to determine the shipment load.

1.3 WAREHOUSE MANAGEMENT

Warehouse management encompasses the principles and processes involved in running the day-to-day operations of a warehouse. At a high level, this includes receiving and organizing warehouse space, scheduling labour, managing inventory and fulfilling orders.

The objective of Warehouse Management (WM) is the combination of planning and control systems and the decision rules used to manage material input, storage, and output flows (Faber et al., 2013). WM implies the optimization and control of distribution and warehouse processes (Ten Hompel, 2006). Nowadays, it is a difficult challenge for companies to manage all their warehouse activities in an efficient way. Therefore, a deep analysis regarding the current situation and processes needs to be performed in order to produce a satisfactory WM structure (Faber N., 2013).

Warehouse management includes the planning and monitoring of activities aimed at satisfying demand. While planning is concerned with determining when and which activities are to be implemented, monitoring is concerned with ensuring that these are carried out according to the plan. Within planning, two levels can be distinguished, a tactical and an operational one. On the tactical level, warehouses draw up plans to manage resources effectively and efficiently. On the operational level, decision rules are used to determine the sequence, schedule, and optimise planned activities. Typical planning problems in warehouses are inventory management and stock location allocation (Van Den Berg & Zijm, 1999). Wise inventory management can significantly reduce warehouse costs, e.g. by applying correct planning policies for production, in the case of production warehouses, or for purchasing, in distribution warehouses, it is possible to reduce the total inventory level while still ensuring a high level of service. Furthermore, proper management of the location of goods in the warehouse can facilitate picking operations.

These are part of the issues addressed by Warehouse Management, which in most cases is supported by an IT system. Such systems are either built specifically for the warehouse or purchased off-the-shelf. There are solutions with broad functionality that support a large number of processes in an organization (e.g. an ERP system), and specific solutions that support a limited number of processes (e.g. a Warehouse Management System, WMS). Warehouse operations are generally invisible to customers, but they play a vital behind-the-scenes role in ensuring on-time delivery. To achieve this goal, good warehouse management ensures all warehouse processes run as efficiently and accurately as possible. For example, warehouse management involves optimizing the use of warehouse space to maximize inventory storage; making inventory easy for staff to find; ensuring adequate staffing; efficiently fulfilling orders; and coordinating communication with suppliers and transportation companies so materials arrive and orders ship on time.

The benefits of good warehouse management—namely fast, high-quality service at low cost—can ripple out to the entire supply chain, strengthening relationships with suppliers as well as customers. But given the many elements involved, optimizing warehouse management can be a complex task. That's why many organizations are turning to warehouse management systems for help.

1.3.1 WMS

Warehouse management systems or WMS play an important role in logistics to maintain effectiveness, controlling movement and storage of materials. This system is critical because it involves chain management. A warehouse management system's main goal is to manage the transportation and storage of goods inside a warehouse as well as to handle all related tasks like shipping, receiving, putting things away, and picking.

It is a database-driven computer application, to improve the efficiency of the warehouse by directing cutaways and to maintain accurate inventory by recording warehouse transactions that aims to simplify the complexity of managing a warehouse.

Warehouse management systems can be standalone programs or components of supply chain management software or an ERP (Enterprise Resource Planning) system. The primary purpose of a WMS is to control the movement and storage of materials within a warehouse. The WMS can be deployed as a paper-based, RF/wireless based or combination of both.

A warehouse control system's main job is to convert information from the upper-level host system, which is typically the warehouse management system, for use in everyday operations. A common objective is to guarantee that information is stored in one system or is automatically collected, eliminating the need for warehouse staff to ever input it again. The interface used to handle operations-level processes, people, and equipment is often a warehouse control system.

Based on warehouse control system, literature distinguishes three types of warehouse management systems:

- Basic WMS: This system is apt to support stock and location control only. It is mainly used to register information. Storing and picking instructions may be generated by the system and possibly displayed on RF-terminals. The warehouse management information is simple and focuses on throughput mainly.
- Advanced WMS: Above the functionality offered by a basic WMS, an advanced WMS is able to plan resources and activities to synchronize the flow of goods in the warehouse. The WMS focuses on throughput, stock and capacity analysis.
- Complex WMS: With a complex WMS the warehouse or group of warehouses can be optimized. Information is available about each product in terms of where it is located (tracking and tracing), what is its destination and why (planning, execution and control). Further, a complex system offers additional functionality like transportation, dock door, and value-added logistics planning which help to optimize the warehouse operations as a whole.

Warehouse management systems can be stand-alone systems or modules of an ERP (Enterprise Resource Planning) system or supply chain execution suite. The primary purpose of a WMS is to control the movement and storage of materials within a warehouse. The WMS can be deployed as a paper-based, RF/wireless based or combination of both.

1.4 INVENTORY MANAGEMENT

The interval between receiving the purchased parts and transforming them into final products varies from industry to industry depending upon the cycle time of manufacture.

It is, therefore, necessary to hold inventories of various kinds to act as a buffer between supply and demand for the efficient operation of the system.

Inventory generally refers to the materials in stock and their main function is to reduce the interdependency between the various stages of the production and delivery system. That is because the impact of any disruptions in one of the subsystems of the whole process will be felt in the other ones. However, it is necessary to highlight that inventory only helps in diminishing the intensity of the impact of disrupted operations in one subsystem over other subsystems and does not eliminate it completely because the amount of inventories is limited (Vidal Holguín, 2005).

Inventory management includes the widest spectrum of activities related to materials. Starting with the primary activities which include when and how much to make or purchase. In addition, the timing of replenishments and decisions about storage are important decisions as well.

The warehouse is the place where the company stores and keeps raw materials, semi-finished and finished products and other items. The warehouse has precisely the function of containing and storing 'stocks' until the time comes for their use. The fact is that most of the time the customer cannot or does not want to wait and therefore stocks have a strategic function and importance for businesses: that of releasing the needs of the production process from the way demand arises. Inventories also have the function of allowing production processes that must be carried out in sequence, but which have different speeds, to continue without interruption. On the other hand, however, the existence of inventories creates a number of problems that have to be managed.

"In fact, the investment in stock constitutes a monetary fund that costs money, in that it does not bear interest if the capital is one's own, or really costs money in interest expense if the capital is third party; that is locked up and can hardly be disinvested, at least in the short term; it represents a constant danger of obsolescence and physical decay. Furthermore, materials take up space in the warehouse, require work (maintenance) for their storage, costs for transport, heating, refrigeration and more. Investing in stock, by taking away liquidity from the company, leads to less contractual strength and thus to a more unfavourable fixing of costs and revenues and, sometimes, even to insolvency due to a lack of immediate monetary availability. Not only that, but a company with smaller inventories presents a more attractive balance sheet in the eyes of credit and financial interlocutors [...] and is therefore more favoured in raising capital'. (Urgeletti Tinarelli, 1981). All these reasons make it the objective of many companies to compress stock levels as much as possible, without hindering or compromising the production process. Inventories are, therefore, defined as "a set of materials, semi-finished products and products that at a given time are waiting to participate in a transformation or distribution process". (A. Grando,1995). (C. Masini, 1984) defines stocks as "... physical-technical quantities that express one aspect of the correlation between the multiple processes of acquiring the conditions of production, of transformation and of transferring the results of production to third economies...". This definition, certainly complex and perhaps somewhat philosophical, probably means that stocks are defined as all those production factors that are acquired by the enterprise to start the production process, which then undergo certain transformations and become stocks of semi-finished products. Finally, once the production process is over, they are transformed into stocks of finished products.

Inventory management is a set of techniques and tools that provides clear answers to the questions: "When to stock up and how much?". A stockpile management system is the set of policies and controls that make it possible to monitor the quantities in stock, determine what level to maintain, when to replenish and in what quantity. The objective of stock management is to ensure the right quantity of goods in the right place, at the right time and at the lowest possible cost. The BSI 5191 standard defines stocks as 'all tangible assets owned by the company with the exception of real estate, i.e. all finished or otherwise saleable products, all components incorporated into finished products, and all other materials consumed in the conduct of the company's business'. Any company must take care of stock management and ensure that it is carried out efficiently. The function of inventories varies according to the type of company: in manufacturing companies, inventories ensure the smooth running of production, guaranteeing the availability of raw materials and semi-finished products, while in service companies they enable the provision of adequate customer service. Even in trading companies, stocks of finished products are a key element in ensuring the supply of goods at a certain location, in certain quantities and at the required time, in order to meet customer needs.

1.4.1 Stock classification

Stocks are defined as a collection of materials, semi-finished and finished products that at a given time are waiting to participate in a transformation or distribution process and can thus be compared to reservoirs from which production managers and consumers draw.

The first possible classification of stocks is made on the basis of their function, i.e. their role within the purchase-production-sales process.

We distinguish, therefore, between:

- *raw materials*, consisting of incoming production factors, destined for processing, which feed the production process;
- *semi-finished products*, materials that have undergone some transformation, but which have not yet been not yet completed;
- *finished products*, goods that have gone through all stages of production and are ready to be sold. be sold.

Raw material stocks are held in order to make up for delays in supply deliveries or to reduce purchase costs in the event of quantity discounts or depreciation conditions; semi-finished product stocks are accumulated to make up for delivery delays of sub-suppliers or other departments, to free/disconnect departments from production rhythms and schedules, and to allow individual stations to organize themselves with a minimum of autonomy; finally, stocks of finished goods are used to fulfill orders quickly, to cope with cyclical trends in demand, to avoid radical changes in production scheduling in order to cope with irregular demands.

The second classification of stocks is made by intended use:

- *operational stocks*, i.e. stocks that enable the company to carry out its normal production and distribution activities;

- *speculative stocks*, which are built up exclusively for speculative purposes, i.e. to take advantage of a change in the purchase or selling prices and thus minimize the effects of price instability. For example, an enterprise that expects an increase in the purchase price of raw material in the short term may store a certain quantity of that raw material with the aim of reducing costs by constituting a speculative stock;

- *safety stocks*, are built up to cope with uncertain situations regarding supply times and fluctuations in demand.

Operational stocks in turn are divided into:

- *in-transit stocks*, also called transfer or processing stocks, accumulated in relation to the time required to transport a stock unit from one processing point to another, held in storage with the ultimate aim of optimizing the efficiency of the production process. The total amount of stock in transit depends not only on the transit time but also on the quantity to be transported, which in turn is linked to the demand to be satisfied. The amount of this stock is generally represented by the expression: $I = S \times T$ where:

I = in-transit stock required at a certain stage;

S = average sales (or consumption) in the unit of time;

T = time taken to move from the previous stage to the storage point.

The expression indicates, among other things, that in order to reduce the level of in-transit stock, either the relative transfer time is reduced or the consumption/sales rate is increased;

- *organizational stocks*, are used to efficiently organize the stages of the purchase-production-sales process, with the ultimate aim of avoiding malfunctions for the business system as a whole.

These stocks make the various phases of the production-distribution system independent, performing functions of 'flywheel' (in order to overcome the inertia and dead points found in certain phases of the transformation cycle) or of 'shock absorber' (in order to cushion contingent variability of production or sales of the organization) or even of 'lung' (to cope with any possible distortion of the system).

Organizational stocks are in turn subdivided into three broad categories, according to the functions they are called upon to fulfil:

- economic unit stocks (lot size inventory), relating to purchases (or production) in quantities exceeding immediate needs, motivated by possible price discounts or logistics optimization;
- seasonal stocks (buffer stocks), related to the need to compensate for more or less predictable fluctuations in consumer demand;
- preventive stocks (anticipation stocks), whose function is to protect the company from possible supply difficulties or to cope with possible temporary plant shutdowns.

Another possible distinction of stocks considers their use and their role within the production process. In this regard, it is usual to distinguish stocks into:

- *existing stock or actual stock*, which indicates the number of materials actually in stock at a certain time;

- *virtual stock*, which is determined by taking into account not only the materials actually in the warehouse but also the quantities already ordered from suppliers and those committed to customers;

- *normal stock*, which is the stock normally available on average in the warehouse during a certain period of time;

- *minimum stock* which represents the minimum quantity of materials to be kept in the warehouse, below which the company runs the risk that production or distribution may be interrupted;
- *maximum stock* which represents the maximum quantity of materials to be held in stock beyond which the company would incur excessive financial and operating costs and would have excessive time to dispose of such stock.

1.4.2 Methods of stock management

Before describing stock management techniques, the two fundamental methods of managing purchasing and production are described (Mocellin, 2017):

- *Push management*: push management means scheduling purchases and production based on the forecast of the next use. Forecasts can be based on time series analysis (data collected in previous periods) or they can be intuitive forecasts of demand trends. In this method, we can in turn distinguish between procurement on stock and procurement on the forecast.
- *Pull management*: Pull management means planning purchasing and production based on the certainty of subsequent use. The certainty is ensured by the presence of customer orders.

<u>Procurement to customer order</u>

With this method, the materials required for the production of a product are procured from time to time, for a specific customer request. The technique consists of waiting for the arrival of a customer order in order to determine the raw material requirements and subsequently issue the appropriate supply order. Subsequently, issue the appropriate supply order. The necessary condition to be able to implement this method is the availability of sufficient time for procurement and manufacture of the product, which must be longer than the lead time required by the customer.

This system makes it possible to propose a diversified and customized offer to the customer, tailored to his needs, without having to stock huge quantities of variants of the same product; for this reason, it is widely used in companies that work on the order. The main advantage of this system is the drastic reduction of stocks, as theoretically no safety stock is required. This technique, however, also has disadvantages, as the supply lead time has a direct impact on the service lead time: a delay in procurement can, in fact, lead to a delay in the delivery of the product to the customer. A further weakness of the model is the increase in logistical costs due to the fact that orders of raw materials for the manufacture of products required at different times cannot be grouped together.

Stock-based procurement

The stock replenishment model is based on maintaining a stock of products stock and consists of issuing a supply order when a certain threshold in the stock level is reached. reaching a certain threshold in the stock level. This methodology implies restoring the stock, irrespective of the arrival of a customer order, even in the absence of an immediate requirement. The two techniques that are part of this stock management model are (Mocellin, 2017): - replenishment to point of reorder; - replenishment at a pre-determined periodic replenishment.

The limitations of stock replenishment

The first limitation of these methods concerns the procurement lead time, since if this time is very long, the security stock will have to be higher and the level of reorder level will also be higher. This leads to high stock levels in the warehouse and a higher reordering frequency. The second limitation of stock replenishment methods concerns the nature of the demand. In fact, the more random the demand, the less appropriate these methods are, since the principle behind these techniques, is to systematically restore the stock, whether or not there is an immediate need.

Forecast procurement

Forecast procurement consists of forecasting the demand for finished products, to supply the raw materials needed to manufacture them before the arrival of customer orders. This method does not have the disadvantages of the previous methods in that it avoids including the procurement lead time in the overall order lead time, but without having to maintain the of the order, but without having to keep a large stock in the warehouse, as it works on a demand forecast. working on a demand forecast.

An example of forecast-based procurement is the MRP (Material Requirements Planning) method, which allows, after estimating future demand for finished products, to determine the raw material requirements during the time frame in question and to generate the corresponding purchase orders in good time. A further advantage is the possibility of aggregating orders for suppliers as the system allows them to be planned over a fairly long-time horizon.

The main problem with the forecast-based procurement method is its dependence on the reliability of the demand forecast. The smaller the deviation between forecast and actual demand, the smaller the stock in the warehouse will be. For this reason, in contexts where variability is very high and it is difficult to apply forecasting techniques, the application of this method becomes impossible. However, it can be said that the forecast-based procurement model is widely used, as it is the most elaborate and best performing, provided that the system to detect the demand for finished products is effective.

1.4.3 ABC ANALYSIS

A first point to be addressed for proper stock management may be to understand which items within the assortment are to be exercised more control over, as there may be a possibility that only a part of the products in stock incorporates most of the total value. Pareto analysis, or also called ABC analysis, is often used in this analysis. This tool divides the consumption over a period of time of all items in the warehouse, classifying them decreasingly according to the quantity stored or the immobilized value. From this, a cumulative function is created of the value of each item according to the number of items. From the function, the division of the items into three classes is extrapolated. In particular, the number of items worth 70-80% are the type A materials, for which very careful management is required. Type C materials are those that correspond to a very small part of the value in stock, 10-15% for which a less strict control is adopted. Class B items, depending on the case, are associated with either class A or class C.

ABC analysis is a stock management technique that allows articles to be classified and organized according to their rotation. It is fundamental both for planning a correct strategy for allocating resources in the warehouse, and for increasing operational efficiency by reducing the operational time of picking.

This approach is useful when storing products with different values. Goods are organized according to the investment that is allocated to each of them. In other words: the higher the cost of the goods, the more attention will be paid to them.

With regard to the management of stockpiled materials, an ABC analysis is used to divide the stock into three categories, identifying for each item the relative impact according to the discriminating variable considered, defining which are the critical points and where to focus attention. The three categories are:

● Class A: can be defined as the 'money-maker' of the company, i.e. it represents that part of the stock items that generates about 80% of the revenue. It is considered as a protected and priority class.
● Class B: these are the articles that generate about 15% of revenue. They can easily swing towards class A or class C.
● Class C: these are slow-moving or unproductive inventories. This group brings very little value to the business.

ABC analysis is carried out by putting articles as the variable in the abscissa and a variable expressed as a cumulative percentage in the ordinate. The most significant variables in the ordinate are turnover, consumption and average stock, but we can use any variable of interest. In most cases, the division into classes is done as depicted in the figure below. I set for class A a limit value in the ordinate of 80% to which corresponds in the abscissa about 20% of the articles; for class B in the ordinate a value between 80% and 95% and in the abscissa I expect about 30% of the articles; finally class C in the ordinate is bounded between 95% and 100% while in the abscissa I reveal about 50% of the articles.

