Improving Strategic Planning in a Ceramic Industry Company

Marta Rafaela Faria Pereira

Master's Dissertation

Advisor at FEUP: Prof. Sara Martins

U. PORTO

FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO

Mestrado em Engenharia e Gestão Industrial

2022-07-11

Abstract

A ceramic industry Portuguese company is facing difficulties regarding the ability to respond to demand quickly and in full quantity, which is a critical competitive advantage of any successful business. In this sense, the focus of this dissertation is on improving the service level and customer satisfaction.

The delay in order delivery prompted the subsequent dissertation, which aims to improve strategic planning through a hybrid strategy tailored to the Client Company's demand.

The classification of references was performed with the objective of grouping products with similar characteristics to facilitate strategy definition. An ABC-XYZ analysis divided the 296 ceramic references into 9 categories, on the basis of the volume and variability of sales criteria. A make-to-stock strategy was defined for categories with low variability and make-to-order for categories with high variability. To adopt a more personalised approach for the Client's needs, a third strategy was created, named mould make-to-stock (MMTS), for references that belong to an intermediate zone of the defined criteria. In the MMTS a mould inventory was built to establish a production lead time of 17 days rather than 38 days, increasing responsiveness without overburdening the expedition warehouse and increasing the holding costs.

The previous steps served as a framework for the definition of inventory policies, including levels of replenishment and safety stock, adjusted to demand and to a third criterion related to the importance of the series, i.e., the collection of products of which a reference is a part.

In the past the company's service level goal was 80%, which was only achieved in one month in 2021. The service levels obtained within this academic project are between 85% and 95%, translating into a reduction of 30% which corresponds to less 848.187 € in tied-up capital in inventory, considering the value added by the mould inventory.

Inventory reduction with controlled and improved service levels translates into a better policy as it reduces holding costs, improves cash flow, and the risk of having inventory such as obsolescence.

This project resulted in better management of the company's resources, leading to a higher level of service and enhanced customer satisfaction.

Resumo

Melhoraria do Planeamento Estratégico de uma Empresa na Indústria da Cerâmica

Uma empresa portuguesa da indústria cerâmica enfrenta dificuldades no que diz respeito à capacidade de responder à procura rapidamente e em quantidade total, o que constitui uma vantagem competitiva crítica de qualquer negócio de sucesso. Neste sentido, o foco desta dissertação é a melhoria do nível de serviço e a satisfação do cliente.

A seguinte dissertação foi motivada pelos atrasos na entrega de encomendas, visando a melhoraria do planeamento estratégico através de uma estratégia híbrida adaptada à procura da Empresa Cliente.

A classificação das referências foi realizada com o objetivo de agrupar produtos com características semelhantes para facilitar a definição da estratégia. Uma análise ABC-XYZ dividiu as 296 referências cerâmicas em 9 categorias, com base nos critérios volume e variabilidade de venda. Foi definida uma estratégia de produção em inventário para categorias com baixa variabilidade e produção por encomenda para categorias com elevada variabilidade. Para adoptar uma abordagem mais personalizada para as necessidades do Cliente, foi criada uma terceira estratégia, denominada produção de moldes para inventário (MMTS), para as referências que pertencem a uma zona intermédia dos critérios definidos. Na MMTS foi construído um inventário de moldes para estabelecer um período de produção de 17 dias em vez de 38 dias, aumentando a capacidade de resposta sem sobrecarregar o armazém de expedição nem aumentar os custos de armazenagem.

As etapas anteriores serviram de enquadramento para a definição de políticas de inventário, incluindo níveis de reposição e inventário de segurança, ajustados à procura e a um terceiro critério relacionado com a importância da série, ou seja, a coleção de produtos de que faz parte uma referência.

No passado, o objetivo do nível de serviço da empresa era de 80%, o que só foi alcançado num mês em 2021. Os níveis de serviço obtidos neste projeto académico situam-se entre 85% e 95%, traduzindo-se numa redução de 30% de capital imobilizado em inventário, o que corresponde a menos 848.187 €, considerando o valor acrescentado pelo inventário de moldes.

A redução de inventário com níveis de serviço controlados e melhorados traduz-se numa melhor política, uma vez que reduz os custos de manutenção, melhora os fluxos de caixa e o risco de ter inventário em obsolescência.

Este projeto promoveu uma melhor gestão dos recursos da empresa, resultando num nível de serviço mais elevado e maior satisfação do cliente.

Acknowledgments

A dissertation is not a mere report written with formulas and words, on blank nights, in an unfamiliar environment that is a new company. It is the culmination of five years full of memories and moments that will stay for life. Moments that make us laugh alone in the middle of the street and think "I miss this...". Because this work is not just a project, I thank all my friends from university. Like John Mayer says, "you are going to live forever in me".

To my parents for supporting me unconditionally and encouraging me to always be resilient because life always ends up giving us the right lemons to make lemonade. I believe it was not easy to educate me for 23 years, but you make it look easy.

To my sister, my self-proclaimed number 1 fan, I thank you for all the unsolicited motivational speeches, the surprises in exam seasons, and a love that makes anyone feel safe.

To my family for all the advice that starts with "I don't know anything about your degree but...". For all the calls from Braga that make me feel like an emigrant, and, at the same time, as if I had never left home. For all the dinners and gatherings that celebrate my return, even though it happens almost every week.

To the Kaizen Institute and Team 10 for giving me a haven in which to develop my skills and, hopefully, become a more complete professional. A special mention to João Soares, Carolina Carvalho, Maria Pires, and Andreia Moreira for all the advice and help.

To Professor Sara Martins for the help, availability, and incentive to make my work the best possible.

To FEUP for being my nest for the last five years from where I leave with nostalgia but always with pride for the person I became and for giving me the wings to fly to new challenges.

"Get your facts first, and then you can distort 'em as much as you please."

Mark Twain

Contents

Acronyms and Symbols

AHP	Analytic Hierarchy Process
ATO	Assembly-to-Order
BS	Batch Size
CODP	Customer Order Decoupling Point
CV	Coefficient of variation
EOQ	Economic Order Quantity
EPEI	Every Part Every Interval
ERP	Enterprise Resource Planning
ETO	Engineer-to-Order
FIFO	First In First Out
FSN	Fast-Moving, Slow-Moving and Non-Moving
HML	High, Medium and Low
IQR	Interquartile Range
KPI	Key Performance Indicator
LB	Lower Boundary
LT	Lead Time
MCABC	Multi-Criteria ABC
MS	Mould Stock
MTO	Make-to-Order
MTS	Make-to-Stock
MMTS	Mould Make-to-Stock
OTIF	On Time In Full
RL	Replenishment Level
SC	Supply Chain
SKU	Stock Keeping Unit
SL	Service Level
SS	Safety Stock
UB	Upper Boundary
VED	Vital, Essential and Desirable
VSM	Value Stream Mapping
WIP	Work-in-Progress

List of Figures

List of Tables

Chapter 1

Introduction

The production of high-quality sanitary goods makes the European Union a global leader in the ceramics sector. In the light of the current political and social global situation, production costs were increased due to dependence on energy from outside the European Union. Furthermore, the ceramics companies' environment is affected by competition from emerging economies with low-cost products, trade barriers, and the challenge of securing qualified human capital (IAPMEI, 2022).

Efficiency and productivity are essential for survival in the described sector, where competitiveness and high consumer demands coexist. Additionally, requirements for production quantity, quality, and waste arise from the exposure to many elements that affect its profitability (Ulewicz et al., 2021). Hence, a Portuguese ceramics product manufacturer, whose name will not be revealed for confidentiality reasons, requested the services of the Kaizen Institute to identify circumstances that could be impeding the achievement of enhanced results.

The hurdles Kaizen Institute's Client Company faces hinder its strategy adaptation to the environment and the achievement of the goals set by the group to which it belongs. As such, the factories produce many references to give the consumer more choices and keep a lot of stock to meet demand promptly, arising from a lengthy setup process and the inability to combine references. Lack of communication between the Logistics and Production teams prevents adjustments to the human and factory capacities, the availability of materials, and the dates of delivery agreed upon with the customers, leading to plans that hardly can be fulfilled. Due to the processes' reliance on human labor, their lengthy lead time, and the abundance of references available to meet a wide variety of consumers, the sector under study clearly illustrates the need to enhance stock management.

The partnership between the firms seeks to identify the multiple factors that may be at the root of the low service level and customer satisfaction faced. Therefore, a diagnosis was made of the value chain to identify potential improvement initiatives, and four indicators were analysed to assess the business's performance, such as plan compliance, work-in-progress, stock level, and lead time.

Determining how to increase the service level is the primary motivation of this thesis developed within the scope of the Master's Degree in Industrial Engineering and Management at the Faculty of Engineering of the University of Porto.

While several approaches can help achieve the common goal, the study will concentrate on the one approach that is given priority among those identified, considering the anticipated advantages. To achieve the desired results with long-term sustainability, the actions outlined aim for significant changes regarding service level, followed by efforts for continuous improvement.

1.1 Kaizen Institute

The Kaizen Institute is a multinational company that has been providing consulting and training services to organisations since 1985, when it was founded by Masaaki Imai. The term Kaizen is recognised as the cornerstone for the long-term competitiveness of an organisation, being formed by the junction of the words "kai" and "zen", meaning change and better. As such, the adopted philosophy and methodologies have continuous improvement as their primary goal.

In Portugal, the activity of this group goes back to 1999, when the first office opened in Vila Nova de Gaia. To date, the team has collaborated with organizations in several areas, from Public to Private Services, Industry, among others, and stands out in the market for its ability to develop successful business plans in such diverse sectors.

1.2 Project Methodology

First, in Kaizen's project, an analysis of the current state was performed, enabling the listing of overall improvement opportunities. Afterwards, data was gathered and assessed to comprehend the effect and possible roots of the business's poor performance in the last years. After compiling solutions for each problem, was performed an effort-impact analysis. As a result, it was possible to develop a feasible work plan over the project's time frame and from which the required outcome was attainable.

To develop the thesis's action plan, literature was reviewed so as to understand the current state of knowledge in this area and the tools used in similar cases. The previously gathered information was insufficient for more specific analyses, so a meeting was held with the Client Company's administrators to obtain and evaluate additional data. As a result, the solution was designed to improve the service level. Its testing was performed in two ways: historical information was compared with the solution's outcome to understand the potential benefits, and the methodology's implementation monitorization throughout 2022 to assess the results and monetary impact.

The timeline given for the thesis's project is three months, split as illustrated in the Gantt chart in Figure 1.1.

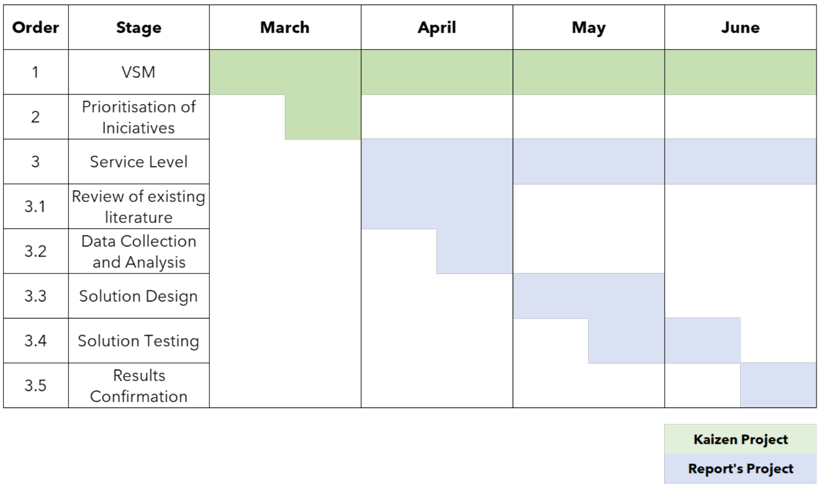

Figure 1.1: Project's Gantt Chart

1.3 Dissertation structure

The dissertation is divided into six chapters. The current one corresponds to the presentation of the project and its objectives, the companies involved in it, and the ceramics industry. The second chapter provides a theoretical framework of the concepts that support the work developed, namely strategic production planning, products' classification, make-to-stock and make-to-order, and the implications for customer service. The third chapter examines the company's starting condition, contextualizing it in terms of structure, production process, planning, and commercialized references, and further identifies the problem. The project's approach is discussed in detail in the fourth chapter, which describes sequentially the implemented solutions. The fifth chapter includes the outcomes of the solutions covered in the preceding chapter, along with reflections regarding the findings. The sixth and last chapter offers some closing thoughts on the project as well as prospective initiatives that will maintain and enhance the developed work.

Chapter 2

Literature Review

In this chapter, the theoretical foundations that will support the dissertation are presented.

Firstly, it explores the Supply Chain (SC) concept and the impact of the customer regarding the service level. The influence of demand introduces the Customer Order Decoupling Point (CODP) and the adjustments it generates in the decision process. Next, the existing production systems are presented, leading to the analysis of the decision levels. The chosen strategies may differ between products. Therefore, several classifications will be presented, as well as the advantages of resorting to them. Finally, value stream mapping is addressed as a tool to identify opportunities for improvement.

2.1 Supply Chain

Current literature proves that there are several definitions for Supply Chain. However, in general, it is comprehended to be the network of facilities and information systems that connects a company to its suppliers and customers as well as within itself (Frazelle, 2002). A more broad definition states that it is the combination of all parties involved in meeting a customer request (Chopra and Meindl, 2007). The value chain is a less broad view of the SC. It consists of the flows that create value within the boundaries of the company. However, all entities in a network contribute to this purpose, not just the focal firm (Christopher, 2016).

The constant exchange of information, materials, and funds makes the SC a dynamic system. According to Chopra and Meindl (2007), the upstream and downstream flows highlight the importance of good coordination between all stakeholders to ensure a responsive chain.

Focusing on the Supply Chain and how to better manage it has become a source of competitive advantage for organizations nowadays (Ellinger et al., 2012). It allows the maximization of the overall value generated by the effective and efficient use of resources (Sukati et al., 2012; Christopher, 2016). For a business to be competitive, it should set itself apart from its rivals from the consumer's perspective and operate at lower costs (Christopher, 2016).

The customer is an integral part of the SC, affecting a company's competitiveness. Understanding consumers' needs and their impression of the service is crucial to satisfy them. And

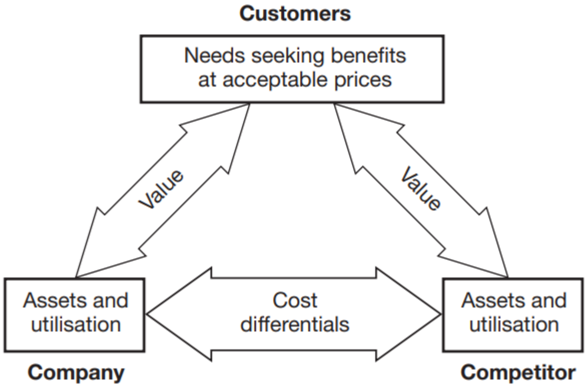

Figure 2.1: Competitive Advantage - Source: Christopher (2016)

given the number of alternatives the market offers clients, the quality of products and services is essential. To adjust production with demand is a strategy to increase customer satisfaction in today's just-in-time world (Hofmann et al., 2012; Christopher, 2016).

Quality, service, cost, and time are the four primary factors that affect customer value. Quality is the functionality of a product; service is the assistance given to the customer; cost includes both the price and the expected lifespan of the product; time is the amount of time it takes to fulfill an order (Christopher, 2016).

SC management's goal is to provide a given level and quality of service to consumers. On-time delivery can be interpreted as a measurement of this service level (SL) and is an element of delivery performance, SC management's most controllable driver of customer satisfaction (Stewart, 1995). Another measure is the on-time, in-full (OTIF), which assesses the proportion of the orders listed within a given time frame that was fulfilled on the agreed time and in its entire quantity (Christopher, 2016). Stewart (1995) identifies the reduction of the lead time as the main way to improve the SL. The entire production lead time contemplates the time between the acquisition of materials and the final product delivery date (Tatsiopoulos and Kingsman, 1983). An aspect also taken into consideration is the work-in-progress (WIP) since it indicates a high level of tied-up capital (Gunasekaran et al., 2001). Tatsiopoulos and Kingsman (1983) mentions that actual processing procedures account for just 10% of the total time, with transit times, contemplating queuing, inspection, and transportation making up the remaining 90%.

As stated by Bhuniya et al. (2021), products linked to a higher service tend to suffer an increase in demand and to attain it, one must look at the SC as a whole and improve every stage.

2.2 Production planning

Planning entails choosing the most advantageous course of action from the available possibilities. The goal of Production Planning tools is to reduce WIP inventories and be more efficient. To choose the best scenario among the alternatives while making a well-reasoned decision, it is necessary to look at the entire SC since a narrow-minded view of it can have harmful consequences in the remaining stages (Greeff and Ghoshal, 2004).

2.2.1 Customer Order Decoupling Point

The Customer Order Decoupling Point is interpreted as the point in a value chain where the product is tied to a client order. It may be referred to as the order penetration point, as well.

According to Olhager (2010), the location of the CODP has a significant impact on the configuration and management of a value chain since it distinguishes between actions driven by consumer orders and by forecasts.

The location of the CODP is a crucial strategic factor for supply networks (Hedenstierna and Ng, 2011) given its implications for the company's goals, including the level of consumer service and inventory investment. As Olhager (2010) explains, the various positions that the CODP may acquire during the value chain result in distinct production strategies, which are addressed further in this chapter. According to previous research, the CODP must be deployed as far upstream as consumers are willing to wait (Hedenstierna and Ng, 2011).

The findings presented by van Donk and van Doorne (2016) reveal a clear link between SC integration (with both customers and suppliers) and CODP positioning. Firms that are driven by orders are more likely to have a high degree of upstream integration, whereas forecast-driven companies are more likely to have a high level of downstream integration.

2.2.2 Push and Pull

To look at an SC through a push and pull perspective is to divide processes into two categories - those that started in anticipation of an order and those motivated by an actual order, respectively (Sarbjit, 2017).

In the push approach, products and parts are produced in expectation of demand. As such, is generated stock to establish a "buffer" that permits the response to variable demand. A pull system is one where consumer demand determines the flow of products to the market, which consequently determines the flow of the components required in manufacturing.

The most conventional approach is a push one (Olhager and Östlund, 1990). However, the establishment of several inventory points increases carrying costs and the risk of products becoming obsolete since forecasts are often inaccurate, resulting in low profits. In contrast, a pull system often implies lower inventory holding costs. The limited stock, however, can force the company not to comply with the request contributing to customer dissatisfaction. Although the use of pull is currently more recommended, there are situations where it cannot be implemented.

Lean manufacturing seeks to increase production while lowering waste and costs (Womack et al., 1992). To achieve this in consonance with Puchkova et al. (2016), inventory levels must be limited, and pull measures must be implemented. Unexpected disturbances may arise, such as fluctuating demand, urgent orders, equipment failures, quality loss concerns, and limited inventory, reducing performance and increasing delivery delays. As such, the key is to have the capacity to be lean while still dealing with disturbances. Therefore, several studies defend that push and pull must be integrated, exploiting both strategies' advantages (Lyonnet and Toscano, 2014).

2.2.3 Production planning strategies

Production planning and management are critical in any company to attain and maintain a high quality of service at the lowest feasible cost (Khojasteh, 2017). To achieve this, the planning and production systems, pull or push, have to be selected, in addition to the appropriate strategy.

Make-to-stock (MTS) dictates that items are manufactured following anticipated demand and then held in stock for sale. Although the MTS strategy can shorten customer lead time, it can also increase inventory expenses (Zandieh and Motallebi, 2018).

The Assembly-to-order (ATO) strategy is a combination of MTS and Make-to-order (MTO), as there is a certain level of customization and a short lead time. Only after receiving a customer's order are production processes carried out. The same method applies to MTO, resulting in longer customer lead time, minimal storage costs, and more flexibility.

As for the Engineer-to-order (ETO), customer requests are obtained before the product design process. The specified demands are used to design the goods, and each order necessitates a unique set of parts, a material list, and a method. As such, it is usually used for complex products. The lead time is rather long, but there are savings in costs, namely in production and inventory.

The various positions the CODP can assume along the value chain result in several production strategies (Olhager, 2010), as shown in Figure 2.2.

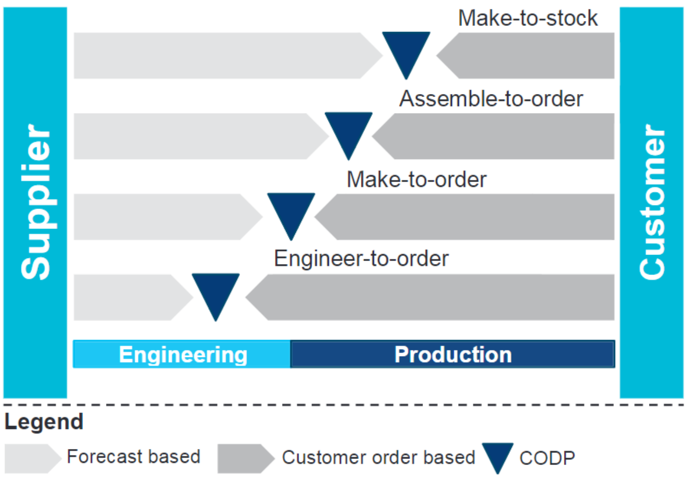

Figure 2.2: Positioning of the CODP for the different production strategies (Willner et al., 2014)

Olhager (2010) indicates that a organization's strategy is related to the capacity to offer product customization or a diverse variety of goods.

