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WAREHOUSING AND INVENTORY MANAGEMENT ACTIVITIES AT MUSA: A PROPOSAL FOR IMPROVEMENTS

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ABSTRACT

This project is developed under logistics and supply chain scope. It has been an evolving subject and it plays an important role in corporate business nowadays. In between all the topics this theme integrates, warehousing and inventory management are seen as critical activities. Inventory management is a fundamental part of the logistics management process due to the costs saving it leads to when having a well implemented structure. Warehousing management is an essential part of every logistics chain since it bridges the producer to the customer, due to its vital role in providing a desired level of customer service at the lowest possible total costs.

Thus, this project is about warehousing and inventory management activities in a Portuguese craft beer company named MUSA. This is a sector that has been developing in Portugal in the last years. Many new players have entered the market recently and MUSA is between them. It is hence meaningful to contribute to the efficiency increasing of the company in such a competitive environment in order to be a step ahead of the market.

Therefore, the goal was to make it possible in the management of these activities of warehousing and inventory management at MUSA. In order to provide value-added suggestions, information about the current management of these activities was collected.

Considering that there are no proper inventory policies defined to each product, one of the main goals was to work on this settlement.

Based on this information appropriate methods were applied. The models used for inventory policies were the continuous and periodic stochastic review models. For SKU classification in terms of importance level, the ABC analysis was performed.

Results show that efficiency could be improved through the adoption of the right stock management policy since it provides a notion of the associated costs and hence capital could be allocated to other investments. The products allocation also allows to get visibility for future investment decisions.

Keywords: Logistics, Warehousing, Inventory Management, Storage, Q Model, P Model, ABC Analysis.

RESUMO

O presente projeto é desenvolvido no âmbito da Logística e Cadeia de Abastecimento. Este tem sido um tema em constante evolução que se tornou essencial para o negócio empresarial nos dias de hoje. De entre todos os subtemas que esta área integra, a gestão de inventário e armazém são vistas como atividades críticas. A gestão de inventário é uma parte fundamental do processo de gestão logístico pois é o ponto de ligação entre o produtor e o cliente devido ao seu importante papel de fornecer o nível de serviço desejado ao menor custo possível.

Neste sentido este projeto trata a gestão de inventário e armazém numa empresa portuguesa de produção de cerveja artesanal, a MUSA. Este é um setor que se tem vindo a desenvolver em Portugal nos últimos anos. Recentemente, este mercado tem assistido à entrada de muitos novos participantes, sendo que a MUSA está entre eles. Consequentemente, é assim que surge a oportunidade de melhorar a eficiência desta empresa num ambiente de competitividade como o que se descreve nos dias de hoje, para de certa forma conseguir superar o mercado.

O objetivo é, então, contribuir nesse aspeto para a gestão destas atividades de inventário e armazenagem na MUSA. Com o intuito de ter sugestões que possam ser uma mais valia, foi recolhida informação acerca da atual gestão destas atividades na empresa.

Tendo em conta que não existem políticas de inventário propriamente definidas para os seus produtos, um dos principais pontos a melhorar passou pela definição das mesmas. Com base no ponto anterior foi posteriormente estudada a alocação de cada item no armazém.

De acordo com a informação recolhida foram também usados métodos apropriados. Modelos estocásticos de revisão contínua e revisão periódica foram utilizados na gestão de inventários. Outro método utilizado foi a análise ABC para a classificação dos produtos de acordo com o nível de importância.

Os resultados demonstram que é possível melhorar a eficiência adotando a política de inventário adequada pois permite ter noção dos custos associados e consequentemente alocar capital para outros tipos de investimento. O mesmo racional de aplica na alocação de cada produto em armazém.

Palavras-chave: Logística, Armazenagem, Gestão de Inventário, Arrumação, Modelo P, Modelo Q, Análise ABC.

List of abbreviations

ABC – Activity-based cost

AHP - Analytical Hierarchy Process

AS/RS - Automated Storage and Retrieval Systems

CEO – Chief Executive Officer

CFO – Chief Financial Officer

COI - Clube-per-Order Index

EOQ – Economic Order Quantity

EPO – Economic Period Order

HORECA – Hotels, Restaurants and Cafes

IPA – India Pale Ale

Kg – Kilograms

Q – Order Quantity

SKU – Stock Keeping Unit

VED - Vital, Essential or Desirable

FSN/FNS - Fast, Slow and Non-moving/Fast, Normal and Slow moving

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1. INTRODUCTION

In this section, the problematic under study is presented, starting with the current challenges faced by the sector and proceeded by a brief description of the company's history. General and specific objectives are defined as well as the research question that supports this project. Moreover, an overview of the methodology used in the case study is presented and, as final topics, the project's whole structure and the scope.

1.1. Defining the problem

In the last four/five years the craft beer market has been facing many new brewery producers. According to data from Nielsen, the market grown up 10% in the first semester of 2017, comparing to the previous year, which was a phenomenon never seen before (Almeida, 2017). The two main players in the beer market are Super Bock from "Unicer" and Sagres from "Central de Cervejas", having together almost 90% of the market share (Oliveira, 2016). Besides these two big producers, there are around 131 brands of craft beer operating in Portugal currently, included in that list the many famous brands like Praxis, Sovina, Letra, Maldita, Vadia, etc. (*Cerveja Artesanal Portuguesa — Lista de Cervejas Artesanais de Portugal*, no date).

Data from Banco de Portugal also shows that the number of companies is increasing. In 2015, there were 51 companies operating in the whole sector of beer production. A year later more 14 firms joined the market. This is due to many micro-breweries which are entering in this market and trying to convince consumers with their new recipes, leading to an increasing competitiveness. Also, from table 1, it is possible to state this strong desire of new competitors to be part of this market. Moreover, most of the players are totally beginners, representing 88% of the market. It also informs the reader that companies with more experience have almost all the business volume, 90%, which illustrates the strong position from seniors. It is then visible the challenge that companies have, in facing the high competitiveness of this sector and get differentiated from the players. Although these trendy desire to entry in this market, companies are currently facing some difficulties in different areas.

Table 1- Beer production sector

Maturity	Number of companies	Business volume
Until 5 years	88%	0%
From 6 to 10 years	6%	10%
More than 10 years	6%	90%

Source: *Banco de Portugal*

As one can confirm from table 2, a key problem is related to the management of inventory. In fact, stock is kept more time in warehouses. In 2015, the average rotation time of inventories was lower in the three quarters when comparing to the respective quarters of 2016. Between 2015 and 2016, the number of days inventories remained in warehouses almost duplicated in the first quarter, registering 43 days and 80 days, respectively. This is the result of new company's arrival. Thus, taking into account that holding costs represents a key cost component for companies that want to have an efficient inventory control system (Berling, 2008), there is a need of exploring the best way of managing this, and hence organizing warehouse.

Table 2 – Average inventories rotation

Year	2015			2016		
Time Period (Quarters)	1st	2nd	3rd	1st	2nd	3rd
Average Rotation time of inventories (number of days)	43	134	301	80	193	313

Source: *Banco de Portugal*

The brewing company under analysis was established in 2016 by the name MUSA. The idea came up while two friends were travelling, Bruno Carrilho, founder and CEO (Chief Executive Officer), Nuno Melo, founder and CFO (Chief Financial Officer). Currently, their production covers four types of beers (*MUSA*, no date). These beers can be found in more than five hundred final distributors. MUSA beer is sold in Portugal, including Madeira and Azores, using the retail and HORECA (Hotels, Restaurants and Cafes) channels, specifically supermarkets, restaurants and coffee shops. They had also reached the international market, representing already 10% of the sales volume. As they initiated the business recently one of their main concerns is to get all the orders ready to answer requests as soon as possible. As they are only capable to produce according to

customers' orders the company presently faces a make-to-order strategy. As customers' orders have been increasing and beer production time could achieve weeks or even months, their objective it is to start producing to stock, passing from a make-to-order strategy to a make-to-stock strategy. The desirable situation would be to answer clients as shortly as possible on time.

Considering the industry's challenge mentioned before, and the recent MUSA's arrival to the market, it is meaningful to evaluate solutions that allow MUSA to deal with those dares, which will be probably the ones faced by the company from now one. In this sense, an analysis to the current stock management was performed. This evaluation considered the costs associated to the stock management system, defined the right quantity to order, when to order and the safety stock to constitute in order to avoid an increasing in the average rotation time of inventories. Linked to this inventory management is the products' allocation which was also assessed taking into account the policies adopted.

The constant entry of new players is generating a highly competitive market, which means MUSA has to be more efficient to first go along with them, and in the future be always one step further. Also, the strong expressions from the two main players operating in the Portuguese market is also a challenge and taking out some of their market share is a tough task. Accordingly, this project aims at helping MUSA's improving its performance in terms of warehouse and inventory management of raw-materials. Particularly, the aim is to propose and evaluate alternative inventory management policies as well as assess SKU (Stock Keeping Unit) allocation in the warehouse.

1.2. Objectives

The main objective of this project is related to the improvement of warehouse and inventory management activities, including the management of inventory of raw materials at MUSA's warehouse. This was achieved by defining inventory management policies for the different raw materials, as well as by assess SKU allocations in the MUSA's company.

Considering this main goal, some specific objectives are defined:

i. Describe and assess the MUSA's warehousing and inventory management activities;

ii. Propose and evaluate alternative inventory management policies;

iii. Assess the current warehousing storage space availability for raw materials and finished products;

iv. Disclose final improvements guidelines.

1.3. Research question

The research question within the scope of the presented project is:

- How to improve MUSA's warehousing and inventory management activities so as to improve its efficiency?

1.4. Methodology

The methodology followed in this project is a methodology by case study because, according to Yin (2017), it has the next features:

i. The key research question is a 'how' question;

ii. The researcher has little or no control over the behavioral events;

iii. The focus of the study is a contemporary phenomenon (as opposed to entirely historical).

In the scope of this case study, the following steps were adopted in order to achieve the objectives presented. It first started with the information collection and its analysis. Afterwards, the MUSA's current situation was described in order to propose stock management policies and then measure its impact in terms of warehousing products allocation. Finally, the results and conclusions were presented. Namely, the research steps further developed are:

Step 1 – Current warehousing and inventory management analysis;

Step 2 – Proposals of improvements within inventory management activities;

Step 3 –SKUs storage space assessment;

Step 4 – Final recommendations

1.5. Scope of the project

This project analyses part of the logistics MUSA's activities. Those are regarding warehousing and inventory management, considering out of scope the transport management, information processing and packaging & unitisation. The warehousing activities under study are sizing and dimensioning, and operation strategy allocation, excluding the overall structure, department layout and equipment selection. According to

the inventory management activities it only considers storage. Regarding the raw materials under analysis, glass bottles, bottle caps and labels were not considering.

1.6. Structure of the project

Considering all the objectives this project purposes to, it is based on a structure with five chapters. The structure is described below.

The first chapter introduces the project itself, its purpose and why it is meaningful in the context. Here is also presented the problems it aims to help answer.

In the second chapter, the three main concepts used during the research are presented. Particularly, it starts by describing logistics, and then the inventory management and warehousing definitions as well as its application in the beverage industry.