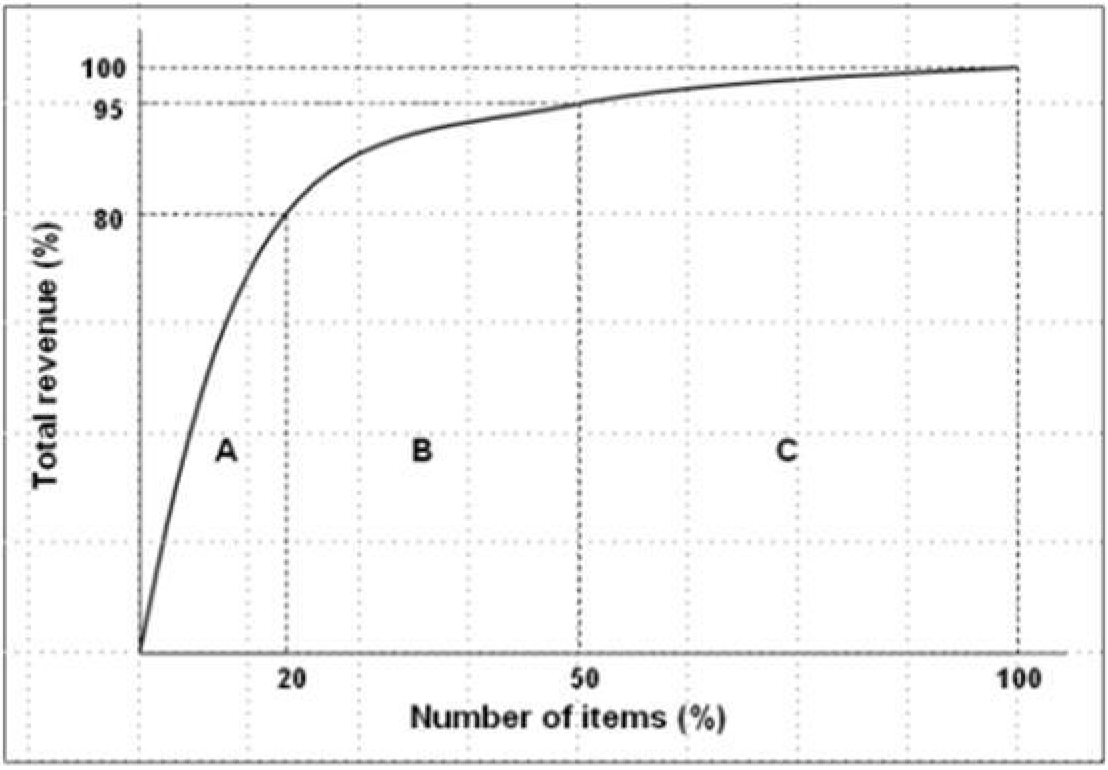

Figure 5: Pareto chart and ABC Analysis

This distribution is not compulsory, on a case-by-case basis, depending on the performance of the variable in the sorted variable, it is possible to distribute the percentages belonging to the classes more appropriately. The meaning of the classes remains the same even if the proportions of the percentages are varied.

ABC analysis of use value

An initial analysis of stock items can be carried out using the usage value. This variable values the consumption of an article in stock, so that each code is assigned its proper weight in the overall total. This evaluation is appropriate, just think of the case of articles, such as small parts, which have high consumption but negligible unit value. If I only consider consumption, I would be comparing a value that does not really describe the strategic importance of the article and could place it in a class that does not belong to it, and I would therefore be managing procurement with an inappropriate criterion. This variable, called use value, I can express with the relation:

$$\text{Use value} = Q^*v \ [€/\text{period}]$$

where

Q: total consumption in the period of analysis [pieces/period]

v: unit value [€/piece] (purchase price per piece)

Once the utilization value of all articles under study has been calculated, the data is sorted in descending order. It is then necessary to calculate the utilization value of the individual article in % and in cumulative %. Finally, a graphical representation allows the result of the analysis to be clearly summarised: on the ordinate is the cumulative % of the variable, in this case, the utilization value, while the abscissa shows the stock items. The limitation of this model is the consideration of only the variable of the utilization value as a representative index of the stock. In this way, I do not consider stocks with the risk of finding high inventories of non-critical articles. To overcome the limitations of the simple ABC analysis on consumption, I supplement the results with another simple ABC analysis by considering the average stock value variable of each article as a variable.

ABC stock analysis

This analysis is carried out by calculating the average stock in the warehouse, over the analysis period, of each article. Here again, the variable should be valued in such a way as to give each article the correct weight in relation to the cost of stock in the warehouse. To value the stock, the figure obtained must be multiplied by the unit price of the articles. The relation for the calculation of the average stock valorized is:

$$\text{Average stock} = S^* \, v \; [€/\text{period}]$$

where

S: average stock of the article [pieces/period]

v: unit value [€/piece] (piece purchase price)

Then the same procedure as for the ABC analysis of the use value is repeated.

Cross ABC analysis

By simultaneously examining two ABC analyses with respect to their own variables, we obtain a cross ABC XYZ analysis or Cross Analysis, which offers more strategic control and allows us to evaluate stock management performance. Considering finished products, it consists of the crossing of two different simple analyses ABC and XYZ: the first on the basis of movements, i.e. on the turnover generated, the second on the basis of the average stock in the warehouse valued at production cost. From the intersection of the stock classes and turnover, a 3x3 matrix is obtained which provides a concise picture of the warehouse situation. As shown in the figure, 9 material classes are obtained: AX, BY, CZ, AY, AZ, BX, CX, BZ, CY. Sometimes a further category is identified, Class D materials within which there are materials with incorrect data or generated by special situations, which must be evaluated separately.

	X	Y	Z
A	AX	AY	AZ
B	BX	BY	BZ
C	CX	CY	CZ

Figure 6: Cross Analysis ABC XYZ

Along the main diagonal of the table, we can identify the classes AX, BY, CZ: these have a balanced management because high consumption corresponds to higher stock and low consumption to low stock. The articles above the main diagonal (class AY, AZ, BZ) are articles that have a higher stock class than consumption and are therefore managed worse than average. These are articles that have a low utilization value but high stocks. Therefore, inventories must be decreased and procurement policies revised through demand management methods. On the other hand, articles that are below the main diagonal (class BX, CX, CY) have a lower stock class than consumption and are therefore managed better than average. These are optimally managed articles with high turnover and low stock. This matrix represents an insight that can identify the most critical areas where action can be taken to improve the process and check which material management methods are according to the position in the table. The periodic performance of this analysis also makes it possible to grasp the evolution of categories over time and the movement of individual articles from one class to another, which serves to highlight the possible need to vary the procurement criteria in order to achieve management improvements and reduce stocks.

Management indices

For a complete warehouse analysis, we can use indices that express the company's management situation from several aspects. These parameters constitute guidelines indicating where to act in optimizing management and which data to use both to compare events occurring in different time periods and to determine the parameters to be used in the calculations. Two main indicators are the turnover ratio and the coverage ratio.

- Inventory turnover ratio: plays a key role in measuring the financial efficiency of management. The turnover ratio of a given item expresses the number of times, in a certain period of time, the material is 'renewed' or 'rotates' in the warehouse. An annual rotation index of 5 means that the material rotates five times in twelve months. It also gives us an initial insight into the level of warehouse management and the period that goods stay in the warehouse before entering the value-generating process.

A high turnover ratio number means that the stock rotates many times; a low rotation index, on the other hand, means that the stock remains more 'idle'. It can be calculated, in quantity or value, as the ratio between the quantity consumed of a product, in a given period, and its average stock.

ITR=total consumption of the period/average stock of the period

It is recommended to calculate this index for different time periods or for individual codes or families of codes, in order to have more meaningful and comparable data. In technical practice, an optimal ITR value is not identified; in fact, you want the value to be as high as possible. With reference to the cross ABCXYZ analysis, I expect class CX to have a higher ITR than all other classes because, in this class, I have articles with the lowest stock and high consumption, so they rotate a lot. The main objective of warehouse management is to increase the turnover ratio, this means for the company rotates the stock in the warehouse more and decreases the idle capital that represents fixed assets.

● *Coverage ratio*: the inverse of ITR is defined as the coverage ratio, which measures how long the stock of a certain product covers the average consumption. The coverage period can be calculated by entering the time period considered in the analysis in days, weeks or months in the numerator and dividing by the value obtained from the turnover ratio. We obtain the time interval in which the material sits in stock.

CR= period considered/ITR

Since goods that remain in stock do not contribute as added value to the finished product but generate operating costs, it is important that the period during which the material remains in stock is as short as possible. This calculation is very important in order to understand the time required for the financial costs invested in the goods to be recovered. The lower the value of the coverage ratio, the better it is for the company.

CHAPTER 2: MANIFATTURA BERLUTI

The purpose of this chapter is to provide a general description of the company that is the subject of this thesis. Some of the main features of Manifattura Berluti will be highlighted, and its history will be explored, highlighting all the most important stages that have marked the company's path and conditioned its business.
The next section will describe in detail the activities that feed the production flows functional to the fulfilment of orders.

2.1 MAISON BERLUTI

The Maison is part of the world-leading luxury group LVMH, along with 70 other brands that are all united by tradition and prestige.
Its story began in 1895, when Alessandro Berluti, a young 30-year-old Italian, brought his creative energy to Paris to practice his craft as a master shoemaker. He named his first model, a lace-up shoe, after himself, Alessandro, and the House took his surname, Berluti. The result is models that are incomparably elegant and comfortable. But more than simply a prestigious shoemaker, Berluti has always represented a certain "*art de vivre*".

Figure 7: classic "Alessandro"

Alessandro Berluti bequeathed his savoir-fair to his son Torello, who continued his father's tradition in Paris where the end of the Great War was celebrated with frenzy in the name of happiness and nobility. Driven by this effervescence, in the 1940s Torello set up shop at 26 rue de Marbeuf a stone's throw from the Champs-Elysées, offering enthusiasts an exceptional service in an unprecedented setting in an atmosphere at once sophisticated and discreet. His made-to-measure shoes in the name of elegance and modernity enrich Maison’s heritage by spreading a precise idea of male elegance throughout the world.

In the 1960s, Torello began to be joined by his only son Talbinio, who began to explore the paths of modernity, starting with the shop's furnishings and giving the Maison those youthful traits that hurled it into the contemporary world. And it is within it that the international jet-set throngs in a comfortable and purist setting. Talbinio's personal contribution to the fashion house's influence is the ready-to-wear shoe collection, thanks to which he manages to turn customers' impatience into professional performance. In the meantime, his reputation spreads all over the world to the delight of the followers of a style that is true to itself, contrasting modernity with the passing of time.

Talbinio is accompanied by Olga Berluti, a woman who imposes her imaginative creativity on a universe that is solely masculine. He transformed the shop into a private salon where one could converse in good company, thus turning the purchase of a pair of shoes into amusement for connoisseurs.

Olga created a completely new and decidedly nonconformist moccasin at that time, which was named *'Andy'* after Andy Warhol, who enthusiastically took possession of it. It was precisely in those years that Olga gave voice to the imagination of her time, anticipating the desires of a cosmopolitan and enlightened clientele in search of a style as well as a product. She thus created a club, winking at male rituals, a circle of initiates, passionate about footwear, seasoning the codes of 'good taste' with a pinch of insolence and circumventing conventions with lightness. She invented a range of exclusive, bold

and intense shades thanks to patina at a time when most men's footwear was only black or brown. Thanks to her, today patina is one of the symbols and hallmarks of the Berluti fashion house.
To this day, the historic boutique at 26 rue de Marbeuf is still open and continues to be the historical symbol of the maison's birth.
Naturally, new areas of expression have been explored: leather goods in 2005, and in 2011 a ready-to-wear line was launched, thanks to the artistic director at the time, Alessandro Sartori, and the acquisition in 2012 of the Arnys ateliers. In this way, the Berluti Maison is able to offer a complete *prêt-à-porter* collection and the possibility of having a made-to-measure wardrobe, thanks also to the presence of the *atelier sur mesure* located in the immediate vicinity of the historic Marbeuf boutique, which carries on the tradition of made-to-measure shoe savoir-faire.

Hand-assembled and customizable from the wooden last to the choice of leather and patinas, Berluti bespoke shoes combine absolute comfort and unique flair. As opposed to ready-to-wear shoes, or "*demi-mesure*" shoes, which are simple adaptations of existing models, bespoke shoes are created from scratch. The client is at the very centre of the process, and the future shoe will be created according to the morphology of his foot. Shape, soles, colours… everything is adapted to the client's desires, needs and specifications. This includes the choice of leather – from the emblematic Venezia leather to more exotic hides.
By the 1990s, Olga Berluti had developed Venezia leather, a material so supple and fine that it promotes and enhances cutting-edge colour creativity. This calfskin undergoes an exclusive Maison tanning process, giving the shoe remarkable flexibility and traction. It is a full-grain, uncoated leather made from select hides of exceptional quality; the shoe's pieces are cut from its most perfect sections.
Since 2013, Berluti has internationalized its distribution network with the opening of new boutiques in Paris, but also in London, Shanghai, Tokyo and more recently New York. They

offer the entire Berluti wardrobe and range, including bespoke. Incorporated into the House in 2012, the tailoring savoir-faire of the Arnys workshops gave life to the Grande Mesure service. Complementing its shoemaking knowledge, this new offer opens infinite horizons with the possibility of a bespoke wardrobe. Present in the world's greatest capital cities, the House's deployment phase continues, to offer the Berluti experience all over the world.

Figure 8: diverse patinature per la "Andy"

2.2 MANIFATTURA BERLUTI

The elegant shoes and magnificent leather goods that can be purchased in over 50 Berluti boutiques around the world are developed and produced in Manifattura Berluti, a workshop located in the town of Gaibanella in the province of Ferrara.
Berluti produces and sells clothing for men, footwear and leather accessories. In the recently built headquarters of Manifattura Berluti, the products are created starting from different types of leather. The Maison is known worldwide for these products: footwear,

belts, bags and wallets are handmade of calf leather, kangaroo and alligator, and are often made with different finishes and made to measure.
Manifattura Berluti was established in 1991 under the name Atelier StefanoBi and was subsequently purchased by the Berluti Maison in 1992.
The first expansion of the atelier took place in 1998 with the move to the factory in Via Cimarosa in Ferrara and, two years later, Atelier StefanoBi took the name Manifattura Ferrarese. From this moment on, the expansion of Manifattura Ferrarese is very strong. Since 2003, shoes are produced under licence for the most important brands in the fashion world of the time, and since 2005 the production of leather goods is introduced, which finally become part of the Berluti collection, further affirming the presence of the Maison in the luxury market. These years also saw the second expansion of the factory, which moved to Via Paganini, also in the city of Ferrara.
In 2008, the company ceased to produce shoes under licence for other brands, and in 2012 Manifattura Ferrarese took its current name of Manifattura Berluti.
In 2015, Manifattura Berluti moved to its current workshop, which was designed by Paris-based architecture firm Barthélémy-Grino with the creative collaboration of Berluti Style. This workshop is not a factory, but rather genuine manufacturer. The intelligence of hands and the transmission of gestures are echoed in the care taken with the details of the building's construction. It is perfectly integrated into the Ferrara countryside and is immediately recognizable by the important use of wood, visible in the exterior cladding. The red cedar chosen has not been treated and over time will create a patina similar to those of Berluti products, thus becoming more beautiful as the seasons pass. A peculiarity of this building is its shape, which respects, in its proportions, those of an enormous shoebox.

The factory is divided into two main departments:

- the development and industrialization department, which includes the modeling, product development, industrialization, new launch coordination, technical office and special productions divisions;
- the production department, which includes the planning, raw material and component purchasing, and sales departments.

In each of these two divisions, there is a production chain. Within the former are the nesting, cutting, stitching, shoe assembly and leather goods assembly ateliers and the fundamental point of the Maison, the finishing atelier. In these ateliers, the designs from the style take shape and are produced in the form of a prototype that will later be industrialized for production. In addition, catalog products in exotic materials and all special productions, which may be special customer orders, exclusive mini-collections or collections in collaboration with other Maisons of the LVMH group, are processed in them. These ateliers are less numerous than those in the manufacturing division because of their purpose and the types of orders they handle. These ateliers process the items from the Berluti catalog, which are subsequently supplied to all of the boutiques across the world.

In recognition of the importance of craftmanship excellence and of its master leatherworkers, Berluti has established the Académie du Savoir-faire to train future generations of leather craftsmen. The need for new artisans, the lack of adequately trained profiles in the territory, the increase in the average age of the company and the need to preserve the Savor-faire, created the need for the Académie. To maintain this tradition, Berluti created an in-house training school managed directly by the company's artisans. By alternating theoretical and practical lessons, students have the opportunity to develop their talents in accordance with their specific aptitudes and to undertake the profession of craftsman. The education promotes training in the various stages of the production cycle: cutting, stitching, assembly and finishing. The development method of the course consists of theoretical lessons and training on the job with continuous feedback between students and tutors. At the end of the course there is a final exam and a certificate that certifies the knowledge and skills acquired. The Académie is recognized at European level as a training center of excellence in the field of footwear and leather goods production and is supported by a close partnership with public authorities.

2.3 SUPPLY CHAIN

In any industry, especially in fashion industry, to get from a raw material to a finished product, a massive process is necessary, and many competences and production techniques are also essential.

The process, starting from raw materials in order to produce finished products, is not a static process, but quite the opposite. The procedure is complicated, and it needs continuous innovation to enhance the quality of the product. This is the only path that a company such as Berluti must follow, to launch a unique product that represents a reference point in all the world.

Within Manifattura Berluti, leather is collected, treated, and stored at the tanneries that supply the manufacturing industry. The manufacturing industry creates the finished products from the leather, which, thanks to distribution logistics, are sent to the various stores where they are retailed. Therefore, to schematize how much described, it is possible to articulate the model in three main parts: supply, production, and distribution. Supply concerns the procurement of raw materials or components that will be transformed or assembled to manufacture the final article.

For Berluti, the trickiest part of this phase is the supply of raw material since leather is the common material for all the brand's products and it is undoubtedly the most important in terms of processing, cash flow and criticality in the supply. The other components such as metalwork, laces, soles and consumables usually do not present major supply issues, and this means that the impact of these materials on the supply chain can be considered negligible compared to the criticality in the availability of leather.

The manufacturing of Berluti's product portfolio is ensured by the Gaibanella (FE) plant for shoes and by several Italian manufacturers for small and large leather goods. The company maintains daily contacts with its suppliers and subcontractors, as the efficiency of the work and the relations with them represents a crucial point of planning; a delay due to the most disparate reasons can compromise the delivery of a product by breaking the promise made to the customer. Once production is complete, the products are sent to the central warehouse in France and from there all products are distributed to meet the needs of the various stores around the world.