The four strategies can be reduced to two, MTO and MTS since ETO is included in MTO (Willner et al., 2014) and ATO is an amalgamation of both strategies (Zandieh and Motallebi, 2018).

In industries using MTS strategies, production is carried out in large batches and with low lead times (Willner et al., 2014). Consequently, it is more predictable, and processes are more uniform, leading to easier management (Stevenson* et al., 2005). In contrast, the two main advantages of resorting to an MTO strategy are that it allows a certain level of customization and low inventory levels (Willner et al., 2014). Even though MTO is becoming increasingly common, choosing this strategy and having it be inadequate results in unnecessary costs (Stevenson* et al., 2005). Organizations can categorise Stock Keeping Units (SKUs) to accurately define which approach should be implemented (van Kampen and van Donk, 2014).

Both Zandieh and Motallebi (2018) and Beemsterboer et al. (2015) defend that, in most cases, adopting a hybrid approach is preferable to applying a single policy to all products, regarding flexibility and diverse output. Nevertheless, combining these policies can be difficult due to demand unpredictability and the dynamic nature of operations (Zandieh and Motallebi, 2018).

2.2.4 Decision Levels

Daily challenges require decisions about future courses of action, considering the available information (Matteson and Hawkins, 1990). Given the connection between the different stakeholders of an SC, there are significant trade-offs involved (Maravelias and Sung, 2009). As such, should be considered the objectives, mission, and vision, and the linkages between the different functions. In short, the planning problems should be integrated, considering the interrelationships between them (Muñoz et al., 2012).

To attain SC coordination, the planning issues that must be addressed span a wide variety of activities and time frames, as stated by Maravelias and Sung (2009). On that account, decisions can be made on three different levels - operational, tactical, and strategic - that vary on the time horizon considered.

Operational decisions are short-term made with the intention of maximizing performance while exploiting uncertainty's reduction, whereas tactical focus on pricing decisions (Chopra and Meindl, 2007).

Strategic planning is the level with the lengthiest time horizon. At this stage, decisions are usually related to SC setting (Chopra and Meindl, 2007), reflecting the company's interaction with the surrounding environment and are, therefore, assigned to the top management (Elbanna, 2006). Muñoz et al. (2012) claims that, at a strategic level, information stemming from the various levels supports the actions made. Hedenstierna and Ng (2011) suggests that the CODP location is of strategic importance, namely in contexts with highly unpredictable demand.

Creating value for the customer is the strategic primary focus, which can be measured by the service level and customer satisfaction SteadieSeifi (2011); Christopher (2016).

2.3 Product Classification

An Stock Keeping Unit is the individual reference of a product that is singular in function and design (Van Kampen et al., 2012). SCs are becoming more complex and dynamic as they deal with a wide range of SKUs, customers, and suppliers (Hofmann et al., 2012).

As argued by both Van Kampen et al. (2012) and Santos et al. (2015), selling a large number of SKUs usually entails a loss of control in production and stock management. To respond to current demand while dealing with the adversities of the surrounding environment, organisations must try to simplify this complex reality.

Subsequently, it can be advantageous to group SKU in classes (Van Kampen et al., 2012) based on their features. Christopher et al. (2009) defend that there are important features that drive value stream strategy decision-making, such as life-cycle, lead-time, volume, variety, and variability.

van Kampen and van Donk (2014) state companies utilize this type of categorization to make inventory decisions or determine the CODP, supported by Van Kampen et al. (2012) who claim that it is relevant for production, customer service, and inventory management. Because decision criteria apply to all items within a category, classification makes implementation and usage simple (van Kampen and van Donk, 2014).

Many criteria can be considered to suit the context under study (Flores and Whybark, 1987; Ng, 2007). Table 2.1 presents some examples of the criteria defended by authors to be appropriate for product classification.

Table 2.1: Classification Criteria used in the existing literature

Source	Criteria			
	Lead time	Cost	Demand	Product
Ng (2007)	Lead time	Unit Cost	Sales turnover	
Balaji and Kumar (2014)	Lead time	Unit Cost	Sales volume	
Chen et al. (2008)		Unit Cost	Sales volume	Weight and shape
Yang et al. (2017)	Lead time	Profit margin	Frequency	
Ramanathan (2006)	Lead time	Unit cost	Demand volume	Criticality
Onwubolu and Dube (2006)		Unit cost	Demand volume	

Even though the authors vary in the chosen criteria, the most common are lead time, unit cost, and volume of sales, and in almost all cases more than one criterion is employed.

The ABC analysis is a simple and effective study to perform on references to create clusters. When the goal is to assess the effect on the value of the company, this approach can show results with a high precision level (Santos et al., 2015). This analysis results in product categorization into three categories: A, B, and C. Typically, the partition is based on a single criterion (Flores and Whybark, 1987), following the Pareto rule.

Teunter et al. (2010) suggest that the demand volume criterion is more advantageous than the generally used demand value criterion (price multiplied by demand volume) to lower costs while maximizing service level because a higher price typically presupposes higher carrying costs. When a research is conducted based on sales volume, the following categorization is set:

- Group A: up to 80% of the accumulated sales volume;
- Group B: 80 to 95% of the accumulated sales volume;

- Group C: 95 to 100% of the accumulated sales volume;

As such, the majority of the value, around 80%, is accounted for by a small number of items (Santos et al., 2015), usually around 20% (group A). The fact that the ABC study is built on a single metric renders the outcome less accurate (Ng, 2007; Ravinder and Misra, 2016; Flores et al., 1992).

The system VED qualitatively categorizes references as vital (V), essential (E), or desirable (D) (Cavalieri et al., 2008). Notwithstanding its ease of use, this approach categorizes product components or maintenance parts according to the literature.

The high, medium and low analysis (HML) considers cost per unit, and is based on the Pareto principle.

Another technique defines three possible categories: fast-moving, slow-moving, and non-moving (FSN). The FSN is similar to the ABC, VED, and HML since it is modeled on a single criterion (Shibamay et al., 2015).

Flores et al. (1992) propose an Analytic Hierarchy Process (AHP) to minimize the number of criteria to a single and consistent metric. Both qualitative and quantitative criteria can be applied to create a hierarchy of importance. The different elements are organized in branches, and each pair's relative importance is evaluated to determine the final hierarchy. Performing this organization in a broken-down manner, pair by pair, reduces the effect of subjectivity on the study.

Chen et al. (2008) proposes a model named MCABC (multi-criteria ABC), in which the classic ABC approach is combined with more criteria to provide further flexibility to decision-making. The resulting matrix is presented in Figure 2.3.

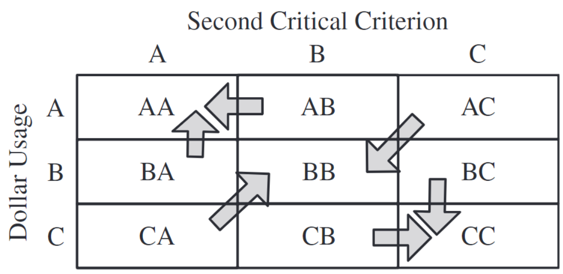

Figure 2.3: MCABC Analysis Matrix - ABC with 2 criteria (Chen et al., 2008)

The Multi-Criteria ABC is defended by Ravinder and Misra (2016) as a well-established and supported approach.

The ABC/XYZ analysis is a two-criteria analysis, the combination of ABC and XYZ methods. The variation of sales is often taken into account in the XYZ analysis. As a result, the degree of fluctuation in demand is assessed during a given time. The coefficient of variation (CV) is used to generate each category. CV can be calculated following the Equation 2.2.

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2} \tag{2.1}$$

$$CV = \frac{\sigma}{\bar{x}} \tag{2.2}$$

Where:
σ is the standard deviation.
$\bar{x}$ is the average value.

Scholz-Reiter et al. (2012) identifies the following ranges for each product based on its corresponding CV:

- Group X: CV < 0,5;
- Group Y: 0,5 < CV < 1,0;
- Group Z: CV > 1,0;

Given that the ABC and XYZ analyses are analogous, it is possible to adopt the Pareto rule, albeit with a different criterion associated. The resulting matrix resembles Figure 2.3, but the XYZ represent the horizontal axis ("second critical criteria"). Evdokimova (2021) recognize frequency as a common criterion for XYZ classification but highlight the limitations of ranking based on a criterion that is affected by seasonality and uneven procurement.

Several models can be employed, so the one that is tailored to both the objectives and the available data should be considered. In view of the influence of dispersion of values, in several methods an outlier analysis should be jointly applied to analyze data more effectively, avoiding skewing.

2.4 Replenishment

(Christopher, 2016) argue that organizations will have an advantage in the market by carrying out core tasks more cost-effectively than rivals. If an MTS approach is incorporated, it is necessary to consider the inventory costs since these are rarely less than 25% of the corresponding value regardless of the industry or company.

When a corporation wants to increase its service level, it must address the replenishment system to improve delivery performance. The policies adopted within this system have an impact on the SC, namely on the earnings (Talluri et al., 2004). The high demand, supply fluctuation, and inventory requirements impact replenishment, resulting in a trade-off between costs and customer satisfaction (Figure 2.4).

The replenishment level (or "order point" as referred to in Figure 2.5) establishes the inventory "point" at which the item's production is prompted. As such, it is the amount of stock required to fulfill demand during the manufacturing lead time, whilst considering the safety stock (Cimorelli, 2013).

$$RL = SS + \overline{D} \times LT_P \tag{2.3}$$

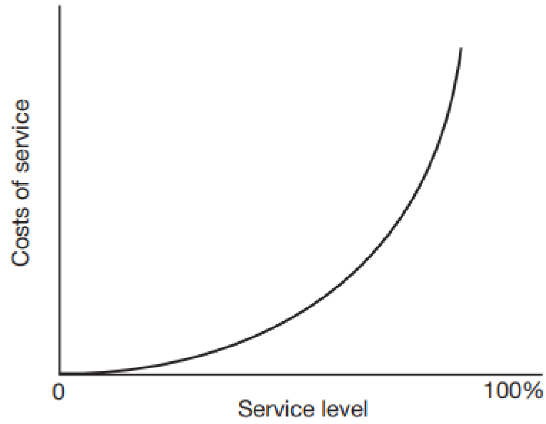

Figure 2.4: Costs of Service - Source: Christopher (2016)

Where:

RL is the replenishment level.

SS is the safety stock.

$\overline{D}$ is the average demand.

LT_P is the average lead time necessary for production.

Safety stock is one of the policies that may also be established. It is a way of preventing disruptions in the SC arising from uncertainties related to suppliers, internal processes, and clients. The advantages of keeping stock and the costs associated have to be balanced, which can be achieved by choosing the correct SS for each SKU (Stadtler and Kilger, 2008).

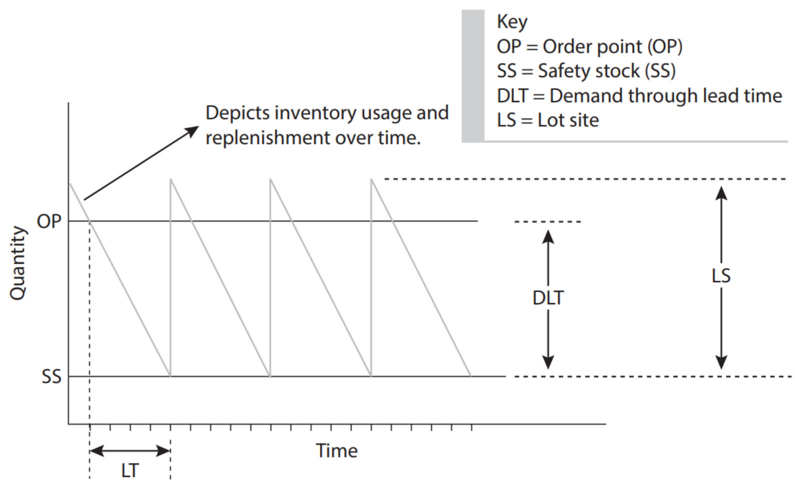

Figure 2.5: Sawtooth diagram of Inventory Level - Source: Cimorelli (2013)

SS can be defined for final products or raw materials to avoid that a given process stops, jeopardising the remaining ones (Stadtler and Kilger, 2008).

The decision to define a SS of 0 for a product or component should be made in situations where its unavailability does not interfere with the company's operations or when the "stock out" cost is lower than the cost of keeping the respective inventory (Santos et al., 2015).

Schmidt et al. (2012) present several different methods for estimating the safety stock, and the literature available offers additional alternatives. Equation 2.4 is presented, factoring in its applicability in the context.

$$SS = Z_{SL} \times \sqrt{LT \cdot \sigma_D^2 + \sigma_{LT}^2 \times \overline{D}^2} \tag{2.4}$$

Where:

Z_{SL} is the safety factor, related to the service level, predicated on a normally distributed demand.

LT is the average replenishment lead time.

σ_D^2 is the demand standard deviation.

σ_{LT}^2 is the lead time standard deviation.

$\overline{D}$ is the average demand.

It should be remarked on the implausible assumption that daily demand and replenishment lead time follow a normal distribution.

As previously indicated, a production order is initiated when the RL is breached. The batch size (BS) typically depends on the overall machine efficiency, setup time, the number of machines, and the number of references to be produced, among other factors (Fulbright, 1979). The average inventory level ($\overline{S}$) of a reference is directly impacted by BS (Schmidt et al., 2012).

$$\overline{S} = SS + \frac{BS}{2} \tag{2.5}$$

The economic order quantity (EOQ) is a common method of determining the BS since it compares the expenses of placing replenishment orders with the costs of keeping inventory (Christopher, 2016). However, this metric does not account for fluctuating demand, and it is challenging to estimate the necessary inputs (Fulbright, 1979).

The every part every interval (EPEI) approach is an alternative method to the EOQ. It is the period between the production of two consecutive orders of the same product (Sundar et al., 2014). As a result, the EPEI of a reference A with a weekly production rate of 1 is 7 (Figure 2.6).

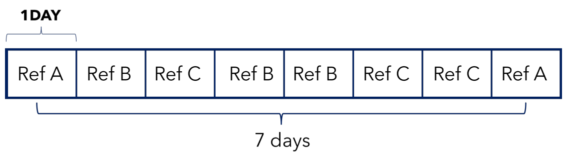

Figure 2.6: Illustrative Example of the EPEI of a Reference A

The batch size can, thus, be calculated using Equation 2.6.

$$BS = \overline{D} \times EPEI \tag{2.6}$$

To ensure that the inventory level is neither high, increasing costs unnecessarily, nor low to satisfy demand, the level of replenishment should differ amongst references depending on their importance. SKU classification aims to categorize products enabling the creation of a framework to determine the inventory policy.

2.5 Value Stream Mapping

The Value Stream Mapping (VSM) was first introduced by Mike Rother And John Shook, in "Learning to See" as a tool that analyses the entire flow of materials and information. It is a key lean instrument since it maps a product's path as it moves through the different stages, intending to add value to the process. Such is possible since this process identifies waste and improvement opportunities. Three main steps are considered to carry out a VSM, namely:

- selection of a product or family of products;
- current state drawing;
- future state drawing;
- implementation plan.

The advantages of doing a VSM is that it works on the big picture since it lists all the value-added and non-value-added actions required to bring a product to life. Additionally, the result is presented in a visual manner. The high number of product types required by customers increases the complexity of the correspondent logistics system. Despite being an instrument with over two decades of existence, it is still useful because it can help better visualize even the most complex systems (Rother and Shook, 2003).

Chapter 3

Analysis of the current situation

This chapter presents the initial state of the company before the beginning of the project. It demonstrates the business's structural organization, the division into factories, and the manufactured products. Additionally, it explains the different processes and sections that alter the product to meet the customer's requirements. Four indicators are analysed to assess the business's condition.

This overview of the original condition seeks to determine which areas should attain greater attention to increase the level of service, which is the focus of this dissertation.

3.1 Client Company

The Client Company was the first business in Portugal to focus solely on producing sanitary items, including furniture, washbasins, toilets and urinals. The firm has 540 employees and divides its operations across three factories (CF1, CF2 and CF3), amounting to a monthly manufacturing capacity of 100.000 pieces. In contrast to CF3, which manufactures furniture and acrylics, CF1 and CF2 create porcelain or stoneware sanitary ware. To meet demand, the space available for production has grown over time, resulting in a layout that is not optimized for the production flow.

The company's current turnover is divided into the domestic, external and group markets (Figure 3.1). A particular aspect is the inclusion of a third market associated with the group, of which the Client Company is a member. More than half of the entire turnover is credited to the group that places orders to meet global clients' demands.

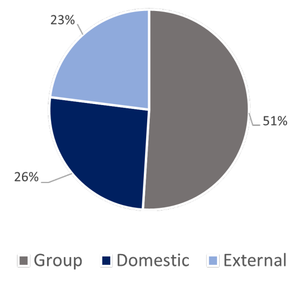

Figure 3.1: Sales distribution in the markets

The Client Company manufactures a wide variety of goods, categorized into eight families: washbasins, toilets, shower trays, tanks, bidets, columns, urinals, and sinks. Available for purchase are 108 collections, which are groups of goods with a similar design.

The diversity of references for the final product results from modifications to a mould, or geometric shape, in several stages. Therefore, one mould can generate several products (Figure 3.2).

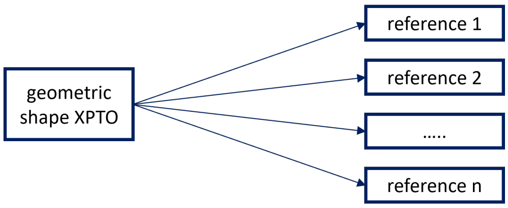

Figure 3.2: Geometric Shape Differentiation

3.2 Production Performance

To map the different flows and readily identify opportunities for improvement, a value stream mapping (VSM) was performed. A more transversal assessment and overview of all the processes and flows that occur to generate a finished product was launched by the conducted VSM. The resultant initial state map is shown in Figure 3.3.

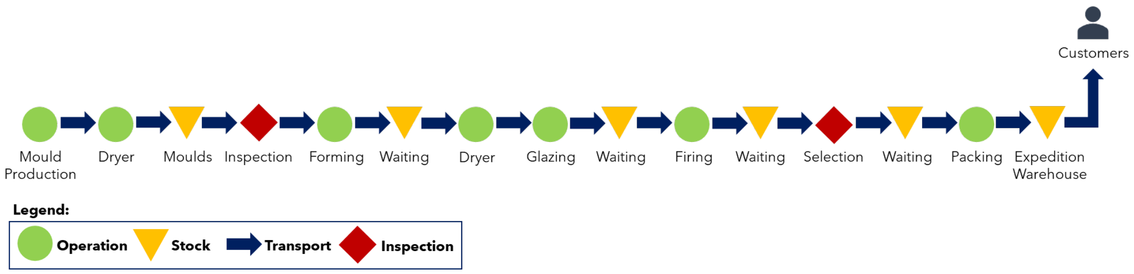

Figure 3.3: Initial State Map

Increasing the service level is commonly associated with improving customer satisfaction. Reducing the lead time, or the period between ordering the materials and delivering the finished product to the customer, can help with the latter. To prioritize the possible courses of action, the manufacturing process was mapped, and the product quality and production planning were analyzed.

3.2.1 Production Process

As presented in Figure 3.3, a component must undergo several phases before assuming its desired final shape. The creation of the plaster moulds occurs in the initial stage. The item is then formed in the pottery and has to be dried in the kiln. Thereafter, it is glazed and baked. Finally, it is inspected, packed, and prepared for shipping to the buyer.

Mould Production

In the mould production section, the necessary moulds are produced. The manufacturing process starts by pouring plaster into the mother mould, which is the piece that will create a portion of the desired cast. The assembled elements are placed in a dryer, where they rest for six to seven days. The mould will not be operated if it is not dry. Doing so compromises its integrity and the safety of the workers. The operator cannot determine whether it has flaws and can be employed in the pottery stage until the specified drying period has passed.

Given the lead time of this process, it is necessary to plan it in an optimized manner, ensuring that the casting benches in the potteries can work at full capacity at all times.

Dryer

Water is added to the ceramic and plaster items to activate their plasticity and cohesiveness. To avoid the development of fissures, the water must be removed from the piece before glazing and from the mould before forming. Therefore, both are placed in a dryer for several days, with periods differing from one case to another.

Forming

In this operation, the manufacturing of the actual product begins. Three distinct types of machinery may be used. There are machines that apply medium and high pressures to the moulds as they are being filled. However, low-pressure casting benches are more commonly utilised.

The sections of the factories set aside for this procedure are partitioned into several "potteries", and each "pottery" is divided into a number of stands. One bench fits one mould, and each stand can hold between 40 and 46 benches (Figure 3.4). Before being put on the stand, each mould is inspected.

Figure 3.4: Moulds in a Production Stand

One mould can be filled one time a day meaning each stand can produce up to 46 pieces per day. Usually, a stand is dedicated to a single geometric form, and the moulds are filled until they reach their life's limit of around 90 casting cycles. Consequently, after the initial set up, it produces the same type of products for 90 days, reducing the flexibility of production.