The forward chapter takes the reader to the methodology of the project.

The fourth chapter is the data analysis, which starts by presenting in detail MUSA's warehousing and inventory management activities, followed by the application of the research steps proposed in the third chapter, together with the key results obtained.

The final chapter encompasses the final conclusions and recommendations to proceed in future researches.

2. LITERATURE REVIEW

This section presents the definition of the concepts used during the project under different authors' perspectives. It is clarified the overall concept of logistics, its origin, importance and the underlying activities. From these activities, the project focus in two main elements: warehousing and inventory management. These are described in more detail in the further sections. For each of these it is presented the definition, models and typologies that may be followed to support the management at those levels, as well as the points of emphasis throughout this study that mostly adequate to final goals. It is also mentioned studies in different industries that had explored the same in-scope problematics, including the industry of this work.

2.1. Logistics overview

The term logistics has been much more widely recognized by the general public in the last years (Coyle *et al*, 2003). Nowadays, the corporate business is full of challenges since it faces competition from multiple dimensions and directions. Michael Porter refers that businesses from this century can only survive and succeed if it is able to face the challenges of the present demands regarding logistics. Companies that could not provide proper logistics for its products and supply the final consumer in time it is demanded for, has lost its reputation in the business world, no matter how good is its product. (Neeraja *et al*, 2014).

The word logistics has its origins on the military times where there was an organized structure responsible for the supply of necessary arms, ammunition and rations, as well as when they were needed (Islam *et al.*, 2013) . Different definitions of logistic exist:

i. According to the definition of the Council of Supply Chain Management Professionals, logistics is "*that part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption in order to meet customer requirements*".

ii. Rushton *et al.* (2011:6) defines logistics with an appropriate modern definition that applies to many industries, being "*the efficient transfer of goods from the source of supply through the place of manufacture to the*

point of consumption in a cost-effective way whilst providing an acceptable service to the customer".

According to Islam *et al.* (2013) there are five key logistics elements, as shown in figure 1, including the transportation of goods from one point to another, warehousing activities, inventory management, packaging, and information processing. The scope of this work is on warehousing and inventory management, so the next sections are devoted to these subjects.

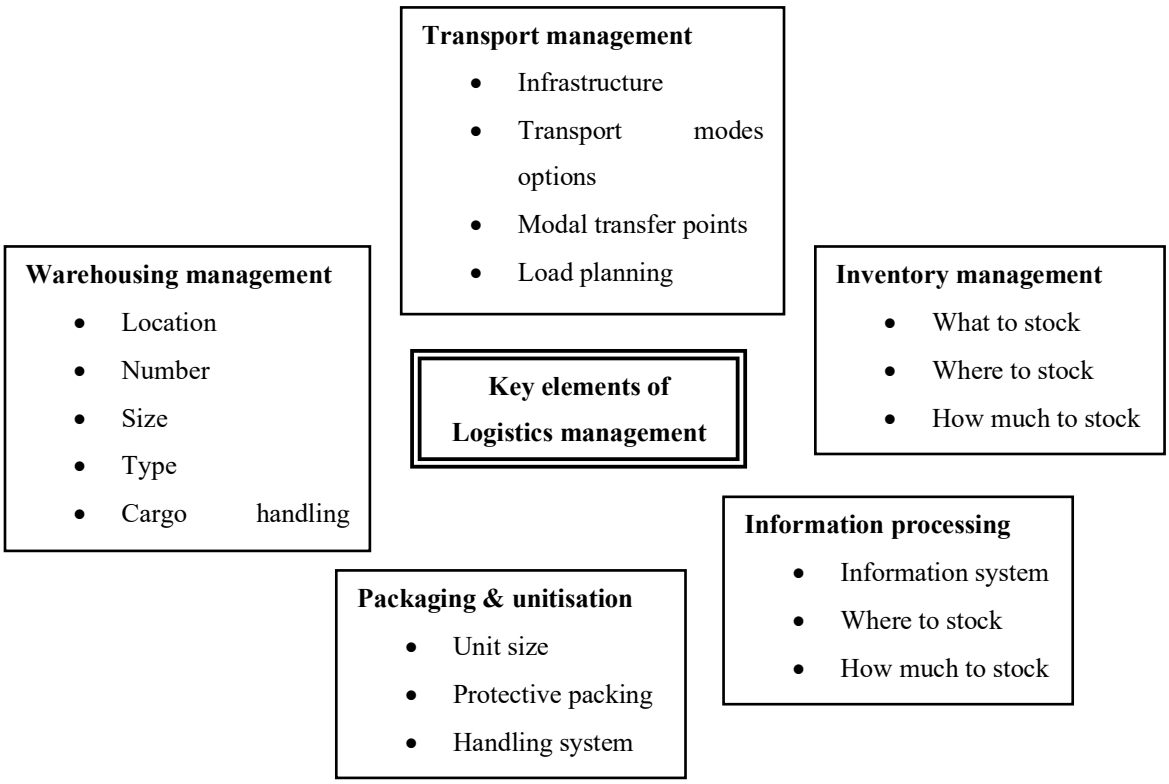

Figure 1 – Key elements of logistics

Source: Adapted from Islam *et al.*, (2013:3)

2.2. Inventory Management

Inventory management is a fundamental part of the logistics management process. It comprises many activities as the administration of raw materials, sub-assemblies, manufactured parts, packing materials, and in-process inventory (Lambert *et al.*, 1998).

The term inventory can be defined as stocks that are held to be used or sold in a future situation (Onanuga *et al*, 2014). If companies do not have a robust inventory system, they will not be able to forecast demands with any kind of accuracy (Onanuga *et al*, 2014). Its main goal is balancing the stock quantity on hold and the time it remains idle to hence control the costs incurred, such as obsolescence costs, etc. (Christopher, 2011). Each organization allocates a considerable amount of capital on materials, exceeding in many cases fifty percent of the total cost of goods produced, which requires a heavy planning and control to reduce the waste impact. The inventory system will directly affect the efficiency of the production, the customer service, the ability of the firm to compete in the market, and the level of sales and profits the firm is able to achieve. Poor materials management can result in stock outs at retail, causing customers to seek substitutes or shop elsewhere (Asaolu *et al.*, 2012). Thus, an effective and efficient inventory system management could result in a reduction of operating costs (Setyaningsih *et al*, 2013).

The next sub-sections are devoted to theoretical part of tools and techniques applicable to this project in terms of inventory management. Managers' objective is to have enough stock quantity to be able to answer customers' requests in a timely fashion, which is hard to achieve when the product requires weeks to be produced. Therefore, they want to change from a make-to-stock to a make-to-order strategy. Considering the smallness of the business in its very beginning and the reduced experience that leads to higher levels of uncertainty they also want to have safety stock to face unexpected situations. ABC classification will be performed considering the need of having a prioritized stock to then attribute the adequate stock management policy. The section ends with a studies' review applicable to the industry.

2.2.1. Inventory policies

One of the steps in inventory management is the stock management policy. According to Carvalho (2017), it works has a necessary input to warehouse dimensions

because the stock policy adopted to each item allows to know the warehousing stock which is necessary to determine the storage space.

In order to check what is the most suitable review model, whose decision depends on the existence or not of random demand and supply, the following aspects should be considered, according to Carvalho (2017):

i. In the supply perspective, if the lead time is fixed and accomplished, it means there is no randomness, i.e., it is deterministic. If the supplier has variable lead times, it represents a random behaviour;

ii. On the demand side, i.e., according to the customer point of view, if the demand quantity is known, it is deterministic, and if it is not, the demand is random.

So, two major groups can be defined: deterministic review models and stochastic review models.

From the Onanuga and Adekunle (2014) point of view, inventory control models can be splitted into three models: deterministic continuous inventory model, considered as the basic Economic Order Quantity (EOQ); the EOQ model with planned shortages; and stochastic continuous model. The first and last models have the same idea as Carvalho (2017) present in his literature but these authors add a different one. That added model allows planned shortages (unlike the basic EOQ), meaning that when a shortage occurs the customers' orders affected will have to wait for the stock to be available.

For the purpose of this project, the nomenclature proposed by Carvalho (2017) is the one used.

2.2.1.1. Deterministic Models

In order to decrease the waste and reduce the major costs associated with inventory, it is necessary to compute the right quantity to be ordered which is referred to as "Economic Order Quantity" (Onanuga *et al.*, 2014).

The EOQ model is a deterministic model where it is not possible to have any kind of variability. So, the demand and supply have to be stable and known. It is then subdivided into three models: Economic Order Quantity which is the quantity that minimizes the stock holding costs and ordering costs; Economic Order Quantity with quantity discounts which requires an analysis of the commercial discount impact in the stock management and has as assumption that the acquisition unitary cost does not change with order quantity; and Economic Order Quantity without instantaneous stock

reposition, where stock entrance and exit occurs at the same moment, demand and stock replenishment are constant overtime. The stock replenishment in the first two cases is instantaneous when the delivery occurs at once, at the time agreed by supplier and customer (Carvalho, 2017).

2.2.1.2. Stochastic Models

These models are designed for situations in which there is demand and/or supply uncertainty. The possibility to have stock outs under demand and/or supply uncertainty is greatly increased, and so a safety stock is needed in order to overcome this possibility. The higher the safety stock, the better the answers' capacity. This safety stock depends on the service level a company wants to offer, and this service level defines the chance of satisfying the order requests in the quantity and moment desired (Carvalho, 2017). According to Carvalho (2017) there are two main stochastic models, as described below.

Continuous Review Model

This model is an adaptation to the EOQ and it works the same way, but it considers the need for a safety stock so as to deal with uncertainty. The stock is continuously verified and when it achieves the re-order point it means that it is necessary to place an order to the supplier. The higher the imposed service level, the lower the probability of stockout, and the higher the safety stock as well as the re-order point. The reorder point is the average demand during lead time plus the safety stock.

With random demand and supply, the company should negotiate lead times to avoid variability from the supply side. The order quantity should minimize total costs, with this cost including purchasing, ordering and holding costs (similarly to the EOQ model described earlier). In fact, this cost can also include the stock out cost, which is the one a company incurs whenever it is not possible to deliver one unit (Carvalho, 2017).

Continuous review model is capable of providing inventory savings than periodic review policy. The advantage of this policy is to allow updating inventory quantities in real time, so it will be easier to know when reorder products in the future. Moreover, it could provide an accurate accounting calculation, because the system could provide the costs of goods sell in real time. On the other hand, the weakness is the time spent to keep inventory updated (Setyaningsih *et al.*, 2013).

Periodic Review Model

According to Periodic Review models, orders are placed in pre-defined and fixed periods of time. The amount to order is calculated based on the difference between the stock on-hand and the target stock. The period between orders should be as much as close to the Economic Period between Orders (EPO) (Carvalho, 2017).

The advantage of this model is the reduced time spent by the person in charge of analysing the amount of inventory. The less positive points are on the inaccuracies when determining the amount of inventory if a business have high sales volume (Setyaningsih *et al*,, 2013).