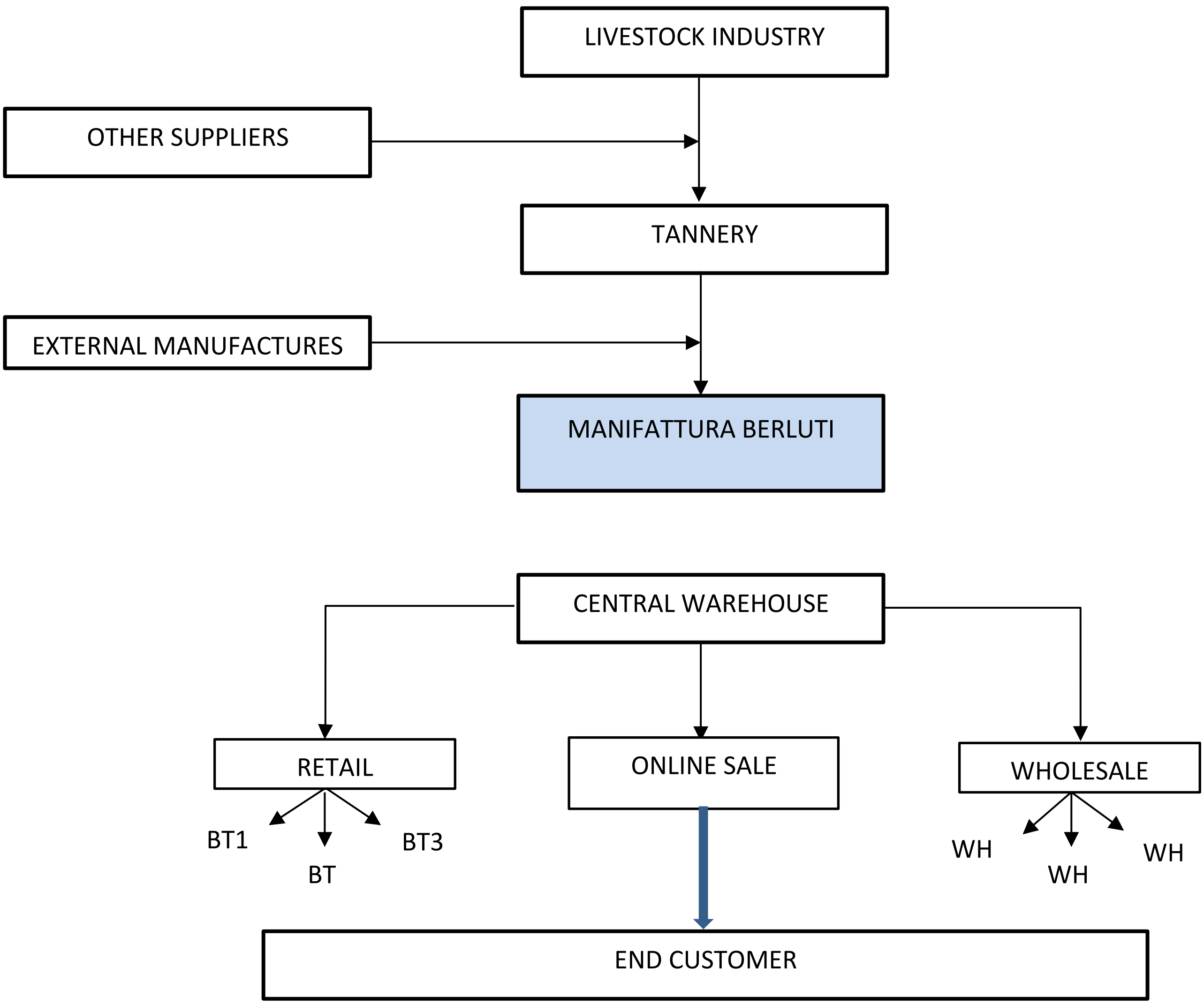

Figure 9: Simplified supply, production and distribution diagram in MB

In the Figure 9 a basic diagram of supply, production and distribution is illustrated. The diagram summarizes all the information provided so far. The company supply is mainly through tanneries which have a close relationship with the livestock industry. Raw materials arrive at Manifattura Berluti from tanneries and from external suppliers and manufacturers. Here the raw materials are inspected by a careful quality control. The production begins.

After a manufacturing process that will be explained in the following paragraphs, the product is shipped to flagship stores, online store and wholesale shops. Obviously, before the shipping process, the product undergoes further quality control to ensure that it is well manufactured. Finally, the product may reach the final consumer.

2.4 THE PRODUCTION PROCESS

The production process of a Berluti 1895 shoe is characterized by four main working stages:

- Cutting
- Stitching
- Assembling
- Finishing

In addition, the cutting phase can be carried out either freehand, by dies, or by nesting the entire leather on special tables equipped with video projectors to mark out the areas to be cut.

Figure 10: Principal Operations of the process

The process always sees the succession of these four phases, to which, for some models, further processes such as perforation, lasing and studding can be added, leaving the general scheme shown in the image on the following page unchanged. It always starts with a cutting phase (code 3500) that generates as output the leather and/or other fabric blanks that will then compose, through the hemming phase (code 5000), that part of the shoe known as the "upper" to which components such as soles, socks, insoles, toe-puffs, etc. still have to be added. The assembling phase (code 7900) brings the shoe to be almost a finished product; however, for men's luxury shoes and in particular for those of Berluti 1895, the production process ends with a patination operation to provide the shoe with a shaded color effect. This stage is called finishing (code 9000). For the purposes of this study, it is also useful to add to the list of main stages the one that, once released, provides the initial input for a picking mission in the parts warehouse for assembly (code 7000).

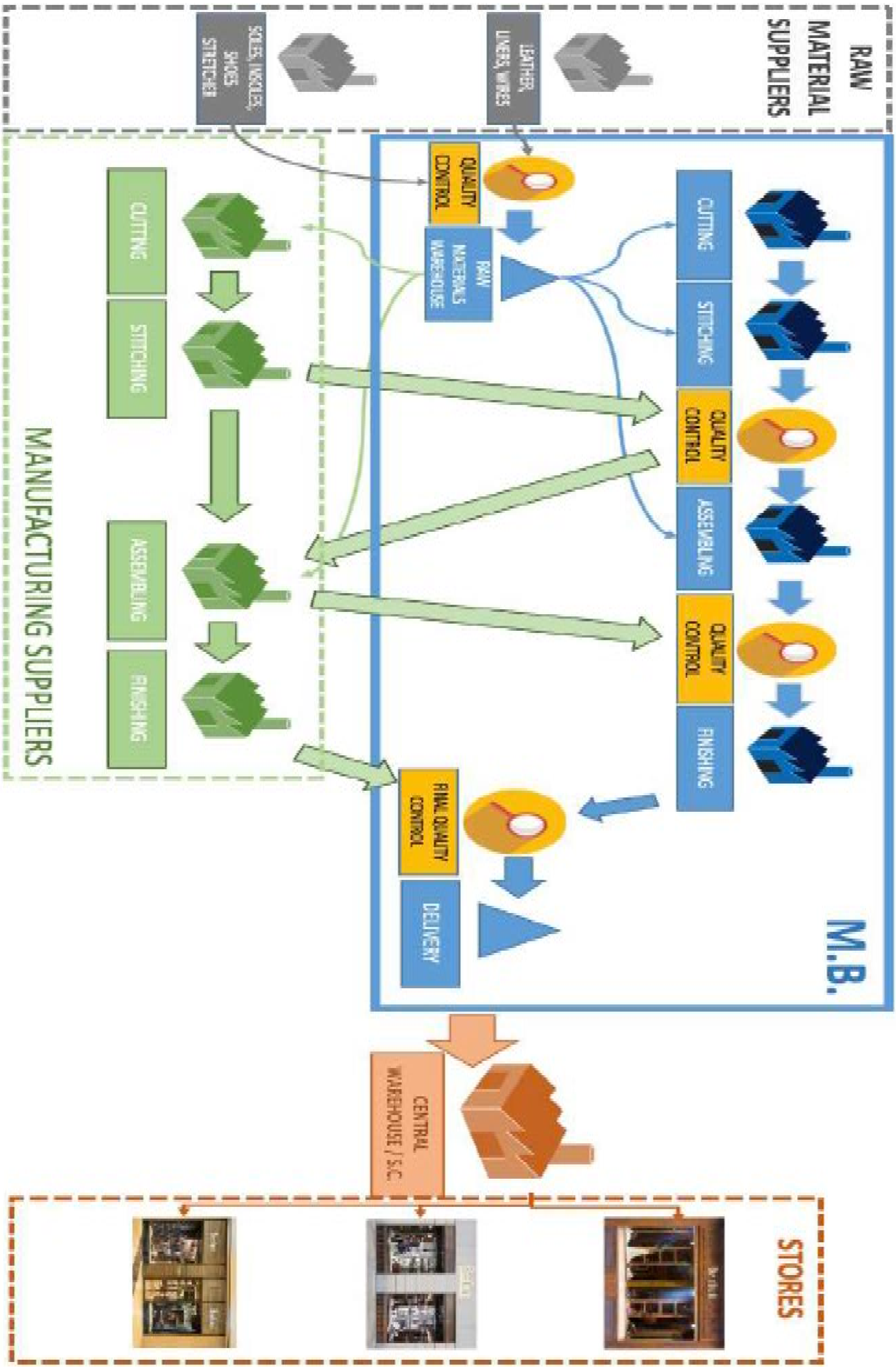

Figure 11: internal and external production process

As can also be seen from the figure on the previous page, the work phases described can be carried out both internally and by an external supplier: in fact, some pairs released for production can start the process and conclude it without leaving the company perimeter, while others may have the first part of processing at external suppliers and then return to Manifattura Berluti to be assembled and finished, others may start their process in internal departments but conclude it at an external supplier and some may even start and conclude their production process completely outside the company perimeter, returning only for final quality control.

The pivotal element of the whole process: the tag

The first peculiarity regarding the organization of production at Manifattura Berluti is that every single product, regardless of whether it is a pair of shoes, a belt, a wallet or a handbag, is registered in the system by means of a numerical identifier known as a 'Production Order' (PO), in jargon 'tag' because the physical print accompanies the individual product throughout all the production phases (both external and internal). A PO is composed of a series of nine numeric digits, the first three of which are always fixed (205) and the last six of which vary progressively according to system entry (e.g. 205402740). The PO encloses the entire 'history' of the individual product in the system: when it was ordered and when it will be requested from the Paris headquarters, when it was 'born' in the system, which and how many components it calls for each work phase, whether or not it is associated with external work phases, and so on.

SPECIAL PRODUCTION PROCESS

The analysis I am going to tackle is the result of my six-month internship as a member of the Special Order planning and production team at Manifattura Berluti and will focus on the ca02 division, specifically the internal raw materials warehouse.

Special production deals with:

- exotic catalog (package croco)
- limited editions and special projects (SO/RTS)
- special order (SO)

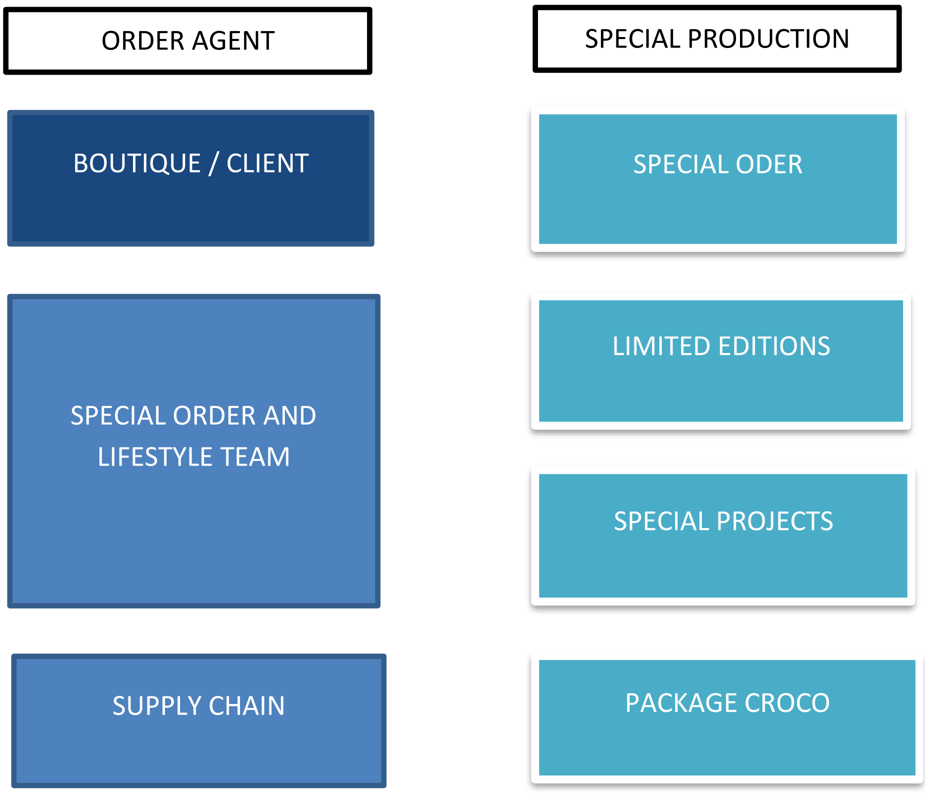

Figure 12: Special Production

The exotic catalog, called **package croco**, is represented by standard catalogmodels, but uses exotic leathers such as alligator and crocodile porosus. The development of this catalog is done in a similar way to the standard catalog, for which the patterns are usually defined following the storyboard, an intermediate step in the development of a collection.

The storyboard initially defines which models in the catalog to propose in the exotic version by communicating the intention and also an estimate of the quantities that could be ordered. From this information, we start by assessing the feasibility of the realization by means of a technical opinion from the industrialization team, and secondly, we study the consumption of the alligator in the cutting phase. I use the word 'study' because for these products, consumption is extremely fundamental given the high cost of the material and this is precisely why it is called package croco, because at this stage we try to maximize the use of the raw material with a mix of large models such as bags but also smaller ones such as wallets. In practice, this study is conducted through the use of paper patterns and alligator skins available in various sizes and following the guidelines of alligator cutting, such as the basic rule of cutting a bag wall to the center of the belly, i.e. with the scales very large and defined, leaving the sides of the alligator, which instead have smaller and irregular scales.

Once this study is conducted, price sheets are compiled, and the results are communicated to the marketing teams. After confirming the collection plan, this catalog is organized into launch groups and *jalons* just like the standard catalog, and the management is exactly the same as the production, but overseen by my team and produced within the ateliers of the development and industrialization department.

This type of order is issued by the supply chain and its follow-up is supported not only by my team but also by the project manager together with the standard catalog of the fashion house.

After defining the models to be included in this catalog, the production process consists of the following steps

- receipt of the order by the supply chain,
- analysis of the order,
- order definition, through the creation of the CDCs, bill of materials, production cycle and formulation of the final price sheets,
- launching into production,
- shipment.

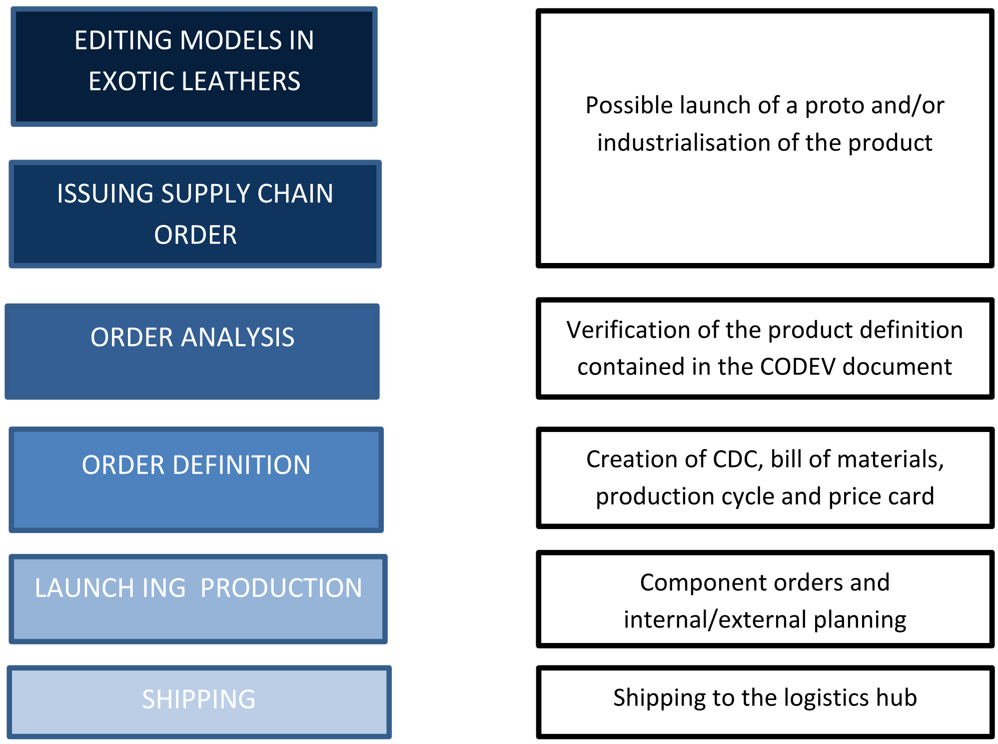

Figure 13: Package Croco: the process

Special customer orders, SO/RTS, limited editions and special projects, on the other hand, are handled by the Special Order and Lifestyle team at the Paris headquarters.
Limited editions and special projects represent small collaborations with other Maisons or mini-collections dedicated, for example, to a special event to be held in one of the Berluti boutiques, such as a new opening.
Special orders ready to sell, on the other hand, represent models in the standard catalog, but for which, following the buying session, the minimum quantity for management in the production department has not been reached. They are called SO RTS because they are managed by the special order team in Paris and manufactured and are available for immediate sale in boutiques, unlike customer special orders.
Customer special orders, henceforth abbreviated to SO, on the other hand, concern those orders that are placed directly by the customer in the boutique. This business, which is growing strongly year after year, gives the customer the opportunity to order a product that, thanks to the very high degree of customization, is unique in the world, this

is because of the number of variants per product that can be produced tends to be so high that it can be compared to infinity.

The starting point for the special order customer is always and in any case the product present in the Berluti standard catalog, both current and, above all, past. This is because the SO catalog contains all the models of the collections that have been created over the years unless there are technical constraints of processes that are no longer feasible or purchasing constraints for components that are no longer available, issues that I will address later in this chapter.