After the necessary time to set, the unmoulding begins in which an operator removes the piece from inside the mould, with or without the aid of a machine. Subsequently, this person is responsible for working on the item by removing excess material, opening orifices, and improving the surface. Lastly, the batch is sent to a drier where it stays for 10 hours and the operator is left to prepare the moulds for the following filling, restarting this cycle.

Glazing

After reaching the necessary degree of humidity in the dryer, the piece goes on to the glazing unit where it obtains the colour that characterises it. The majority of the components have a white exterior due to a glass coating, though different colours can be added. The setup time required for the colour change is about 30 minutes and involves stopping the line.

Firing

The pieces then go to the oven, where they stay for an average of 18 hours so that it is consolidated as a cohesive body.

Selection

The object is forwarded to sorting once it has taken on its final shape to see if it meets the required quality criteria. Several tests are run to ensure there are no additional defects.

The database records the item as saleable if it satisfies all the prerequisites for acceptance and a label with the appropriate reference is placed on the item. If it does not, it is labeled a reject and destroyed, or it is sent to a facility where it may be fixed, depending on the severity of the flaws.

Packing

In this last section, the product is packed together with all the necessary components and information, such as the instruction booklet, so that the customer can assemble it unaided. The various packages are assembled on a pallet and sent to the expedition warehouse, which serves as the last storage location for the parts before being transported to the final user.

The products' differentiation process takes place gradually throughout the various phases. After the creation of the mould, a geometric shape can create several intermediate forms by applying different types of perforations. During glazing, two types of distinction can occur - the application of different logotypes, from 4 logos available or a different colour. The number of pieces whose colour is not white represents less than 1% of sales. In packaging, the product is differentiated by the placement of various types of packaging.

Each differentiation results in the creation of a distinct code. Since the factories can produce 314 geometric shapes, more than 2000 finished product references can be generated.

3.2.2 Product Quality

The International Organization for Standardization (2015) defines quality as the "degree to which a set of inherent characteristics of an object fulfills requirements" (ISO 9000:2015). The Board determined that the Kaizen project's focus should be ceramic goods since the results achieved and production restrictions distinguished CF3's products from the remaining. As such, an analysis of the quality of the products manufactured in both CF1 and CF2 was carried out. Given its impact on customer satisfaction, the status of the quality indicator was assessed to understand whether to address it in the solution's design.

To be approved, a piece has to successfully pass several tests, such as:

- Visual Test where an operator searches for larger flaws and excess material;
- Sound Test that involves striking the piece with a hammer to evaluate the sound produced;
- Level Checking where it is ensured that the piece is not slanted;
- Methylene blue color test which consists in spraying the fluid on the product, highlighting cracks invisible to the human eye.

The examination performed is a subjective evaluation and it varies accordingly to the experience of the operator, with the exception of the level test, where the intervals of acceptance are defined and vary between the references.

A database with information from May 2020 to April 2022 regarding the total number of processed and rejected pieces was accessed. This implied 5884 observations, where each represents one model in a specific month and year and the respective information regarding production (Figure 3.5).

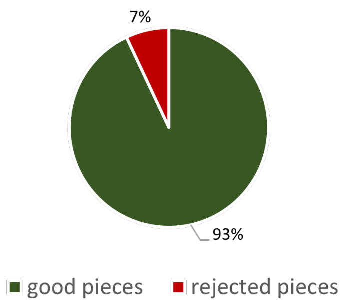

Figure 3.5: Percentage of Approved and Rejected Pieces

It is found that 93% of the parts are approved, and 7% are rejected. The rejected pieces are destroyed representing a loss for the factories of both money, in terms of production costs, and of parts that were expected to reach the final warehouse.

The inspection process described can be improved, particularly in terms of standardisation of criteria, which can vary substantially between operators. However, the volume of rejected pieces is relatively low. Thus, addressing this area is not an action that should be discarded but will not be made a priority. This verdict was corroborated by the directors since they feel this would not be the area where significant results could be obtained. Therefore, it is not further regarded in the present work.

3.3 Production Planning

In the Client Company, the Supply Chain team is responsible for the production planning. SAP is used as an internal software, used by all elements, where the plan is made available. This is an Enterprise Resource Planning (ERP) information system, which combines and integrates information from different areas in a single platform. A particular aspect of this tool is that the information is provided two days late due to a software limitation. For instance, users can obtain information about Monday on Wednesday of the same week.

The SC team uses ABC analysis as a strategic planning tool for product classification. It is the most common and simple method, based on the Pareto rule. However, the classification does not have an established review periodicity. Therefore, it does regard recent sales history and includes discontinued products. Additionally, the firm had not established suitable inventory and production strategies for the diverse references.

Worth noting that, given the rules of the Company's Group and the demand for this type of product, the analysis focuses only on references of finished ceramic products, excluding the remaining materials.

The studies conducted in this dissertation that rely on sales data solely consider the domestic and external markets. An internal rule determines that the group's orders must be responded to following a make-to-order strategy. Additionally, the respective products are stored in external warehouses. Therefore, are not further considered.

To better grasp the company's current information flow, the diagram in Figure 3.6 has been designed.

A customer order listed by the Service staff creates a purchase order in SAP. If there are the requested items in the warehouse's inventory to fill the order, they are allocated and prepared for delivery. If there is not enough in stock, production orders are created. The Planning Team, a division of the SC team, is responsible for checking the current state of the factory, i.e. seeing which models are currently assembled in each stand and if they are nearing the end of their life; what is the expected availability of personnel and raw materials; what moulds are being produced or are in stock. Given the expected capacity, a monthly plan is built. Each production section must match the plan to its resources as closely as feasible to complete it.

Once the plan is complete and available, there is no way to track its fulfillment, and it is not assessed whether an order is delivered on the agreed date between the Salesperson and the customer. In addition, the Production team may have a different prediction than the plan, based on their expected number of operators and overall factory capacity. However, adjustments cannot be performed in advance due to a lack of communication between the two teams. As such, it can't be

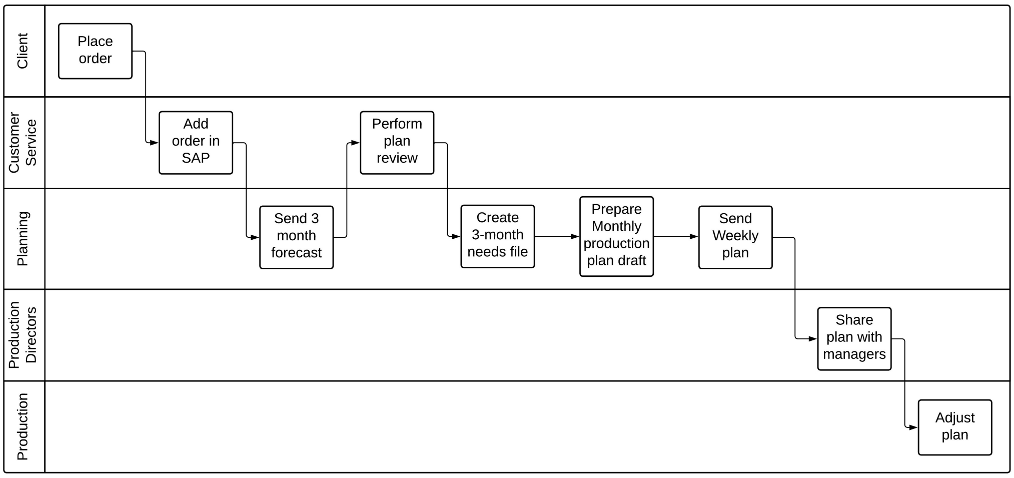

Figure 3.6: Information Flowchart

assessed whether there is overproduction or underproduction of a product or to modify the plan to account for any issues that may cause delays.

The lack of daily visibility of production and work-in-progress (WIP), as well as strategic thinking regarding stock management leads to planning that tries to satisfy the oldest orders or those flagged as urgent at the request of the Group, rather than focusing on customer satisfaction.

The assessment showed that planning is critical to improve the service level. This initiative was prioritized, and four indicators were analyzed to justify the decision made. The indicators — plan compliance, stock level, WIP, and lead time (LT) - will be presented hereafter.

3.3.1 Plan Compliance

The plan compliance represents what the firm has provided in comparison to what it had pledged to deliver at the beginning of each month.

Within a range of 90% and 110% of the quantity of pieces produced in relation to those anticipated, the plan compliance associated with a reference is binary classified as "OK" or "Not OK." Both over and under production negatively affect the indicator, with a 10% tolerance margin. As such, if there is a commitment to producing 1000 pieces of a reference, this is deemed "OK" if between 900 and 1100 pieces are produced. If production is below or above the defined limits, it is registered as "Not OK" and the compliance is negatively impacted.

The overall indicator per month is influenced by all references whose production was planned and whether they were considered "OK" or "Not OK".

As far as the plan compliance is concerned, the data gathered and investigated covers the period between January 2021 and March 2022 (Figure 3.7). The month with the worst result is the first one presented, whereas the best is November 2021. The average compliance is 70%.

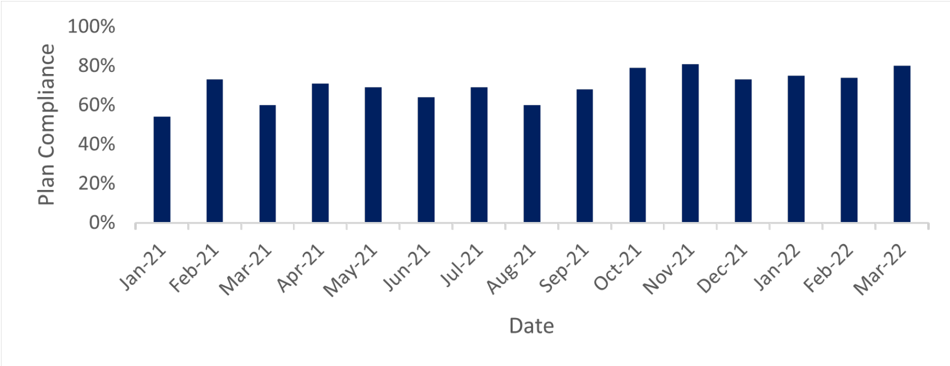

Figure 3.7: Plan Compliance

3.3.2 Stock Level

Nowadays, companies are pressured to reduce their inventories to release the tied-up capital, lowering the holding cost. In light of this and the scope of the study, the stock level ought to be assessed. Companies that decrease their inventory, whether in intermediary or finished goods, see the benefit of increased flexibility and responsiveness to their consumers (Christopher, 2016).

Using data from January to March of 2022, the average stock level can be estimated as 144.845 units. The evidence provided in Table 3.1 refers to the final product inventory in the expedition warehouse.

Table 3.1: Inventory Level

Month/Year	Units in Inventory
January/2022	150.623 units
February/2022	139.823 units
March/2022	144.088 units

The actions defined to improve the service level typically comprise the definition of inventory policies, so this indicator may prove relevant to map the future progress made.

3.3.3 Work-in-Progress

The Work-in-Progress level reflects the pace of transformation of a product. As further noted by Papadopoulos and Vidalis (2001), it dictates the process efficiency and, as a result, the production lead time.

Analysing the WIP allows not only to have a better perception of the functioning of the factories and the material flow but also to evaluate, similarly to the stock level, the amount of capital that is locked up.

SAP information indicates that there is a daily average of 33.533 pieces in WIP in the CF1 and 15.043 pieces in the CF2. In greater detail, the second factory's total can be divided into 5.155, 3.827, and 6.061 pieces in WIP between the units of pottery and glazing, glazing and kiln, and kiln and inspection, respectively (Figure 3.8). Consequently, the daily average totals 48.576 pieces in WIP.

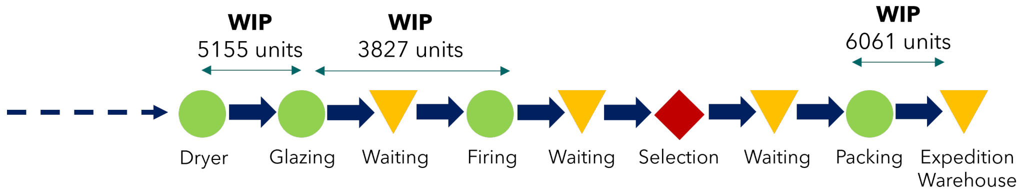

Figure 3.8: Work-in-Progress

Assessing WIP is about contrasting what can be produced with the effective rate of completeness and understanding whether it is a production or a flow level problem.

3.3.4 Lead time

The processing lead time, i.e., the total time the piece is being altered in the different stages can be obtained by resorting to the Little's Law (Medonos et al., 2016). The law, introduced by John Little, is presented in Equation 3.1 (Little, 1961).

$$L = \lambda \times W \tag{3.1}$$

Where:

L is the average number of items in the system, here interpreted as WIP.

λ is the daily average number of items arriving to the system, here as demand.

W is the average time an item is in the system, or, the processing LT.

With an average demand of 79.000 pieces, per month, the result in the CF1 is:

$$W = \frac{33.533 \times 30}{79.000} = 12{,}7 \text{ days} \tag{3.2}$$

As for the CF2, the processing lead time is 11,9 days, considering an average demand of 38.000 products per month.

Worth bearing in mind that both values presented of demand for both factories are the total demand for every type of product and market, and the lead time only considers the period between forming and arrival at the final warehouse.

Since the preceding production LT is measured from the forming stage, it does not consider the mould production. However, this is the longest phase, taking an average of 21 days to produce a mould. Being so, the total time amounts to an average of 33 days.

Despite this, some products are supplied to customers months later than agreed. The average delay for order deliveries is presented in Table 3.2.

Table 3.2: Percentage of Orders delivered in delay in various time frames

Delay Time Frame	Percentage of Orders Delivered
Under 7 days	64,2%
From 8 to 15 days	12,6%
From 16 to 30 days	10,2%
From 31 to 60 days	8,5%
From 61 to 120 days	4,2%
More than 121 days	0,3%

The values presented in Table 3.2 are calculated by dividing the products that fit within each frame by the total number of items sold. The data displayed is an average of the findings from 2021. According to them, 35,8% of orders are delivered more than a week late.

The project will commence with strategic planning due to the time gap between a part's production and delivery (expressed here by the days of delay).

3.4 Service Level

A lack of definition prevents measurement and a lack of measurement prevents improvement. The project's goal of improving service level led to its selection as a key performance indicator (KPI). Relying on fundamental dimensions of project performance, a KPI is a measure of a company's current and future success (Parmenter, 2015).

Once the indicator has been established, it ought to be evaluated. It should be previously set a baseline value to track the benefits of the improvement actions implemented in the future. In an OTIF perspective, the service level was defined regarding orders delivered in full quantity and on time.

$$\text{Service Level} = \frac{\text{Number of Orders delivered in the agreed time}}{\text{Number of Orders planned}} \tag{3.3}$$

Using the available data from January 2021 to March 2022, it was feasible to calculate the monthly service level, resorting to Equation 3.3. The results are shown in Figure 3.9.

As perceived by the Figure 3.9, the values range between 66,2% and 80,9%. The red line indicates that the company administrators view outcomes over 80% as favorable and below as undesirable. As a result, the goal value was only exceeded in July 2021, out of a sample of 15 months.

The service level may be divided by the three markets, in addition to being filtered by month. Resorting to the same database it was possible to establish that the results are dissimilar. The average for each case over the same time period is as follows: 88,4% for the domestic market, 49,1% for the external market, and 81,0% for the Group market. Particularly concerning is the disparity in service quality between the domestic and foreign markets.

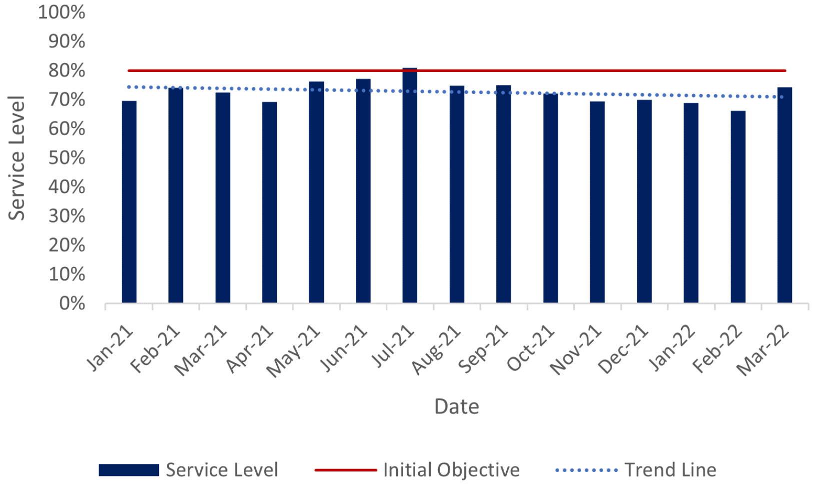

Figure 3.9: Service level distribution from January 2021 to March 2022

There is no consensus on whether to set a higher SL for less or more sold products (Teunter et al., 2010). In any case, rather than defining it for individual references, SKU classification may be used to group them based on common features.

Chapter 4

Methodology

This chapter presents the underlying ideas for addressing the low level of service. The chosen approaches include SKU categorization and the consequent strategic changes to production and inventory.

Firstly, are discussed the methodology's assumptions. Afterward, the available data and the parameters provided by the Client Company are explored. The appropriate criteria are selected, from several options, before proceding to the SKU classification and production strategy setting. Finally, the different inventory policies are described, emphasizing the respective objective and application.

4.1 Data Collection

To outline the solution design regarding the improvement of SL, the consulting team met with two decision-makers with in-depth familiarity with the situation and background of the business. Given the specialists' expertise, their input on the analysis is fundamental.

At their indication, the study will solely focus on ceramic products, despite the wide variety of references produced by the Client Company. Such is attributable to the larger volume of sales related to this material.

Firstly, some assumptions were established for the study, including:

- It is considered that all products have the same lead time. Such is not a rough approximation, given the reality of the production processes;
- Since, as previously mentioned, when a mould is assembled it is usually used until the end of its useful life, in some situations where the order is small, there would be a large build-up of stock. As such, it will be assumed that, when a production order is issued, a mould can be assembled to produce only the necessary units and stored for future needs;
- Given the repercussions of Covid-19, especially at an earlier stage, data from the period before 2021 will not be considered. The bias caused in the conclusions drawn would undermine the future applicability;

- A mould replacement requires zero setup time;
- An additional period of 5 days was included as a reaction lead time to account for the necessity for planning and further tailor the suggested strategy to the realities of the factories;
- Since the quality factor is not regarded in the methodology, the production lead time is the time required to produce a piece that is guaranteed to meet inspection requirements.

In light of the above assumptions, a database including ceramic products' sales data from January 2021 to April 2022 has been made available, with an illustrative example for SKU 57 in Figure A.1 of Appendix A. There are 37.384 observations whose parameters were extracted as displayed in Table 4.1.

Table 4.1: Parameters of the Data regarding Sales

SKU	Denomination	Series	Quantity	Value	Type	Year	Month	Day

Parameters

- SKU corresponds to the finished product reference;
- Denomination is the name of the model associated to the material - one material has one denomination;
- The Series, as explained in Chapter 3, refers to the collection of products to which a item belongs;
- Quantity is the number of products that a given order has;
- The Value relates to the order's total price, which includes all goods, and may be calculated by multiplying the quantity and price of each item;
- The Type refers to the product's material. This variable has been eliminated since it has already been established that the study will be limited to ceramic items;
- Year, Month and Day corresponds to the date in which the order was paid for and finalized.

In order to better work dates, the day, month and year were joined to form a date in the format "dd/mm/yyyy". Thereupon, the information was analysed to search for missing or seemingly incoherent data. Even though there were no blank cells, some designations were distinct when referring to the same SKU. This is due to this field being occasionally manually filled, resulting in minor terminology discrepancies. Seeing that an "SKU" has only one "Denomination", the second parameter was disregarded.

Afterwards, some general information was retrieved using a PivotTable, in Excel. In the period under discussion, 296 references (SKUs) were marketed and products belonging to 10 series were commercialized. It's worth noting that the client's firm has 15 ceramic product series. In addition, they sold items from 8 distinct families, the most popular of which are washbasins and toilets.

4.2 Problem Approach

4.2.1 Criteria Assessment

In the past, the Client Company conducted an ABC analysis, which solely considers the sales volume (volume as in product units). However, the employment of additional criteria may be advantageous since basing the study on one criterion might render it less exact.

Several factors may be taken into consideration for categorizing SKUs based on the accessible literature (Table 4.2).

Table 4.2: Classification Criteria

Quantitative Criteria				Qualitative Criteria
Demand	Cost	Delivery	Caracteristics	General
Volume of Sales	Price	Lead time	Quality	Series
Frequency of Sales	Margin		Volume (m^3)	Family
Sales Variation	Cost		Weight (Kg)	Criticality
Forecast	Stock Cost			

The criteria presented in Table 4.2 are employed in the various classification techniques, such as ABC, HML and ABC-XYZ. To ensure that the final selection of criteria is relevant to the conducted research, it is important to consider both the characteristics of the Client Company and those of the industry. The choice to exclude or include a criterion was made with feedback from the two decision-makers in light of the contextual adjustment.