2.2.2. SKUs classification

Organizations need an appropriate inventory control, and for that they have to find the right stock management policies adapted to the different items. Therefore, as inventory items have different importance levels to the company, they should be classified into categories based on appropriate criteria and standards.

Various methods and models have been so far presented to classify inventory, such as, VED (labels products as vital, essential or desirable), AHP (analytical hierarchy process), FSN/FNS (Fast, Slow and Non-moving/Fast, Normal and Slow moving) between others (van Kampen *et al,* 2012), among which, ABC analysis approach is widely used for planning and inventory control (Karthick *et al.*, 2014). Thus it is the method applied in this project.

It also has a direct application in inventory management due to its important role on inventory planning and control of raw materials, component parts, subassemblies, and goods-in-process as well as finished goods inventory (Lambert *et al.*, 1998).

ABC analysis comes up when classifying products in classes. There are goods that should be assigned with a higher priority than others, so there is a need to organize them into classes so as to then apply the right management policy. Thus, this methodology sets three classes, as the name indicates: class A – most relevant items, class B – middle importance and class C – less significant. According to Carvalho (2017), items can be organized in warehouse following the criteria: number of movements of entry and exit, rotation, volume (m^3), invoicing and combination of these and other methods that can originate ratios (Carvalho, 2017). Usually, this approach is based on the Pareto Principle which is also known as “20-80” law. It says that in the manufacturing organizations, there

are only a few inventories which mostly contribute to the cost of the annual consumption of the organization's inventory system while other inventories have a little contribute to the annual consumption of the inventory system. (Karthick *et al.*, 2014).

This tool has potential to be used to find the right stock management policy for different products categories (Carvalho, 2017):

i. The ones that belong to the first class (A) are highly demanded and valuable. These are the strategic goods that are key to keep the business working, so they should have a higher service level following a continuous review in order to take more control over them;
ii. For the class C items, the best model is the periodic with larger review periods, because they have a less financial weight. So, a simpler stock management policy is enough;
iii. In the B class items, both models can be used, continuous or periodic revision, but in this case with shorter periods between orders, revealing its bigger importance comparing to C items.

2.2.3. Inventory management in the food & beverage industry

There are some published industrial researches, which provide applications of the inventory management methods in practical contexts. Those studies are mentioned below.

The authors Sensi, Longo and Mirabelli (2008) studied a real three-echelon supply chain operating in the beverage sector. The main goal was to compare the actual supply chain structure with optimistic and pessimistic scenarios for analysing the behaviour of different stock management policies and optimizing the inventory system of each part of the supply chain. Results showed that the policy based on optimal review period show a better behaviour when demand has low variability. The continuous review policy presents better results when demand is more variable.

The authors Setyaningsih and Basri (2013) compared the use of inventory policy in formula and enteral food supply. The results demonstrated that all of formula and enteral food supply under study should use periodic review model because the demand of these products is not really high compared to the other food supplies.

The authors Danneke (2006) and Adeyemi and Salami (2010) applied the EOQ model whose aim was having a better control over inventory. Conclusions in using this model was that companies are able to have a well-built policy are able to get the necessary stock without incurring unnecessary costs.

Emeka (2014) assessed the impact of materials management on profitability of Nigeria brewing companies. The conclusion was that materials procurement and storage have significant effect on profitability of brewing companies. It was also discovered that materials inventory is an integral part of profitability in brewing companies and that interdepartmental collaboration considerably contributed to brewing companies' profits. The main finding was that effective materials management is crucial to brewing firms in creating profits.

Smith (2011) and Karthick *et al.* (2014) consider the ABC classification for items. The objective was to better plan and estimates inventory. Conclusions were that effective applications of ABC analysis brings many benefits to most companies, in terms of costs reduced, and should insure the efficient use of working capital funds and enable the company to consistently provide a quality product to the customer.

2.3. Warehousing management

Over time, warehousing has gained importance within the logistics system. Currently, it is a fundamental part of every logistics chain. It bridges the producer to the customer, due to its vital role in providing a desired level of customer service at the lowest possible total costs (Lambert *et al.*, 1998).

Warehousing is defined as "*that part of a firm's logistics system that stores products (raw materials, parts, goods-in-process, finished goods) at and between point of origin and point of consumption, and provides information to management on the status, condition, and disposition of items being stored*" (Lambert *et al.*, 1998: 266).

Warehouses are a key aspect of modern supply chains and play a vital role in the success, or failure of businesses today. It is defined as any location where stocks of material are held on their journey through supply chains. As well as storage, warehouses can be used for a number of other activities. It is expensive to run and need careful planning (Waters, 2003). Their presence in the supply chain becomes essential due to the fact that supplier lead times cannot be reduced cost effectively to the short lead times required by customers, and hence these customers need to be served from inventory than to order (Baker *et al.,* 2009).

2.3.1. Types of warehouses

Warehouses can assume different roles within the supply chain. Its nature depends on the type of product as well as its stage along the process.

According to Berg and Zijm (1999), warehouses can be distinguished in three other types:

- Distribution warehouses: hold products from many suppliers to then deliver to different customers.
- Production warehouses: store raw materials, semi-finished products and finished products in the production facility.
- Contract warehouses: holds inventory from more than one customer and performs the warehousing activity on behalf. It usually occurs when this service is subcontracted.

According to Frazelle (2016) there are three types of warehouses:

- Raw material and component warehouses: contain raw materials at its point of induction into a manufacturing or assembly process.
- Work-in-process warehouses: stores partially-finished products at various stages along an assembly or production line.
- Finished goods warehouses: hold products ready to be sold. These warehouses work as a buffer regarding variations between production and demand.

The company under analysis has its own production and thus works with raw materials and finished goods. According to the classification of the last author, the warehouse assumes two typologies, raw material and finished goods, and so this is the focus along the project.

2.3.2. Warehousing planning levels

As mentioned by Gu *et al.* (2010), warehouse design planning includes five main decisions as illustrated in figure 2: the overall structure, the department layout, the operation strategy, the equipment selection and the sizing and dimensioning. These activities are all interrelated between them.

- *Overall structure* (or conceptual design) determines the material flow pattern within the warehouse, the specification of functional departments, and the flow relationships between departments.

- *Sizing and dimensioning* decisions determine the characteristics of the warehouse as well as the space allocation among various warehouse departments.
- *Department layout* is the detailed configuration within a warehouse department, for example, aisle configuration in the retrieval area, pallet block-stacking pattern in the reserve storage area, and configuration of an Automated Storage/Retrieval System (AS/RS).
- *Equipment selection* decisions determine an appropriate automation level for the warehouse, and identify equipment types for storage, transportation, order picking, and sorting.
- *Operation Strategy Selection* determines how the warehouse will be operated, for example, with regards to storage and order picking. Operation strategies refer to those decisions about operations that have global effects on other design decisions, and therefore need to be considered in the design phase.

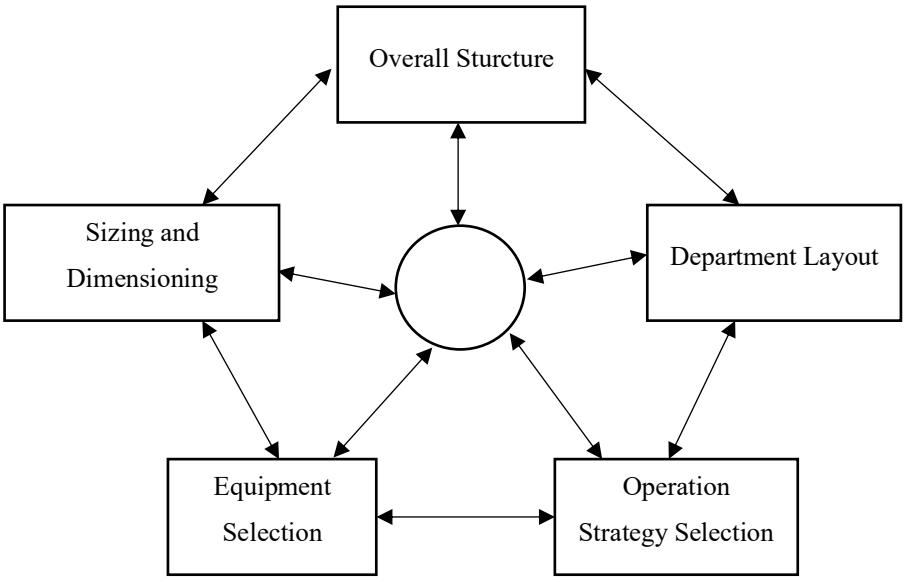

Figure 2 – Warehouse design
Source: Adapted from Gu *et al.*, (2010: 540)

Taking into the account the activities in scope, the planning levels further analysed in this project are sizing and dimensioning, and operation strategy selection. Next section's purpose is to define the storage and picking activities, since the planning of these activities is performed at an operation strategy selection level.

2.3.3. Warehousing activities

From the arrival of an order to the warehouse until its exit, there are many procedures to accomplish: receiving, buffering, storage, order picking, handling, maintenance and shipping materials (figure 3) (Jacyna *et al.*, 2015).

This project is focused on improvements in terms of the allocation of SKUs in the warehouse. A review on the types of storage is useful since inventory management policies for each item are influenced by the warehouse space available. Thus, this allocation is impacted by the storage activities, and so this is the focus and is further detailed below.

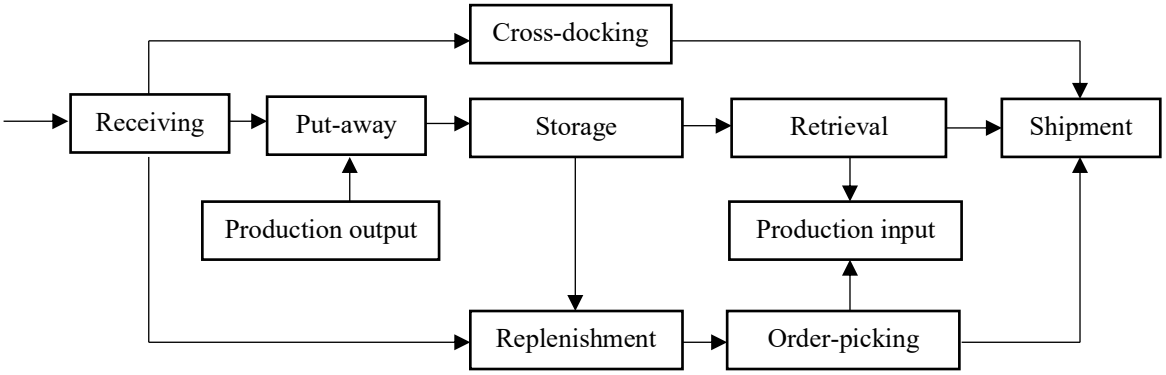

Figure 3 – Typical elements of warehousing process.
Source: Adapted from Jacyna *et al.*, (2015: 49).

2.3.3.1.Storage

Storage is concerned with the organization of goods held in the warehouse in order to achieve high space utilization and facilitate efficient material handling (Gu *et al.*, 2007).

Types of storage

According to different authors, the reader can find many designations for the types of storage. Below it is described some authors' perspective on this typology.