Following the choice of the product to be ordered, the customer, using special catalogs present in all the boutiques, can choose, both footwear and leather goods

- the type of leather and the colour of the patina,
- the type and colour of the lining,
- the finish of the metal components,
- the creation of a tattoo.

It is possible to create a tattoo on our products using the same technique as on people. It is possible to choose such tattoos from a permanent catalog, but also from catalogs that are updated over the years as a result of collaborations with artists. But the degree of customization of this service increases considerably from the moment the customer is provided with the possibility of delivering a drawing of the tattoo he wishes to have reproduced on his order, from the photo of his child to that of his four-legged friend, but also to the coat of arms of his family or a simple phrase that invokes some nice memory. This service is made possible by expert tattoo artists working at Manifattura Berluti's finishing atelier. For more complex tattoos, there is always a study before the order is issued to assess the criticalities and propose possible solutions to satisfy the customer's requests.

As far as footwear is concerned, the possibility of choice increases, since the customer can also choose the type of shoe construction, such as blake, Goodyear, and Norwegian, but also the type of bottom. Precisely for SO, a catalog of bottoms has been developed

that can be used for all footwear, except for trainers and sandals for which there are technical restrictions due to the type of footwear being incompatible with the use of leather-constructed bottoms. This catalog includes many bottoms that are hand-built at the time of assembly, as opposed to production bottoms that are only developed for a specific last and cannot be used on different lasts and are purchased assembled and ready to be fitted to the upper. Therefore, starting with the chosen piece of leather, the bottom is constructed by hand, which will be adapted to the shape of the shoe, assembled with the heel and welt and then coloured according to the customer's wishes. Another feature of the SO is to supply, for each order fulfilled, a red-colored wooden tile, unlike the standard catalog for which tiles are only supplied for elegant, natural-coloured footwear. For large leather goods, in addition to those already listed, the customer can choose the type of shoulder strap from a catalog developed for SO, and for small leather goods, the customer can decide to order the interior of the product in patinated leather, unlike those in the catalog, which are all produced with a standard uncoated lining.
The final customization that can be requested is the positioning of the Berluti script. The Berluti script is a distinctive sign of the Maison and represents an inscription from an ancient French parchment that Olga Berluti fell in love with and wanted to reproduce on Berluti leather. On this parchment, a signature and seal larger than the rest of the inscription are evident and are impressed on the leather by means of a lasing process.

Special order management and production process

SOs are issued by boutique sales staff via an online platform called BSpecial. The following information is entered when the order is placed:

- customer name,
- product code from the standard catalog,
- material type,
- patina colour,
- size, for footwear and belts,

- type of shoe construction,
- colour of lining,
- type of shoe bottom,
- type of last,
- shoe fit,

In addition to this information entered via a predefined template for all types of orders, it is possible to enter comments regarding

- the patina, which may be different depending on the physical part of the product,
- global comments on the order.

To facilitate the realization according to all customer requirements, it is also possible to insert attachments with more specific indications and photos.

Figure 14: SO process from Bspecial platform

When the order is entered, the system generates an automatic e-mail addressed to the Paris team and the order is entered with the status created.

After 48 hours after the order has been entered, its status changes to validated. During this time, the Paris team has the opportunity to view the order and, if it does not conform, communicate the necessary changes to the boutique. As soon as the order is validated, an e-mail is automatically sent to my team, which represents the official issue of the order. With the validated status, a SKU is also generated which will then be unique for that individual order. If there is also an attachment, a second email will arrive with the link to download the file. Each order, as the subject of the e-mail, has a purchase order defined by the first three letters of the boutique code, followed by a unique numeric code. This PO is not a single one per SKU ordered, but refers to the total order that has been entered into the system for that customer and can therefore include as many SKUs as there are products ordered.

Every day, one of my tasks is to print out all the orders that arrive with the purpose of:

- further check the conformity of the order and that no information necessary for launching it into production is missing, if this is the case I have to ask the SO team in Paris for clarification as they are the only interlocutors with the sales staff in the boutiques,
- classify the order according to its type and determine the expected delivery date. This second step is crucial for the subsequent entry of the sales order into the SAP management system.

Depending on the type of product, we have different order reasons. For footwear we have

- standard footwear, such as elegant footwear with a built or to-be-built leather bottom,
- non-standard footwear, such as trainers or footwear with a rubber bottom for which the procurement time is longer than for a leather-constructed bottom,
- standard and non-standard footwear in an exotic material, for which the cutting and especially finishing time is considerably longer than for Berluti leather,
- footwear with a certain placement of the lettering, for which an intermediate stage between cutting and hemming of the upper is necessary to send it to the supplier who carries out the lasing operation,
- footwear with tattooing.

For leather goods, the subdivision is similar to that of footwear, with standard, exotic, lettered and tattooed categories. For each category listed above, a lead time and a consequently expected delivery date are associated, following a calendar that is updated and shared each year, also considering the summer closure and possible winter closure.

In this phase of control and classification, the requirement for lasts is also analyzed, a component that is supplied with all footwear ordered, except for sandals.

This requirement is handled in two ways

- for shoe lasts for which a specific tree has been developed in the standard catalog, the order is issued on a weekly basis and per individual customer order,
- for lasts for which a specific tree has not been developed, universal trees are used, which are instead managed on a stock basis with a reorder with a cadence that varies depending on the number of orders arriving weekly.

Following this first step, I deliver the orders to the employees responsible for a specific product type.

The next step involves entering all the information required to launch the orders into production in SAP:

- the creation of the material master file, this step is initially carried out by the Paris team, which activates the SKU created and makes it visible to manufacturing SAP and then the other information is entered by us,
- the creation of the bill of materials,
- the creation of the production cycle,
- the creation of the sales order.

All these steps must be carried out for each individual order, as the SKUs are unique, at the end of which the production order is generated and the bill of lading issued, which will accompany the product through all the processing stages until dispatch.

The process described up to this point concerns the operations required to complete the order management phase. As soon as the production order is generated, in the BSpecial portal, the status of the order will change from validated to defined product, thanks to the direct connection between the portal and the SAP of Manifattura Berluti, and from this moment on, the production phase of the special order can begin.

As explained above, the production order, called a tag, is presented in paper format with all the components of the bill of materials associated with a specific machining phase accompanied by a barcode necessary for the system advancement of the machining operations by the machining center. The tags are then handed over to the cutting workshop manager who is to carry out the first machining phase of the production cycle. After delivery of the tags, a stock analysis of the necessary components is carried out. This analysis can be subdivided into

- leather analysis, which is carried out by the leather warehouse staff,
- component analysis, which is carried out by the employees of the SO team.

The leather warehouse is managed with stock for all types of leather in the special order catalog and is managed independently by its employees who, when they notice that the stock of a type of leather is running low, place an order with the purchasing department. As far as components are concerned, on the other hand, the components required for the orders issued to the cutting workshop are extracted from the SAP management system and then the stock component by component is analyzed, leading to two possible results:

- for components that are also used in the product catalog and for which there is a stock in free use in the production department warehouse, a request is made to transfer them,
- for components used exclusively for the SO, the stock in the development department's warehouse is analyzed on sight and, if it is not available, a single order is placed with the supplier who produces it.

This very artisanal management is also due to the fact that many components, having numerous color and model variants, are not all encoded in the management system and are instead loaded as generic components, thus creating stocks that are unreadable by us from the management system and not even having correct unloading of materials at the time of the advancement of the production order phases. As soon as the first stage of the production order is confirmed and thus advanced, the status on the online portal changes from product defined to production launched. Every week, the progress of the SO order book is analyzed by sending a report to the Paris team with any delays present and specifying the new expected delivery date, so that the expected delivery date can

be updated on the BSpecial portal and made visible to the boutiques, which will notify the customer when they can go to pick up the ordered product.
When the product undergoes the last necessary processing, i.e. finishing, before being processed by the final quality control, it is checked by my team to ensure that the order conforms, i.e. that the product has been manufactured according to the customer's desire specifications. Unfortunately, it may happen that the order does not conform to the customer's requirements, so it will be necessary to re-prioritize the order. This may happen in the event that there is an error in the bill of materials of the order, due to an oversight on the part of the craftsmen or due to a change after the order has been issued that has not been carried out.
After the positive outcome of the conformity check and the final quality control, the product will be sent to the logistics center which will in turn ship it to the boutique igi with any delays present, specifying the new expected delivery date, so that the expected delivery date can be updated on the BSpecial portal and made visible to the boutiques, which will notify the customer when he/she can go to pick up the ordered product. who issued the order. At this moment the status of the order changes from production launched to dispatched from Ferrara. In exceptional cases, the shipment from Manifattura Berluti may also be destined directly to the boutique, for example in the case of a delayed product so as to save the pole's logistical time.
The other subsequent statuses visible on the portal are:
- shipped from the logistics hub,
- in boutique,
- sold.

CHAPTER 3. APPLICATION OF A LEAN WAREHOUSING TOOL IN MANIFATTURA BERLUTI

The structure of the following chapter serves to introduce the Lean Warehousing project implemented at Manifattura Berluti. Starting from the AS-IS situation of the warehouse of the production plant at Gaibanella (FE), all the various phases of analysis and reasoning used to achieve the set objective are described and argued.
Data and codes reported and analyzed in the following chapter are relative and correspond to a trend design increased by a percentage, in order to comply with the confidentiality rules of the company analyzed.
The project will run over the following period: July 2022-November 2022 (approximately 5 months).

3.1 ORGANIZATION OF THE WAREHOUSE: WHAT HAS BEEN DONE

In order to better understand the analysis of the project that we will carry out later, it is necessary to introduce and explain what are the different materials that are used for the production of Berluti products and how their management is currently organized.
Two macro-categories of materials can be distinguished with their relative procurement and different stocking.
- materials needed in the cutting phase, such as leather, linings, fabrics:
- components used in the assembly and assembly stages.

3.1.1 Leather warehouse

The materials consumed in the cutting phase of the order are stored in the leather warehouse of the development department where the temperature is controlled to create the necessary conditions for storage. They are placed on the shelves rolled and divided into bundles and all labelled with their own SAP code and subdivided by macro-

category according to their intended use, such as leather used for cutting shoes, bags and small leather goods.
The management of this stock is entrusted to the head of the cutting workshop who, if necessary, takes the materials required for the progress of current orders.
Previously, at the start of the project, its procurement only took place when the material was running low, a situation that was detected by seeing the station reserved for that material almost empty, with a subsequent purchase request to the purchasing office, which issued the order for a certain quantity that was not determined by a real analysis of the need, but rather by the experience of the head of the department in terms of the consumption trend of that particular material.

The desire for the introduction of lean techniques in the warehouse arose from the need that previously one found oneself without the necessary stock to cut certain orders, thus causing a delay in deliveries.
Since there are a very large number of leather types in the leather warehouse, as they are also used by the product development teams, it was necessary to classify the materials present by dedicated business. As explained at the outset, the SO business is based on a catalogue where the types of hides, linings and fabrics available for a special order are present, and it is these materials on which this analysis is based.
The starting point was the inventory of the materials concerned, because these materials are also used for other company businesses but are not downloaded into the system because the BOMs of the products being developed are formulated in the system with generic codes. This criticality has been stemmed thanks to the possibility, when confirming the progress of the cutting phase in SAP, of manually entering the code and quantity of the material used, an action that makes it possible to unload the materials correctly, thus obtaining real and analyzable stocks.
Another critical issue that was present and has been resolved concerns the coding of hides. In fact, many materials were registered in the system under several codes, a factor

that did not facilitate the unloading process and created confusion in the stock control and reordering phase. To solve this problem, bundling of codes and a rectification of those leathers that were the same, under a single code, i.e. those with the same base, the same colour, and whether or not lasing was present, was requested and implemented.

Furthermore, in order to reduce the risk of production waste, the stock of Berluti leather, after being purchased by the tanneries, will undergo an additional washing process, so as to allow the craftsmen to identify as many defects as possible during cutting.

3.1.2 Assembly components warehouse

The management of stocks of components required during assembly is similar, but also includes the use of the MRP of the SAP management system. This is because the lead time for the production of an SO includes the time needed to purchase these components, unlike the procurement of cutting materials which, being chosen by the customer from a defined catalogue, must always be available in the warehouse.
In the case of the components warehouse, a physical restructuring of the dedicated space was carried out. As the warehouse is spread over a ground floor and a mezzanine floor, the space was organized as follows
- ground floor, consisting of two aisles, was dedicated to the materials required for product development and industrialization, storing the materials in a system using generic codes,
- mezzanine floor, dedicated exclusively to materials needed for special orders,

Subsequently, a coding was also carried out of all materials in the warehouse for SO use for which there was a stock attributed to a generic code, thus making it possible to create specific stocks in SAP, necessary for the correct use of MRP.

Currently, the materials dedicated to the assembly of footwear for which a stock is foreseen are:

- spurs and toe caps which can be used on several models available in the catalogue,
- materials for the construction of special order bottoms.

For all other components, since the quantity of materials that may be ordered is exponential and for use according to the shoe size scales, procurement only takes place upon receipt of the production order.

Currently, this purchase order is made following the analysis of each individual production order and for each individual component when the bill of materials is drawn up, an extremely time-consuming analysis job with a high margin of error given the ever-increasing quantity of orders being issued.

The purpose of this action, which is still in the development phase, is for the MRP to generate the list of purchase orders to be issued for all components by coding all materials, following the actual stock.

The basis for the correct functioning of this action is to have correct inventories in the SAP management system, which may seem a trivial and obvious factor for an organization, but for such a handcrafted and singular production it is not at all simple and it is precisely on this that there will be a point of attention to monitor the inventories with more frequent inventories to verify the correct unloading in the system of all components.

3.2 Introduction to the project

The department of special production (ca02) of Manifattura Berluti has decided to start a new project in 2022 to implement Lean Warehousing techniques and tools in order to improve the level of service in the warehouse for the various raw materials codes in stock. The materials taken into consideration and which we will be analysing are cutting materials, including hides, fabrics and linings, all of which are part of the leather stock.

The main objective of the project is to reduce the number of inventories by trying to reach a minimum stock value. This value will clearly have to meet market demand adequately, without having to resort to stock shortages. In addition, this operation will allow the company to revise the procurement policies used until now.

It is essential to be able to fully exploit the various techniques that the Lean philosophy aims to teach, which will enable the following 'target objectives' to be achieved:

- Increasing the level of service: by improving the efficiency and reliability of processes throughout the supply chain, minimizing possible stock-outs, it is possible to increase the level of service offered.
- Reduce production lead-time: having excellent management and control of the flow of materials in the warehouse makes it possible to avoid downtimes and downtime, thus reducing production lead time.
- Reduce average stock: by using the ABC cross matrix, the aim is to reduce the average stock of the codes with the greatest impact, while at the same time increasing the rotation index.

The supervisors of the project intend to arrive at full speed by going through a series of specific analyses to assess the actual improvement made in relation to the ambitious goals set.

In fact, a monthly meeting is held, where, together with the supervisors, the various results obtained will be discussed and analysed in depth, and subsequently, the various future steps will be decided and clarified, in order to always have the full security of advancing correctly with the project, without falling into small errors that would "distort" the results.

The project took place between July 2022 and November 2022 (about 5 months).

3.3 Initial project situation (AS-IS)

The AS-IS situation of the special production warehouse before the implementation of the project was as follows.

COD	LEATHER	BASE	TYPE	DESCRIPTION	UM	QTY	VALUE €
101	CANGURO	CUOIO	LISCIO	CANGURO CUOIO LISCIO	DM2	584,49	674,50 €
102	CANGURO	CAFFE	LISCIO	CANGURO CAFFE LISCIO	DM2	250,34	286,13 €
103	GRAINE/DOLLARO	CACAO	LISCIO	GRAINE/DOLLARO CACAO LISCIO	DM2	881,15	1.323,49 €
104	GLORIA	AZZURRO	LISCIO	GLORIA AZZURRO LISCIO	DM2	6.165,36	7.262,79 €
105	GLORIA	BLU	LISCIO	GLORIA BLU LISCIO	DM2	5.760,09	6.698,98 €
106	GLORIA	CACAO	LISCIO	GLORIA CACAO LISCIO	DM2	2.527,20	3.027,59 €
107	GLORIA	CILIEGIO	LISCIO	GLORIA CILIEGIO LISCIO	DM2	0,00	- €
108	GLORIA	LEGNO	LISCIO	GLORIA LEGNO LISCIO	DM2	3.080,40	3.755,01 €
109	GLORIA	MOCASSIN	LISCIO	GLORIA MOCASSIN LISCIO	DM2	3.523,20	4.129,19 €
110	GLORIA	NATURALE	LISCIO	GLORIA NATURALE LISCIO	DM2	2.301,60	2.665,25 €
111	GLORIA	NERO	LISCIO	GLORIA NERO LISCIO	DM2	0,00	- €
112	GLORIA	NEUTRO	LISCIO	GLORIA NEUTRO LISCIO	DM2	1.257,94	1.455,43 €
113	GLORIA	PERLA	LISCIO	GLORIA PERLA LISCIO	DM2	7.901,34	9.331,48 €
114	GLORIA	ROSSO	LISCIO	GLORIA ROSSO LISCIO	DM2	4.735,20	5.516,51 €
115	GLORIA	TDM	LISCIO	GLORIA TDM LISCIO	DM2	200,40	234,87 €
116	GLORIA	VERDE	LISCIO	GLORIA VERDE LISCIO	DM2	7.032,00	8.782,97 €
117	TORO	TAUPE	LISCIO	TORO TAUPE LISCIO	DM2	3,00	5,73 €
118	ROMA	AVIO	LASERATO	ROMA AVIO LASERATO	DM2	561,60	607,09 €
119	ROMA	AZZURRO	LASERATO	ROMA AZZURRO LASERATO	DM2	910,80	863,44 €
120	ROMA	BLU	LASERATO	ROMA BLU LASERATO	DM2	574,80	435,13 €
121	ROMA	CACAO	LASERATO	ROMA CACAO LASERATO	DM2	0,00	- €
122	ROMA	CILIEGIO	LASERATO	ROMA CILIEGIO LASERATO	DM2	1.102,80	926,35 €
123	GLORIA	CACAO	LASERATO	GLORIA CACAO LASERATO	DM2	6,00	7,20 €
125	GLORIA	NERO	LASERATO	GLORIA NERO LASERATO	DM2	1.858,20	1.822,89 €
126	GLORIA	NEUTRO	LASERATO	GLORIA NEUTRO LASERATO	DM2	1.160,40	1.043,20 €
127	GLORIA	TDM	LASERATO	GLORIA TDM LASERATO	DM2	1.285,20	2.060,18 €
128	ROMA	LEGNO	LASERATO	ROMA LEGNO LASERATO	DM2	1.100,40	959,55 €
129	ROMA	NERO	LASERATO	ROMA NERO LASERATO	DM2	0,00	- €
130	ROMA	ROSSO	LASERATO	ROMA ROSSO LASERATO	DM2	541,20	439,99 €
131	ROMA	TDM	LASERATO	ROMA TDM LASERATO	DM2	670,80	519,20 €
132	ROMA	AVIO	LISCIO	ROMA AVIO LISCIO	DM2	2.983,20	3.189,04 €
133	ROMA	AZZURRO	LISCIO	ROMA AZZURRO LISCIO	DM2	13.256,38	13.614,30 €
134	ROMA	CRUST BIANCO	LISCIO	ROMA CRUST BIANCO LISCIO	DM2	13.401,56	13.776,81 €
135	ROMA	BLU	LISCIO	ROMA BLU LISCIO	DM2	11.002,80	9.880,51 €
136	ROMA	CACAO	LISCIO	ROMA CACAO LISCIO	DM2	21.406,79	21.749,30 €
137	ROMA	CILIEGIO	LISCIO	ROMA CILIEGIO LISCIO	DM2	911,73	939,99 €
138	ROMA	LEGNO	LISCIO	ROMA LEGNO LISCIO	DM2	3.584,56	3.763,79 €
139	ROMA	MADEIRA	LISCIO	ROMA MADEIRA LISCIO	DM2	2.191,20	2.305,14 €