Quality and lead time were instantly disregarded in light of the foregoing considerations. Frequency and demand forecasting were eliminated, with just sales variation included, to prevent the influence of a phenomenon from being duplicated by adding related factors.

Internal factors like price, cost, and margin will not be included in the research, given that the model emphasizes enhancing consumer satisfaction. Since the cost is calculated considering the weight, the second will be dismissed similarly.

Each part's price accounts for the average stock cost and, consequently, the related volume. There are no feasible means to consider the stock cost by reference since the cost is an average value. Therefore, the cost and volume of the stock will not be taken into account.

The product's series was included seeing that it was noted by the decision-makers that some series are more strategically important in terms of market position, and ought to be given priority. The family was omitted since particular families are more marketable than others, such as toilets, and the disparities between each one are discernible through the sales volume.

The final criterion, criticality, was omitted due to the possible subjectivity of the definition of the various levels and the fact that its most frequent application is related to spare parts.

The three criteria selected after the sorting phase, and the respective definition, are listed hereunder.

- Volume of sales - sales between January 2021 and March 2022;

- Sales Variation - measure of the statistical dispersion of sales;
- Product's Series - the collection that a product belongs to.

4.2.2 Classification

Considering the applicability and similarity with the analysis formerly used, it was decided to first perform an ABC-XYZ analysis. The first two criteria - sales volume and coefficient of variation - are interrelated.

For the ABC analysis, the references are listed according to sales volume in the year under consideration. The percentage of each product in the overall sales value is determined, followed by the computation of the cumulative volume. References are categorized as A if their cumulative value is under 80%. Between 80% and 95% are assigned the B classification, whereas the remaining items belong to the C category.

For XYZ, the Equation 2.2, described in Chapter 2, was used to compute the CV for each reference, considering sales frequency. The proportion each reference contributed to the overall CV value was determined, after the references were listed in descending order of CV. The cumulative value and the Pareto rule were used to separate the three categories into Z, defined as references representing 80% of the CV, Y for 15%, and X for the remaining 5%. An iterative procedure of applying hypotheses resulted in the selection of these thresholds, based on the Pareto principle.

The matrix in Figure 4.1 is the outcome of the ABC and XYZ studies combined.

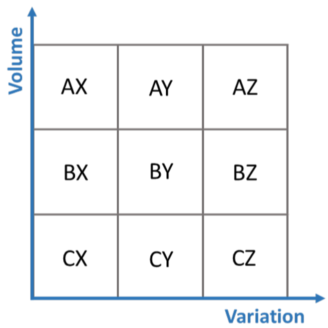

Figure 4.1: ABC-XYZ Matrix

As an illustration, a reference λ will be categorized as AZ if its annual sales are high, falling within the representative 80% of the entire volume, and take place, at the dispersion level, essentially arbitrarily.

The approach discussed overlooks the concept of "series" in favor of two criteria. It was jointly established that the series should be included to enhance the definition of the replenishment and safety stock levels, preserving the defined strategy based on the sales volume and variability. Each series was given a priority rank by the two decision-makers, ranging from 1 to 3, with 1 being the lowest importance and 3 the highest.

As perceived in Table 4.3, a series' sales volume, i.e., number of units sold does not necessarily indicate how significant it is. The administrators recognize that strategic choices on market entry or margin advantages are to be considered, as well.

Table 4.3: Series Information between January 2021 and March 2022

Series	Priority	Number of Units Sold	Number of References
BY	2	67.429	16
Cr	3	17.986	9
Special	3	122.577	89
Gl	3	74.864	22
Gr	2	48.139	9
Mun	1	83.936	74
Nx	1	62.197	49
PP	2	38.704	9
PPA	2	39.044	10
Rg	1	49.927	9

The team involved and the administrators discussed the rating displayed in the Table 4.3 to make sure it was accurately expressing the significance of each, cohesively. As a result, the series Cr, Special, and Gl are highlighted as the most important to the corporation currently. It should be noted that this categorization may need to be updated in the future to account for alterations in the market, clients, or even the industry.

Figure 4.2 displays the model that was developed by the two teams, emphasizing the criteria and their different levels.

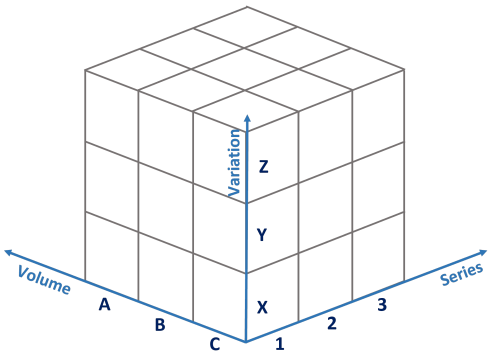

Figure 4.2: Three-criteria method

4.2.3 Production Strategies

It is necessary to link specific product attributes to each production strategy to be able to categorize it. The strategies were established, as shown in Table 4.4, in light of the fact that a hybrid strategy enables a better adjustment to the features of the supplied items, as was claimed previously.

Table 4.4: Criteria for each Production Strategy

MTS	**MTO**
High Volume of Sales	Low Volume of Sales
Low Variability	High Variability

In Chapter 3, the production lead time is shown to be around 33 days. The overall duration rises to 38 days after accounting for the reaction lead time. Consequently, the option for a mould inventory - MTS (MMTS) - was created, in addition to MTO and MTS.

The inventories of moulds and finished products seek to improve the production flow and guarantee a faster response to customer demand. Their use bears greater planning complexity and associated costs regarding items and storage. Nevertheless, it is necessary to evaluate the trade-off between advantages and disadvantages in the context. The creation of inventory based on historical and strategic grounds may result in cost reduction and further benefits as intended. The specific creation of the MMTS option seeks to reduce waiting time without burdening the expedition warehouse, in the light of the available space in the moulds section.

The scheme in Figure 4.3 was constructed, assigning a production strategy to each categorization, by taking into account Table 4.4 and the input from the decision-makers.

AX **MTS**	AY **MTS**	AZ **MTO**
BX **MTS**	BY **MMTS**	BZ **MTO**
CX **MTS**	CY **MMTS**	CZ **MTO**

Figure 4.3: Production Strategy for each Category of the ABC-XYZ Matrix

It is apprehensible from the strategies associated with each category that, for instance, an AX reference will be automatically assigned to an order, granted that the safety stock is not reached, a BZ product will be produced, from the creation of the mould to the final stage, after the company receives a customer order, employing an average of 38 days, and a CY will be produced in 17 days if the mould stock is responsive to the needs.

Due to their low variability, X-classified items are less likely to remain in stock for a long time, increasing costs and becoming obsolete. Based on this and the production lead time, it seems appropriate to implement an MTS strategy for these products, keeping them in stock in quantities following demand and their ABC classification.

Regardless of the disparity in quantity, the variability of Z products is high. Producing them to keep in inventory would imply assuming the risk of holding them there for long periods. Therefore, they have been associated with the MTO strategy and will be produced on demand.

Concerns arise regarding the quadrants in the second column, which are intermediate in terms of variability. The MMTS strategy was established to mitigate these "grey" areas where adopting any of the two other options would lead to negative results, either at cost or service level. However, the lead time of MMTS is around 17 days. Given the frequency of demand empirically estimated by the decision-makers, the number of moulds is unable to meet the demand for high quantities with the anticipated quickness. As such, was defined an MTS strategy for the AY classification, with the highest sales volume among the three Y categories.

The applicability of push and pull production systems was considered to determine which should be employed in the factories. A pull MTS strategy was chosen regarding MTS and MMTS. Consequently, there is stock, but its creation is triggered by actual sales rather than forecasts that "pull" material to the different stages.

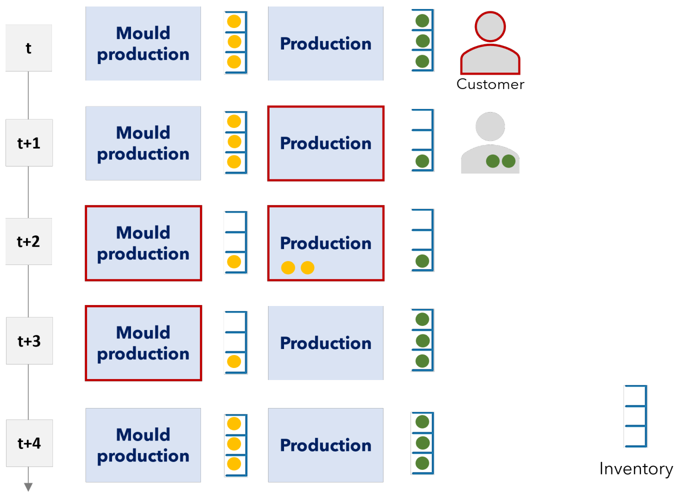

Figure 4.4: Make-to-Stock with Pull Replenishment

Figure 4.4 is an illustrative example of the chosen strategy. In the presented scheme, the products and mould production began (highlighted in red) since it was supposed the predetermined replenishment level for both had been reached.

4.2.4 Inventory Policies

The next step is to identify products that require additional attention and in-depth study. As a result, it was established that references with an MTS and MMTS strategies will undergo a separate analysis.

There is the possibility of outliers skewing the results, such as the hypothetical case of an AX reference that has a stable and considerable daily demand. However, the set inventory levels could increase if one order is significantly distinct from the others.

The Interquartile Range (IQR) study aims at assessing the range of variability where the majority of the data points reside by measuring the spread of half of the data. A value is regarded as an outlier if it is below the lower boundary (LB) or above the upper boundary (UB). These thresholds are defined to be similar to the Gaussian Distribution, where an outlier is regarded if it lies beyond the range $\mu \pm 3\sigma$, as seen in Figure 4.5.

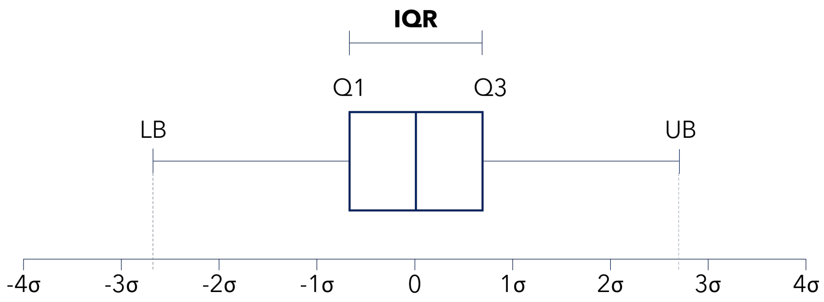

Figure 4.5: Representation of the Interquartile Range Method - Adapted from Vinutha et al. (2018)

Considering the impact of maintaining or removing outliers, results for possibly skewed distributions are more accurate when using the IQR (Vinutha et al., 2018). The outliers were identified, as presented in Figure 4.5.

To conduct this study, 6 parameters must be estimated. Firstly, the median is calculated to obtain the first (Q1) and third (Q3) quartiles. These two values are necessary to obtain the following parameters.

$$IQR = Q3 - Q1 \tag{4.1}$$

$$LB = Q1 - 1,5 \times IQR \tag{4.2}$$

$$UB = Q3 + 1,5 \times IQR \tag{4.3}$$

Values above UB or below LB are considered outliers. The average sales of the corresponding reference were used to replace sales that were an outlier. The following steps will be performed with data free of outliers.

The approach defined by the decision-makers is that all incoming orders of a given product that exceed the respective UB will be treated as MTO so as not to disrupt the inventory and the response capacity to the other customers. The customer should be informed that the order will require at least the entire production LT, from the production of the moulds to the packing of the items, even if there is stock to fulfill the order.

After having the strategies determined and the outliers considered, the following stage is to define the level of replenishment and safety stock. MTO references will be omitted from this phase since their manufacturing solely commences after a customer order is received. Given the dissertation's development time, it is not feasible to determine the real benefits of the implemented solutions. To identify the effectiveness of the inventory policy, the first three months of 2022 were used to evaluate the tool's impact, providing an accurate foundation for comparison.

A relevant service level to the situation must be considered to compute the safety stock (Equation 4.4) for each MTS strategy reference. To address the cost and service level trade-off, two scenarios were explored - one more conservative and the other with higher risk implied. In the first one, the priority 1 series was attributed an 80% service level, based on the initial service level baseline. For series with a priority of 2, it was determined to enhance the level assumed in the calculation, hence increasing the inventory quantity. After deliberation, it consented that the estimate would be 85%, and the priority 3 would be 90%. In the second scenario, each service level was increased by 5%, thus setting 85% for priority 1, 90% for 2, and 95% for series of priority 2.

This information is used to compute the Z, which is the inverse of the normal cumulative distribution. Because statistics demonstrate that demand typically does not follow any precise distribution, the normal distribution will be used, as it can be observed in industrial environments (Schmidt et al., 2012).

The lead time considered for the MTS will be 38 days. As the LT is assumed to be constant, the standard deviation (σ) was considered 0. The demand's standard deviation will be calculated for each reference, considering the historic sales.

$$SS = Z_{SL} \times \sqrt{LT \cdot \sigma_D^2} \tag{4.4}$$

The RL (Equation 2.3) is the addition of the safety stock with the multiplication between the average consumption and the respective lead time. The average consumption was calculated by dividing the total sales by the total number of days.

A production order is triggered when the inventory level of a reference falls below the RL, and the batch size (BS) is determined using Equation 2.6.

The EPEI linked to each reference is set by the Client Company in SAP, and operational limitations and restrictions are factored in. As a result, the software will automatically generate and alter these estimates over time to account for demand changes.

Equation 2.5 is used to determine the average inventory level ($\overline{S}$) of a given reference.

The MMTS strategy could use a similar methodology, but the outcome would refer to finished product references rather than moulds. Given that each mould produces 90 pieces, there are two conceivable outcomes: either manufacturing too many moulds or increasing the lead time by producing the necessary moulds considering the number of parts they can generate. Furthermore, the daily average reference consumption that the mould will produce was accounted for by the mould stock (Equation 4.5).

$$MS = Z_{SL} \times \sigma_D + \overline{D} \tag{4.5}$$

The MS refers to the mould stock for a given reference, and the acquired results were rounded up to the closest unit. The average demand ($\overline{D}$) equals the necessary forms in a steady-state environment. The additional components contemplate the service level and the standard deviation to absorb inherent market variability.

The number of moulds is then determined, but it is still unclear when to place the production order for the replenishment. Since a mould is operational for 90 days, an order will be issued after 64 fillings (Figure 4.6). This is a conservative decision in a scenario where the piece is used consecutively in the following 26 days, which is the production lead time considering the reaction time. Orders will be placed through a tool developed in this section that allows the mapping of the mould inventory at any time in collaboration with SAP data that track the in and outflows. The quantity to be produced corresponds to the number of forms to replace.

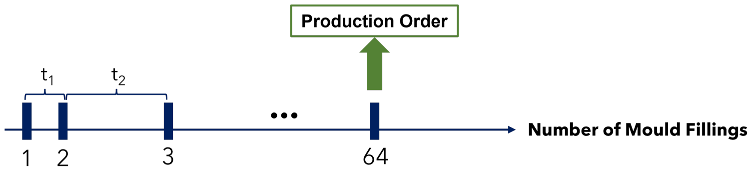

Figure 4.6: Mould Order Point

A product needs 17 days to be ready for delivery after a mould is created, which includes 12 days for production and 5 days for reaction time.

In brief, the methodology mentioned was developed to enhance the Client Company's level of service. Following the methodology, the 296 references are divided into 9 categories based on the sales volume and demand variability. Their differences allow for differentiation into 3 production strategies. The next phase for the MTS and MMTS strategies is to specify inventory policies, resulting in levels of replenishment and safety stock, which are influenced by a third criterion connected to the importance of the product's series.

Chapter 5

Results

This chapter aims to present the results of the application of the described methodology to improve the Client Company's strategic planning, beginning with the classification of SKUs through the ABC-XYZ analysis, progressing to the definition of production strategies, and concluding with the definition of replenishment and safety stock levels for the references.

The approach outlined is summarized in the final section, where the impact on the company's capital, both in units and monetary value, can be perceived.

5.1 Classification and Strategy Setting

The ABC analysis performed yields the findings depicted in Figure 5.1.

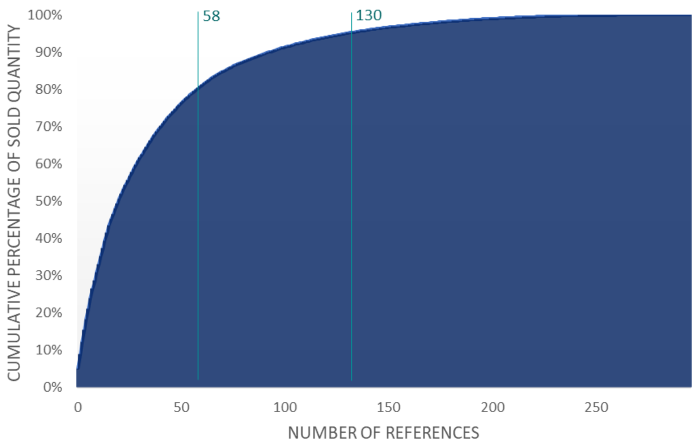

Figure 5.1: ABC Analysis

Of the total 296 finished product references studied, 58 represent around 80% of the sales in number and around 20% of the total number of references, being categorized as A; 72 make up for 15% of the total sales and, therefore, defined as B; and the remaining 166 as C, for 5% of the total quantity sold.

Regarding the XYZ analysis, Figure 5.2 pictures a chart illustrating the coefficient of variation that the references add to the overall value by resorting to the cumulative percentage. The analysis translated into 83 X, 98 Y, and 115 Z references. Regarding consumption frequency, it may be inferred that X pieces are consumed every 4 days or more frequently. Y pieces are sold up to every 19 days, while the remaining are Z.

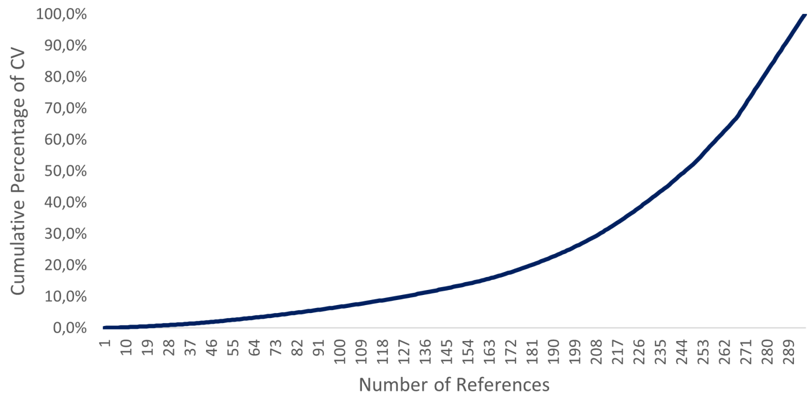

Figure 5.2: XYZ Analysis

The ABC-XYZ matrix shown in Table 5.1 is the result of the combination of the two analyses formerly mentioned. Switching from a one-criteria to a two-criteria classification method allows the creation of 9 different categories instead of 3, allowing the consequent policies to be adjusted more adequately and robustly. The number of references linked to each combination is indicated in each highlighted quadrant.

Table 5.1: Number of References per Classification of the ABC-XYZ Analysis

	X	Y	Z	Total
A	48	9	1	58
B	30	28	14	72
C	5	61	100	166
Total	83	98	115	296

The four extreme quadrants of the analysis translate into:

- 48 AX references with high sales volume and low variability;
- 1 AZ reference with high volume and high variability;
- 5 CX references with low volume and low variability;
- 100 CZ references with low volume and high variability.

The decision to choose this classification is supported by the quadrants' simple interpretation and their applicability in a practical context. The results are shown in greater detail in Figure A.2 of Appendix A.

This dissertation focuses on SKU classification from the standpoint of production and operations management, particularly production strategies and inventory management as a decision-support tool. The 296 references were divided accordingly to the three defined strategies - MTS, MMTS, and MTO (Table 5.2).

Table 5.2: Production Strategies with ABC-XYZ analysis

Production Strategy	Classifications	Total Number
MTO	AZ; BZ; CZ	115
MTS	AX; AY; BX; CX	92
MMTS	BY; CY	89

There are 115 products sold in less quantity or frequency associated with the MTO strategy, as it does not justifiable for them to condition the inventory level. Linked with the MTS strategy, since the risk of being left with tied-up capital or obsolescence is lower, there are 92 items sold more and more frequently. The remaining are associated with the new intermediate strategy created.

5.2 Inventory Policies

The Client Company had not set inventory policies and only produced in response to backlog, more urgent orders, and the availability of moulds and stands. Due to production restrictions, several items that were infrequently purchased were overproduced, increasing the amount of inventory in the expedition warehouse. Using the ABC/XYZ matrix connected to a production strategy, inventory levels can be dynamically controlled based on the product category.

5.2.1 Outlier Detection

To ensure that the data utilized in the subsequent calculations would be reliable, the process of outlier detection was first initiated. With the employment of the Interquartile Range method, 1.546 outliers were found in a total of 604.803 units sold in 20.883 separate orders (Figure B.3 of Appendix B). The MTS and MMTS products total 417.738 sold units, scattered in 20.327 distinct orders. Of the 20.327 observations, 1.504 were flagged by the IQR method, which represents circa 7,40% of outliers. The estimate obtained does not seem to be inconsistent with the context of ceramic product sales.