In the storage activity, Carvalho (2017) designates three storage types: random location, fixed location, and mixed location.

Random location storage allocates each item to a storage place arbitrarily designated. As different references are not located in the same place, the need of a higher organization and control will need to be in place as the products movement. This option is sometimes less advantageous because it can lead to the distance increase in the picking

process. On the other side, it is a good method because it provides an efficient space usage, as well the particularity of its flexibility to fill the space available (Carvalho, 2017).

Fixed location storage assigns the items always in a fixed area, which can be previously settled according to some criteria. A disadvantage is the space left because of the products allocation – the dimensions are created to support the maximum stock and most of the times that stock level is never reached. Another disadvantage is the difficulty to increase the storage area since it is a static system (Carvalho, 2017).

Mixed location storage is a result of the combination of the above criteria. It saves products according to any pre-defined criteria (fixed location) and inside each zone items are stored randomly (Carvalho, 2017).

Dekker *et al.*, (2004) sets three widely used methodologies, random storage, dedicated storage and grouped storage, whose definitions are pretty similar when comparing to the previous author.

Besides random and dedicated storage methods considered by Carvalho (2017), (De Koster *et al.*, 2007) considers more three methods: closest open location storage, full turnover storage and class based storage. In the first, products are stored in the first empty location found, which commonly leads to a full occupation in the depot area and more spaces available at the back. The full turnover organizes storage as the turnover level. Products that record more sales are located at the easiest accessible zone which is usually near the depot. The opposite occurs for the slow-moving items. The class-based storage combines the methods referred before and groups the products according to its popularity as it was explained previously in the section 2.2.2. (SKUs classification).

For the application of some of the above typologies it is required a criterion to follow in the storage activity. Some of the widely used are: rotation, volume, and ratio between volume and number of entry and exit movements. The last one is the two firsts methods working together which result in a mixed method where the storage is subdivided into different areas and the items are organized according to the criteria already established, combined with the possibility to locate them randomly inside that area (Carvalho, 2017).

Throughout the project the Carvalhos' typologies are the ones adopted. For the case of this project the type of storage is fixed location since the SKUs are currently organized in a dedicated area which is under controlled temperatures for two of the three SKUs and for the other there is also a pre-defined space in the warehouse.

2.3.4. Warehousing in the beverage industry

Gu et al. (2010) says there are some published industrial case studies, which provide applications of the various design and operation methods in practical contexts. Those studies are mentioned below.

Graves, Hausman and Schwarz (1977) compare random storage, dedicated storage, and class-based storage in single-command and dual-command AS/RS using both analytical models and simulations. They show that significant reductions in travel time are obtainable from dedicated storage compared with random storage, and also that class-based storage with relatively few classes yields travel time reductions that are close to those obtained by dedicated storage.

Zeng, Mahan *et al.* (2002), van Oudheusden *et al.* (1988) investigated problems associated to storage location assignment, each one in a different type of warehouse and, apart from that, conclusion was that substantial benefits can be achieved by appropriately designing and operating a warehouse .

Although, Gu (2010) also refers that there is a significant need for more industrial case studies in the field of warehouse design.

2.4. Warehousing and inventory management in the brewer industry

Some authors have been recently developing research including inventory management and warehousing applied to the brewer industry in particular. Below are mentioned some of those studies.

Kao *et al.* (2018) applied the ABC classification in order to develop storage strategy of goods in a beverage company. The aim was to increase the efficiency of storage management. The author also adopts the EOQ stock control model for the stock management of beverages to determine the appropriate ordering level and safety stock and minimize stock cost. Conclusions are about the essential role that inventory storage and maintenance play in the processes of warehouse operation management.

Gallmann *et al.* (2011) performed a case-based analysis to understand how best performing companies strive to improve their service levels, under the assumption that not only inventory management but also warehouse management plays a key role in achieving this goal. The empirical analysis shows that this holds when the companies deal with a very high number of SKUs and they need to properly manage warehousing process to guarantee fast, complete and correct deliveries to customers. For the case of this study,

the company has few SKUs but the aim is also to guarantee fast, complete and correct deliveries to customers, making thus sense to gather both, warehousing and inventory management.

Based on the literature review that was performed, and according to the author's knowledge, there is a clear lack of studies combining research on warehousing and inventory management issues in the brewer industry. Thus, this project aims at supporting warehousing and inventory management decisions in the brewer industry.

2.5. Contribute of the project

Based on the literature review presented above, it is possible to conclude that the contribute of this project is two-fold. First, this project contributes to the daily practice of MUSA's company, by proposing different solutions that have potential to improve its performance in terms of both warehousing and inventory management activities. Secondly, it contributes to the scientific literature in the area by combining proposals of improvements in terms of both warehousing and inventory management in the brewery industry, which is not a common practice in the area.

3. METHODOLOGY

This section is divided in two parts. The first part classifies the methodology used in this project and the second includes a description of each case study step.

3.1. Methodology

According to Yin (2017), this is methodology by case study, since it accomplishes the following:

i. The key research question is a ‘how’ question;
ii. The researcher has little or no control over the behavioral events;
iii. The focus of the study is a contemporary phenomenon (as opposed to entirely historical).

This is an explanatory case study because a "how" question is being asked about a contemporary set of events over which the investigator has little or no control.

This is a single-unit case study because it is only one case that will be used to address research question. Furthermore, it is justifiable under certain conditions, it represents a critical test of existing theory, and it is a unique event.

3.2. Case Study Research Steps

As shown in Figure 1, this study involves four research steps. The first comprises the data collection and its analysis, through field direct observation and interviews to the company’s founders.

The second is the application of the methods mentioned previously to improve the efficiency of the company in terms of inventory management. The step after concerns the warehousing operation strategy selection in terms of storage and also the sizing and dimensioning. This third step is more qualitative. The last step is the recommendations considering the conclusions of the previous steps.

Thus, next sections are devoted to the explanation of each of the steps.

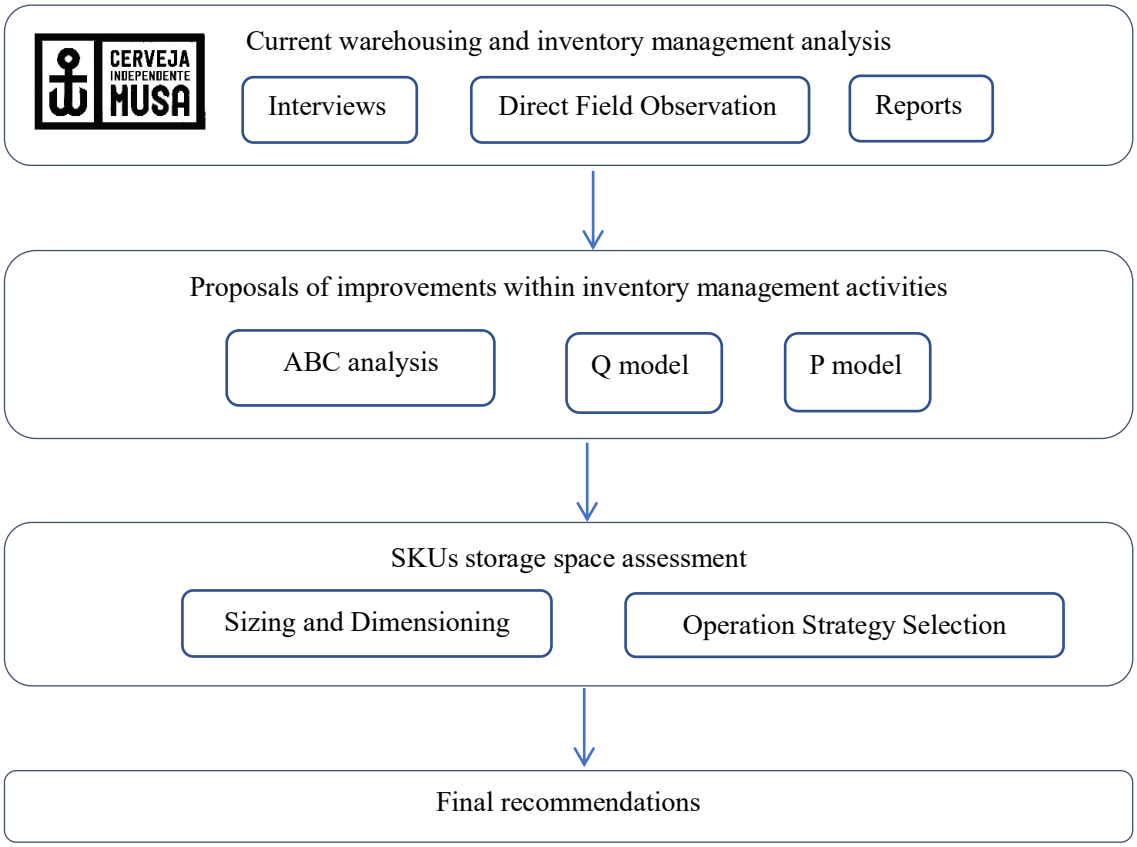

Figure 4 – Methodology Structure

3.2.1. Step 1: Current warehousing and inventory management analysis

The first step of the methodology is the description of the current warehousing and inventory management activities at MUSA's warehouse. For the accomplishment of this step many information was collected. Company's official documents such as the warehouse plant and orders invoices were used to analyse the layout and to get information regarding the products respectively. Direct field observation was done to get notion about company's organization and layout. Semi-structured interviews directed to the managers were used in order to gather information about goals and perspectives regarding warehousing and inventory management. Focus group is also part of this step- in order to argue about the tools and methods performed. Many related information is gathered in this phase, such as:

- Warehouse type;
- Equipment used in warehousing activities;
- Storage methods used;

- Existing storage materials;
- Level of automation of the warehouse;
- Layout distribution (storing area occupied, offices, production area, etc);
- Warehouse plant;
- Sales history over a period;
- Stock management policies adopted.

The current process of inventory management at MUSA is as follows:

Figure 5 – Inventory management procedure

3.2.2. Step 2 – Proposals of improvements within inventory management activities

This step involved the setting of inventory management policies. Two distinct phases were required to perform this step. A first one to collect data need and a second one for the calculations. Thus, current problems were described, to then present improvement proposals and final results. In order to perform the calculations required for this settlement, the following data was collected on the first phase:

- supplier lead times,
- company's holding and ordering costs,
- acquisition costs by SKU and
- sales volume of finished product.

The methods used in this data gathering were structured, semi-structured interviews and reports.

Afterwards, the calculation of the economic order quantity was made under different models. Accordingly, based on the literature review presented above, different models may be suggested:

i. The Q model, i.e., the fixed order quantity model or continuous review model, should be used when the quantity to order is always the same and when period between orders can change each time. This could be used for

the most important items, which in ABC analysis are the "A" category. The formulas for the calculations under this model are presented below.