Figure 15: Situation AS-IS warehouse ca02 of Manifattura Berluti on July 2022

COD	LEATHER	BASE	TYPE	DESCRIPTION	UM	QTY	VALUE €
229	CS CACH	BORDO	LISCIO	CS CACH BORDO LISCIO	DM2	1.316,37	1.345,34 €
230	CS CACH	PRUGNA	LISCIO	CS CACH PRUGNA LISCIO	DM2	2.575,54	2.621,90 €
231	CS CACH	ECLIPSE BLUE	LISCIO	CS CACH ECLIPSE BLUE LISCIO	DM2	4.978,12	4.689,39 €
232	CS CACH	INDACO	LISCIO	CS CACH INDACO LISCIO	DM2	244,50	238,88 €
233	CS CACH	CARAMEL	LASERATO	CS CACH CARAMEL LASERATO	DM2	225,12	214,54 €
234	CS CACH	RUST	LASERATO	CS CACH RUST LASERATO	DM2	488,40	467,40 €
235	CS CACH	TDM	LASERATO	CS CACH TDM LASERATO	DM2	502,80	420,84 €
236	CS CACH	NERO	LASERATO	CS CACH NERO LASERATO	DM2	705,60	596,23 €
237	CS CACH	PRUGNA	LASERATO	CS CACH PRUGNA LASERATO	DM2	0,00	- €
238	CS CACH	ECLIPSE BLUE	LASERATO	CS CACH ECLIPSE BLUE LASERATO	DM2	1.365,60	4.551,54 €
239	CS CACH	INDACO	LASERATO	CS CACH INDACO LASERATO	DM2	4.848,00	9.996,58 €
240	ROMA	MARGHERITA	LASERATO	ROMA MARGHERITA LASERATO	DM2	925,06	732,64 €
241	TORO	GOCHOKI FACADE	LISCIO	TORO GOCHOKI FACADE LISCIO	DM2	757,92	1.395,33 €
242	GLORIA	MARGHERITA	LASERATO	GLORIA MARGHERITA LASERATO	DM2	2.229,60	3.866,13 €
243	POLO	BIANCO	LASERATO	POLO BIANCO LASERATO	DM2	460,80	603,19 €
244	GLORIA	ALLUMINIO	LISCIO	GLORIA ALLUMINIO LISCIO	DM2	9.651,60	11.736,34 €
245	GLORIA	ALLUMINIO	LASERATO	GLORIA ALLUMINIO LASERATO	DM2	1.498,80	1.428,36 €
246	VITELLO FIORE	KENTUCKY	LISCIO	VITELLO FIORE KENTUCKY LISCIO	DM2	1.691,40	1.706,62 €
247	VITELLO FIORE	CACAO	LISCIO	VITELLO FIORE CACAO LISCIO	DM2	996,00	2.250,96 €
248	TESSUTO	NERO	LISCIO	TESSUTO NERO LISCIO	M	0,00	- €
249	TESSUTO	ANTHRACITE	LISCIO	TESSUTO ANTHRACITE LISCIO	M	45,97	2,94 €
251	TESSUTO	NERO	LASERATO	TESSUTO NERO LASERATO	M	60,48	4,48 €
252	CANGURO	VERDE	LISCIO	CANGURO VERDE LISCIO	DM2	3.321,67	3.936,18 €
253	CANGURO	MALACHITE	LISCIO	CANGURO MALACHITE LISCIO	DM2	3.938,16	4.355,60 €
254	CANGURO	TIBETAN RED	LISCIO	CANGURO TIBETAN RED LISCIO	DM2	1.482,75	2.062,50 €
255	CANGURO	CHARCOAL	LISCIO	CANGURO CHARCOAL LISCIO	DM2	5.099,12	5.542,74 €
256	CAPRA ASIAGO	NERO	LISCIO	CAPRA ASIAGO NERO LISCIO	DM2	85,68	207,43 €
257	GLORIA	VERDE	LASERATO	GLORIA VERDE LASERATO	DM2	1.748,40	2.131,30 €
258	TESSUTO	NERO	LISCIO	TESSUTO NERO LISCIO	M	72,07	4,40 €
259	GLORIA	BLU	LASERATO	GLORIA BLU LASERATO	DM2	1.596,00	1.615,15 €
260	GARDENA	NERO	LISCIO	GARDENA NERO LISCIO	DM2	8.253,60	31.999,21 €
261	GARDENA	BIANCO	LISCIO	GARDENA BIANCO LISCIO	DM2	9.539,99	31.357,94 €
262	GARDENA	GIALLO	LISCIO	GARDENA GIALLO LISCIO	DM2	2.606,40	8.567,24 €
263	GARDENA	MER DU SUD	LISCIO	GARDENA MER DU SUD LISCIO	DM2	1.362,00	4.539,54 €
264	TESSUTO	NATURALE	LISCIO	TESSUTO NATURALE LISCIO	M	270,39	19,20 €
265	TESSUTO	NERO	LISCIO	TESSUTO NERO LISCIO	DM2	3.148,80	8.996,12 €
266	GARDENA	NERO	LISCIO	GARDENA NERO LISCIO	DM2	18.486,00	65.107,69 €
						577.837,02	1.078.620,06 €

Figure 16: Situation AS-IS warehouse ca02 of Manifattura Berluti on July 2022

The results shown in the figure derive from an initial analysis performed on warehouse data dating back to July 2022. The data were taken from an extraction of the SAP management programme, whereby for each type of leather, the quantity of the stock present in the warehouse at that time and its relative value in € were indicated.

It can be pointed out that:

- The total value of the warehouse is about €1 million;
- The most stocked leather categories are Roma and Gloria;

• The categories that have the greatest impact on inventory, taking into account both total value and stock quantity, are ROMA (Qty=36; val€= 163.441,34 €), CS SPORTY (Qty= 24; val€= 103.621,12 €) e GARDENA (Qty=21; val€= 532.147,40 €).

TIPO PELLE	NUMERO	VALORE TOT
ROMA	36	163.441,34 €
GLORIA	25	89.843,32 €
CS SPORTY	24	103.621,12 €
GARDENA	21	532.147,40 €
CS CACH	21	69.631,40 €
CANGURO	10	41.876,81 €
TESSUTO	8	9.035,84 €
GLAZED CALF	4	12.073,52 €
VITELLO FIORE	3	11.131,02 €
CAPRA	3	4.535,64 €
POLO	2	21.318,58 €

Figure 17: Items-value in stock by product category

The current situation in the warehouse of ca02 in Manifattura Berluti illustrates that the value of inventories is very high; this problem arises from the fact that the company treats 'contract' production as 'repetitive'.

A distinction must be made between the two existing types of production; for 'made-to-order' production, one must start buying on a pure need basis, ordering material exactly when it is needed, without creating a stockpile. For 'repetitive' production, on the other hand, one must try to introduce the various techniques made available by Lean Management, which involve having a minimum stock and thus lowering the total stock value. Our project will focus precisely on trying to solve this problem.

3.2.1 Analysis of codes

In order to continue the analysis of stock codes, it was decided to introduce constraints, which allow the study to be restricted to only those points that are of most interest to the company.

We then decide to look only at those material codes for which consumption was recorded in the year 2021 and for which the unit value is reported, in order to be able to carry out the subsequent analysis without errors. Thus we obtain the repetitive production codes for which we want to introduce lean management techniques in order to have minimum stock in the warehouse. For each of these codes, the preferred supplier is also identified. By doing this, it is possible to have an overview of the supplier base, going to see which ones present critical lead times during material delivery. Indeed, the availability of material, especially in this global post-pandemic period, is very difficult and it is useful to have a schedule of each supplier.

A list was drawn up of suppliers with a significant delay in the delivery time of the material ordered. With these, it was decided to eliminate safety stocks in the warehouse and to submit a forecast to the supplier of the various quantities required using OFAs (open supplier orders).

The OFAs are processed as follows:

● First, the orders received from our customers are considered, assessing the quantity and the requested delivery date;

● Based on these values, we estimate and analyse how the consumption of the various codes requested will be distributed in the medium to long term, producing a forecast table where the quantities to be purchased are shown month by month.

● Then, the table is sent to our supplier and open orders are issued, so that our supplier can see in the medium to long term (6 months ahead) the quantities he will have to send us. Each open order, if confirmed, will be set out in a closed supplier order (approx. 1-2 months in advance) and accepted by our supplier, who undertakes to meet the required quantity and delivery time.

By doing this, the supplier company has a medium- to long-term view of the supply load and can better organise itself to avoid repeated delays. This choice at Manifattura Berluti was fundamental because, by not doing this and adapting to the supplier's timeframe, a situation of continuous delays in cylinder delivery was created. For example, an order with a medium to high value is held up because there is a lack of leather for production. This problem, in addition to causing delays, leads to a general disorder within the production plant both from the point of view of space management and logistics (forklift movements and organisation of transport).

3.2.2 Calculation of turnover and coverage ratio

Once we highlighted the value of the purchase codes, we continued our analysis by calculating the turnover ratio and the coverage ratio. As mentioned earlier, these two indices are important to better understand how our stock "rotates".

The turnover index was calculated for each individual buy code in the stock. This index can be used to make various organizational and management evaluations. On the other hand, the coverage index represents the average time an article remains in stock, has been expressed in days and is calculated using the reciprocal of the rotation index.

In this delicate phase of data extraction, the support of my manager was helpful. Through the use of a SAP transaction, it was possible to make an extraction on a Microsoft Excel sheet and process all necessary stock and consumption data in tabular form in order to carry out operations on the data in the columns.

First, on two different worksheets, we reported all the various annual stock and consumption values for each individual code for the year 2021. Next, we calculated the average stock over 12 months and total annual consumption.

ITR = tot consumption of the period/medium stock of the period

Some examples of ITR calculations can be seen in the following figures.

COD	LEATHER	BASE	TYPE	DESCRIPTION	CONSUMPTION TOT 2021	STOCK TOT 2021	MEDIUM STOCK 12 MONTHS	ITR
101	CANGURO	CUOIO	LISCIO	CANGURO CUOIO LISCIO	204	881	73	2,315152126
102	CANGURO	CAFFE	LISCIO	CANGURO CAFFE LISCIO	89	15.800	1.317	0,056202475
103	GRAINE/DOLLARO	CACAO	LISCIO	GRAINE/DOLLARO CACAO LISCIO	150	22.906	1.909	0,065485442
104	GLORIA	AZZURRO	LISCIO	GLORIA AZZURRO LISCIO	26.049	27.799	2.317	9,370332171
105	GLORIA	BLU	LISCIO	GLORIA BLU LISCIO	23.423	1.291	108	181,3814316
106	GLORIA	CACAO	LISCIO	GLORIA CACAO LISCIO	65.384	6.519	543	100,2985745
107	GLORIA	CILIEGIO	LISCIO	GLORIA CILIEGIO LISCIO	36	6.473	539	0,055616734
108	GLORIA	LEGNO	LISCIO	GLORIA LEGNO LISCIO	3.420	7.729	644	4,42482685
109	GLORIA	MOCASSIN	LISCIO	GLORIA MOCASSIN LISCIO	3.584	38.858	3.238	0,922428204
110	GLORIA	NATURALE	LISCIO	GLORIA NATURALE LISCIO	2.190	17.002	1.417	1,287878841
111	GLORIA	NERO	LISCIO	GLORIA NERO LISCIO	91.231	10.798	900	84,49102675
112	GLORIA	NEUTRO	LISCIO	GLORIA NEUTRO LISCIO	19.992	12.567	1.047	15,90896673
113	GLORIA	PERLA	LISCIO	GLORIA PERLA LISCIO	6.826	13.143	1.095	5,193550354
114	GLORIA	ROSSO	LISCIO	GLORIA ROSSO LISCIO	10.343	15.711	1.309	6,583345109
115	GLORIA	TDM	LISCIO	GLORIA TDM LISCIO	29.279	13.486	1.124	21,71115857
116	GLORIA	VERDE	LISCIO	GLORIA VERDE LISCIO	24.228	802	67	302,245509
117	TORO	TAUPE	LISCIO	TORO TAUPE LISCIO	2.903	7.337	611	3,957037946
118	ROMA	AVIO	LASERATO	ROMA AVIO LASERATO	440	5.952	496	0,739941285
119	ROMA	AZZURRO	LASERATO	ROMA AZZURRO LASERATO	9.386	3.284	274	28,58185823
120	ROMA	BLU	LASERATO	ROMA BLU LASERATO	5.160	1.306	109	39,52169557
121	ROMA	CACAO	LASERATO	ROMA CACAO LASERATO	4.872	5.101	425	9,550808643
122	ROMA	CILIEGIO	LASERATO	ROMA CILIEGIO LASERATO	794	3.418	285	2,324462687
123	GLORIA	CACAO	LASERATO	GLORIA CACAO LASERATO	10.168	3.105	259	32,74969079
125	GLORIA	NERO	LASERATO	GLORIA NERO LASERATO	13.885	3.879	323	35,7979278
126	GLORIA	NEUTRO	LASERATO	GLORIA NEUTRO LASERATO	3.766	2.466	205	15,27414826
127	GLORIA	TDM	LASERATO	GLORIA TDM LASERATO	4.460	14.617	1.218	3,051483627
128	ROMA	LEGNO	LASERATO	ROMA LEGNO LASERATO	2.050	2.616	218	7,833716075
129	ROMA	NERO	LASERATO	ROMA NERO LASERATO	12.699	5.263	439	24,13053541
130	ROMA	ROSSO	LASERATO	ROMA ROSSO LASERATO	2.243	7.540	628	2,974693618
131	ROMA	TDM	LASERATO	ROMA TDM LASERATO	2.041	44.627	3.719	0,45739623
132	ROMA	AVIO	LISCIO	ROMA AVIO LISCIO	4.068	14.531	1.211	2,799577503
133	ROMA	AZZURRO	LISCIO	ROMA AZZURRO LISCIO	68.036	28.207	2.351	24,1201092
134	ROMA	CRUST BIANCO	LISCIO	ROMA CRUST BIANCO LISCIO	17.748	25.563	2.130	6,94285458
135	ROMA	BLU	LISCIO	ROMA BLU LISCIO	57.561	7.123	594	80,80826067
136	ROMA	CACAO	LISCIO	ROMA CACAO LISCIO	128.918	7.951	663	162,1494536
137	ROMA	CILIEGIO	LISCIO	ROMA CILIEGIO LISCIO	16.096	4.414	368	36,46521491
138	ROMA	LEGNO	LISCIO	ROMA LEGNO LISCIO	11.849	17.337	1.445	6,834457282
139	ROMA	MADEIRA	LISCIO	ROMA MADEIRA LISCIO	3.569	8.470	706	4,213233833