The Figure 5.3 is an illustrative example of a boxplot representing the sales dispersion of one of the references that featured outliers. The difference between references with multiple and without outliers is evident in Figures B.1 and B.2 of Appendix B.

The figure reveals the existence of values significantly dissimilar from the majority. If these values remained in the model, they would bias the values calculated below. Table 5.3 depicts the required parameters to perform the IQR method, measured for Reference 2 shown in Figure 5.3, including First Quartile (Q1), Median (M), Third Quartile (Q3), Interquartile Range (IQR), Upper Boundary, and Lower Boundary.

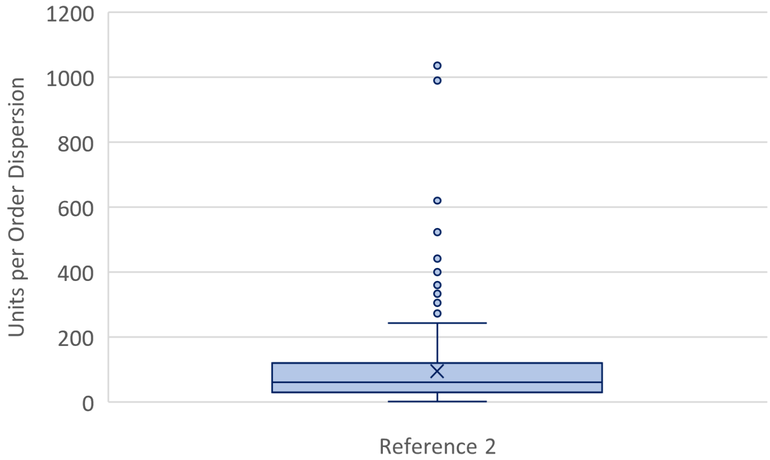

Figure 5.3: Bloxplot of the Sales Dispersion of Reference 2

Table 5.3: Interquartile Range Method Parameters for Reference 2

Reference	Q1	M	Q3	IQR	UB	LB
2	30	60	119	89	251	-103

LB was disregarded since a sale cannot represent a negative value. Considering the UB of Reference 2, orders over 251 units should be fulfilled as an MTO case rather than based on the inventory that is available at the moment. Requests for fewer units than the UB will be fulfilled via the established method, in this case, MTS. As a result, the inventory will be assessed, and the products will be directly allocated to the client, granting an immediate response.

Afterwards, the safety stock and replenishment levels were determined for MTS references to evaluate the effect of eliminating the outliers on the inventory. For that purpose, a service level of 80% was set, which equals the Company's initial goal. Therefore, all parameters are identical for both scenarios, except for the one being assessed. The situations before and after outlier removal are compared in Table 5.4.

Table 5.4: Comparison of the Units of the Inventory Policies before and after Outlier Removal

Scenario	Safety Stock	Replenishment Level
With Outliers	19.975 units	81.646 units
Without Outliers	10.917 units	59.169 units

A difference of 9.058 units is found when comparing the two distinct safety stock totals, and 22.477 units for the replenishment levels. The discrepancy between the two values demonstrates the need to address outliers to ensure that the established stock levels accurately represent reality. Such is further supported by the drawbacks of having high stock levels, including the underlying costs, which can have a negative influence on the company's profit.

5.2.2 Inventory Levels for the Initial and Future Situation

Thereupon, the inventory records were studied to determine the references the Client Company had available in the expedition warehouse at the start of the project. The average stock values were determined by assessing the first quarter of 2022. It is found that 84 previously stocked goods are now integrated into the MTO plan. The sum of the daily stock average of the references equals 15.902 units. The warehouses report units from solely 245 references of the studied 296 in addition to holding inventory from 84 MTO references. These differences prove that the company was neither following a suitable strategic policy nor creating an inventory of required items. The 84 stock items now defined as MTO prove that the approach set out in this dissertation is in significant contrast to the company's initial situation.

It was found that 9 previously MTO and 80 MTS references are now classified as BY or CY, following the MMTS strategy. Since this intermediate technique is new to the company and distinct from the approaches typically suggested in the literature, a comparative analysis is required to comprehend the changes it will carry.

Concerning the previously MTO products, in the first three months of 2022, 68 requests were closed, corresponding to a total of 1.177 units. Had the defined methodology been implemented, there could already be moulds in the inventory, following the average sales of the previous year, a conjecture that will be verified in the stabilized stage of the methodology's operationalization. Of the 68 orders, 7 contain more units than the number of moulds specified for the particular reference. As reflected in a 17-day response time for 61 cases, 18 days for 4, 19 days for 2, and 21 days for 1 reference. In the initial situation, these requests were satisfied in at least 38 days. As a result, the delivery period for goods with limited demand can be shortened.

As for the 80 former MTS products, the number of units in inventory at the beginning of January 2022 would be able to respond to three months' demand, and there would be between 0 and 680 units in the expedition warehouse in 42 particular cases. It can be inferred that, in some cases, there may be overproduction, namely in the situations closest to the upper limit of the final inventory level. For reference 92, despite the average daily demand being 26 units, 980 units are in stock at the start of the year. The inventory comprised 680 of these pieces at the end of March 2022. The above remarks demonstrate that changing strategies in this case and similar situations can be advantageous because it lowers stock levels without compromising service levels. The adjustment in production strategy results in a delivery time between 17 and 20 days for the 42 references. Despite this increase, the final inventory decreases by 9.451 units resulting from this adjustment in production strategy. These references do not have such a significant impact on the SL as if they were MTS, considering their demand. This trade-off between SL and inventory level reinforces the decision to readjust the strategy of these intermediate quadrants.

The remaining 38 formerly MTS references suffered stock-out, meaning that they did not have enough units available to satisfy all of the orders from customers. There were 7.266 goods in shortage, ranging from 2 to 1.587 units for each reference. The Company needed at least 38 days to restock these units after stock-out, whereas with mould inventory it could do so in 17 to 22 days.

5.2.3 Scenario Comparison

The 2 MTS related scenarios created that differ in service level are compared to the initial state in Table 5.5 and the findings are displayed in greater depth in Figure B.4 of Appendix B. It should be reminded that the SL changes depending on the priority of the product series. The value of the capital considers the cost of the references, and it is calculated by multiplying the average weight by the average cost per kilogram and by the number of units. The cost is 1,9 €/kg, and the average weight is 19,89 kg.

The stock in the baseline scenario is the average of three months' records for 245 references of the existing 296. The values for the conservative and higher risk scenarios were obtained by calculating the average stock level (Equation 2.5).

Table 5.5: Comparison of the different Scenarios in the MTS strategy

	Baseline	Conservative Scenario	Higher Risk Scenario
Service Level	73%	85%-95%	80%-90%
Total SS Units	-	17.599	14.028
Total RL Units	-	65.850	62.279
Average Units in Stock	76.406	53.169	49.598
Capital in inventory	2.887.459,1 €	2.009.308,1 €	1.874.365,1 €

Additionally, Table 5.5 presents the total replenishment and safety stock values for each scenario. From the lowest to the highest MTS reference in the model hierarchy, the SS for each product ranges between 6 and 1.150 units, and the RL between 33 and 2.963 units.

The economic benefit of the conservative scenario compared to the baseline is 878.151,0 € and the higher risk is 1.013.093,8 €. Choosing the more conservative scenario, implies having an additional 134.942,8 € in inventory when compared to the higher risk one. Aside from the financial advantages of having less inventory at the level of capital assets, there are others like preventing obsolescence and needing less storage space. Based on the trade-off between SL and related costs and the fact that the Company's low service level was the project's driving factor, the team decided to pursue the conservative and most cautious course of action.

Reference 2, so far used as an illustrative example, is from the priority 1 Mun series. As a result, in the first scenario, the related level of service is 85%, while in the second it is 80%. Table 5.6 provides a comparison of the various situations regarding average units in stock, SS, and RL. Since this reference was already in stock in the first months of 2022, the initial situation's average stock can be compared too.

The Table 5.6 depicts higher numbers for both scenarios created when compared to the baseline proving that a possible consequence of the policy discussed is the increase of the average inventory level. As expected, both levels are higher for the conservative scenario than for the higher risk alternative.

Table 5.6: Inventory Policies for Reference 2

	Baseline	Conservative Scenario	Higher Risk Scenario
Average Units in Stock	1.368	2.873	2.806
Safety Stock	-	357	290
Replenishment Level	-	2.482	2.415

The values presented thus far are based on the expedition warehouse. To evaluate the gain concerning the established inventory policies, the monetary implication of creating a mould stock (MS) must be considered. The values associated with the two scenarios are contrasted in Table 5.7 and in greater detail in Figure B.5 of Appendix B. So, the average cost of one mould was set as 11,34 €. The policies are not divided in SS and RL as formerly because, as was indicated in the previous chapter, a mould is viewed as a tool, so its production is driven according to its usage.

Table 5.7: Comparison of the different Scenarios for service level in the MMTS strategy

	Baseline	Conservative Scenario	Higher Risk Scenario
Service Level	-	85%-95%	80%-90%
Mould Units in Stock	-	2.643	2.302
Capital in inventory	-	29.964,1 €	26.093,3 €

The two scenarios differ in 341 moulds, which represent 3.870,9 €. The administrators decided to select the situation with the higher SL after weighing the differences between the two possibilities and the available space in the mould section.

To provide an illustrative example, in similarity to Reference 2 covered thus far, Reference 90 is discussed, belonging to the same priority 1 Mun series but of AY classification with an MMTS strategy. The average daily sales figure is 39 units, and the standard deviation is 19 units. As mentioned in Chapter 4, the required stock of moulds is the average value of 39 added to the standard deviation of 19 multiplied by Z, a parameter related to the SL. For the established level of 85%, there will be 58 items in mould stock. The parts' replacement will be prompted after 64 fills.

5.2.4 Approach Overview

A solution where a greater level of service, between 85% and 95%, is desired was chosen for both strategies. It was agreed to begin with these SLs to create realistic goals, but the literature encourages the construction of higher levels, so these may increase in the future. Table 5.8 provides a summary of the data of the inventory policies' decisions regarding both MTS and MMTS.

The balance and scenario comparisons based on the inventory consider the capital value. However, the impact of the holding cost, i.e., keeping an item in the warehouse for a longer or shorter period is not evaluated due to a lack of data.

Table 5.8: Summary of the Chosen Scenario's Metrics

MTS	SS	17.599
	RL	65.850
	Capital	2.009.308,1 €
MMTS	MS	2.643
	Capital	29.964,1 €
Total Capital		2.039.272,1 €

Given the backlog or the delayed orders that the company has, the service level will not immediately grow to its optimum potential. Production and Planning will follow the established methodology while also attempting to clear all backlogs accumulated. As a result, the KPI SL will improve gradually, although it is anticipated production of both factories will clear the backlog by the end of 2022 by working supplementary hours.

Production planning benefits the defined approach, amplifying its advantages. Factories warehouses employ a FIFO (first in, first out) policy where products produced first are used or sold first. The FIFO policy will benefit stock management, benefits tracking, and parts' deterioration avoidance, namely moulds.

The role played by the Sales team in the context discussed is to work with the customer to agree on a delivery time that is coherent with the production schedule and the responsiveness to needs providing the three set lead times. The only way to raise the level of service will be through this collaborative effort.

Chapter 6

Conclusion

6.1 Final Considerations

Given the Client Company's challenges in the ceramics sector regarding service level, a project was launched to enhance strategic planning.

The SKU classification enabled reference grouping with similar characteristics, facilitating the assignment of an appropriate strategy. In contrast with the previous one-criterion ABC analysis, the adoption of the ABC-XYZ analysis combined the sales volume with the variability criterion based on the coefficient of variation, resulting in more reliable results. A third criterion was added to reflect the importance of the product series, based on the strategic remarks of the administrators.

Previously, regarding production strategies, the Client Company had two alternatives - MTO, production to order, and MTS, production to stock. To adopt a more personalised approach for the Client's needs, a third strategy (MMTS) was created, consisting in the production of moulds for stock. Each category was assigned a strategy.

Before proceeding to inventory policies, an analysis was conducted to assess the existence and impact of outliers. When comparing the data with and without outliers, it is perceived a difference of 9.058 units for the two distinct safety stock totals, and 22.477 units for the replenishment levels. The disparity in values demonstrates the importance of conducting preliminary data analysis to ensure consequent policies are adjusted to demand.

Of the 296 references analysed, it was perceived that 84 MTO references were previously in inventory, which translates into a reduction of 15.902 units in average daily stock, i.e., 600.952,5 € in capital. Additionally, 89 references were classified as MMTS. For those previously MTO, this translates into a decrease in response time, insuring a better customer service. As for MTS, the decrease in units in inventory is 9.451, that is, 357.162,7 €.

The contrast between the initial situation and solution proves that the creation of the MMTS strategy is fundamental to better manage the trade-off between SL and associated costs.

To establish the replenishment and safety stock levels, two scenarios were created, a more conservative with higher level of service and a higher risk one with lower level of service. The first scenario resulted in a 30% reduction in the inventory capital, and the second in a 35% reduction.

The defined solution selects the conservative scenario and entails establishing a service level between 85% and 95%, depending on the priority of the series in question. The average inventory level in the expedition warehouse would be 53.169 units, with 2.653 units in the moulds warehouse. This equates to a total reduction of 848.187 € in inventory capital. The classification of each reference, as well as the strategies associated with it, should be reviewed annually.

In today's volatile world, trends constantly shift consumers' product perceptions so stock management becomes even more critical. Despite the higher service level and shorter lead time for delivery in some cases, the company will have lower costs, a higher cash flow and reduced risks, demonstrating that the solution design met and surpassed the Client Company's objectives.

The main benefit of the dissertation's approach is centered on the allocation of resources in currently sold products and the withdrawal of those that are not in sufficient demand, ensuring not only lower costs but also a higher level of service. Better managing the organisation's limited resources ultimately leads to enhanced customer satisfaction.

6.2 Limitations and Future Perspectives

The proposed methodology's limitations are the setup time being considered null and the quality factor being neglected. Changing moulds of a stand is a time-consuming process and involves human labour, and despite being a controlled indicator, to guarantee 10 good pieces, it is necessary to produce about 11.

Support with initiatives at lower levels is required to sustain the strategic actions defined. Hence, future stages involve process and organizational culture enhancements, described hereafter.

At the time strategic planning initiative was launched, it was acknowledged that efforts were required to enhance visibility and communication between the Planning and Production Teams. By ensuring that the plan reflects the productive capacity of the factory and that production can respond to the needs created, is it possible to guarantee compliance with the defined lead times and thus meet the established service level. For this purpose, a parallel effort was undertaken, resulting in a file where Planning displays in real-time what must be manufactured and Production displays what it is produced, each day. As indicated in Chapter 3, SAP has the limitation of having a two-day delay when updating information, so the file enables the monitoring and flagging of potential delays at any moment. Therefore, the Sales team can alter the delivery agreements in conformity.

The dimensioning of the warehouses is the project's following proposal. Once the strategy is established, the natural next step is to ensure that the necessary elements are in place on the factory floor for it to be properly implemented. Therefore, warehouse dimensions will be redefined as well as their layout, the placement of each reference, and the method of tracking it. A tool will be implemented to guarantee the constant update of inventory values.

The assumption of a null setup time does not reflect reality so a process will begin to minimize the time needed to change moulds in stands, bringing reality closer to the present solution.

In a more distant future, where the issues presented above have already been addressed, the quality of the parts may be improved, focusing on process control rather than inspection.