- **Economic Order Quantity (units):**

$$(1) \qquad Q^* = \sqrt{\frac{2 \times D \times S}{H}}$$

D : Average demand

Q : Order quantity (units)

S : Order cost per unit (euros per order)

$(H = i \times c)$: Stock Holding Cost per unit (euros per unit per year)

- **Demand standard deviation during lead time (units):**

$$(2) \qquad \sigma = \sqrt{\bar{L} \times \sigma_d^2 + D^2 \times \sigma_L^2}$$

σ_d : Demand standard deviation (units per day or week)

σ_L : Lead time standard deviation (days)

$\bar{L}$: Average lead time (days)

- **Reorder Point (units):**

$$(3) \qquad R = D \times L + z \times \sigma$$

$(ss = z \times \sigma)$: Safety stock (units)

z : service level

- **Annual Acquisition Cost (currency units):**

$$(4) \qquad \bar{D} \times c$$

- **Annual Ordering Cost (currency units):**

$$(5) \qquad \frac{\bar{D}}{Q} \times S$$

- **Annual Holding Cost (currency units):**

$$(6) \qquad \left(\frac{Q}{2} + ss\right) \times H$$

- **Total Costs (currency units):**

$$TC = \overline{D} \times c + \frac{\overline{D}}{Q} \times S + \left(\frac{Q}{2} + ss\right) \times H \quad (7)$$

ii. The P model, i.e., the fixed time period model or periodic review model may be used for the cases where the quantity to order is not fixed and the periods between orders' (P) colocation is pre-established with the supplier. This is usually used for "C" category products, which have less impact. The formulas for the calculations under this model are presented below. The order quantity corresponds to the difference between the target stock (T) and stock available at the moment.

- **Target stock (units):**

$$T = D \times (L + P) + z \times \sigma_{P+L} \quad (8)$$

($ss = z \times \sigma_{P+L}$) : safety stock (units)

z : service level (%)

L : Lead time (days or weeks)

P : Period between orders (days or weeks)

- **Demand standard deviation during the period $P + L$ (units):**

$$\sigma_{P+L} = \sqrt{(P + \bar{L}) \times \sigma_d^2 + D^2 \times \sigma_L^2} \quad (9)$$

- **Order quantity (units):**

$$Q = T - Available\ Stock \quad (10)$$

- **Annual Acquisition Cost (currency units):**

$$\overline{D} \times c \quad (11)$$

- **Annual Ordering Cost (currency units):**

$$n \times S \quad (12)$$

- **Annual Holding Cost (currency units):**

$$\left(\frac{\overline{D} \times P}{2} + ss\right) \times H \quad (13)$$

- **Total Costs (currency units):**

$$TC = \overline{D} \times c + n \times S + \left(\frac{\overline{D} \times P}{2} + SS\right) \times H \quad (14)$$

In this project both policies were analysed and thus two proposals were presented. A first proposal considered the continuous review model (Q model) which has fixed quantity to all the raw materials. The logic is on the support provided to the company regarding their current situation of ordering an approximated fixed quantity for all their products. A second proposal, which sets a different policy - continuous and periodic review - for each raw material, makes sense due to the different consumptions the raw materials have between them. This suggestion presents the most adequate policy depending on the importance of each raw material. This importance is achieved based on a ABC classification, further mentioned. This method is widely used as concluded from literature review section 2.2.2.

Accordingly, the step after was the ABC analysis. This method was performed in order to have the SKUs prioritized in terms of importance. The steps to perform this analysis were the following:

- List each product in descending order according to product usage value (order according to any other criteria that could be used)
- Total up the usage value of all the SKUs
- Compute the weight percentage of each SKU on its total
- Calculate the cumulative weight percentage of the previous step
- Calculate the weight percentage of items per SKU
- Compute the cumulative weight percentage of items per SKU

Considering this last cumulative weight percentage of items per SKU, the classification should be as follows:

- Attribute the letter A to the SKUs that weight until 20%
- Classify as B the SKUs weighting between 20% and 50%
- Categorize as C SKUs whose weight is above 50%

Once this analysis is accomplished, adequate policies could be attributed to each SKU, based on what was mentioned before on 3.2.2.i. and 3.2.2.ii.

3.2.3. Step 3 – SKUs storage space assessment;

In the third step an impact assessment of proposed policies for raw materials on space available in the warehouse was performed. This analysis was done to provide the managers information about whether the current space available is enough to store all the SKUs used in production or if related future investments are needed considering the conclusions retrieved from the EOQ quantities calculated previously. Also, the same assessment for finished products was done once the company want to change from a make to order to a make to stock strategy.

Two main phases were accomplished to achieve the results.

The first stage implied the collection of information about storage spaces availability and organization in the warehouse. This was getting through direct field observation and interviews to MUSA's managers. Afterwards, data about areas was retrieved from the company's plant official document provided by the managers.

A second part included the calculations of maximum stock of raw materials and respective maximum capacity as well as maximum warehouse inventory of finished products and its dedicated areas capacity.

3.2.4. Step 4 – Final recommendations

Based on the results of step 3 final suggestions according to inventory management policies are proposed, against the current MUSA's warehouse scenario. Also, based on the results of the step 4, recommendations on warehousing operation strategy and sizing and dimensions are provided.

4. CASE STUDY

This chapter starts by presenting the studied company and how the business started. A description of its current situation regarding its activities, products and logistical procedures, and also its main suppliers and clients is presented. Afterwards and according to methodology steps, data collected and analysed is displayed in this section related to orders, warehouse layout, warehousing activities, products allocation and space usage. The current status of inventory management is assessed and inventory management policies for each SKU of raw-material are achieved. Also, in the warehousing matter, operation strategy and sizing and dimensioning are analysed. Then, using the information obtained in the data treatment step, quantitative and qualitative methods are applied. Finally, proposals of improvements are presented to then provide final conclusions and suggestions of improvements.

MUSA History

The company has born associated to two friends thinking that it was time to drink even better beer in Portugal when they were travelling. And it was there, in 2016, that the idea came up and the receipt for the MUSA beer was found. The two co-founders are Bruno Carrilho, who is also CEO, and Nuno Melo, who is CFO as well. They are looking for producing four main types of beers. The first one is "*Mick Lager*" which is lighter in terms of alcohol and it is more similar to the industrial ones, despite having characteristics of a craft beer. "*Red Zeppelin Ale*" is a bit stronger beer than the first one, and a bit acid, and it is in the middle in terms of taste, between the previous and the next. The stronger is called "*Born In The IPA*", India Pale Ale, a type of hop beer from the biggest range of pale ale which has a sharp bitterness and has more alcohol percentage. Its origin is in the British trips to India where it was too warm to keep beer, so they created a stronger one with more hop to last longer. A different type is the "*Twist and Stout*" that is a dark beer but it is soft at the same time. The company team is composed by eight people, including the co-founders and a brewer (*MUSA*, no date).

Currently they deliver their products through more than thirty final distributors, in the Horeca (Hotel/Restaurant/Cafe), mass market and retail (food and small home appliance) channels. MUSA beer is spread from the south until the north of Portugal.

The challenges and expected results since the beginning of their activity are:

- Achieving the leader position as craft beer company in Portugal in the next three years;
- Achieving the Iberian top five in five years in terms of market share;
- Achieving a sales volume of 5 million, approximately, in 5 years and 25 million (approximately) in 10 years.
- Achieving a number of 3,500 sales points through HORECA channel in Portugal and Spain in five years and increasing this number to 15,000 in ten years.
- 2/3 of the exported productions of five years, with extension to more than five foreign markets.

4.1. Current warehousing and inventory management analysis - Step 1

This section presents a description of company's current situation regarding human resources, warehouse organization, layout and operating procedures, equipment and machinery available. All this information was collected through interviews directed to Bruno Carrilho (CEO), Bárbara Simões (Marketing Manager) and Sara Silvestre (Quality manager) and direct field observation. The questions that provide the input information for this step were (see appendix 10 for further details in interview guide and appendix 11 for respective report):

- What are the goods used to produce the final product?
- What is the safety stock for each SKU?
- What is the service level actually provided?
- How is suppliers' answers capacity? Namely lead times?
- Do you categorize your SKUs following any criteria?
- What are the warehousing dimensions?
- What includes your warehousing system?
- What is the warehouse typology in terms of temperature?
- How do you currently organize the orders?
- What is the criterion used for products location in the warehouse?
- What are your main objectives?
- What are the main goals/challenges in terms of warehousing and inventory management?

4.1.1. Human Resources

The company started with two partners who then expanded their team. The team is, today, composed by fourteen elements, including them. Between them, 12 are working in the warehouse. Those are:

- Marketing department: 2 people
- Financial department: 2 people
- Sales department: 2 people
- Production/Quality department: 6 people

4.1.2. Layout

Figure 6 shows the company's plant. In order to summarize layout areas, the plant was separated in three parts (A, B and C). This includes:

- Reception/ bar (A): reception and taproom area to welcome clients who want to do business and/or enjoy a beer or eat something, a kitchen, a space dedicated to store stuff that gives support to the bar, female and male toilets and toilets' antechamber;
- Warehouse and production (B): include a staff toilet, men's and women's clothing, shower, circulation area which give access to the previous ones, production area, malt storage area, a refrigerator area to store hops and yeast storage area, kegs storage area, finished bottle area, empty bottle area and bottling area;
- Offices and other (C): area at the back of the warehouse, which contains the offices and an area reserved as trash deposit.

For a more detailed look into each of these areas see appendix 6.

Table 3 – Main plant areas

Area	Dimension (square meters)
Reception/Bar (A)	103,2
Production/Warehouse (B)	301,43
Offices and other (C)	30,48
Total	434,93

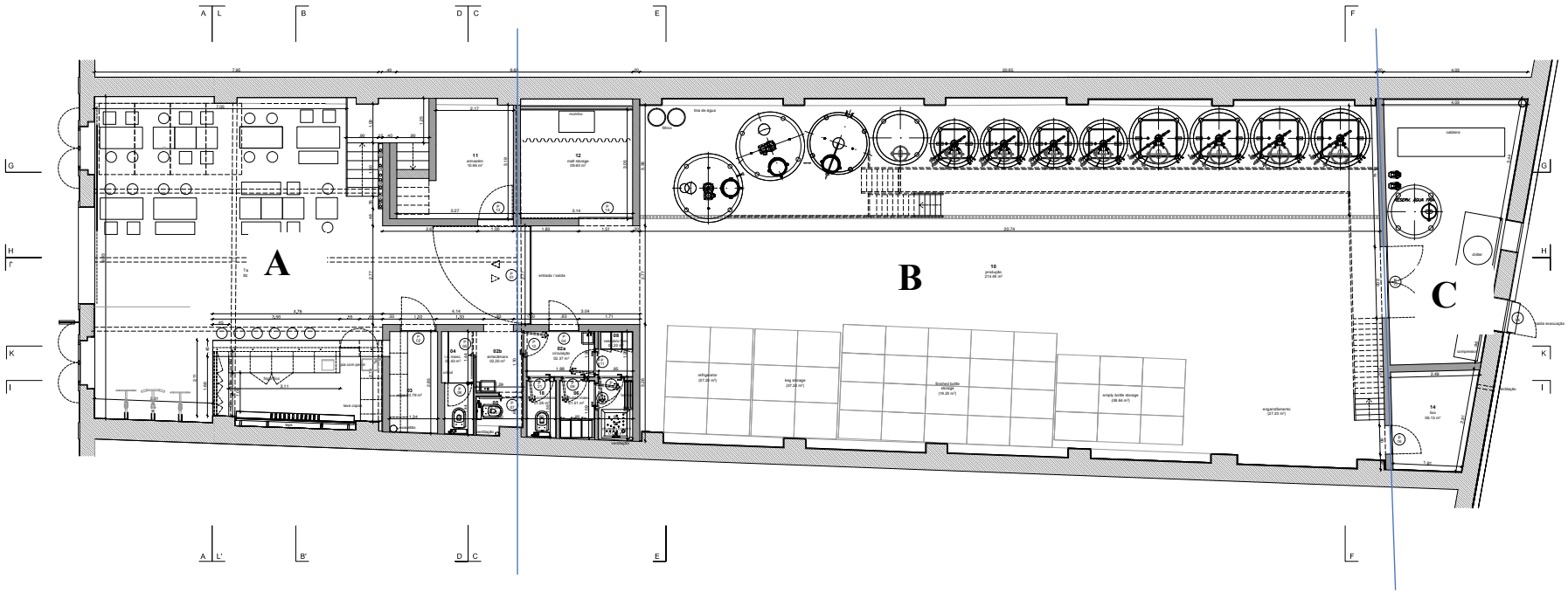

Figure 6 – MUSA's Warehouse Layout

Source: Adapted from MUSA (2017)