Figure 18: Annual IDR calculation

COD	LEATHER	BASE	TYPE	DESCRIPTION	CONSUMPTION TOT 2021	STOCK TOT 2021	MEDIUM STOCK 12 MONTHS	ITR
226	CS CACH	FORESTA	LISCIO	CS CACH FORESTA LISCIO	1.720	8.470	706	2,030145011
227	CS CACH	NERO	LISCIO	CS CACH NERO LISCIO	12.901	6.807	567	18,95325382
228	CS CACH	GRIGIO	LISCIO	CS CACH GRIGIO LISCIO	16.316	9.817	818	16,62046929
229	CS CACH	BORDO	LISCIO	CS CACH BORDO LISCIO	666	1.388	116	4,796984566
230	CS CACH	PRUGNA	LISCIO	CS CACH PRUGNA LISCIO	1.516	2.978	248	5,090102398
231	CS CACH	ECLIPSE BLUE	LISCIO	CS CACH ECLIPSE BLUE LISCIO	16.547	5.777	481	28,64098044
232	CS CACH	INDACO	LISCIO	CS CACH INDACO LISCIO	2.832	3.119	260	9,081289435
233	CS CACH	CARAMEL	LASERATO	CS CACH CARAMEL LASERATO	525	290	24	18,11258278
234	CS CACH	RUST	LASERATO	CS CACH RUST LASERATO	348	632	53	5,5028463
235	CS CACH	TDM	LASERATO	CS CACH TDM LASERATO	763	743	62	10,27463651
236	CS CACH	NERO	LASERATO	CS CACH NERO LASERATO	833	832	69	10,01443001
237	CS CACH	PRUGNA	LASERATO	CS CACH PRUGNA LASERATO	79	206	17	3,853564547
238	CS CACH	ECLIPSE BLUE	LASERATO	CS CACH ECLIPSE BLUE LASERATO	305	1.496	125	2,036888532
239	CS CACH	INDACO	LASERATO	CS CACH INDACO LASERATO	1.231	5.118	427	2,405627198
240	ROMA	MARGHERITA	LASERATO	ROMA MARGHERITA LASERATO	2.120	2.166	180	9,789568166
241	TORO	GOCHOKI FACADE	LISCIO	TORO GOCHOKI FACADE LISCIO	2.136	675	56	31,63885531
242	GLORIA	MARGHERITA	LASERATO	GLORIA MARGHERITA LASERATO	1.870	2.314	193	8,080912863
243	POLO	BIANCO	LASERATO	POLO BIANCO LASERATO	13.141	6.134	511	21,42511969
244	GLORIA	ALLUMINIO	LISCIO	GLORIA ALLUMINIO LISCIO	68.532	22.775	1.898	30,09115972
245	GLORIA	ALLUMINIO	LASERATO	GLORIA ALLUMINIO LASERATO	7.452	4.093	341	18,20628513
246	VITELLO FIORE	KENTUCKY	LISCIO	VITELLO FIORE KENTUCKY LISCIO	402	1.691	141	2,377438808
247	VITELLO FIORE	CACAO	LISCIO	VITELLO FIORE CACAO LISCIO	60	996	83	0,602409639
248	TESSUTO	NERO	LISCIO	TESSUTO NERO LISCIO	191	41	3	46,25743551
249	TESSUTO	ANTHRACITE	LISCIO	TESSUTO ANTHRACITE LISCIO	72	29	2	24,72980248
251	TESSUTO	NERO	LASERATO	TESSUTO NERO LASERATO	396	74	6	53,39029447
252	CANGURO	VERDE	LISCIO	CANGURO VERDE LISCIO	937	3.562	297	2,631351615
253	CANGURO	MALACHITE	LISCIO	CANGURO MALACHITE LISCIO	1.235	4.298	358	2,872862806
254	CANGURO	TIBETAN RED	LISCIO	CANGURO TIBETAN RED LISCIO	634	1.729	144	3,665092349
255	CANGURO	CHARCOAL	LISCIO	CANGURO CHARCOAL LISCIO	1.145	5.651	471	2,025797651
256	CAPRA ASIAGO	NERO	LISCIO	CAPRA ASIAGO NERO LISCIO	85	132	11	6,43115942
257	GLORIA	VERDE	LASERATO	GLORIA VERDE LASERATO	2.810	1.868	156	15,04174695
258	TESSUTO	NERO	LISCIO	TESSUTO NERO LISCIO	185	88	7	21,14122916
259	GLORIA	BLU	LASERATO	GLORIA BLU LASERATO	3.626	1.968	164	18,42682927
260	GARDENA	NERO	LISCIO	GARDENA NERO LISCIO	9.097	7.416	618	12,26699029
261	GARDENA	BIANCO	LISCIO	GARDENA BIANCO LISCIO	14.357	8.413	701	17,0646548
262	GARDENA	GIALLO	LISCIO	GARDENA GIALLO LISCIO	3.228	3.446	287	9,366295265
263	GARDENA	MER DU SUD	LISCIO	GARDENA MER DU SUD LISCIO	3.691	2.297	191	16,07106583
264	TESSUTO	NATURALE	LISCIO	TESSUTO NATURALE LISCIO	363	229	19	15,88078581

Figure 19: Annual IDR calculation

Once we had calculated the ITR of all the codes in stock, we proceeded with the calculation of their coverage ratio, defined as the ratio of 365 days to our turnover ratio.

CR or IDR and IDC buy codes in stock (days)= 365/ITR

The results are shown in the following pictures.

COD	LEATHER	BASE	TYPE	DESCRIPTION	ITR	CR
101	CANGURO	CUOIO	LISCIO	CANGURO CUOIO LISCIO	2,315152126	157,657026
102	CANGURO	CAFFE	LISCIO	CANGURO CAFFE LISCIO	0,056202475	6494,37595
103	GRAINE/DOLLARO	CACAO	LISCIO	GRAINE/DOLLARO CACAO LISCIO	0,065485442	5573,7579
104	GLORIA	AZZURRO	LISCIO	GLORIA AZZURRO LISCIO	9,370332171	38,952728
105	GLORIA	BLU	LISCIO	GLORIA BLU LISCIO	181,3814316	2,01233388
106	GLORIA	CACAO	LISCIO	GLORIA CACAO LISCIO	100,2985745	3,63913447
107	GLORIA	CILIEGIO	LISCIO	GLORIA CILIEGIO LISCIO	0,055616734	6562,773
108	GLORIA	LEGNO	LISCIO	GLORIA LEGNO LISCIO	4,42482685	82,4891035
109	GLORIA	MOCASSIN	LISCIO	GLORIA MOCASSIN LISCIO	0,922428204	395,694753
110	GLORIA	NATURALE	LISCIO	GLORIA NATURALE LISCIO	1,287878841	283,411753
111	GLORIA	NERO	LISCIO	GLORIA NERO LISCIO	84,49102675	4,31998538
112	GLORIA	NEUTRO	LISCIO	GLORIA NEUTRO LISCIO	15,90896673	22,9430362
113	GLORIA	PERLA	LISCIO	GLORIA PERLA LISCIO	5,193550354	70,2794765
114	GLORIA	ROSSO	LISCIO	GLORIA ROSSO LISCIO	6,583345109	55,4429388
115	GLORIA	TDM	LISCIO	GLORIA TDM LISCIO	21,71115857	16,8116316
116	GLORIA	VERDE	LISCIO	GLORIA VERDE LISCIO	302,245509	1,20762754
117	TORO	TAUPE	LISCIO	TORO TAUPE LISCIO	3,957037946	92,2407126
118	ROMA	AVIO	LASERATO	ROMA AVIO LASERATO	0,739941285	493,282383
119	ROMA	AZZURRO	LASERATO	ROMA AZZURRO LASERATO	28,58185823	12,7703383
120	ROMA	BLU	LASERATO	ROMA BLU LASERATO	39,52169557	9,23543372
121	ROMA	CACAO	LASERATO	ROMA CACAO LASERATO	9,550808643	38,2166593
122	ROMA	CILIEGIO	LASERATO	ROMA CILIEGIO LASERATO	2,324462687	157,025536
123	GLORIA	CACAO	LASERATO	GLORIA CACAO LASERATO	32,74969079	11,1451434
125	GLORIA	NERO	LASERATO	GLORIA NERO LASERATO	35,7979278	10,1961209
126	GLORIA	NEUTRO	LASERATO	GLORIA NEUTRO LASERATO	15,27414826	23,8965862
127	GLORIA	TDM	LASERATO	GLORIA TDM LASERATO	3,051483627	119,613947
128	ROMA	LEGNO	LASERATO	ROMA LEGNO LASERATO	7,833716075	46,5934681
129	ROMA	NERO	LASERATO	ROMA NERO LASERATO	24,13053541	15,126063
130	ROMA	ROSSO	LASERATO	ROMA ROSSO LASERATO	2,974693618	122,701712
131	ROMA	TDM	LASERATO	ROMA TDM LASERATO	0,45739623	797,995208
132	ROMA	AVIO	LISCIO	ROMA AVIO LISCIO	2,799577503	130,376816
133	ROMA	AZZURRO	LISCIO	ROMA AZZURRO LISCIO	24,1201092	15,1326015
134	ROMA	CRUST BIANCO	LISCIO	ROMA CRUST BIANCO LISCIO	6,94285458	52,5720359
135	ROMA	BLU	LISCIO	ROMA BLU LISCIO	80,80826067	4,51686495
136	ROMA	CACAO	LISCIO	ROMA CACAO LISCIO	162,1494536	2,25100974
137	ROMA	CILIEGIO	LISCIO	ROMA CILIEGIO LISCIO	36,46521491	10,0095393
138	ROMA	LEGNO	LISCIO	ROMA LEGNO LISCIO	6,834457282	53,4058499
139	ROMA	MADEIRA	LISCIO	ROMA MADEIRA LISCIO	4,213233833	86,6317927

Figure 20: ITR and CR codes in stock.

COD	LEATHER	BASE	TYPE	DESCRIPTION	ITR	CR
229	CS CACH	BORDO	LISCIO	CS CACH BORDO LISCIO	4,796984566	76,0894672
230	CS CACH	PRUGNA	LISCIO	CS CACH PRUGNA LISCIO	5,090102398	71,7077912
231	CS CACH	ECLIPSE BLUE	LISCIO	CS CACH ECLIPSE BLUE LISCIO	28,64098044	12,7439771
232	CS CACH	INDACO	LISCIO	CS CACH INDACO LISCIO	9,081289435	40,1925302
233	CS CACH	CARAMEL	LASERATO	CS CACH CARAMEL LASERATO	18,11258278	20,1517367
234	CS CACH	RUST	LASERATO	CS CACH RUST LASERATO	5,5028463	66,3293103
235	CS CACH	TDM	LASERATO	CS CACH TDM LASERATO	10,27463651	35,5243711
236	CS CACH	NERO	LASERATO	CS CACH NERO LASERATO	10,01443001	36,4474063
237	CS CACH	PRUGNA	LASERATO	CS CACH PRUGNA LASERATO	3,853564547	94,7175
238	CS CACH	ECLIPSE BLUE	LASERATO	CS CACH ECLIPSE BLUE LASERATO	2,036888532	179,194882
239	CS CACH	INDACO	LASERATO	CS CACH INDACO LASERATO	2,405627198	151,727583
240	ROMA	MARGHERITA	LASERATO	ROMA MARGHERITA LASERATO	9,789568166	37,2845864
241	TORO	GOCHOKI FACADE	LISCIO	TORO GOCHOKI FACADE LISCIO	31,63885531	11,5364477
242	GLORIA	MARGHERITA	LASERATO	GLORIA MARGHERITA LASERATO	8,080912863	45,1681643
243	POLO	BIANCO	LASERATO	POLO BIANCO LASERATO	21,42511969	17,0360775
244	GLORIA	ALLUMINIO	LISCIO	GLORIA ALLUMINIO LISCIO	30,09115972	12,1298083
245	GLORIA	ALLUMINIO	LASERATO	GLORIA ALLUMINIO LASERATO	18,20628513	20,0480217
246	VITELLO FIORE	KENTUCKY	LISCIO	VITELLO FIORE KENTUCKY LISCIO	2,377438808	153,526559
247	VITELLO FIORE	CACAO	LISCIO	VITELLO FIORE CACAO LISCIO	0,602409639	605,9
248	TESSUTO	NERO	LISCIO	TESSUTO NERO LISCIO	46,25743551	7,89062333
249	TESSUTO	ANTHRACITE	LISCIO	TESSUTO ANTHRACITE LISCIO	24,72980248	14,7595194
251	TESSUTO	NERO	LASERATO	TESSUTO NERO LASERATO	53,39029447	6,83644853
252	CANGURO	VERDE	LISCIO	CANGURO VERDE LISCIO	2,631351615	138,711983
253	CANGURO	MALACHITE	LISCIO	CANGURO MALACHITE LISCIO	2,872862806	127,050968
254	CANGURO	TIBETAN RED	LISCIO	CANGURO TIBETAN RED LISCIO	3,665092349	99,5882137
255	CANGURO	CHARCOAL	LISCIO	CANGURO CHARCOAL LISCIO	2,025797651	180,175942
256	CAPRA ASIAGO	NERO	LISCIO	CAPRA ASIAGO NERO LISCIO	6,43115942	56,7549296
257	GLORIA	VERDE	LASERATO	GLORIA VERDE LASERATO	15,04174695	24,2657985
258	TESSUTO	NERO	LISCIO	TESSUTO NERO LISCIO	21,14122916	17,2648429
259	GLORIA	BLU	LASERATO	GLORIA BLU LASERATO	18,42682927	19,8080741
260	GARDENA	NERO	LISCIO	GARDENA NERO LISCIO	12,26699029	29,7546498
261	GARDENA	BIANCO	LISCIO	GARDENA BIANCO LISCIO	17,0646548	21,3892402
262	GARDENA	GIALLO	LISCIO	GARDENA GIALLO LISCIO	9,366295265	38,9695167
263	GARDENA	MER DU SUD	LISCIO	GARDENA MER DU SUD LISCIO	16,07106583	22,7116237
264	TESSUTO	NATURALE	LISCIO	TESSUTO NATURALE LISCIO	15,88078581	22,9837493
265	TESSUTO	NERO	LISCIO	TESSUTO NERO LISCIO	6,201035145	58,8611404
266	GARDENA	NERO	LISCIO	GARDENA NERO LISCIO	61,86353417	5,90008322

Figure 21: ITR and CR codes in stock.

The results in the table show us that many codes have a very high coverage index, which results in very high running costs. It is therefore important to try to reduce the period in which the material sits idle as much as possible.

3.3 ABC CROSS ANALYSIS

Once the turnover ratio and coverage ratio had been calculated, we continued our analysis with the calculation of the cross ABC analysis. First, we calculate for each stock code the value of stock and valorized consumptions.

3.3.1 Calculation of valorized consumption value

To calculate this value, we recorded each stock movement on a table in order to obtain the annual consumption of each stock code. The following data were extrapolated from SAP's management software, which shows for each individual code the monthly consumption that occurred and the unit value in €/DM2.

Once this data was obtained, we proceeded with the calculation of the valorized use value, defined as the product between the annual consumption and the unit value per piece. We then expressed the values obtained as a cumulative frequency with respect to the use value. The reference value is the total use value (VI= €4,177,495.48/year), i.e. the sum of all use values of the items considered in the analysis. After sorting the articles in descending order with respect to the usage value, the percentage ratio was calculated and subsequently also the cumulative frequency, by summing the percentage ratio of the j-th article with the value of the cumulative frequency relative to the (j-th)-1 article.

Some examples of the calculations performed and the results obtained can be seen in the following pictures.

COD	DESCRIPTION	ANNUAL CONSUMPTION (DM2	VALUE PER UNIT	VIj (€/year	VI%	CUMULATIVE VI%
155	GARDENA NERO LISCIO	166145,1372	3,251	540.137,84	12,930%	12,930%
142	ROMA NERO LISCIO	282085,0332	1,008	284.341,71	6,807%	19,736%
266	GARDENA NERO LISCIO	66040,56	3,522	232.594,85	5,568%	25,304%
148	GARDENA BORDO LISCIO	68972,8824	3,058	210.919,07	5,049%	30,353%
151	GARDENA ROUGE ROI LISCIO	68567,4264	3,035	208.102,14	4,982%	35,334%
152	GARDENA NATURALE LISCIO	49022,4768	3,225	158.097,49	3,785%	39,119%
176	GARDENA BLU FASH LISCIO	49524,0144	3,066	151.840,63	3,635%	42,754%
182	GARDENA ARANCIO LISCIO	42737,4024	3,089	132.015,84	3,160%	45,914%
136	ROMA CACAO LISCIO	128918,4084	1,016	130.981,10	3,135%	49,049%
149	GARDENA CIOCCOLATO LISCIO	32895,4788	3,315	109.048,51	2,610%	51,660%
111	GLORIA NERO LISCIO	91230,8016	1,155	105.371,58	2,522%	54,182%
146	ROMA TDM LISCIO	101251,2084	1,012	102.466,22	2,453%	56,635%
159	GARDENA VIOLA LISCIO	30916,2024	3,068	94.850,91	2,271%	58,905%
154	GARDENA NAVY BLU LISCIO	31082,4024	3,02	93.868,86	2,247%	61,152%
157	GARDENA OLIVA LISCIO	29706,6264	3,085	91.644,94	2,194%	63,346%
244	GLORIA ALLUMINIO LISCIO	68532,0036	1,216	83.334,92	1,995%	65,341%
106	GLORIA CACAO LISCIO	65384,4	1,198	78.330,51	1,875%	67,216%
133	ROMA AZZURRO LISCIO	68036,3928	1,027	69.873,38	1,673%	68,889%
173	ROMA ALLUMINIO LISCIO	55319,9724	1,101	60.907,29	1,458%	70,347%
194	POLO BIANCO LISCIO	30221,0928	2,012	60.804,84	1,456%	71,802%
135	ROMA BLU LISCIO	57561,156	0,898	51.689,92	1,237%	73,040%
261	GARDENA BIANCO LISCIO	14356,8108	3,287	47.190,84	1,130%	74,169%
143	ROMA NEUTRO LISCIO	44251,2024	1,032	45.667,24	1,093%	75,262%
147	ROMA VERDE LISCIO	40864,7988	1,014	41.436,91	0,992%	76,254%
260	GARDENA NERO LISCIO	9097,2	3,877	35.269,84	0,844%	77,099%
115	GLORIA TDM LISCIO	29278,8	1,172	34.314,75	0,821%	77,920%
171	ROMA MARGHERITA LISCIO	33036,888	1,017	33.598,52	0,804%	78,724%
206	CS SPORTY PIOMBO LISCIO	11063,2032	3,03	33.521,51	0,802%	79,527%
140	ROMA MOCASSIN LISCIO	32133,6	1,04	33.418,94	0,800%	80,327%
209	CS SPORTY INDACO LISCIO	6597,6984	5,021	33.127,04	0,793%	81,120%
189	PLUME NERO LISCIO	13803,012	2,328	32.133,41	0,769%	81,889%
104	GLORIA AZZURRO LISCIO	26048,64	1,178	30.685,30	0,735%	82,623%
116	GLORIA VERDE LISCIO	24228	1,249	30.260,77	0,724%	83,348%