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Appendix A

Classification of SKUs

SKU	Denomination	Series	Quantity	Value	Type	Year	Month	Day
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2022	JAN	6
57	L\POUSAR PO	Nx	2	€ 59,3	Ceramics	2022	JAN	10
57	L\POUSAR PO	Nx	32	€ 474,6	Ceramics	2022	JAN	11
57	L\POUSAR PO	Nx	160	€ 2 372,8	Ceramics	2022	JAN	14
57	L\POUSAR PO	Nx	64	€ 949,1	Ceramics	2022	JAN	18
57	L\POUSAR PO	Nx	33	€ 507,1	Ceramics	2022	JAN	21
57	L\POUSAR PO	Nx	9	€ 266,9	Ceramics	2022	FEV	8
57	L\POUSAR PO	Nx	68	€ 1 067,7	Ceramics	2022	FEV	11
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2022	FEV	14
57	L\POUSAR PO	Nx	4	€ 118,6	Ceramics	2022	FEV	17
57	L\POUSAR PO	Nx	2	€ 59,3	Ceramics	2022	FEV	18
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2022	FEV	23
57	L\POUSAR PO	Nx	2	€ 59,3	Ceramics	2022	MAR	16
57	L\POUSAR PO	Nx	3	€ 89,0	Ceramics	2022	MAR	24
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2022	MAR	25
57	L\POUSAR PO	Nx	18	€ 533,7	Ceramics	2022	ABR	4
57	L\POUSAR PO	Nx	128	€ 1 898,2	Ceramics	2022	ABR	5
57	L\POUSAR PO	Nx	3	€ 89,0	Ceramics	2022	ABR	6
57	L\POUSAR PO	Nx	192	€ 2 847,4	Ceramics	2022	ABR	8
57	L\POUSAR PO	Nx	26	€ 770,9	Ceramics	2022	ABR	11
57	L\POUSAR PO	Nx	47	€ 1 393,6	Ceramics	2022	ABR	20
57	L\POUSAR PO	Nx	9	€ 266,9	Ceramics	2022	ABR	27
57	L\POUSAR PO	Nx	2	€ 59,3	Ceramics	2022	ABR	29
57	L\POUSAR PO	Nx	3	€ 113,9	Ceramics	2021	JAN	8
57	L\POUSAR PO	Nx	4	€ 56,9	Ceramics	2021	JAN	12
57	L\POUSAR PO	Nx	2	€ 56,9	Ceramics	2021	JAN	18
57	L\POUSAR PO	Nx	2	€ 28,5	Ceramics	2021	JAN	19
57	L\POUSAR PO	Nx	1	€ 31,2	Ceramics	2021	JAN	19
57	L\POUSAR PO	Nx	1	€ 85,4	Ceramics	2021	JAN	26
57	TOP POP ART 5	Nx	3	€ 43,9	Ceramics	2021	JAN	26
57	L\POUSAR PO	Nx	2	€ 113,9	Ceramics	2021	JAN	27
57	L\POUSAR PO	Nx	4	€ 56,9	Ceramics	2021	JAN	28
57	L\POUSAR PO	Nx	2	€ 28,5	Ceramics	2021	JAN	29
57	L\POUSAR PO	Nx	1	€ 142,3	Ceramics	2021	JAN	29
57	L\POUSAR PO	Nx	5	€ 113,9	Ceramics	2021	FEV	5
57	L\POUSAR PO	Nx	4	€ 28,5	Ceramics	2021	FEV	8
57	L\POUSAR PO	Nx	1	€ 28,5	Ceramics	2021	FEV	10
57	L\POUSAR PO	Nx	1	€ 28,5	Ceramics	2021	FEV	10
57	L\POUSAR PO	Nx	1	€ 56,9	Ceramics	2021	FEV	11
57	L\POUSAR PO	Nx	2	€ 28,5	Ceramics	2021	FEV	15
57	L\POUSAR PO	Nx	1	€ 56,9	Ceramics	2021	FEV	15
57	L\POUSAR PO	Nx	2	€ 28,5	Ceramics	2021	FEV	18
57	L\POUSAR PO	Nx	1	€ 56,9	Ceramics	2021	FEV	18
57	L\POUSAR PO	Nx	2	€ 435,5	Ceramics	2021	FEV	19
57	L\POUSAR PO	Nx	32	€ 28,5	Ceramics	2021	FEV	22
57	L\POUSAR PO	Nx	1	€ 435,5	Ceramics	2021	FEV	23
57	L\POUSAR PO	Nx	32	€ 28,5	Ceramics	2021	FEV	23
57	L\POUSAR PO	Nx	1	€ 82,1	Ceramics	2021	FEV	24
57	L\POUSAR PO	Nx	3	€ 56,9	Ceramics	2021	FEV	25
57	L\POUSAR PO	Nx	2	€ 1 306,6	Ceramics	2021	FEV	25
57	L\POUSAR PO	Nx	96	€ 28,5	Ceramics	2021	FEV	26
57	L\POUSAR PO	Nx	1	€ 28,5	Ceramics	2021	MAR	5
57	L\POUSAR PO	Nx	1	€ 56,9	Ceramics	2021	MAR	10
57	L\POUSAR PO	Nx	2	€ 28,5	Ceramics	2021	MAR	11
57	L\POUSAR PO	Nx	1	€ 28,5	Ceramics	2021	MAR	11
57	L\POUSAR PO	Nx	1	€ 142,3	Ceramics	2021	MAR	18
57	L\POUSAR PO	Nx	5	€ 56,9	Ceramics	2021	MAR	23
57	L\POUSAR PO	Nx	2	€ 164,2	Ceramics	2021	MAR	24
57	L\POUSAR PO	Nx	6	€ 28,5	Ceramics	2021	MAR	26
57	L\POUSAR PO	Nx	1	€ 2 177,6	Ceramics	2021	MAR	29
57	L\POUSAR PO	Nx	160	€ 227,7	Ceramics	2021	MAR	30
57	L\POUSAR PO	Nx	8	€ 31,9	Ceramics	2021	ABR	7
57	L\POUSAR PO	Nx	1	€ 58,1	Ceramics	2021	ABR	8
57	L\POUSAR PO	Nx	2	€ 29,1	Ceramics	2021	ABR	8
57	L\POUSAR PO	Nx	1	€ 142,3	Ceramics	2021	ABR	14
57	L\POUSAR PO	Nx	5	€ 29,1	Ceramics	2021	ABR	27
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	ABR	28
57	L\POUSAR PO	Nx	1	€ 58,1	Ceramics	2021	ABR	29
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	MAI	4
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	MAI	6
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	MAI	6
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	MAI	6
57	L\POUSAR PO	Nx	32	€ 435,5	Ceramics	2021	MAI	11
57	L\POUSAR PO	Nx	16	€ 465,0	Ceramics	2021	MAI	17
57	L\POUSAR PO	Nx	128	€ 1 742,1	Ceramics	2021	MAI	21
57	L\POUSAR PO	Nx	2	€ 58,1	Ceramics	2021	MAI	24
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	MAI	24
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	MAI	28
57	L\POUSAR PO	Nx	15	€ 426,9	Ceramics	2021	MAI	28
57	L\POUSAR PO	Nx	5	€ 142,3	Ceramics	2021	JUN	1
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	JUN	14
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	JUN	15
57	L\POUSAR PO	Nx	3	€ 87,2	Ceramics	2021	JUN	15
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	JUN	15
57	L\POUSAR PO	Nx	128	€ 1 898,2	Ceramics	2021	JUN	17
57	L\POUSAR PO	Nx	32	€ 474,6	Ceramics	2021	JUN	21
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	JUN	21
57	L\POUSAR PO	Nx	12	€ 370,7	Ceramics	2021	JUN	29
57	TOP POP ART 5	Nx	8	€ 192,7	Ceramics	2021	JUN	29
57	L\POUSAR PO	Nx	2	€ 58,1	Ceramics	2021	JUL	7
57	L\POUSAR PO	Nx	160	€ 2 372,8	Ceramics	2021	JUL	7
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	JUL	8
57	L\POUSAR PO	Nx	2	€ 61,2	Ceramics	2021	JUL	8
57	L\POUSAR PO	Nx	3	€ 87,2	Ceramics	2021	JUL	8
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	JUL	12
57	L\POUSAR PO	Nx	1	€ 29,1	Ceramics	2021	JUL	14
57	L\POUSAR PO	Nx	2	€ 58,1	Ceramics	2021	JUL	14
57	L\POUSAR PO	Nx	10	€ 290,6	Ceramics	2021	JUL	14
57	L\POUSAR PO	Nx	2	€ 59,3	Ceramics	2021	JUL	20
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	JUL	22
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	AGT	5
57	L\POUSAR PO	Nx	6	€ 177,9	Ceramics	2021	AGT	10
57	L\POUSAR PO	Nx	11	€ 326,2	Ceramics	2021	AGT	17
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	AGT	18
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	AGT	23
57	L\POUSAR PO	Nx	2	€ 59,3	Ceramics	2021	AGT	25
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	AGT	26
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	AGT	31
57	L\POUSAR PO	Nx	4	€ 118,6	Ceramics	2021	AGT	31
57	L\POUSAR PO	Nx	6	€ 177,9	Ceramics	2021	SET	2
57	L\POUSAR PO	Nx	3	€ 89,0	Ceramics	2021	SET	2
57	L\POUSAR PO	Nx	128	€ 1 898,2	Ceramics	2021	SET	10
57	L\POUSAR PO	Nx	40	€ 1 138,4	Ceramics	2021	SET	10
57	L\POUSAR PO	Nx	2	€ 59,3	Ceramics	2021	SET	14
57	L\POUSAR PO	Nx	64	€ 949,1	Ceramics	2021	SET	17
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	SET	21
57	L\POUSAR PO	Nx	64	€ 949,1	Ceramics	2021	SET	22
57	L\POUSAR PO	Nx	2	€ 59,3	Ceramics	2021	SET	23
57	L\POUSAR PO	Nx	96	€ 1 423,7	Ceramics	2021	SET	24
57	L\POUSAR PO	Nx	32	€ 474,6	Ceramics	2021	SET	27
57	L\POUSAR PO	Nx	13	€ 385,5	Ceramics	2021	SET	27
57	L\POUSAR PO	Nx	32	€ 474,6	Ceramics	2021	SET	30
57	L\POUSAR PO	Nx	64	€ 949,1	Ceramics	2021	OUT	20
57	L\POUSAR PO	Nx	2	€ 59,3	Ceramics	2021	OUT	26
57	L\POUSAR PO	Nx	64	€ 949,1	Ceramics	2021	OUT	26
57	L\POUSAR PO	Nx	64	€ 949,1	Ceramics	2021	NOV	12
57	TOP POP ART 5	Nx	3	€ 65,8	Ceramics	2021	NOV	16
57	L\POUSAR PO	Nx	96	€ 1 423,7	Ceramics	2021	NOV	19
57	L\POUSAR PO	Nx	64	€ 949,1	Ceramics	2021	NOV	23
57	L\POUSAR PO	Nx	64	€ 949,1	Ceramics	2021	NOV	26
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	NOV	29
57	TOP POP ART 5	Nx	10	€ 231,0	Ceramics	2021	NOV	30
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	DEZ	6
57	L\POUSAR PO	Nx	96	€ 1 423,7	Ceramics	2021	DEZ	15
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	DEZ	16
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	DEZ	16
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	DEZ	16
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	DEZ	22
57	L\POUSAR PO	Nx	1	€ 29,7	Ceramics	2021	DEZ	22
57	L\POUSAR PO	Nx	10	€ 285,0	Ceramics	2021	DEZ	22
57	L\POUSAR PO	Nx	12	€ 355,8	Ceramics	2021	DEZ	27

Figure A.1: Sales Data from SKU 57

SKU	Quantity	% of Sales	Classif. 1	CV	% of CV	Classif. 2	Classification
1	30881	5,11%	A	0,42	0,03%	X	AX
2	23119	3,82%	A	0,56	0,04%	X	AX
3	19717	3,26%	A	0,32	0,02%	X	AX
4	19304	3,19%	A	0,54	0,03%	X	AX
5	18084	2,99%	A	0,58	0,04%	X	AX
6	16731	2,77%	A	0,37	0,02%	X	AX
7	16357	2,70%	A	0,33	0,02%	X	AX
8	15843	2,62%	A	0,62	0,04%	X	AX
9	13510	2,23%	A	0,50	0,03%	X	AX
10	13397	2,22%	A	1,46	0,09%	X	AX
11	13093	2,16%	A	0,40	0,03%	X	AX
12	12972	2,14%	A	0,33	0,02%	X	AX
13	12784	2,11%	A	1,33	0,09%	X	AX
14	12522	2,07%	A	0,59	0,04%	X	AX
15	12233	2,02%	A	0,54	0,03%	X	AX
16	11989	1,98%	A	0,69	0,04%	X	AX
17	10920	1,81%	A	0,53	0,03%	X	AX
18	8532	1,41%	A	0,76	0,05%	X	AX
19	8464	1,40%	A	0,48	0,03%	X	AX
20	8148	1,35%	A	1,57	0,10%	Y	AY
21	8070	1,33%	A	0,87	0,06%	X	AX
22	7932	1,31%	A	1,69	0,11%	Y	AY
23	7208	1,19%	A	0,56	0,04%	X	AX
24	7109	1,18%	A	0,61	0,04%	X	AX
25	6997	1,16%	A	0,58	0,04%	X	AX
26	6581	1,09%	A	0,74	0,05%	X	AX
27	6509	1,08%	A	0,38	0,02%	X	AX
28	6379	1,05%	A	2,20	0,14%	Y	AY
29	6319	1,04%	A	1,35	0,09%	X	AX
30	5867	0,97%	A	0,44	0,03%	X	AX
31	5777	0,96%	A	0,65	0,04%	X	AX
32	5755	0,95%	A	2,35	0,15%	Y	AY
33	5581	0,92%	A	1,36	0,09%	X	AX
34	5341	0,88%	A	0,89	0,06%	X	AX
35	5248	0,87%	A	1,43	0,09%	X	AX
36	5120	0,85%	A	2,15	0,14%	Y	AY
37	4876	0,81%	A	0,72	0,05%	X	AX
38	4864	0,80%	A	0,79	0,05%	X	AX
39	4840	0,80%	A	0,62	0,04%	X	AX
40	4616	0,76%	A	1,18	0,08%	X	AX
41	4490	0,74%	A	1,62	0,10%	Y	AY
42	4354	0,72%	A	1,03	0,07%	X	AX
43	4168	0,69%	A	4,10	0,26%	Y	AY
44	3888	0,64%	A	5,57	0,36%	Z	AZ
45	3847	0,64%	A	1,06	0,07%	X	AX
46	3832	0,63%	A	0,45	0,03%	X	AX
47	3831	0,63%	A	0,63	0,04%	X	AX
48	3700	0,61%	A	3,87	0,25%	Y	AY
49	3693	0,61%	A	1,22	0,08%	X	AX
50	3490	0,58%	A	0,84	0,05%	X	AX
51	3438	0,57%	A	3,87	0,25%	Y	AY
52	3372	0,56%	A	0,78	0,05%	X	AX
53	3118	0,52%	A	0,57	0,04%	X	AX
54	2994	0,50%	A	0,76	0,05%	X	AX
55	2981	0,49%	A	0,74	0,05%	X	AX
56	2905	0,48%	A	1,49	0,10%	X	AX
57	2862	0,47%	A	1,39	0,09%	X	AX
58	2780	0,46%	A	0,76	0,05%	X	AX
59	2672	0,44%	B	1,87	0,12%	Y	BY
60	2661	0,44%	B	4,86	0,31%	Z	BZ
61	2642	0,44%	B	0,81	0,05%	X	BX
62	2621	0,43%	B	3,77	0,24%	Y	BY
63	2494	0,41%	B	1,44	0,09%	X	BX
64	2358	0,39%	B	1,13	0,07%	X	BX
65	2281	0,38%	B	5,88	0,38%	Z	BZ
66	2280	0,38%	B	3,77	0,24%	Y	BY
67	2198	0,36%	B	4,22	0,27%	Z	BZ
68	1984	0,33%	B	3,98	0,26%	Y	BY
69	1961	0,32%	B	0,93	0,06%	X	BX
70	1917	0,32%	B	0,76	0,05%	X	BX
71	1885	0,31%	B	0,67	0,04%	X	BX
72	1840	0,30%	B	2,81	0,18%	Y	BY
73	1714	0,28%	B	1,19	0,08%	X	BX
74	1692	0,28%	B	2,81	0,18%	Y	BY
75	1681	0,28%	B	1,81	0,12%	Y	BY
76	1620	0,27%	B	1,23	0,08%	X	BX
77	1613	0,27%	B	1,64	0,11%	Y	BY
78	1566	0,26%	B	1,54	0,10%	Y	BY
79	1543	0,26%	B	0,87	0,06%	X	BX
80	1494	0,25%	B	4,68	0,30%	Z	BZ
81	1353	0,22%	B	1,75	0,11%	Y	BY
82	1341	0,22%	B	1,87	0,12%	Y	BY
83	1336	0,22%	B	1,37	0,09%	X	BX
84	1320	0,22%	B	0,95	0,06%	X	BX
85	1314	0,22%	B	4,36	0,28%	Z	BZ
86	1241	0,21%	B	1,87	0,12%	Y	BY
87	1217	0,20%	B	1,39	0,09%	X	BX
88	1204	0,20%	B	1,60	0,10%	Y	BY
89	1190	0,20%	B	5,30	0,34%	Z	BZ
90	1170	0,19%	B	3,11	0,20%	Y	BY
91	1149	0,19%	B	1,27	0,08%	X	BX
92	1144	0,19%	B	2,50	0,16%	Y	BY
93	1134	0,19%	B	1,91	0,12%	Y	BY
94	1127	0,19%	B	1,82	0,12%	Y	BY
95	1122	0,19%	B	1,13	0,07%	X	BX
96	1112	0,18%	B	4,86	0,31%	Z	BZ
97	1067	0,18%	B	1,19	0,08%	X	BX
98	1064	0,18%	B	1,08	0,07%	X	BX
99	1061	0,18%	B	1,68	0,11%	Y	BY
100	1021	0,17%	B	1,13	0,07%	X	BX
101	949	0,16%	B	1,17	0,08%	X	BX
102	930	0,15%	B	2,10	0,14%	Y	BY
103	905	0,15%	B	1,35	0,09%	X	BX
104	896	0,15%	B	1,65	0,11%	Y	BY
105	888	0,15%	B	1,02	0,07%	X	BX
106	880	0,15%	B	1,52	0,10%	Y	BY
107	878	0,15%	B	1,46	0,09%	X	BX
108	856	0,14%	B	1,22	0,08%	X	BX
109	830	0,14%	B	1,37	0,09%	X	BX
110	824	0,14%	B	2,61	0,17%	Y	BY
111	819	0,14%	B	1,73	0,11%	Y	BY
112	809	0,13%	B	1,69	0,11%	Y	BY
113	790	0,13%	B	1,15	0,07%	X	BX
114	776	0,13%	B	1,20	0,08%	X	BX
115	759	0,13%	B	1,55	0,10%	Y	BY
116	757	0,13%	B	1,47	0,09%	X	BX
117	744	0,12%	B	5,30	0,34%	Z	BZ
118	738	0,12%	B	8,89	0,57%	Z	BZ
119	734	0,12%	B	1,17	0,08%	X	BX
120	713	0,12%	B	1,49	0,10%	X	BX
121	682	0,11%	B	1,73	0,11%	Y	BY
122	678	0,11%	B	5,88	0,38%	Z	BZ
123	662	0,11%	B	1,34	0,09%	X	BX
124	645	0,11%	B	1,40	0,09%	X	BX
125	619	0,10%	B	5,88	0,38%	Z	BZ
126	607	0,10%	B	1,73	0,11%	Y	BY
127	601	0,10%	B	7,94	0,51%	Z	BZ
128	600	0,10%	B	8,89	0,57%	Z	BZ
129	580	0,10%	B	1,65	0,11%	Y	BY
130	579	0,10%	B	6,24	0,40%	Z	BZ
131	570	0,09%	C	8,89	0,57%	Z	CZ
132	570	0,09%	C	5,88	0,38%	Z	CZ
133	560	0,09%	C	4,86	0,31%	Z	CZ
134	555	0,09%	C	5,57	0,36%	Z	CZ
135	552	0,09%	C	4,36	0,28%	Z	CZ
136	545	0,09%	C	7,94	0,51%	Z	CZ
137	526	0,09%	C	1,86	0,12%	Y	CY
138	520	0,09%	C	5,07	0,33%	Z	CZ
139	512	0,08%	C	3,29	0,21%	Y	CY
140	510	0,08%	C	1,52	0,10%	Y	CY
141	498	0,08%	C	1,24	0,08%	X	CX
142	497	0,08%	C	8,89	0,57%	Z	CZ
143	472	0,08%	C	1,29	0,08%	X	CX
144	471	0,08%	C	4,36	0,28%	Z	CZ
145	449	0,07%	C	3,00	0,19%	Y	CY
146	432	0,07%	C	1,57	0,10%	Y	CY
147	421	0,07%	C	5,07	0,33%	Z	CZ
148	420	0,07%	C	8,89	0,57%	Z	CZ
149	420	0,07%	C	2,32	0,15%	Y	CY
150	416	0,07%	C	3,87	0,25%	Y	CY
151	390	0,06%	C	1,26	0,08%	X	CX
152	380	0,06%	C	1,72	0,11%	Y	CY
153	378	0,06%	C	1,56	0,10%	Y	CY
154	373	0,06%	C	2,24	0,14%	Y	CY
155	367	0,06%	C	1,22	0,08%	X	CX
156	367	0,06%	C	2,15	0,14%	Y	CY
157	355	0,06%	C	1,13	0,07%	X	CX
158	355	0,06%	C	6,24	0,40%	Z	CZ
159	349	0,06%	C	1,64	0,11%	Y	CY
160	345	0,06%	C	1,89	0,12%	Y	CY
161	342	0,06%	C	2,10	0,14%	Y	CY
162	340	0,06%	C	6,24	0,40%	Z	CZ
163	330	0,05%	C	2,47	0,16%	Y	CY
164	330	0,05%	C	7,23	0,46%	Z	CZ
165	329	0,05%	C	1,59	0,10%	Y	CY
166	325	0,05%	C	2,54	0,16%	Y	CY
167	322	0,05%	C	2,06	0,13%	Y	CY
168	320	0,05%	C	6,69	0,43%	Z	CZ
169	309	0,05%	C	2,44	0,16%	Y	CY
170	306	0,05%	C	1,93	0,12%	Y	CY
171	303	0,05%	C	2,38	0,15%	Y	CY
172	301	0,05%	C	17,86	1,15%	Z	CZ
173	301	0,05%	C	1,64	0,11%	Y	CY
174	301	0,05%	C	17,86	1,15%	Z	CZ
175	301	0,05%	C	1,65	0,11%	Y	CY
176	296	0,05%	C	2,32	0,15%	Y	CY
177	295	0,05%	C	1,91	0,12%	Y	CY
178	290	0,05%	C	8,89	0,57%	Z	CZ
179	270	0,04%	C	7,94	0,51%	Z	CZ
180	269	0,04%	C	2,41	0,15%	Y	CY
181	267	0,04%	C	1,87	0,12%	Y	CY
182	264	0,04%	C	7,94	0,51%	Z	CZ
183	261	0,04%	C	2,00	0,13%	Y	CY
184	251	0,04%	C	2,22	0,14%	Y	CY
185	243	0,04%	C	1,94	0,12%	Y	CY
186	240	0,04%	C	1,91	0,12%	Y	CY
187	240	0,04%	C	12,61	0,81%	Z	CZ
188	236	0,04%	C	7,94	0,51%	Z	CZ
189	235	0,04%	C	2,44	0,16%	Y	CY
190	228	0,04%	C	10,28	0,66%	Z	CZ
191	220	0,04%	C	5,88	0,38%	Z	CZ
192	219	0,04%	C	2,20	0,14%	Y	CY
193	212	0,04%	C	10,28	0,66%	Z	CZ
194	210	0,03%	C	6,69	0,43%	Z	CZ
195	205	0,03%	C	5,30	0,34%	Z	CZ
196	186	0,03%	C	1,70	0,11%	Y	CY
197	184	0,03%	C	10,28	0,66%	Z	CZ
198	182	0,03%	C	3,77	0,24%	Y	CY
199	180	0,03%	C	2,54	0,16%	Y	CY
200	180	0,03%	C	10,28	0,66%	Z	CZ
201	180	0,03%	C	2,32	0,15%	Y	CY
202	178	0,03%	C	2,13	0,14%	Y	CY
203	168	0,03%	C	2,61	0,17%	Y	CY
204	168	0,03%	C	2,38	0,15%	Y	CY
205	167	0,03%	C	2,08	0,13%	Y	CY
206	164	0,03%	C	2,41	0,15%	Y	CY
207	162	0,03%	C	17,86	1,15%	Z	CZ
208	160	0,03%	C	10,28	0,66%	Z	CZ
209	160	0,03%	C	7,94	0,51%	Z	CZ
210	156	0,03%	C	2,24	0,14%	Y	CY
211	149	0,02%	C	2,10	0,14%	Y	CY
212	144	0,02%	C	17,86	1,15%	Z	CZ
213	144	0,02%	C	17,86	1,15%	Z	CZ
214	142	0,02%	C	2,38	0,15%	Y	CY
215	140	0,02%	C	8,89	0,57%	Z	CZ
216	136	0,02%	C	8,89	0,57%	Z	CZ
217	134	0,02%	C	5,07	0,33%	Z	CZ
218	132	0,02%	C	2,72	0,18%	Y	CY
219	130	0,02%	C	3,05	0,20%	Y	CY
220	129	0,02%	C	2,44	0,16%	Y	CY
221	123	0,02%	C	7,94	0,51%	Z	CZ
222	122	0,02%	C	7,23	0,46%	Z	CZ
223	122	0,02%	C	2,22	0,14%	Y	CY
224	120	0,02%	C	7,23	0,46%	Z	CZ
225	120	0,02%	C	12,61	0,81%	Z	CZ
226	115	0,02%	C	4,10	0,26%	Y	CY
227	114	0,02%	C	2,57	0,17%	Y	CY
228	113	0,02%	C	2,72	0,18%	Y	CY
229	106	0,02%	C	4,22	0,27%	Y	CY
230	97	0,02%	C	4,22	0,27%	Y	CY
231	96	0,02%	C	10,28	0,66%	Z	CZ
232	90	0,01%	C	4,10	0,26%	Y	CY
233	90	0,01%	C	12,61	0,81%	Z	CZ
234	90	0,01%	C	12,61	0,81%	Z	CZ
235	90	0,01%	C	17,86	1,15%	Z	CZ
236	80	0,01%	C	12,61	0,81%	Z	CZ
237	77	0,01%	C	2,85	0,18%	Y	CY
238	61	0,01%	C	4,68	0,30%	Z	CZ
239	60	0,01%	C	17,86	1,15%	Z	CZ
240	60	0,01%	C	12,61	0,81%	Z	CZ
241	59	0,01%	C	2,95	0,19%	Y	CY
242	55	0,01%	C	3,36	0,22%	Y	CY
243	54	0,01%	C	3,29	0,21%	Y	CY
244	54	0,01%	C	17,86	1,15%	Z	CZ
245	48	0,01%	C	17,86	1,15%	Z	CZ
246	47	0,01%	C	7,23	0,46%	Z	CZ
247	44	0,01%	C	3,44	0,22%	Y	CY
248	42	0,01%	C	12,61	0,81%	Z	CZ
249	42	0,01%	C	4,68	0,30%	Z	CZ
250	35	0,01%	C	12,61	0,81%	Z	CZ
251	34	0,01%	C	8,89	0,57%	Z	CZ
252	33	0,01%	C	4,22	0,27%	Y	CY
253	32	0,01%	C	6,69	0,43%	Z	CZ
254	32	0,01%	C	17,86	1,15%	Z	CZ
255	31	0,01%	C	8,89	0,57%	Z	CZ
256	30	0,00%	C	17,86	1,15%	Z	CZ
257	30	0,00%	C	17,86	1,15%	Z	CZ
258	30	0,00%	C	10,28	0,66%	Z	CZ
259	30	0,00%	C	17,86	1,15%	Z	CZ
260	30	0,00%	C	10,28	0,66%	Z	CZ
261	30	0,00%	C	17,86	1,15%	Z	CZ
262	28	0,00%	C	12,61	0,81%	Z	CZ
263	26	0,00%	C	8,89	0,57%	Z	CZ
264	24	0,00%	C	7,94	0,51%	Z	CZ
265	23	0,00%	C	8,89	0,57%	Z	CZ
266	21	0,00%	C	17,86	1,15%	Z	CZ
267	20	0,00%	C	17,86	1,15%	Z	CZ
268	19	0,00%	C	10,28	0,66%	Z	CZ
269	18	0,00%	C	10,28	0,66%	Z	CZ
270	15	0,00%	C	7,23	0,46%	Z	CZ
271	15	0,00%	C	10,28	0,66%	Z	CZ
272	13	0,00%	C	17,86	1,15%	Z	CZ
273	13	0,00%	C	8,89	0,57%	Z	CZ
274	12	0,00%	C	17,86	1,15%	Z	CZ
275	11	0,00%	C	12,61	0,81%	Z	CZ
276	10	0,00%	C	12,61	0,81%	Z	CZ
277	10	0,00%	C	17,86	1,15%	Z	CZ
278	7	0,00%	C	12,61	0,81%	Z	CZ
279	5	0,00%	C	7,94	0,51%	Z	CZ
280	5	0,00%	C	17,86	1,15%	Z	CZ
281	5	0,00%	C	17,86	1,15%	Z	CZ
282	4	0,00%	C	12,61	0,81%	Z	CZ
283	4	0,00%	C	8,89	0,57%	Z	CZ
284	4	0,00%	C	8,89	0,57%	Z	CZ
285	3	0,00%	C	17,86	1,15%	Z	CZ
286	2	0,00%	C	12,61	0,81%	Z	CZ
287	2	0,00%	C	12,61	0,81%	Z	CZ
288	2	0,00%	C	12,61	0,81%	Z	CZ
289	2	0,00%	C	12,61	0,81%	Z	CZ
290	1	0,00%	C	17,86	1,15%	Z	CZ
291	1	0,00%	C	17,86	1,15%	Z	CZ
292	1	0,00%	C	17,86	1,15%	Z	CZ
293	1	0,00%	C	17,86	1,15%	Z	CZ
294	1	0,00%	C	17,86	1,15%	Z	CZ
295	1	0,00%	C	17,86	1,15%	Z	CZ
296	1	0,00%	C	17,86	1,15%	Z	CZ