4.1.3. Equipment

The production equipment is composed by:

- malt mill
- mash tun, boiling tank, hot water tank
- ice water tank
- bottle filler
- maturation tank
- fermentation tank

The storage equipment is composed by:

- Pallets
- Electric Forklift (Appendix 1, figure 4)
- Conventional racks (Appendix 1, figure 1)
- Refrigerator (Appendix 1, figure 2)

4.1.4. Warehousing activities

As previously mentioned in the literature review, the warehousing process follows the common activities of receiving, buffering, storage, order picking, handling, maintenance and shipping materials. In MUSA's warehouse raw-materials are received and stored in the appropriate places. Then items are picked and used for production. It is a more simplified process when compared to other warehouses due to its size and the fact that it is mainly a production warehouse that stores raw materials and not only a stock-holding warehouse. When transformed into finished product, it is shipped to the final destination. Each SKU of raw material has a proper area to be stored, which means it follows a dedicated storage policy.

4.1.5. Inventory Management

MUSA's warehouse manages inventory for raw materials, semi-finished products and finished products.

The inventory system for raw materials is currently described by the monthly ordering of approximately fixed quantities. The period between orders could be variable. For these goods there are no inventory policies defined, and no safety stock settled.

The semi-finished products are managed on the raw materials basis, being orders placed between a certain period of time that could vary and in fixed quantities. These products were not part of the project analysis.

Regarding the inventory management of finished product, there is no proper stock constituted since they currently adopt a make-to-order strategy, which is to produce according customers' orders placement. They are currently providing a service level of 95% to their customers.

As mentioned before, the objective is to go for a make-to-stock strategy taking into account the difficulties they face when an order is commanded. The difficulty comes from the time-consuming process beer takes to be produced. The goal is to have warehousing stock to answer customers' order as promptly as possible.

4.1.6. SKUs

The SKUs used to produce the final product, or in other words, to produce beers are hops, malt and yeast (see list of raw materials in Appendix 2). To achieve final product semi-finished products are also needed. Those are glass bottles, bottles caps, labels, card boxes and aluminium kegs. This products type was out of scope of this project. So, let us focus on the raw materials.

Each of the raw material has many different types, depending on the provider and other product specifications. The total number of SKUs from the malt family is 24, from the hops family the total is 11 and yeast types are 4. According to the recipe to produce a specific beer, a certain type(s) of malt, hops and yeast are used to produce the liquid. From all of these, hops and yeast have to be stored under controlled temperatures, while others can stay at room temperatures. Malt is received in bags of 25 Kg (Kilograms), hops is delivered in batches of 20/25 Kg (depending on the provider) and Yeast is provided on quantities of 0,5 Kg.

Regarding packaging materials, these are bottles, labels, caps, barrels, and card boxes but this was not considered in this project.

The finished products are six different beers, each one with its own receipt. The names are: Born in the IPA, Mick Lager, Red Zeppelin Ale, Twist and Stout, Saison O'Connor and Frank APA. MUSA's also has four more beers, but those are in produced based on a partnership with other craft breweries, which are not considered for the purpose of this project.

4.2. Proposals of improvement within inventory management activities – Step 2

As noted in section 4.1, the lack of inventory management policies bring significance to progress in this step for proposal and evaluation of alternative inventory management policies. The presented proposals are only for raw materials and, as mentioned in section 3.2.2, the policies under analysis are the continuous and periodic review considering the uncertainty level from demand side. Also, different scenarios were considered, namely different demand deviations and different service levels. The calculations under these policies required information retrieved from interviews and documents provided by the company. The data collected was composed by sales of finished products, suppliers lead times, lead time supplier's deviation, raw materials' consumptions, acquisition cost of each raw material and warehouse holding and ordering costs. Sources can be seen in appendix 7.

Based on the sales of final products the annual demand/consumption for each raw material was calculated. Acknowledging the uncertainty that characterizes future demand, and assuming a normal distribution for the annual demand of raw materials, three different scenarios were considered, namely, standard deviation of 5%, 10% and 20%. These were the values assumed due to lack of information from company's side.

In addition to the before mentioned data, and so as to evaluate the impact of alternative inventory management policies, three service levels were considered: 99%, 95% and 90%. The 99% service level was attributed due to the fact it is the desired service level the company want to achieve in the future. The 95% service level is the current service level provided by the company. The 90% level was also considered for the attribution levels in the ABC analysis.

Afterwards, using this data as input, and so as to evaluate different proposals of inventory management policies in conditions of pure uncertainty from demand and supply side, two stochastic models were considered – continuous review model (see appendix 8) and periodic review model with periods of 15, 30 and 40 days for malts, periods of 105, 120 and 130 days for hops and periods of 155, 170 and 180 days for yeasts (see appendix 9). The periods' attributed values for each of the raw materials were based on the continuous review model average period between orders. Calculations were done based on formulas mentioned in section 3.2.2.

The last part of this step was to analyse these different policies comparing total costs spent with each of them.

Proposal A – Continuous Review Model (Q model)

The Economic Order Quantity is always fixed unlike the period between orders, which is variable, although the possibility of having an average period. Depending on the desirable service level, reorder point and safety stock present different results, as well as the annual total cost. Let us consider an optimistic and pessimistic scenario for the Q model:

- Optimistic scenario considers 90% service level and 5% demand standard deviation for malts (table 4), hops (table 5) and yeast (table 6).
- Pessimistic scenario considers 99% service level and 20 % demand standard deviation for malts (table 7), hops (table 8) and yeast (table 9).

Optimistic: 90% Service Level and 5% Demand Standard Deviation

Table 4 –Continuous Review Policy for malts' family under an optimistic scenario

Malts	EOQ (Kg)	Safety Stock (Kg)	Reorder Point (Kg)	TC (Euros)	Average order period (days)
Acidulated	34,05	2,65	18,07	8965,54	33
Barley flakes	21,92	1,10	7,49	13021,29	51
Carafa Spec II	20,79	0,99	6,74	13670,41	54
Carafa Spec III	19,35	0,85	5,84	14612,48	58
Carahell	58,50	7,81	53,36	6247,18	19
Caramunich II	23,57	1,27	8,66	12164,67	48
Carapils	36,04	2,97	20,26	8448,83	31
Carared	42,56	4,13	28,24	7505,44	26
Dextrin Malt	39,06	3,48	23,79	7781,97	29
Finest Lager Malt	66,43	10,07	68,80	6905,83	17
Maris Otter Simpson	105,07	25,19	172,12	5986,42	11
Melanoidin	21,59	1,06	7,27	13171,52	52
Munich I	54,49	6,78	46,30	6322,47	21
Oat flakes	24,47	1,37	9,34	11858,64	46
Pale Ale Simpson	139,41	44,35	303,02	6882,13	8
Pale Wheat	25,78	1,52	10,36	11186,57	44

Pilsner	82,91	15,69	107,18	5604,39	14
Roasted barley	17,30	0,68	4,67	16224,88	65
Vienna	29,85	2,03	13,89	9831,98	38
Wheat flakes	34,05	2,65	18,08	8986,01	33
Dextrose	10,64	0,26	1,76	25863,27	106
Golden Naked Oats	11,81	0,32	2,18	23468,56	95
Golden Promise	44,20	4,46	30,46	7236,81	25
Oat Malt	9,59	0,21	1,43	28612,97	117

Table 5 - Continuous Review Policy for hops' family under an optimistic scenario

Hops	**EOQ (Kg)**	**Safety Stock (Kg)**	**Reorder Point (Kg)**	**TC (Euros)**	**Average order period (days)**
Bullion	6,111	0,089	0,43	44730,00	177
Centennial	4,813	0,055	0,27	56501,89	225
Citra	17,300	0,711	3,48	19142,86	62
Columbus	12,118	0,349	1,71	23534,21	89
Fuggles	5,360	0,068	0,33	50833,52	202
Mosaic	16,174	0,621	3,04	19704,63	67
Simcoe	7,300	0,127	0,62	37891,42	148
Spalter Select	10,802	0,277	1,36	27025,60	100
Summit	9,913	0,233	1,14	28648,03	109
Tradition	9,201	0,201	0,98	30091,13	117
Saaz	4,660	0,052	0,25	58335,10	232

Table 6 - Continuous Review Policy for yeasts' family under an optimistic scenario

Yeast	**EOQ (Kg)**	**Safety Stock (Kg)**	**Reorder Point (Kg)**	**TC (Euros)**	**Average order period (days)**
SAFALE US-05	9,600	0,219	1,07	30920,89	113
SAFALE S-04	5,181	0,064	0,31	53102,59	209
SAFLAGER W34/70	8,607	0,176	0,86	34939,75	126
BSaison	2,947	0,021	0,10	91788,80	367

Pessimistic: 99% Service Level and 20% Demand Standard Deviation

Table 7 – Continuous Review Policy for malts' family under a pessimistic scenario