Figure 22: ABC analysis: calculation of valorized use value

187	ROMA ALLUMINIO LASERATO	12129,6	0,898	10.892,38	0,261%	93,193%
203	CS SPORTY FORESTA LISCIO	4064,4024	2,639	10.725,96	0,257%	93,450%
262	GARDENA GIALLO LISCIO	3228	3,287	10.610,44	0,254%	93,704%
200	CS SPORTY RUST LISCIO	3651,6024	2,813	10.271,96	0,246%	93,950%
167	ROMA NEUTRO LASERATO	11812,2	0,86	10.158,49	0,243%	94,193%
129	ROMA NERO LASERATO	12699,312	0,773	9.816,57	0,235%	94,428%
119	ROMA AZZURRO LASERATO	9386,4	0,948	8.898,31	0,213%	94,641%
202	CS SPORTY TDM LISCIO	3578,4024	2,388	8.545,22	0,205%	94,845%
113	GLORIA PERLA LISCIO	6826,14	1,181	8.061,67	0,193%	95,038%
127	GLORIA TDM LASERATO	4460,4	1,603	7.150,02	0,171%	95,210%
245	GLORIA ALLUMINIO LASERATO	7452	0,953	7.101,76	0,170%	95,380%
198	CS SPORTY SABBIA LISCIO	2271,6024	3,036	6.896,58	0,165%	95,545%
199	CS SPORTY CARAMEL LISCIO	2101,2024	3,03	6.366,64	0,152%	95,697%
161	CS CACH MUSTARD LISCIO	5372,4	1,165	6.258,85	0,150%	95,847%
179	VITELLO FIORE NERO LISCIO	6153,6	0,956	5.882,84	0,141%	95,988%
188	GARDENA TABACCO BIS LISCIO	1711,4688	3,282	5.617,04	0,134%	96,122%
117	TORO TAUPE LISCIO	2903,1996	1,91	5.545,11	0,133%	96,255%
220	CS SPORTY INDACO LASERATO	2240,4	2,374	5.318,71	0,127%	96,382%
207	CS SPORTY PRUGNA LISCIO	2110,4604	2,487	5.248,72	0,126%	96,508%
180	GLAZED CALF/ROIS NERO LISCIO	3175,2024	1,59	5.048,57	0,121%	96,629%
178	GLORIA AZZURRO LASERATO	4485,6	1,119	5.019,39	0,120%	96,749%
174	CS SPORTY GRIGIO LISCIO	1598,4	3,005	4.803,19	0,115%	96,864%
132	ROMA AVIO LISCIO	4068	1,069	4.348,69	0,104%	96,968%
177	GLORIA CRUST BIANCO LISCIO	3778,8	1,113	4.205,80	0,101%	97,069%
109	GLORIA MOCASSIN LISCIO	3584,4	1,172	4.200,92	0,101%	97,169%
108	GLORIA LEGNO LISCIO	3420	1,219	4.168,98	0,100%	97,269%
196	CANGURO MARRONE LISCIO	2774,4024	1,444	4.006,24	0,096%	97,365%
164	ROMA VERDE LASERATO	4521,6	0,875	3.956,40	0,095%	97,460%
241	TORO GOCHOKI FACADE LISCIO	2136,0024	1,841	3.932,38	0,094%	97,554%
120	ROMA BLU LASERATO	5160	0,757	3.906,12	0,094%	97,647%
121	ROMA CACAO LASERATO	4872,0012	0,795	3.873,24	0,093%	97,740%
162	CANGURO COLORI VARI LISCIO	2680,7832	1,418	3.801,35	0,091%	97,831%
139	ROMA MADEIRA LISCIO	3568,8	1,052	3.754,38	0,090%	97,921%
259	GLORIA BLU LASERATO	3626,4	1,012	3.669,92	0,088%	98,009%

Figure 23: ABC analysis: calculation of valorized use value

Having identified the utilization value in cumulative percentage form, I go on to check the class limits of the analysis:

● Class A: codes presenting utilization value in cumulative percentage form up to 80% → 28;

● Class B: codes presenting utilization value in cumulative percentage form greater than 80% and less than 95% → 36;

● Class C: codes with cumulative percentage use value greater than 95% → 96.

3.3.2 Calculation of valorized stock value

Using the same reasoning as for the calculation of the utilization value, we calculate the valorized stock value. Again, the various data were obtained by using the SAP management software and then reported in an Excel spreadsheet. I go on to valorized the average stock by multiplying the data obtained by the unit price of the article, thus obtaining the variable expressing the average valorized stock of each article (SMj).

Similarly to what was said above for valorized consumption, we express the values obtained as a cumulative frequency. The reference value is the sum of the average valorized stock of the articles (SM= 1,923,921.845 €/year). I order the articles in descending order with respect to the value of the average valorized stock and calculate the percentage ratio; I calculate the cumulative frequency by adding the percentage ratio of the j-th article with the value of the cumulative frequency relative to the (j-th)- 1 article. Some examples of the calculations performed and the results obtained can be seen in the following pictures.

COD	DESCRIPTION	ANNUAL MEDIUM STOCK (DM2	VALUE PER UNIT	SMj (€/year	SM%	CUMULATIVE SM%
148	GARDENA BORDO LISCIO	29.676,948	3,058	90.752,107	4,717%	4,717%
140	ROMA MOCASSIN LISCIO	70.770,874	1,040	73.601,709	3,826%	8,543%
151	GARDENA ROUGE ROI LISCIO	23.371,596	3,035	70.932,794	3,687%	12,230%
154	GARDENA NAVY BLU LISCIO	22.857,408	3,020	69.029,372	3,588%	15,817%
176	GARDENA BLU FASH LISCIO	21.702,449	3,066	66.539,708	3,459%	19,276%
182	GARDENA ARANCIO LISCIO	18.611,251	3,089	57.490,155	2,988%	22,264%
155	GARDENA NERO LISCIO	16.874,340	3,251	54.858,479	2,851%	25,116%
109	GLORIA MOCASSIN LISCIO	38.858,309	1,172	45.541,938	2,367%	27,483%
194	POLO BIANCO LISCIO	22.497,986	2,012	45.265,949	2,353%	29,836%
266	GARDENA NERO LISCIO	10.675,200	3,522	37.598,054	1,954%	31,790%
152	GARDENA NATURALE LISCIO	11.593,200	3,225	37.388,070	1,943%	33,733%
131	ROMA TDM LASERATO	44.626,516	0,774	34.540,923	1,795%	35,528%
149	GARDENA CIOCCOLATO LISCIO	10.412,425	3,315	34.517,190	1,794%	37,323%
103	GRAINE/DOLLARO CACAO LISCIO	22.905,854	1,502	34.404,593	1,788%	39,111%
104	GLORIA AZZURRO LISCIO	27.799,057	1,178	32.747,289	1,702%	40,813%
133	ROMA AZZURRO LISCIO	28.207,332	1,027	28.968,930	1,506%	42,319%
260	GARDENA NERO LISCIO	7.416,000	3,877	28.751,832	1,494%	43,813%
244	GLORIA ALLUMINIO LISCIO	22.774,796	1,216	27.694,152	1,439%	45,253%
261	GARDENA BIANCO LISCIO	8.413,186	3,287	27.654,141	1,437%	46,690%
204	CS SPORTY OFF-BLACK LISCIO	10.483,488	2,568	26.921,597	1,399%	48,089%
134	ROMA CRUST BIANCO LISCIO	25.562,972	1,028	26.278,736	1,366%	49,455%
203	CS SPORTY FORESTA LISCIO	9.430,966	2,639	24.888,318	1,294%	50,749%
141	ROMA NATURALE LISCIO	24.075,587	1,030	24.797,854	1,289%	52,038%
145	ROMA ROSSO LISCIO	27.660,702	0,877	24.258,436	1,261%	53,299%
127	GLORIA TDM LASERATO	14.617,152	1,603	23.431,295	1,218%	54,516%
146	ROMA TDM LISCIO	22.970,099	1,012	23.245,740	1,208%	55,725%
265	TESSUTO NERO LISCIO	8.052,204	2,857	23.005,147	1,196%	56,920%
171	ROMA MARGHERITA LISCIO	20.955,365	1,017	21.311,606	1,108%	58,028%
209	CS SPORTY INDACO LISCIO	4.128,768	5,021	20.730,544	1,078%	59,106%
110	GLORIA NATURALE LISCIO	17.001,602	1,158	19.687,856	1,023%	60,129%
159	GARDENA VIOLA LISCIO	6.099,725	3,068	18.713,956	0,973%	61,102%
114	GLORIA ROSSO LISCIO	15.710,556	1,165	18.302,798	0,951%	62,053%
199	CS SPORTY CARAMEL LISCIO	6.020,400	3,030	18.241,812	0,948%	63,001%

Figure 24: ABC Analysis: Calculation of the valorized stock value

187	ROMA ALLUMINIO LASERATO	9.199,981	0,898	8.261,583	0,429%	84,603%
179	VITELLO FIORE NERO LISCIO	8.508,000	0,956	8.133,648	0,423%	85,026%
136	ROMA CACAO LISCIO	7.950,592	1,016	8.077,801	0,420%	85,445%
243	POLO BIANCO LASERATO	6.133,548	1,309	8.028,814	0,417%	85,863%
180	GLAZED CALF/ROIS NERO LISCIO	4.943,285	1,590	7.859,823	0,409%	86,271%
106	GLORIA CACAO LISCIO	6.518,976	1,198	7.809,733	0,406%	86,677%
227	CS CACH NERO LISCIO	6.806,854	1,131	7.698,551	0,400%	87,077%
107	GLORIA CILIEGIO LISCIO	6.472,872	1,185	7.670,353	0,399%	87,476%
263	GARDENA MER DU SUD LISCIO	2.296,800	3,333	7.655,234	0,398%	87,874%
225	CS CACH TDM LISCIO	6.587,904	1,118	7.365,277	0,383%	88,257%
196	CANGURO MARRONE LISCIO	4.761,106	1,444	6.875,036	0,357%	88,614%
221	CS CACH SABBIA LISCIO	7.052,153	0,961	6.777,119	0,352%	88,966%
178	GLORIA AZZURRO LASERATO	5.895,816	1,119	6.597,418	0,343%	89,309%
161	CS CACH MUSTARD LISCIO	5.580,353	1,165	6.501,111	0,338%	89,647%
118	ROMA AVIO LASERATO	5.951,824	1,081	6.433,921	0,334%	89,982%
135	ROMA BLU LISCIO	7.123,177	0,898	6.396,613	0,332%	90,314%
255	CANGURO CHARCOAL LISCIO	5.651,119	1,087	6.142,767	0,319%	90,633%
130	ROMA ROSSO LASERATO	7.539,600	0,813	6.129,695	0,319%	90,952%
224	CS CACH TABACCO LISCIO	6.659,256	0,914	6.086,560	0,316%	91,268%
143	ROMA NEUTRO LISCIO	5.834,400	1,032	6.021,101	0,313%	91,581%
144	ROMA PERLA LISCIO	6.344,478	0,914	5.798,853	0,301%	91,883%
214	CS SPORTY FORESTA LASERATO	2.916,888	1,878	5.477,916	0,285%	92,167%
231	CS CACH ECLIPSE BLUE LISCIO	5.777,321	0,942	5.442,236	0,283%	92,450%
222	CS CACH CARAMEL LISCIO	5.674,320	0,952	5.401,953	0,281%	92,731%
220	CS SPORTY INDACO LASERATO	2.143,368	2,374	5.088,356	0,264%	92,995%
238	CS CACH ECLIPSE BLUE LASERATO	1.496,400	3,333	4.987,501	0,259%	93,255%
253	CANGURO MALACHITE LISCIO	4.298,160	1,106	4.753,765	0,247%	93,502%
137	ROMA CILIEGIO LISCIO	4.413,960	1,031	4.550,793	0,237%	93,738%
195	CS CACH EBANO LISCIO	4.693,680	0,968	4.543,482	0,236%	93,975%
252	CANGURO VERDE LISCIO	3.561,677	1,185	4.220,587	0,219%	94,194%
129	ROMA NERO LASERATO	5.262,756	0,773	4.068,110	0,211%	94,405%
121	ROMA CACAO LASERATO	5.101,140	0,795	4.055,406	0,211%	94,616%
242	GLORIA MARGHERITA LASERATO	2.313,600	1,734	4.011,782	0,209%	94,825%
177	GLORIA CRUST BIANCO LISCIO	3.516,000	1,113	3.913,308	0,203%	95,028%

Figure 25: ABC Analysis: Calculation of the valorized stock value

I will divide the values found into classes according to the limits defined above for the variable use value, resulting in the following subdivision:

- Class A: codes presenting average stock value in cumulative percentage form up to 80% → 56;
- Class B: codes presenting average stock value in cumulative percentage form greater than 80% and less than 95% → 42;
- Class C: codes with average stock value in cumulative percentage form greater than 95% → 62.

3.4 Cross ABC-XYZ stock-consumption analysis

The two individual analyses carried out in the previous paragraph result in a cross ABC analysis. To make the analysis as clear as possible, we decide to associate stocks with classes A, B and C and consumption with classes X, Y and Z. By cross-referencing the data, it is possible to associate a particular class with each article under analysis, thus obtaining 9 classes: AX, AY, AZ, BX, BY, BZ, CX, CY, CZ.

X-axis: valorized consumption

Y-axis: valorized stock

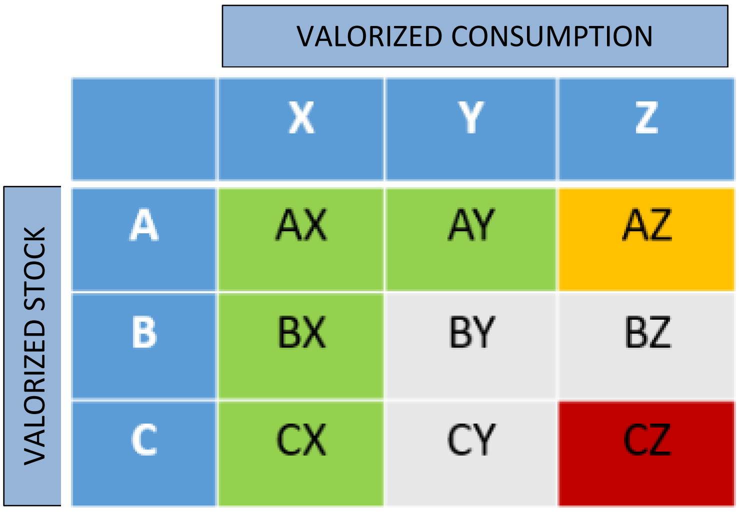

Figure 26: Cross Analysis ABC XYZ

The figure below shows the result of the cross ABC analysis. We exclude from our study class D, i.e. those codes with no consumption during the year, because their presence is minimal. For each class, the number of codes present, the consumption and stock values and the turnover index are shown.

			CONSUMPTION							
			X		Y		Z		TOT	
			N	%	N	%	N	%	N	%
STOCK	A	cod	22	13,75%	19	11,88%	15	9,38%	56	35,00%
		val. consumption	2.689.774,752	64,39%	376.965,301	9,02%	60.783,455	1,46%	3127523,508	74,87%
		val. stock	807.844,859	41,99%	429.116,330	22,30%	295.491,099	15,36%	1.532.452,288	79,65%
		ITR	3,330		0,878		0,206		2,041	
	B	cod	4	2,50%	12	7,50%	26	16,25%	42	26,25%
		val. consumption	306.668,773	7,34%	170.751,917	4,09%	74.401,037	1,78%	551.821,727	13,21%
		val. stock	28.305,248	1,47%	89.985,196	4,68%	173.609,145	9,02%	291.899,589	15,17%
		ITR	10,834		1,898		0,429		1,890	
	C	cod	2	1,25%	5	3,13%	55	34,38%	62	38,75%
		val. consumption	325.778,619	7,80%	92.222,297	2,21%	80.149,324	1,92%	498.150,240	11,92%
		val. stock	342,228	0,02%	13.146,960	0,68%	86.080,780	4,47%	99.569,968	5,18%
		ITR	951,934		7,015		0,931		5,003	
	TOT	**cod**	28	17,50%	36	22,50%	96	60,00%	160	100,00%
		val. consumption	3.322.222,145	79,53%	639.939,515	15,32%	215.333,816	5,15%	4.177.495,476	100,00%
		val. stock	836.492,336	43,48%	532.248,486	27,66%	555.181,024	28,86%	1.923.921,845	100,00%
		ITR	3,972		1,202		0,388		2,171	

Figure 27: ABC cross analysis of the company

By carefully analyzing the data collected in the figure, relating to 160 codes, we can identify the most critical areas that require special management attention. The total annual use value is € 4,177,495.476, while the average capital stock is € 1,923,921.845. To box AX, intersecting classes A of stock and classes X of consumption, belong 22 codes, 13.75% of the total. These items are particularly critical as they account for about 64% of consumption and the average stock is about 42% of the entire capital considered. Clearly, these codes must always be present in order to prevent the company from serious stock-out situations and/or loss of credibility and trust with customers. At the same time, by reducing the stock quantities of these products as much as possible, enormous advantages can be achieved in terms of stock management costs. This can be achieved by acting on two variables: the economic lot (EOQ) and the safety stock (SS).

Quadrant CX, the ideal situation, characterized by low stock levels and high turnover, has only two stock codes. In class AZ, the worst, there are 15 codes. This group has the lowest turnover index value of 0.20. The accumulation of these codes is critical for the company:

the high level of stock is not justified by the low turnover generated. For this reason, a complete review of their management would be appropriate.
The class BY represents a situation of consistency, comprising 12 codes, 7.5% of the total, with correctly managed stock and turnover values. The AY, BX, BZ and CY quadrants do not involve any particular criticality. The class CZ is made up of more than 34% of the existing codes, we find most articles in this class that fall under the management of the chamois category. This class has the largest number of articles, however, it is not the most important because articles in this class have relatively low consumption and stocks, due to the low unit price.

It is evident that the class with the greatest impact is AX, in fact the 22 codes present have a strong impact on stock values, these being gloria and gardena, as predicted at the beginning of the analysis. The management of these codes will be analyzed in the next section, with the aim of reducing their average stock.

3.4.1 Review of stock management parameters

In this section, an attempt will be made to improve the handling of articles belonging to class AX of the cross ABC-XYZ matrix developed earlier, by reducing the average stock in the warehouse. The safety stock and reorder points will therefore be calculated for each code belonging to this class. The values obtained will then be compared with those loaded into the company software to check whether they are compatible with those obtained from the data processing. Subsequently, the value of the economic purchase lot (EOQ) will also be calculated.

Safety stock calculation with variable lead time

To carry out this calculation, it is appropriate to take into account the variability of lead time, in the case of procurement from external suppliers. Delays or early deliveries can develop in relation to the planned LT. In the case of delays, this can lead to stock shortages, while early delivery can lead to overstock, i.e. excessive quantities of items in stock.

Quantifying the average delivery period and its standard deviation θLT, assuming constant consumption, the time safety stock is calculated with the following formula:

$SS_{LT} = Z \cdot \theta_{LT} \cdot \mathrm{D}$

where:

θ_{LT} = standard deviation of the lead time;

Z = safety factor;

D = demand over the period (constant) [dm2/period].

<u>Calculation of safety stock with variable consumption</u>

As with lead time variability, the consumption of a generic article may vary from that calculated using historical data. If demand is lower than expected, there will be overstock effects, which will increase the cost of holding stock. Conversely, if consumption turns out to be higher than expected, the company may not be able to satisfy all demands (stockout), resulting in economic losses. The consumption safety stock serves to mitigate this phenomenon. As with lead time, the average consumption Cm within a given period is calculated for each item, and the relative standard deviation θc.