Figure A.2: ABC-XYZ Analysis

Appendix B

Inventory Management

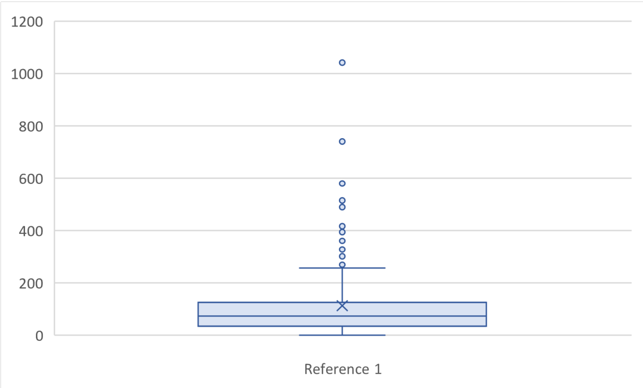

Figure B.1: Reference With Outliers

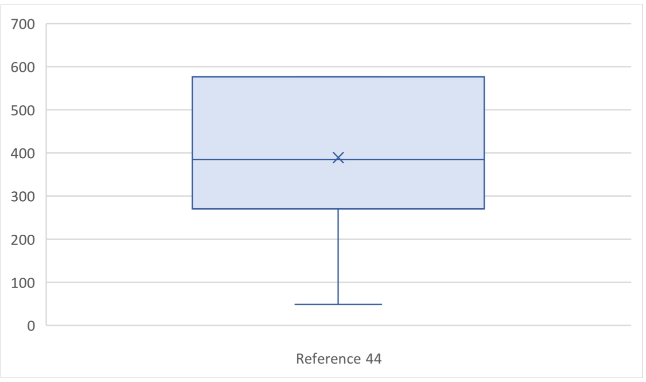

Figure B.2: Reference Without Outliers

SKU	Q1	M	Q3	IQR	UB	LB	Number Outliers
287	1,0	1,0	1,0	0,0	1,0	1,0	0
172	301,0	301,0	301,0	0,0	301,0	301,0	0
26	7,0	21,5	48,0	41,0	109,5	-54,5	9
18	30,0	30,0	60,5	30,5	106,3	-15,8	8
229	1,0	1,0	1,0	0,0	1,0	1,0	3
40	5,0	12,5	30,0	25,0	67,5	-32,5	14
178	20,0	37,5	90,0	70,0	195,0	-85,0	1
8	30,0	42,0	90,0	60,0	180,0	-60,0	13
193	1,0	1,0	105,5	104,5	262,3	-155,8	0
42	5,0	11,0	30,0	25,0	67,5	-32,5	10
284	1,0	1,0	1,0	0,0	1,0	1,0	0
4	30,0	60,0	94,0	64,0	190,0	-66,0	20
199	1,0	1,0	2,0	1,0	3,5	-0,5	3
49	2,8	5,0	30,0	27,3	70,9	-38,1	12
288	1,0	1,0	1,0	0,0	1,0	1,0	0
5	30,0	60,0	90,5	60,5	181,3	-60,8	16
270	1,0	1,0	1,0	0,0	1,0	1,0	1
87	2,0	4,0	12,0	10,0	27,0	-13,0	13
100	1,0	3,0	5,0	4,0	11,0	-5,0	14
175	1,0	2,0	3,0	2,0	6,0	-2,0	9
196	1,0	1,0	2,0	1,0	3,5	-0,5	11
195	8,0	20,0	25,0	17,0	50,5	-17,5	0
123	2,0	3,0	6,0	4,0	12,0	-4,0	11
139	1,5	17,0	24,0	22,5	57,8	-32,3	0
217	1,0	6,5	15,0	14,0	36,0	-20,0	1
253	1,0	2,0	3,5	2,5	7,3	-2,8	1
69	2,0	6,0	12,3	10,3	27,6	-13,4	16
275	3,3	5,5	7,8	4,5	14,5	-3,5	0
259	30,0	30,0	30,0	0,0	30,0	30,0	0
256	30,0	30,0	30,0	0,0	30,0	30,0	0
181	1,0	2,0	3,5	2,5	7,3	-2,8	6
203	1,0	1,0	3,0	2,0	6,0	-2,0	8
103	1,0	3,0	10,0	9,0	23,5	-12,5	9
170	1,0	2,5	5,0	4,0	11,0	-5,0	6
114	1,0	3,0	6,0	5,0	13,5	-6,5	15
180	2,0	3,0	8,0	6,0	17,0	-7,0	3
140	1,0	2,0	5,0	4,0	11,0	-5,0	11
237	1,0	1,0	2,0	1,0	3,5	-0,5	5
219	1,0	2,0	3,0	2,0	6,0	-2,0	6
110	1,0	7,0	30,0	29,0	73,5	-42,5	2
73	3,0	8,0	19,3	16,3	43,6	-21,4	4
83	2,0	5,0	11,0	9,0	24,5	-11,5	20
91	1,0	3,0	9,5	8,5	22,3	-11,8	12
163	1,0	2,0	7,0	6,0	16,0	-8,0	8
50	2,0	6,0	19,0	17,0	44,5	-23,5	14
107	1,0	3,0	8,8	7,8	20,4	-10,6	8
184	1,0	1,0	5,0	4,0	11,0	-5,0	8
58	3,0	9,0	20,0	17,0	45,5	-22,5	5
84	2,0	5,0	10,0	8,0	22,0	-10,0	9
25	9,8	21,5	43,0	33,3	92,9	-40,1	6
63	6,8	16,5	29,3	22,5	63,0	-27,0	8
23	9,0	23,0	42,3	33,3	92,1	-40,9	7
120	1,0	3,0	8,0	7,0	18,5	-9,5	12
129	1,0	3,0	7,0	6,0	16,0	-8,0	11
151	1,0	2,0	4,0	3,0	8,5	-3,5	9
141	1,0	2,0	4,8	3,8	10,4	-4,6	10
153	1,0	2,0	5,0	4,0	11,0	-5,0	6
210	1,0	2,0	3,0	2,0	6,0	-2,0	5
198	1,0	1,0	7,0	6,0	16,0	-8,0	5
46	4,0	11,0	21,8	17,8	48,4	-22,6	5
47	4,0	12,0	27,0	23,0	61,5	-30,5	4
269	4,0	6,0	8,0	4,0	14,0	-2,0	0
251	1,0	3,5	11,0	10,0	26,0	-14,0	0
11	20,0	38,0	67,0	47,0	137,5	-50,5	11
12	16,8	34,0	66,0	49,3	139,9	-57,1	8
273	1,0	3,0	5,3	4,3	11,6	-5,4	0
185	1,0	2,0	4,5	3,5	9,8	-4,3	6
264	1,0	1,0	1,0	0,0	1,0	1,0	1
241	1,0	1,0	2,0	1,0	3,5	-0,5	4
242	1,0	1,0	2,0	1,0	3,5	-0,5	3
282	2,0	2,0	2,0	0,0	2,0	2,0	0
218	1,0	1,5	5,0	4,0	11,0	-5,0	3
232	1,0	2,5	5,0	4,0	11,0	-5,0	2
292	1,0	1,0	1,0	0,0	1,0	1,0	0
71	2,0	4,0	10,0	8,0	22,0	-10,0	25
220	1,0	1,0	3,8	2,8	7,9	-3,1	7
31	3,0	9,0	18,3	15,3	41,1	-19,9	25
281	5,0	5,0	5,0	0,0	5,0	5,0	0
211	1,0	2,0	2,0	1,0	3,5	-0,5	11
238	2,0	2,0	7,0	5,0	14,5	-5,5	0
79	1,0	4,0	10,0	9,0	23,5	-12,5	15
249	1,0	1,0	2,8	1,8	5,4	-1,6	3
248	21,0	21,0	21,0	0,0	21,0	21,0	0
143	1,0	2,0	4,0	3,0	8,5	-3,5	14
39	5,8	14,0	26,0	20,3	56,4	-24,6	19
127	100,0	100,0	200,0	100,0	350,0	-50,0	0
125	12,0	20,0	48,0	36,0	102,0	-42,0	2
67	72,0	72,0	144,0	72,0	252,0	-36,0	3
44	312,0	384,0	576,0	264,0	972,0	-84,0	0
128	114,0	120,0	156,0	42,0	219,0	51,0	1
20	60,0	77,5	120,0	60,0	210,0	-30,0	1
271	5,0	5,0	5,0	0,0	5,0	5,0	0
112	1,0	3,0	12,0	11,0	28,5	-15,5	6
258	5,0	5,0	12,5	7,5	23,8	-6,3	0
2	30,0	60,0	118,5	88,5	251,3	-102,8	12
265	1,0	1,0	5,8	4,8	12,9	-6,1	1
36	15,0	30,0	100,0	85,0	227,5	-112,5	4
215	20,0	22,5	37,5	17,5	63,8	-6,3	1
22	30,0	60,0	120,0	90,0	255,0	-105,0	2
48	112,5	150,0	285,0	172,5	543,8	-146,3	0
164	30,0	30,0	52,5	22,5	86,3	-3,8	1
28	30,0	60,0	140,0	110,0	305,0	-135,0	4
222	2,8	15,0	28,0	25,3	65,9	-35,1	0
32	18,0	60,0	193,0	175,0	455,5	-244,5	1
188	25,0	60,0	60,0	35,0	112,5	-27,5	0
10	60,0	90,0	150,0	90,0	285,0	-75,0	11
72	30,0	30,0	60,0	30,0	105,0	-15,0	3
43	144,0	192,0	312,0	168,0	564,0	-108,0	1
16	4,0	11,0	34,0	30,0	79,0	-41,0	31
221	8,0	20,0	22,0	14,0	43,0	-13,0	1
1	35,5	73,5	126,0	90,5	261,8	-100,3	29
234	37,5	45,0	52,5	15,0	75,0	15,0	0
286	1,0	1,0	1,0	0,0	1,0	1,0	0
171	1,0	1,0	2,0	1,0	3,5	-0,5	8
65	180,0	240,0	360,0	180,0	630,0	-90,0	0
131	82,5	105,0	165,0	82,5	288,8	-41,3	1
161	1,0	2,0	5,0	4,0	11,0	-5,0	7
289	1,0	1,0	1,0	0,0	1,0	1,0	0
60	120,0	200,0	340,0	220,0	670,0	-210,0	0
52	3,0	6,0	18,5	15,5	41,8	-20,3	18
252	1,0	1,0	2,0	1,0	3,5	-0,5	2
294	1,0	1,0	1,0	0,0	1,0	1,0	0
53	3,3	10,0	18,0	14,8	40,1	-18,9	11
55	5,0	10,0	18,0	13,0	37,5	-14,5	15
109	2,0	4,0	9,0	7,0	19,5	-8,5	11
152	1,0	3,0	6,0	5,0	13,5	-6,5	7
126	1,0	2,0	7,3	6,3	16,6	-8,4	9
165	1,0	1,0	3,0	2,0	6,0	-2,0	7
98	2,0	3,0	7,0	5,0	14,5	-5,5	14
177	1,0	2,0	6,0	5,0	13,5	-6,5	3
255	3,3	5,0	9,5	6,3	18,9	-6,1	1
105	2,0	4,0	8,0	6,0	17,0	-7,0	7
97	2,0	5,0	11,0	9,0	24,5	-11,5	8
116	1,0	4,0	12,0	11,0	28,5	-15,5	2
124	1,0	2,0	6,0	5,0	13,5	-6,5	13
240	30,0	30,0	30,0	0,0	30,0	30,0	0
24	13,0	19,0	42,8	29,8	87,4	-31,6	10
15	15,0	30,0	55,5	40,5	116,3	-45,8	14
95	1,0	3,0	8,0	7,0	18,5	-9,5	18
37	5,0	15,0	29,5	24,5	66,3	-31,8	14
260	5,0	6,0	13,0	8,0	25,0	-7,0	0
54	3,0	11,0	22,0	19,0	50,5	-25,5	6
30	6,0	16,0	30,0	24,0	66,0	-30,0	12
99	2,0	6,0	18,5	16,5	43,3	-22,8	2
64	1,8	4,0	26,0	24,3	62,4	-34,6	4
17	13,3	31,0	59,8	46,5	129,5	-56,5	11
104	1,0	3,0	10,0	9,0	23,5	-12,5	11
3	27,0	50,5	92,3	65,3	190,1	-70,9	9
121	1,0	3,0	10,0	9,0	23,5	-12,5	6
230	1,0	3,0	10,0	9,0	23,5	-12,5	0
34	6,0	24,0	38,0	32,0	86,0	-42,0	11
277	10,0	10,0	10,0	0,0	10,0	10,0	0
9	17,0	42,0	73,0	56,0	157,0	-67,0	9
142	88,8	108,5	144,0	55,3	226,9	5,9	0
119	1,0	2,0	5,0	4,0	11,0	-5,0	13
70	2,0	6,0	13,0	11,0	29,5	-14,5	10
167	1,0	3,0	6,0	5,0	13,5	-6,5	8
246	3,3	10,0	10,0	6,8	20,1	-6,9	0
106	1,0	3,0	7,0	6,0	16,0	-8,0	14
102	1,0	4,0	16,0	15,0	38,5	-21,5	8
276	4,5	5,0	5,5	1,0	7,0	3,0	0
82	1,0	5,0	15,0	14,0	36,0	-20,0	9
296	1,0	1,0	1,0	0,0	1,0	1,0	0
290	1,0	1,0	1,0	0,0	1,0	1,0	0
41	1,0	3,0	96,0	95,0	238,5	-141,5	3
57	2,0	4,0	32,0	30,0	77,0	-43,0	12
111	1,0	4,0	10,0	9,0	23,5	-12,5	11
86	1,0	4,0	17,5	16,5	42,3	-23,8	8
158	7,0	12,5	47,5	40,5	108,3	-53,8	2
250	11,3	17,5	23,8	12,5	42,5	-7,5	0
38	4,0	11,0	27,0	23,0	61,5	-30,5	18
293	1,0	1,0	1,0	0,0	1,0	1,0	0
144	1,0	8,0	20,0	19,0	48,5	-27,5	3
257	30,0	30,0	30,0	0,0	30,0	30,0	0
280	5,0	5,0	5,0	0,0	5,0	5,0	0
145	1,0	1,0	6,3	5,3	14,1	-6,9	3
295	1,0	1,0	1,0	0,0	1,0	1,0	0
263	4,0	7,5	10,0	6,0	19,0	-5,0	0
166	1,0	1,0	2,0	1,0	3,5	-0,5	9
213	144,0	144,0	144,0	0,0	144,0	144,0	0
278	2,3	3,5	4,8	2,5	8,5	-1,5	0
243	1,0	1,0	2,0	1,0	3,5	-0,5	2
285	3,0	3,0	3,0	0,0	3,0	3,0	0
283	1,0	1,0	1,0	0,0	1,0	1,0	0
27	6,0	15,0	34,0	28,0	76,0	-36,0	10
157	1,0	2,0	3,0	2,0	6,0	-2,0	8
146	1,0	3,0	7,0	6,0	16,0	-8,0	4
261	30,0	30,0	30,0	0,0	30,0	30,0	0
159	1,0	2,0	3,5	2,5	7,3	-2,8	9
189	1,0	2,0	7,8	6,8	17,9	-9,1	3
160	1,0	2,0	6,0	5,0	13,5	-6,5	5
156	1,0	2,0	5,0	4,0	11,0	-5,0	7
108	2,0	3,0	8,0	6,0	17,0	-7,0	12
186	2,0	2,0	5,0	3,0	9,5	-2,5	3
201	1,0	2,0	4,0	3,0	8,5	-3,5	6
204	1,0	2,0	4,0	3,0	8,5	-3,5	2
192	1,0	1,0	2,0	1,0	3,5	-0,5	8
223	1,0	1,0	2,0	1,0	3,5	-0,5	7
101	1,0	3,0	6,0	5,0	13,5	-6,5	20
202	1,0	2,0	3,8	2,8	7,9	-3,1	6
228	1,0	2,0	4,0	3,0	8,5	-3,5	3
214	1,0	1,5	3,0	2,0	6,0	-2,0	5
77	1,0	2,0	6,0	5,0	13,5	-6,5	15
81	1,0	4,0	16,0	15,0	38,5	-21,5	7
76	2,0	5,0	15,0	13,0	34,5	-17,5	7
155	1,0	2,0	3,0	2,0	6,0	-2,0	9
183	1,0	2,0	4,3	3,3	9,1	-3,9	7
279	1,0	1,0	1,0	0,0	1,0	1,0	0
113	1,0	3,0	7,0	6,0	16,0	-8,0	10
247	1,0	1,0	2,0	1,0	3,5	-0,5	2
61	3,0	9,0	20,0	17,0	45,5	-22,5	7
154	1,0	2,0	7,0	6,0	16,0	-8,0	9
173	1,0	2,0	3,0	2,0	6,0	-2,0	10
169	1,0	2,0	4,0	3,0	8,5	-3,5	9
93	2,0	3,0	16,0	14,0	37,0	-19,0	10
205	1,0	2,0	3,0	2,0	6,0	-2,0	4
7	20,0	44,0	76,5	56,5	161,3	-64,8	14
6	22,0	40,5	76,0	54,0	157,0	-59,0	18
226	1,0	1,0	3,8	2,8	7,9	-3,1	2
227	1,0	1,0	2,0	1,0	3,5	-0,5	8
176	1,0	1,0	3,0	2,0	6,0	-2,0	8
14	15,0	32,0	60,0	45,0	127,5	-52,5	15
19	9,0	24,0	41,0	32,0	89,0	-39,0	18
45	7,0	18,0	33,5	26,5	73,3	-32,8	11
115	2,0	2,0	5,0	3,0	9,5	-2,5	15
206	1,0	2,0	4,0	3,0	8,5	-3,5	2
135	20,0	20,0	60,0	40,0	120,0	-40,0	0
90	20,0	40,0	57,5	37,5	113,8	-36,3	0
132	30,0	60,0	90,0	60,0	180,0	-60,0	0
66	60,0	90,0	150,0	90,0	285,0	-75,0	1
274	12,0	12,0	12,0	0,0	12,0	12,0	0
136	64,0	64,0	128,0	64,0	224,0	-32,0	1
266	21,0	21,0	21,0	0,0	21,0	21,0	0
147	28,0	28,0	35,0	7,0	45,5	17,5	3
133	28,0	28,0	56,0	28,0	98,0	-14,0	0
191	12,0	24,0	28,0	16,0	52,0	-12,0	0
74	40,0	40,0	40,0	0,0	40,0	40,0	7
138	38,0	48,0	48,0	10,0	63,0	23,0	0
150	16,0	16,0	20,0	4,0	26,0	10,0	5
13	72,0	96,0	144,0	72,0	252,0	-36,0	2
35	40,0	40,0	60,0	20,0	90,0	10,0	6
130	32,0	64,0	72,0	40,0	132,0	-28,0	1
224	15,0	15,0	26,3	11,3	43,1	-1,9	0
209	20,0	20,0	20,0	0,0	20,0	20,0	1
207	162,0	162,0	162,0	0,0	162,0	162,0	0
197	60,0	60,0	62,0	2,0	65,0	57,0	0
168	30,0	60,0	60,0	30,0	105,0	-15,0	0
182	18,0	54,0	54,0	36,0	108,0	-36,0	1
187	75,0	120,0	165,0	90,0	300,0	-60,0	0
80	60,0	67,5	141,8	81,8	264,4	-62,6	1
89	40,0	60,0	110,0	70,0	215,0	-65,0	2
96	54,0	108,0	108,0	54,0	189,0	-27,0	0
118	60,0	129,0	253,5	193,5	543,8	-230,3	0
254	32,0	32,0	32,0	0,0	32,0	32,0	0
162	20,0	20,0	45,0	25,0	82,5	-17,5	1
194	15,0	30,0	30,0	15,0	52,5	-7,5	1
245	48,0	48,0	48,0	0,0	48,0	48,0	0
216	24,0	32,0	42,0	18,0	69,0	-3,0	0
236	30,0	40,0	50,0	20,0	80,0	0,0	0
92	20,0	20,0	28,0	8,0	40,0	8,0	1
117	32,0	40,0	80,0	48,0	152,0	-40,0	1
59	24,0	48,0	48,0	24,0	84,0	-12,0	1
179	18,0	36,0	54,0	36,0	108,0	-36,0	1
190	54,0	84,0	102,0	48,0	174,0	-18,0	0
231	24,0	24,0	36,0	12,0	54,0	6,0	0
68	40,0	60,0	150,0	110,0	315,0	-125,0	0
148	105,0	120,0	120,0	15,0	142,5	82,5	0
225	60,0	60,0	60,0	0,0	60,0	60,0	0
200	60,0	60,0	60,0	0,0	60,0	60,0	0
244	54,0	54,0	54,0	0,0	54,0	54,0	0
239	60,0	60,0	60,0	0,0	60,0	60,0	0
233	30,0	45,0	60,0	30,0	105,0	-15,0	0
212	144,0	144,0	144,0	0,0	144,0	144,0	0
267	20,0	20,0	20,0	0,0	20,0	20,0	0
56	2,0	18,0	41,0	39,0	99,5	-56,5	7
88	2,0	5,5	11,8	9,8	26,4	-12,6	15
137	1,0	2,0	9,0	8,0	21,0	-11,0	3
78	1,0	9,0	23,0	22,0	56,0	-32,0	3
268	5,0	9,0	9,0	4,0	15,0	-1,0	0
33	2,0	28,0	84,0	82,0	207,0	-121,0	3
75	1,0	14,0	28,0	27,0	68,5	-39,5	8
29	2,0	30,0	84,0	82,0	207,0	-121,0	1
149	1,0	1,5	13,0	12,0	31,0	-17,0	1
94	2,0	8,0	23,5	21,5	55,8	-30,3	4
272	13,0	13,0	13,0	0,0	13,0	13,0	0
62	96,0	120,0	168,0	72,0	276,0	-12,0	0
85	60,0	75,0	97,5	37,5	153,8	3,8	1
51	96,0	168,0	246,0	150,0	471,0	-129,0	0
235	90,0	90,0	90,0	0,0	90,0	90,0	0
134	28,3	32,0	44,0	15,8	67,6	4,6	2
174	301,0	301,0	301,0	0,0	301,0	301,0	0
122	26,0	64,0	96,0	70,0	201,0	-79,0	0
21	4,0	28,0	58,8	54,8	140,9	-78,1	7
262	14,0	14,0	14,0	0,0	14,0	14,0	0
291	1,0	1,0	1,0	0,0	1,0	1,0	0
208	48,0	64,0	64,0	16,0	88,0	24,0	0