Malts	EOQ (units)	Safety Stock (units)	Reorder Point (units)	TC (Euros)	Average order period (days)
Acidulated	34,05	5,14	20,57	9 542,84	33,10
Barley flakes	21,92	2,13	8,53	13 598,60	51,41
Carafa Spec II	20,79	1,92	7,67	14 247,72	54,20
Carafa Spec III	19,35	1,66	6,64	15 189,78	58,25
Carahell	58,50	15,18	60,73	6 824,48	19,26
Caramunich II	23,57	2,46	9,86	12 741,98	47,82
Carapils	36,04	5,76	23,05	9 026,13	31,27
Carared	42,56	8,03	32,14	8 082,74	26,48
Dextrin Malt	39,06	6,77	27,07	8 359,27	28,85
Finest Lager Malt	66,43	19,57	78,30	7 483,14	16,97
Maris Otter Simpson	105,07	48,95	195,88	6 563,73	10,73
Melanoidin	21,59	2,07	8,27	13 748,83	52,19
Munich I	54,49	13,17	52,69	6 899,77	20,68
Oat flakes	24,47	2,66	10,63	12 435,94	46,05
Pale Ale Simpson	139,41	86,18	344,85	7 459,44	8,08
Pale Wheat	25,78	2,95	11,80	11 763,87	43,71
Pilsner	82,91	30,48	121,97	6 181,70	13,59
Roasted barley	17,30	1,33	5,31	16 802,19	65,12
Vienna	29,85	3,95	15,81	10 409,29	37,75
Wheat flakes	34,05	5,14	20,58	9 563,32	33,09
Dextrose	10,64	0,50	2,01	26 440,58	105,93
Golden Naked Oats	11,81	0,62	2,48	24 045,87	95,40
Golden Promise	44,20	8,66	34,67	7 814,12	25,50
Oat Malt	9,59	0,41	1,63	29 190,27	117,49

Table 8 - Continuous Review Policy for hops' family under a pessimistic scenario

Hops	EOQ (units)	Safety Stock (units)	Reorder Point (units)	TC (Euros)	Average order period (days)
Bullion	6,11	0,17	0,51	45 305,53	176,91
Centennial	4,81	0,10	0,32	57 077,43	224,60
Citra	17,30	1,35	4,12	19 718,40	62,49
Columbus	12,12	0,66	2,02	24 109,75	89,21
Fuggles	5,36	0,13	0,40	51 409,06	201,71
Mosaic	16,17	1,18	3,60	20 280,17	66,84
Simcoe	7,30	0,24	0,73	38 466,96	148,10
Spalter Select	10,80	0,53	1,61	27 601,14	100,08
Summit	9,91	0,44	1,35	29 223,57	109,06
Tradition	9,20	0,38	1,17	30 666,67	117,50
Saaz	4,66	0,10	0,30	58 910,64	232,00

Table 9 - Continuous Review Policy for yeasts' family under a pessimistic scenario

Yeast	EOQ (units)	Safety Stock (units)	Reorder Point (units)	TC (Euros)	Average order period (days)
SAFALE US-05	9,60	0,42	1,27	31 496,42	112,62
SAFALE S-04	5,18	0,12	0,37	53 678,13	208,67
SAFLAGER W34/70	8,61	0,33	1,02	35 515,29	125,61
BSaison	2,95	0,04	0,12	92 364,34	366,82

Comparing the results from table 4 and 7, it is possible to conclude that costs are higher under a pessimistic scenario for entire malts family.

Crossing checking the figures of hops family considering an optimistic and a pessimistic scenario (tables 5 and 8), it is also possible to confirm that a pessimistic scenario provides increased costs.

Similarly, when comparing the yeasts for both scenarios, they all present less costs under the optimistic scenario.

This naturally happens due to the less amount of safety stock needed when service levels are inferior, which is the case for the optimistic scenario. If the trust level is higher,

less are the unexpected events and less safety stock is required, thus lower costs are incurred.

Proposal B – Continuous and Periodic Review Model based on the ABC classification

For this proposal, an ABC analysis was first performed to all the SKUs. Items were classified according to its importance in terms of consumptions levels: Products classified as "A" are the most relevant ones, which means they present higher usage rates. "C" products are the less important, being used less frequently. Items whose categorization is "B" have an intermediate importance between the two classes mentioned before. The steps taken to achieve the classification were as follows (see appendix 5 for detailed results, and the below table for a summary):

i. Organization of the annual consumption/demand of SKUs from the highest to the lowest level of consumption;
ii. Calculation of the weight of each item considering its consumption;
iii. Calculation of the weight of the analysed items;
iv. Classification of the items into A, B or C, accordingly.

The below table presents a summary of the results of the ABC analysis.

ABC analysis

Table 10 – ABC Analysis Summary

ABC Classification	Anual Demand (Kg)	Annual Demand Weight (%)	Annual Demand Cumulative Weight (%)	Number of items	Number of items Weight (%)	Number of items Cumulative weight (%)
A	16 005,44	78,78%	78,78%	7	18%	18%
B	3 528,04	17,37%	96,15%	12	31%	49%
C	782,67	3,85%	100,00%	20	51%	100%
Total	20 316,15	100,00%		39	100%	

Based on this classification, the most appropriate model was attributed to each class items based on literature recommendations:

i. For the class A SKUs, higher service levels should be established, and the continuous review model should be adopted since this model allows a stricter control over inventory based on its continuous monitoring;

ii. SKUs from class C should adopt the periodic review model due to its reduced importance regarding financial matters;

iii. Finally, class B items could adopt both models, a Q model or a P model with shorter periods between orders, when compared with C items. For these items, the Q model and P model with shorter periods were used in the analysis. The Period was settled taking into account the average period between orders in model Q and selected the one that minimizes costs.

Analysis under two different scenarios - optimistic when the standard deviation is lower and pessimistic when the standard deviation is higher - were performed to each raw material taking into account the selection of the review model based on the products categorization. Results are shown in tables below.

Optimistic: 5 % standard deviation

Table 11 – Stock Management Policies according to ABC Analysis: Optimistic Scenario

Raw Materials	ABC	Service Level (%)	Model	Period (days)	EOQ (kg)	Safety Stock (kg)	Reorder Point (kg)	Target Stock (kg)	Total Costs (euros)
Pale Ale Simpson	A	99	Q	-	139,41	80,74	339,41	-	7 384,34
Maris Otter Simpson	A	99	Q	-	105,07	45,86	192,79	-	6 488,63
Pilsner	A	99	Q	-	82,91	28,56	120,05	-	6 106,60
Finest Lager Malt	A	99	Q	-	66,43	18,33	77,06	-	7 408,04
Carahell	A	99	Q	-	58,50	14,22	59,77	-	6 749,38
Munich I	A	99	Q	-	54,49	12,33	51,85	-	6 824,67
Golden Promise	A	99	Q	-	44,20	8,12	34,12	-	7 739,02
Carared	B	95	Q	-	42,56	5,30	29,41	-	7 677,62
			P	30	-	5,35	-	77,67	7 734,04
Dextrin Malt	B	95	Q	-	39,06	4,46	24,77	-	7 954,15
			P	30	-	4,50	-	65,43	7 966,64
Carapils	B	95	Q	-	36,04	3,80	21,09	-	8 621,01
			P	30	-	3,83	-	55,71	8 634,87
Wheat flakes	B	95	Q	-	34,05	3,39	18,83	-	9 158,19
			P	30	-	3,42	-	49,73	9 203,42

Acidulated	B	95	Q	-	34,05	3,39	18,82	-	9 137,72
			P	30	-	3,42	-	49,70	9 183,15
Vienna	B	95	Q	-	29,85	2,61	14,47	-	10 004,17
			P	40	-	2,64	-	46,13	10 028,85
Pale Wheat	B	95	Q	-	25,78	1,94	10,79	-	11 358,75
			P	40	-	1,97	-	34,41	11 409,37
Oat flakes	B	95	Q	-	24,47	1,75	9,72	-	12 030,82
			P	40	-	1,77	-	31,00	12 149,37
Caramunich II	B	95	Q	-	23,57	1,62	9,02	-	12 336,86
			P	40	-	1,64	-	28,75	12 528,34
Barley flakes	B	95	Q	-	21,92	1,41	7,80	-	13 193,47
			P	40	-	1,42	-	24,87	13 590,46
Melanoidin	B	95	Q	-	21,59	1,36	7,57	-	13 343,71
			P	40	-	1,38	-	24,14	13 795,29
Carafa Spec II	B	95	Q	-	20,79	1,26	7,02	-	13 842,60
			P	40	-	1,28	-	22,38	14 452,49
Carafa Spec III	C	90	P	40	-	0,86	-	19,13	15 610,88
Citra	C	90	P	105	-	0,70	-	31,23	21 373,25
Roasted barley	C	90	P	40	-	0,69	-	15,31	18 110,57
Mosaic	C	90	P	105	-	0,60	-	26,63	21 649,29
Columbus	C	90	P	105	-	0,36	-	15,98	23 849,11
Golden Naked Oats	C	90	P	40	-	0,32	-	7,13	32 608,74
Spalter Select	C	90	P	105	-	0,26	-	11,52	28 144,32
Dextrose	C	90	P	40	-	0,42	-	9,26	26 305,63
Summit	C	90	P	105	-	0,24	-	10,69	28 687,96
SAFALE US-05	C	90	P	155	-	0,21	-	13,05	33 154,04
Oat Malt	C	90	P	40	-	0,21	-	4,70	46 486,70
Tradition	C	90	P	120	-	0,21	-	10,39	30 120,93
SAFLAGER W34/70	C	90	P	155	-	0,18	-	11,49	35 661,13
Simcoe	C	90	P	130	-	0,13	-	7,03	38 229,30
Bullion	C	90	P	130	-	0,09	-	4,93	46 855,09
Fuggles	C	90	P	130	-	0,07	-	3,79	55 765,73
SAFALE S-04	C	90	P	180	-	0,05	-	3,84	60 945,49
Centennial	C	90	P	130	-	0,06	-	3,06	65 068,66
Saaz	C	90	P	130	-	0,05	-	2,87	68 288,27
BSaison	C	90	P	180	-	0,02	-	1,55	115 880,62

Pessimistic: 20 % standard deviation

Table 12 – Stock Management Policies according to ABC Analysis: Pessimistic Scenario

Raw Materials	ABC	Service Level (%)	Model	Period (days)	EOQ (kg)	Safety Stock (kg)	Reorder Point (kg)	Target Stock (kg)	Total Costs (euros)
Pale Ale Simpson	A	99	Q	-	139,41	86,18	344,85	-	7 459,44
Maris Otter Simpson	A	99	Q	-	105,07	48,95	195,88	-	6 563,73
Pilsner	A	99	Q	-	82,91	30,48	121,97	-	6 181,70
Finest Lager Malt	A	99	Q	-	66,43	19,57	78,30	-	7 483,14
Carahell	A	99	Q	-	58,50	15,18	60,73	-	6 824,48
Munich I	A	99	Q	-	54,49	13,17	52,69	-	6 899,77
Golden Promise	A	99	Q	-	44,20	8,66	34,67	-	7 814,12
Carared	B	95	Q	-	42,56	5,65	29,76	-	7 730,48
			P	30	-	6,35	-	78,67	7 822,53
Dextrin Malt	B	95	Q	-	39,06	4,76	25,07	-	8 007,01
			P	30	-	5,35	-	66,27	8 115,13
Carapils	B	95	Q	-	36,04	4,05	21,35	-	8 673,87
			P	30	-	4,55	-	56,43	8 783,12
Wheat flakes	B	95	Q	-	34,05	3,62	19,05	-	9 211,05
			P	30	-	4,06	-	50,37	9 351,91
Acidulated	B	95	Q	-	34,05	3,62	19,04	-	9 190,58
			P	30	-	4,06	-	50,34	9 331,64
Vienna	B	95	Q	-	29,85	2,78	14,64	-	10 057,03
			P	40	-	3,23	-	46,72	10 206,82
Pale Wheat	B	95	Q	-	25,78	2,07	10,92	-	11 411,61
			P	40	-	2,41	-	34,85	11 587,34
Oat flakes	B	95	Q	-	24,47	1,87	9,84	-	12 083,68
			P	40	-	2,17	-	31,40	12 327,34
Caramunich II	B	95	Q	-	23,57	1,73	9,13	-	12 389,72
			P	40	-	2,01	-	29,12	12 706,31
Barley flakes	B	95	Q	-	21,92	1,50	7,90	-	13 246,33
			P	40	-	1,74	-	25,19	13 768,43
Melanoidin	B	95	Q	-	21,59	1,46	7,66	-	13 396,57
			P	40	-	1,69	-	24,45	13 973,26
Carafa Spec II	B	95	Q	-	20,79	1,35	7,10	-	13 895,46
			P	40	-	1,57	-	22,66	14 630,46
Carafa Spec III	C	90	P	40	-	1,06	-	19,33	15 749,78
Citra	C	90	P	105	-	1,00	-	31,52	21 647,01
Roasted barley	C	90	P	40	-	0,85	-	15,46	18 249,47
Mosaic	C	90	P	105	-	0,85	-	26,88	21 923,05