The SS on consumption is defined as:

$SS_C = Z \cdot \theta c \cdot \sqrt{} LT$

where:

θc = standard deviation of consumption [dm2/period];

Z = safety factor;

LT = supply lead time [period].

The period considered must be the same both in calculating average consumption and in expressing the lead time.

Typically, the variability of lead time is much smaller than that of demand, and therefore it can generally be assumed without serious error that the overall safety stock is equal to the stock on demand uncertainty alone (De Toni and Panizzolo, 2018).

Based on this statement, we continue our study by calculating the demand-only safety stock, which, as mentioned above, is dependent on the level of service in the form of the parameter Z, the standard deviation of consumption and the lead time.

Recall that the service level deemed acceptable by the company for AX codes is 90 %, while the target level is 95 %. The values of the Z factor associated with this LS are expressed in the figure below.

Service level	***Z***
90%	*1,29*
95%	*1,65*

Figure 28: Values of the parameter Z

The Lead Time of suppliers delivering codes belonging to this class is around one month; with the project managers, it was decided to consider a constant LT of 1 working month for all codes presented.

After calculating the safety stock values for the two service levels mentioned above, we calculate the reorder point (ROP) defined as:

ROP= AC*LT + SS

Where:

- AC=average consumption [dm2/month];
- LT=supplier lead time [months];
- SS= safety stock [dm2].

The data for the calculation of the SS and company ROP were obtained by extrapolating the data from the SAP software, and were then processed and arranged in an Excel file. Some of the results obtained are as follows:

COD	DESCRIPTION	AV MONTH CONSUMPT	DEV.ST	LT	Z1 (90%)	SS (Z1)	Z2 (95%)	SS (Z2)	ROP (Z1)	ROP (Z2)
111	GLORIA NERO LISCIO	7.602,567	5.968,724	1	1,29	7.699,7	1,65	9.848,4	15.302,2	17.451,0
115	GLORIA TDM LISCIO	2.439,900	1.821,357	1	1,29	2.349,6	1,65	3.005,2	4.789,5	5.445,1
133	ROMA AZZURRO LISCIO	5.669,699	4.813,632	1	1,29	6.209,6	1,65	7.942,5	11.879,3	13.612,2
146	ROMA TDM LISCIO	8.437,601	3.437,612	1	1,29	4.434,5	1,65	5.672,1	12.872,1	14.109,7
148	GARDENA BORDO LISCIO	5.747,740	5.905,951	1	1,29	7.618,7	1,65	9.744,8	13.366,4	15.492,6
149	GARDENA CIOCCOLATO LISCIO	2.741,290	701,546	1	1,29	905,0	1,65	1.157,6	3.646,3	3.898,8
151	GARDENA ROUGE ROI LISCIO	5.713,952	2.309,435	1	1,29	2.979,2	1,65	3.810,6	8.693,1	9.524,5
152	GARDENA NATURALE LISCIO	4.085,206	1.240,627	1	1,29	1.600,4	1,65	2.047,0	5.685,6	6.132,2
154	GARDENA NAVY BLU LISCIO	2.590,200	1.912,211	1	1,29	2.466,8	1,65	3.155,1	5.057,0	5.745,3
155	GARDENA NERO LISCIO	13.845,428	3.522,175	1	1,29	4.543,6	1,65	5.811,6	18.389,0	19.657,0
157	GARDENA OLIVA LISCIO	2.475,552	940,184	1	1,29	1.212,8	1,65	1.551,3	3.688,4	4.026,9
159	GARDENA VIOLA LISCIO	2.576,350	697,655	1	1,29	900,0	1,65	1.151,1	3.476,3	3.727,5
171	ROMA MARGHERITA LISCIO	2.753,074	1.596,225	1	1,29	2.059,1	1,65	2.633,8	4.812,2	5.386,8
173	ROMA ALLUMINIO LISCIO	4.609,998	2.512,258	1	1,29	3.240,8	1,65	4.145,2	7.850,8	8.755,2
176	GARDENA BLU FASH LISCIO	4.127,001	3.803,827	1	1,29	4.906,9	1,65	6.276,3	9.033,9	10.403,3
182	GARDENA ARANCIO LISCIO	3.561,450	2.297,439	1	1,29	2.963,7	1,65	3.790,8	6.525,1	7.352,2
194	POLO BIANCO LISCIO	2.518,424	1.640,484	1	1,29	2.116,2	1,65	2.706,8	4.634,6	5.225,2
206	CS SPORTY PIOMBO LISCIO	921,934	1.286,665	1	1,29	1.659,8	1,65	2.123,0	2.581,7	3.044,9
244	GLORIA ALLUMINIO LISCIO	5.711,000	7.506,363	1	1,29	9.683,2	1,65	12.385,5	15.394,2	18.096,5
260	GARDENA NERO LISCIO	758,100	876,173	1	1,29	1.130,3	1,65	1.445,7	1.888,4	2.203,8
261	GARDENA BIANCO LISCIO	1.196,401	502,451	1	1,29	648,2	1,65	829,0	1.844,6	2.025,4
266	GARDENA NERO LISCIO	5.503,380	4.511,515	1	1,29	5.819,9	1,65	7.444,0	11.323,2	12.947,4

Figure 29: Example of AX-codes for SS and ROP calculation

It can be seen that the parameters entered in the company management system differ from the data obtained from the theoretical analysis. For this reason, we continue our study by calculating the economic reorder lot and then the average stock, in order to analyze the management of these codes in even more detail.

Calculation of the economic purchase lot

Dealing only with buy codes, we now focus on the second key variable of our study, namely the Economic Order Quantity (EOQ). The EOQ represents the number of units of a single article that should be specified each time an order is placed, in order to minimize the total costs of stock management of that single article in the planned time interval.

It is defined as follows:

$$EOQ = \sqrt{\frac{2 \cdot D \cdot K}{c \cdot i}}$$

where,

- D = demand in the period [dm2/period];
- K = order issue cost [€];
- c = product unit cost [€/dm2];
- i = holding cost rate (calculated as a percentage of unit cost).

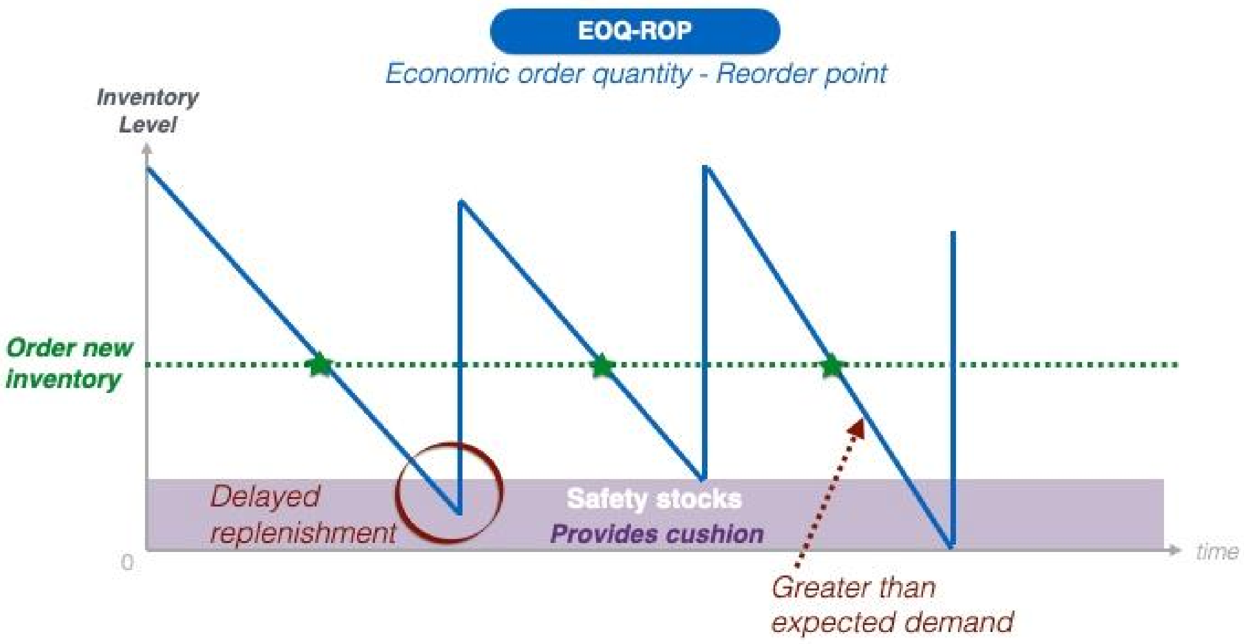

Figure 30: EOQ – ROP graph

For our calculations, in agreement with the project leaders, the following values were taken into account: K = 30 €/order and i = 25%.

For the value of K, an average order issuing cost was estimated and used as a constant reference value.

For the calculation of index i, the company provided the values of each cost category as shown in the table below:

Cost category	**Cost in % of stock value**
Warehouse costs	11,82%
Costs of moving goods	4,92%
IT and maintenance costs	1,76%
Costs of perishable goods	2,16%
Other general costs	4,27%
TOTAL storage costs	**24,93% ~ 25%**

Figure 31: Estimation of i

The results obtained can be seen in the figure below.

COD	DESCRIPTION	ANNUAL DEMAND (DM2	i %	K (€/order	VALUE PER UNIT (	EOQ (DM)
111	GLORIA NERO LISCIO	91.230,802	0,25	30	1,155	4.354
115	GLORIA TDM LISCIO	29.278,800	0,25	30	1,172	2.449
133	ROMA AZZURRO LISCIO	68.036,393	0,25	30	1,027	3.987
146	ROMA TDM LISCIO	101.251,208	0,25	30	1,012	4.900
148	GARDENA BORDO LISCIO	68.972,882	0,25	30	3,058	2.327
149	GARDENA CIOCCOLATO LISCIO	32.895,479	0,25	30	3,315	1.543
151	GARDENA ROUGE ROI LISCIO	68.567,426	0,25	30	3,035	2.329
152	GARDENA NATURALE LISCIO	49.022,477	0,25	30	3,225	1.910
154	GARDENA NAVY BLU LISCIO	31.082,402	0,25	30	3,020	1.572
155	GARDENA NERO LISCIO	166.145,137	0,25	30	3,251	3.502
157	GARDENA OLIVA LISCIO	29.706,626	0,25	30	3,085	1.520
159	GARDENA VIOLA LISCIO	30.916,202	0,25	30	3,068	1.555
171	ROMA MARGHERITA LISCIO	33.036,888	0,25	30	1,017	2.792
173	ROMA ALLUMINIO LISCIO	55.319,972	0,25	30	1,101	3.473
176	GARDENA BLU FASH LISCIO	49.524,014	0,25	30	3,066	1.969
182	GARDENA ARANCIO LISCIO	42.737,402	0,25	30	3,089	1.822
194	POLO BIANCO LISCIO	30.221,093	0,25	30	2,012	1.899
206	CS SPORTY PIOMBO LISCIO	11.063,203	0,25	30	3,030	936
244	GLORIA ALLUMINIO LISCIO	68.532,004	0,25	30	1,216	3.678
260	GARDENA NERO LISCIO	9.097,200	0,25	30	3,877	750
261	GARDENA BIANCO LISCIO	14.356,811	0,25	30	3,287	1.024
266	GARDENA NERO LISCIO	66.040,560	0,25	30	3,522	2.121

Figure 32: Example of EOQ AX-codes.

Calculation of average stock

At this point in the analysis, all the fundamental parameters for stock management have been calculated: the safety stock, the reorder point and the economic purchase lot.

We are now ready to calculate the average stock, which can be expressed by the following relationship:

$$G_m = \frac{Q}{2} + SS$$

It is then possible to use the rounded EOQ and safety stock values, calculated analytically with reference to the 95 percent service level, to estimate the average stock of each item in the warehouse. This value will then be compared with the company's data to show whether the parameter revision work can improve stock management.

We obtain:

COD	DESCRIPTION	EOQ (DM)	SS (Z2)	EOQ/2 + SS	value per unit €	val EOQ/2 + SS	val annual av stock
111	GLORIA NERO LISCIO	4.354	9848	12.025	1,155	13.889,31	12.471,33
115	GLORIA TDM LISCIO	2.449	3005	4.230	1,172	4.957,02	15.805,12
133	ROMA AZZURRO LISCIO	3.987	7942	9.936	1,027	10.204,48	28.968,93
146	ROMA TDM LISCIO	4.900	5672	8.122	1,012	8.219,63	23.245,74
148	GARDENA BORDO LISCIO	2.327	9745	10.908	3,058	33.357,06	90.752,11
149	GARDENA CIOCCOLATO LISCIO	1.543	1158	1.929	3,315	6.395,19	34.517,19
151	GARDENA ROUGE ROI LISCIO	2.329	3811	4.975	3,035	15.098,64	70.932,79
152	GARDENA NATURALE LISCIO	1.910	2047	3.002	3,225	9.681,60	37.388,07
154	GARDENA NAVY BLU LISCIO	1.572	3155	3.941	3,020	11.901,76	69.029,37
155	GARDENA NERO LISCIO	3.502	5812	7.563	3,251	24.586,30	54.858,48
157	GARDENA OLIVA LISCIO	1.520	1551	2.311	3,085	7.130,70	13.102,27
159	GARDENA VIOLA LISCIO	1.555	1151	1.929	3,068	5.917,26	18.713,96
171	ROMA MARGHERITA LISCIO	2.792	2634	4.030	1,017	4.098,37	21.311,61
173	ROMA ALLUMINIO LISCIO	3.473	4145	5.882	1,101	6.475,55	10.906,51
176	GARDENA BLU FASH LISCIO	1.969	6276	7.261	3,066	22.261,53	66.539,71
182	GARDENA ARANCIO LISCIO	1.822	3791	4.702	3,089	14.524,12	57.490,15
194	POLO BIANCO LISCIO	1.899	2707	3.656	2,012	7.356,13	45.265,95
206	CS SPORTY PIOMBO LISCIO	936	2123	2.591	3,030	7.850,88	14.847,40
244	GLORIA ALLUMINIO LISCIO	3.678	12385	14.224	1,216	17.296,86	27.694,15
260	GARDENA NERO LISCIO	750	1446	1.821	3,877	7.059,64	28.751,83
261	GARDENA BIANCO LISCIO	1.024	829	1.341	3,287	4.407,76	27.654,14
266	GARDENA NERO LISCIO	2.121	7444	8.505	3,522	29.953,50	37.598,05
	TOT			124.883		272.623	807.845

Figure 33: Example of AX codes - average stock calculation.

Overall, the newly calculated parameters allow an improvement in the handling of the codes considered to belong to the AX class, the most important for the company. The analytically calculated average stock is 124,883 DM2, which is much lower than the actual average stock value of 807,845 DM2.

The calculated safety stock, using a service level of 95 %, is significantly lower than the company values. Reducing the amount of stock in the warehouse in turn reduces the total cost of stock. Simulating the turnover ratio using the newly calculated stock value and keeping the average monthly turnover constant, we obtain the following value for class AA:

ITR= Total valued consumption / average valued stock = 9.87

We note that the value of the turnover index for this class also increases. The figures below show the values of Class AA of the ABC matrix by inserting the new parameters and the comparison with the starting company data is also shown.

INITIAL SITUATION			CONSUMPTION X	
			N	%
STOCK	A	cod	22	13,75%
		val. consumption	2.689.774,752	64,39%
		val. stock	807.844,859	41,99%
		ITR	3,330	

SITUATION AFTER CALCULATION			CONSUMPTION X	
			N	%
STOCK	A	cod	22	13,75%
		val. consumption	2.689.774,752	64,39%
		val. stock	272.623,312	41,99%
		ITR	9,866	

Figure 34: Comparison of initial situation with new data

From Figure 34 we can see that from an economic and financial point of view we have a reduction of approximately 535.221 € in the stock value.

We can therefore conclude, that the data entered in the management system are not completely correct and this revision of stock management will certainly bring benefits within the company.

CONCLUSION

In an increasingly competitive industrial environment where reducing customer response times, overall costs and waste are strategic success factors, it makes sense for companies to review their inventory management to ensure lean, efficient and accurate processes. The objective of this thesis was to reduce stock in the warehouse by reviewing the various product procurement policies, focusing only on those purchase codes that have the greatest impact on the warehouse. Using the various tools made available by the Lean philosophy, it was possible, starting from the AS-IS situation of the warehouse, to review and modify the various stocks in the warehouse. It was noted that it was very difficult to find materials to process; this leads to delays in delivery times and creates havoc in customer relations. Precisely for this reason, and especially in this particular era, it is absolutely recommended to periodically check the company management in order to catch any changes for each class. Cross ABC-XYZ analysis uses multiple data and a dynamic, i.e. time-varying tool. It is absolutely recommended to periodically check the business management in order to catch any changes for each class. It is precisely from these continuous improvement activities, even small ones, that we obtain the necessary conditions for correct and effective stock management. Management that first and foremost ensures clear benefits in monetary terms, ensures a synchronized flow of products and services, i.e. what the customer wants, in the correct quantities and at the desired times, and finally improves the entire logistics-distribution chain. Inventory management is a key function that determines the state of the supply chain as well as impacts on the financial state of the balance sheet. Every organization constantly strives to maintain an optimal inventory, to be able to meet its requirements and to avoid excessive or insufficient inventory, which can have an impact on financial and production figures. During these months of apprenticeship, the collaboration between the production planning and programming office, the purchasing office and the warehouse managers made it possible to delve into all the details concerning the products in the warehouse, which are necessary to obtain the most detailed and accurate analysis.

The theoretical application of Lean Warehousing tools was not the only lever of the project's success, it also depended on many other factors.
The changes made and the various considerations made during the course of the project were useful and made it possible to review certain points that had not been addressed for several years.

This gives rise to ideas for future ideas, such as extending the same analysis also to the warehouse for the storage of assembly materials, or starting two internal projects: one concerning the complete analysis of the supplier base and one concerning the introduction of the kanban technique on certain products. The latter technique is already used for some codes and wants to be extended, where possible, for as many codes as possible. It allows efficiency to be improved through reduced investment.

In conclusion, I was able to see how Lean principles can be applied to manufacturing realities, where the final quality of the output depends heavily on the manual skills of the operators.
Lean Production is not a technique, or a set of them, but a philosophy that allows you to make the leap in quality, enhancing value for the end customer and eliminating any form of waste, especially if implemented within warehouse management policies.

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