Figure B.3: Interquartile Range Method Results and Number of Outliers

SKU	Series Priority	EPEI	Sales Average	Sales StdDevp	Service Level	SS	RL	Average Stock
1	2	60	67,0	53,0	85%	339	2883	2347
2	1	90	55,9	55,9	80%	290	2415	2806
3	3	30	55,0	42,6	90%	336	2425	1161
4	2	60	46,6	41,6	85%	266	2038	1665
5	1	90	46,9	38,1	80%	197	1981	2309
6	2	60	41,8	35,3	85%	225	1814	1480
7	1	90	43,7	35,1	80%	182	1842	2147
8	3	30	37,5	40,8	90%	322	1746	885
9	2	60	37,0	36,0	85%	230	1636	1340
10	2	60	33,3	58,9	85%	377	1641	1374
11	3	30	36,8	31,2	90%	246	1644	798
12	2	60	37,5	31,5	85%	201	1625	1325
13	2	60	38,9	49,0	85%	313	1791	1480
14	3	30	26,2	27,4	90%	217	1212	610
15	2	60	26,4	25,4	85%	163	1164	954
16	3	30	10,7	15,1	90%	120	526	280
17	3	30	27,9	27,6	90%	218	1277	636
18	1	90	24,4	25,1	80%	130	1058	1230
19	3	30	20,4	19,2	90%	152	928	458
20	3	30	24,9	53,0	90%	419	1365	792
21	2	60	21,9	41,3	85%	264	1095	920
22	2	60	20,9	51,5	85%	329	1125	957
23	3	30	20,6	21,2	90%	168	950	476
24	2	60	18,9	20,6	85%	131	851	699
25	1	90	20,0	21,9	80%	114	873	1013
26	3	30	17,4	22,6	90%	179	840	440
27	2	60	18,0	17,8	85%	114	798	654
28	2	60	14,2	66,5	85%	425	964	851
29	3	30	19,2	55,7	90%	440	1170	728
30	3	30	15,5	14,9	90%	118	706	350
31	2	60	6,8	7,9	85%	50	308	253
32	2	60	16,7	110,1	85%	703	1339	1205
33	2	60	15,8	48,3	85%	308	907	781
34	2	60	13,2	19,2	85%	123	625	519
35	3	30	14,7	17,3	90%	136	696	357
36	3	30	9,9	52,7	90%	416	793	565
37	1	90	11,8	14,9	80%	77	525	607
38	3	30	9,2	14,5	90%	114	465	253
39	2	60	11,4	12,6	85%	80	512	421
40	1	90	6,6	13,8	80%	71	324	370
41	2	60	11,4	61,6	85%	394	827	736
42	1	90	8,0	14,8	80%	77	383	439
43	3	30	11,8	113,4	90%	896	1344	1073
45	2	60	9,2	16,6	85%	106	454	381
46	3	30	11,3	11,2	90%	89	518	258
47	3	30	11,3	13,3	90%	105	533	274
48	1	90	11,6	107,4	80%	557	997	1078
49	3	30	5,0	15,0	90%	118	309	194
50	1	90	5,7	9,4	80%	49	267	307
51	2	60	10,7	93,5	85%	597	1006	920
52	2	60	6,1	10,1	85%	64	294	246
53	3	30	8,5	8,5	90%	67	391	195
54	1	90	8,2	10,7	80%	55	367	424
55	2	60	7,3	8,4	85%	54	331	273
56	3	30	7,0	24,9	90%	197	465	303
57	2	60	4,4	18,3	85%	117	284	249
58	3	30	7,6	10,2	90%	81	371	195
61	3	30	7,2	10,7	90%	84	358	193
63	2	60	5,5	12,6	85%	81	289	245
64	1	90	5,8	17,0	80%	88	308	348
69	3	30	3,6	5,9	90%	47	185	101
70	1	90	5,0	6,9	80%	36	224	259
71	3	30	3,6	4,5	90%	35	172	89
73	1	90	4,5	9,7	80%	51	221	252
76	2	60	3,5	8,2	85%	52	185	157
79	3	30	3,0	4,8	90%	38	153	84
83	2	60	1,7	4,5	85%	29	94	81
84	3	30	3,5	5,7	90%	45	177	97
87	1	90	1,9	5,0	80%	26	98	112
91	2	60	1,8	5,2	85%	33	102	87
95	1	90	1,7	3,7	80%	19	85	98
97	1	90	2,5	4,7	80%	24	120	138
98	1	90	1,8	3,0	80%	16	85	97
100	2	60	1,3	2,3	85%	14	64	54
101	3	30	1,3	2,4	90%	19	69	38
103	3	30	1,9	5,2	90%	41	112	69
105	2	60	2,3	3,8	85%	24	114	95
107	1	90	1,4	4,0	80%	21	73	83
108	1	90	1,7	3,5	80%	18	83	95
109	3	30	1,8	4,3	90%	34	102	61
113	2	60	1,8	3,8	85%	24	93	78
114	2	60	1,5	2,9	85%	18	74	62
116	3	30	2,2	6,9	90%	55	138	87
119	2	60	1,2	2,2	85%	14	60	51
120	3	30	1,3	3,5	90%	28	77	47
123	2	60	1,3	2,9	85%	19	69	58
124	3	30	1,0	2,4	90%	19	58	35
141	3	30	1,1	2,2	90%	17	58	33
143	1	90	0,9	1,5	80%	8	41	48
151	2	60	0,9	1,6	85%	10	43	36
155	1	90	0,8	1,2	80%	6	37	42
157	1	90	0,9	1,4	80%	7	42	48

SKU	Series Priority	EPEI	Sales Average	Sales StdDevp	Service Level	SS	RL	Average Stock
1	2	60	67	53	90%	419	2963	2427
2	1	90	56	56	85%	357	2482	2873
3	3	30	55	43	95%	432	2520	1256
4	2	60	47	42	90%	328	2100	1727
5	1	90	47	38	85%	243	2026	2355
6	2	60	42	35	90%	279	1868	1533
7	1	90	44	35	85%	224	1884	2189
8	3	30	37	41	95%	414	1838	976
9	2	60	37	36	90%	285	1691	1395
10	2	60	33	59	90%	466	1730	1464
11	3	30	37	31	95%	316	1714	868
12	2	60	37	31	90%	249	1672	1372
13	2	60	39	49	90%	387	1865	1554
14	3	30	26	27	95%	278	1273	671
15	2	60	26	25	90%	201	1203	992
16	3	30	11	15	95%	154	560	314
17	3	30	28	28	95%	280	1339	698
18	1	90	24	25	85%	160	1089	1260
19	3	30	20	19	95%	195	971	501
20	3	30	25	53	95%	538	1483	911
21	2	60	22	41	90%	326	1158	983
22	2	60	21	52	90%	407	1202	1035
23	3	30	21	21	95%	215	998	524
24	2	60	19	21	90%	162	882	730
25	1	90	20	22	85%	140	899	1039
26	3	30	17	23	95%	230	891	491
27	2	60	18	18	90%	141	825	681
28	2	60	14	67	90%	525	1065	951
29	3	30	19	56	95%	565	1295	853
30	3	30	15	15	95%	151	739	383
31	2	60	7	8	90%	62	319	265
32	2	60	17	110	90%	870	1506	1372
33	2	60	16	48	90%	381	980	854
34	2	60	13	19	90%	152	654	548
35	3	30	15	17	95%	175	734	396
36	3	30	10	53	95%	534	911	683
37	1	90	12	15	85%	95	542	625
38	3	30	9	14	95%	147	497	285
39	2	60	11	13	90%	99	531	440
40	1	90	7	14	85%	88	340	387
41	2	60	11	62	90%	487	920	829
42	1	90	8	15	85%	94	400	457
43	3	30	12	113	95%	1150	1598	1327
45	2	60	9	17	90%	131	479	406
46	3	30	11	11	95%	114	543	283
47	3	30	11	13	95%	135	563	304
48	1	90	12	107	85%	686	1126	1207
49	3	30	5	15	95%	152	343	227
50	1	90	6	9	85%	60	278	318
51	2	60	11	93	90%	739	1147	1061
52	2	60	6	10	90%	80	310	261
53	3	30	9	8	95%	86	410	214
54	1	90	8	11	85%	68	380	437
55	2	60	7	8	90%	66	344	285
56	3	30	7	25	95%	253	521	359
57	2	60	4	18	90%	145	312	277
58	3	30	8	10	95%	104	394	218
61	3	30	7	11	95%	108	382	216
63	2	60	5	13	90%	100	308	264
64	1	90	6	17	85%	108	328	369
69	3	30	4	6	95%	60	198	114
70	1	90	5	7	85%	44	232	267
71	3	30	4	4	95%	45	182	99
73	1	90	4	10	85%	62	232	264
76	2	60	3	8	90%	65	197	169
79	3	30	3	5	95%	49	164	94
83	2	60	2	4	90%	35	101	87
84	3	30	3	6	95%	58	189	110
87	1	90	2	5	85%	32	104	118
91	2	60	2	5	90%	41	110	95
95	1	90	2	4	85%	24	90	102
97	1	90	3	5	85%	30	126	143
98	1	90	2	3	85%	19	88	101
100	2	60	1	2	90%	18	68	57
101	3	30	1	2	95%	24	74	44
103	3	30	2	5	95%	53	124	81
105	2	60	2	4	90%	30	119	101
107	1	90	1	4	85%	26	78	88
108	1	90	2	3	85%	22	88	100
109	3	30	2	4	95%	44	112	71
113	2	60	2	4	90%	30	98	84
114	2	60	1	3	90%	23	78	66
116	3	30	2	7	95%	70	153	103
119	2	60	1	2	90%	18	64	54
120	3	30	1	4	95%	36	84	55
123	2	60	1	3	90%	23	73	62
124	3	30	1	2	95%	25	64	40
141	3	30	1	2	95%	22	63	38
143	1	90	1	1	85%	9	43	49
151	2	60	1	2	90%	12	45	38
155	1	90	1	1	85%	8	38	44
157	1	90	1	1	85%	9	44	50

Figure B.4: Higher Risk Scenario vs Conservative Scenario for the MTS references

SKU	Series Priority	Service Level	Sales Average	Sales StdDevp	Stock
229	2	85%	6	15	22
199	2	85%	4	12	17
78	3	90%	16	20	43
137	1	80%	7	15	20
59	2	85%	38	16	54
150	2	85%	21	9	30
203	2	85%	4	6	10
66	3	90%	109	70	199
180	3	90%	6	6	14
90	1	80%	39	19	55
237	3	90%	2	2	5
206	1	80%	3	5	8
176	2	85%	6	13	19
227	2	85%	3	4	7
184	2	85%	5	7	12
205	3	90%	3	3	7
153	3	90%	4	6	11
93	2	85%	16	27	44
173	1	80%	3	5	8
247	1	80%	2	2	3
183	3	90%	4	6	11
242	2	85%	2	3	5
214	1	80%	3	4	6
228	2	85%	3	3	6
220	1	80%	3	3	5
211	3	90%	3	3	6
202	3	90%	3	3	7
72	1	80%	51	55	98
171	2	85%	6	15	22
161	3	90%	6	11	20
223	1	80%	2	3	4
192	2	85%	4	13	17
204	2	85%	4	5	9
201	3	90%	4	3	8
186	3	90%	3	3	7
156	2	85%	6	11	18
160	1	80%	5	6	10
189	1	80%	5	6	10
159	1	80%	4	6	9
146	2	85%	5	5	10
243	1	80%	2	3	4
166	2	85%	8	34	42
145	2	85%	14	43	59
86	3	90%	17	35	62
111	3	90%	10	14	29
82	2	85%	19	38	59
102	3	90%	16	28	52
106	2	85%	9	16	26
167	3	90%	5	5	12
230	2	85%	6	6	12
121	1	80%	9	12	19
104	3	90%	10	17	33
99	3	90%	13	17	35
177	3	90%	4	5	11
165	1	80%	4	8	10
126	2	85%	8	14	22
152	2	85%	5	5	10
252	3	90%	2	2	5
112	1	80%	10	14	22
232	3	90%	5	7	14
218	2	85%	3	4	8
77	2	85%	19	51	72
81	1	80%	17	49	58
241	3	90%	2	2	4
185	3	90%	4	5	10
154	1	80%	7	11	16
198	3	90%	9	13	26
169	2	85%	7	17	24
210	3	90%	3	3	7
129	3	90%	7	9	19
226	2	85%	6	16	23
163	3	90%	7	11	21
110	3	90%	20	27	55
115	2	85%	8	24	32
219	3	90%	4	6	12
140	2	85%	5	9	15
170	2	85%	5	5	10
74	2	85%	47	17	64
181	2	85%	4	6	10
92	2	85%	26	12	38
139	3	90%	19	18	42
68	1	80%	104	78	170
88	3	90%	13	21	40
196	1	80%	2	3	5
175	3	90%	4	6	11
149	1	80%	1	7	7
62	3	90%	7	34	51
75	3	90%	4	17	25
94	2	85%	3	11	14

SKU	Series Priority	Service Level	Sales Average	Sales StdDevp	Stock
229	2	90%	6	15	26
199	2	90%	4	12	20
78	3	95%	16	20	50
137	1	85%	7	15	23
59	2	90%	38	16	58
150	2	90%	21	9	32
203	2	90%	4	6	12
66	3	95%	109	70	224
180	3	95%	6	6	16
90	1	85%	39	19	58
237	3	95%	2	2	6
206	1	85%	3	5	9
176	2	90%	6	13	23
227	2	90%	3	4	8
184	2	90%	5	7	13
205	3	95%	3	3	8
153	3	95%	4	6	13
93	2	90%	16	27	51
173	1	85%	3	5	9
247	1	85%	2	2	3
183	3	95%	4	6	14
242	2	90%	2	3	6
214	1	85%	3	4	7
228	2	90%	3	3	6
220	1	85%	3	3	6
211	3	95%	3	3	7
202	3	95%	3	3	9
72	1	85%	51	55	108
171	2	90%	6	15	25
161	3	95%	6	11	23
223	1	85%	2	3	5
192	2	90%	4	13	20
204	2	90%	4	5	10
201	3	95%	4	3	9
186	3	95%	3	3	8
156	2	90%	6	11	21
160	1	85%	5	6	11
189	1	85%	5	6	12
159	1	85%	4	6	11
146	2	90%	5	5	11
243	1	85%	2	3	5
166	2	90%	8	34	51
145	2	90%	14	43	69
86	3	95%	17	35	75
111	3	95%	10	14	34
82	2	90%	19	38	68
102	3	95%	16	28	62
106	2	90%	9	16	30
167	3	95%	5	5	14
230	2	90%	6	6	14
121	1	85%	9	12	21
104	3	95%	10	17	39
99	3	95%	13	17	41
177	3	95%	4	5	12
165	1	85%	4	8	12
126	2	90%	8	14	25
152	2	90%	5	5	11
252	3	95%	2	2	5
112	1	85%	10	14	24
232	3	95%	5	7	16
218	2	90%	3	4	8
77	2	90%	19	51	84
81	1	85%	17	49	68
241	3	95%	2	2	4
185	3	95%	4	5	11
154	1	85%	7	11	18
198	3	95%	9	13	30
169	2	90%	7	17	28
210	3	95%	3	3	8
129	3	95%	7	9	22
226	2	90%	6	16	27
163	3	95%	7	11	25
110	3	95%	20	27	65
115	2	90%	8	24	38
219	3	95%	4	6	14
140	2	90%	5	9	17
170	2	90%	5	5	11
74	2	90%	47	17	69
181	2	90%	4	6	12
92	2	90%	26	12	41
139	3	95%	19	18	49
68	1	85%	104	78	185
88	3	95%	13	21	47
196	1	85%	2	3	6
175	3	95%	4	6	13
149	1	85%	1	7	8
62	3	95%	7	34	63
75	3	95%	4	17	32
94	2	90%	3	11	17

Figure B.5: Higher Risk Scenario vs Conservative Scenario for the MMTS references