Columbus	C	90	P	105	-	0,51	-	16,13	24 122,88
Golden Naked Oats	C	90	P	40	-	0,39	-	7,2	32 747,65
Spalter Select	C	90	P	105	-	0,37	-	11,62	28 418,09
Dextrose	C	90	P	40	-	0,51	-	9,35	26 444,53
Summit	C	90	P	105	-	0,34	-	10,79	28 961,73
SAFALE US-05	C	90	P	155	-	0,32	-	13,16	33 520,94
Oat Malt	C	90	P	40	-	0,26	-	4,75	46 625,60
Tradition	C	90	P	120	-	0,30	-	10,48	30 423,77
SAFLAGER W34/70	C	90	P	155	-	0,29	-	11,59	36 028,03
Simcoe	C	90	P	130	-	0,20	-	7,10	38 550,95
Bullion	C	90	P	130	-	0,14	-	4,97	47 176,74
Fuggles	C	90	P	130	-	0,11	-	3,83	56 087,39
SAFALE S-04	C	90	P	180	-	0,09	-	3,87	61 355,36
Centennial	C	90	P	130	-	0,08	-	3,09	65 390,32
Saaz	C	90	P	130	-	0,08	-	2,89	68 609,93
BSaison	C	90	P	180	-	0,04	-	1,56	116 290,48

The lower the standard deviation, the lower the reorder point, safety stock and total cost, as expected. Also, when comparing total inventory costs in both models, it is possible to state that Q review model presents lower costs. Thus, the Q model should be used in 18% of the items that contribute more for sales and P model for the ones with less importance which represent 51% of the items and have large periods between orders. The remaining 31% of the goods whose classification is “B” due to its middle importance compared to the previous ones could either follow a P or Q model. This means that this last model requires less time to be put in practice. Regarding the order quantity, it was not possible to compute that amount for the periodic review model due to fact that the values considered for demand/consumption are an average and the fact that this quantity will depend on the warehoused stock at the moment of the inventory review.

If the company do not measure inventory properly it could result in excess of stock and thence higher is the cost incurred for having stock which is not being used and which is occupying space. Consequently, other types of investment that could be needed and done are not even being considered.

Comparison of Proposals

Due to a high number of raw materials analysed, the results obtained for only one randomly chosen raw material (namely, Acidulated) is presented in this section,

according to the results shown in tables and figures below (see appendix 3 and 4 for complete list of raw materials costs comparison).

Table 13 - Acidulated total costs comparison for different models and under different scenarios

	The below percentages correpond to demand standard deviations; Total costs are in Euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Acidulated	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	9 467,74	9 483,16	9 542,84	12 072,91	12 103,41	12 218,05	9 516,22	9 561,46	9 727,19	9 623,03	9 677,93	9 875,88
Total Cost (95% Service Level)	9 137,72	9 148,57	9 190,58	11 741,36	11 762,82	11 843,52	9 183,15	9 214,99	9 331,64	9 288,95	9 327,59	9 466,92
Total Cost (90% Service Level)	8 965,54	8 974,01	9 006,79	11 568,38	11 585,13	11 648,11	9 009,37	9 034,23	9 125,27	9 114,64	9 144,80	9 253,55

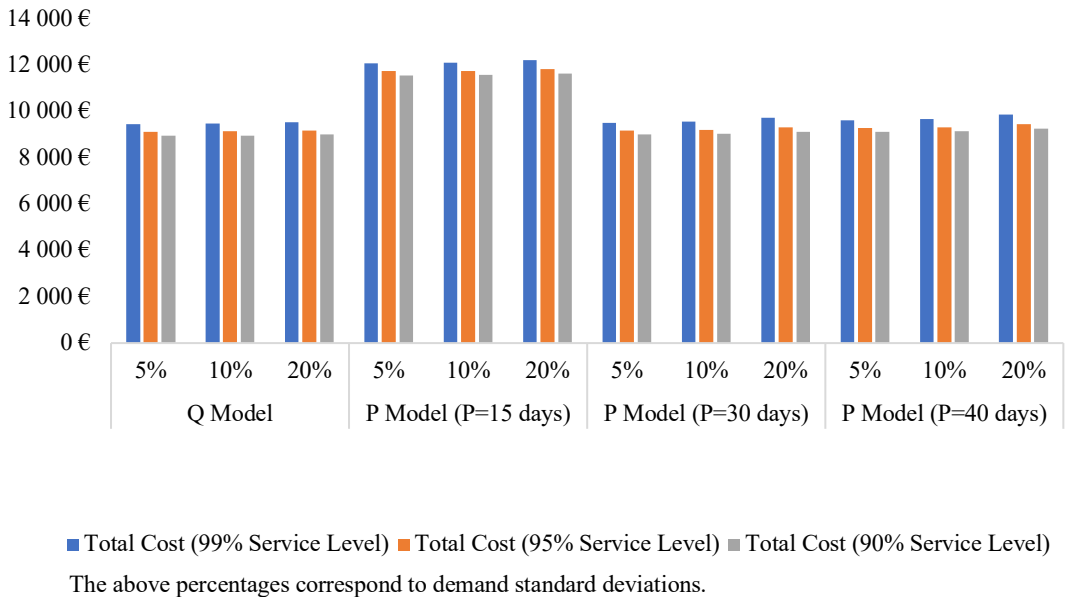

Figure 7 - Acidulated total costs comparison for different models and under different scenarios

Results from table 13 and figure 7 show that continuous review model always present lower costs no matter what the service level is and the standard deviation. This conclusion is also valid for the remaining goods of the three families (see appendix 4).

If a pessimistic scenario is considered (99% service level and 20% demand standard deviation), the total cost incurred in adopting the Q model is 9542,84 euros against the

lower cost achieved in a P model of 9727,19,81 euros, which is when the period is 30 days.

If an optimistic scenario is assumed (90% service level and 5% demand standard deviation) the total cost spent with a continuous review policy is 8965,54 euros while in a periodic review model the lower cost achieved is 9009,37 euros with a period between orders of 30 days.

Crossing out what theory says in section 2.2.1.2 (*Continuous Review Model*) and taking into account the results from table 13, the Q model has a lower total inventory cost, but it requires more time to maintain inventory updated unless there is an automatic system. The P model has higher total inventory costs but has a reduction of time to analyse the amount of inventory.

4.3. SKUs storage space assessment – Step 3

This step aims to provide an assessment of the current space available to store raw materials according to the stock management policy proposed to each SKU in proposal B. Also, an assessment to the space available to store finished products is performed based on the average monthly sales. A dedicated storage is followed since all the items have specific places to be stored (see appendix 6). Thus, a storage assessment was performed for the two different scenarios considered for demand standard deviations in the previous section (optimistic and a pessimistic) and for both situations - non-controlled (malts) and controlled temperature.

This assessment was separated into two parts, one considering only malts and one considering hops and yeast. The reason behind this distinction is that malts have a specific storage area, as it is possible to confirm from figure 6. Hops and yeast have to be stored in controlled temperature unlike malts, and hence have also a particular place to be in. Furthermore, the following assumptions were taken:

- This assessment only measures the maximum kilograms capacity. It does not consider pallets organization by SKU.
- Euro pallets is the material used to store items. Measures: 0,8 meters (m) width by 1,2 meters length. It occupies a total area of 0,96 square meters (m^2). Maximum weight is 1500 Kg or a maximum height of 1,44 m.
- Malts storage total area: 9,60 m^2. Capacity: 10 pallets which corresponds to a total weight of 15000 kg.

- Controlled temperature total area: 7,20 m^2. Capacity: 7 pallets which converted to weight is 10500 kg.
- For raw materials which follow a continuous review policy, it is assumed that the warehouse needs to have capacity for the maximum number of units of each SKU, that corresponds to the reorder point plus the EOQ.
- For raw materials whose policy is based on a P model, it is assumed that the warehouse needs to have capacity for the maximum stock which for this model is the target stock. The order quantity is the difference between the target stock and the stock at the moment. Thus, the quantity never goes beyond that.

Next tables present the maximum stock required for each SKU under optimistic (5% demand standard deviation) and pessimistic (20% demand standard deviation) scenarios. The tables also show the total maximum capacity available for the respective raw materials stored under controlled and non-controlled temperatures.

Optimistic: 5% demand deviation

Table 14 – Maximum warehouse inventory for non-controlled temperature SKUs: Optimistic scenario

Malts (non-controlled temperatures)	ABC Classification	Service Level (%)	Model	Period (days)	EOQ (kg)	Reorder Point (kg)	Target Stock (kg)	Maximum Warehouse inventory (Kg)
Pale Ale Simpson	A	99	Q	-	139,41	339,41	-	478,81
Maris Otter Simpson	A	99	Q	-	105,07	192,79	-	297,85
Pilsner	A	99	Q	-	82,91	120,05	-	202,95
Finest Lager Malt	A	99	Q	-	66,43	77,06	-	143,49
Carahell	A	99	Q	-	58,50	59,77	-	118,27
Munich I	A	99	Q	-	54,49	51,85	-	106,34
Golden Promise	A	99	Q	-	44,20	34,12	-	78,32
Carared	B	95	Q	-	42,56	29,41	-	71,96
	B		P	40	-	-	77,67	77,67
Dextrin Malt	B	95	Q	-	39,06	24,77	-	63,83
	B		P	40	-	-	65,43	65,43
Carapils	B	95	Q	-	36,04	21,09	-	57,14
	B		P	40	-	-	55,71	55,71
Wheat flakes	B	95	Q	-	34,05	18,83	-	52,88
	B		P	40	-	-	49,73	49,73
Acidulated	B	95	Q	-	34,05	18,82	-	52,86
	B		P	40	-	-	49,70	49,70
Vienna	B	95	Q	-	29,85	14,47	-	44,32

	B		P	40	-	-	46,13	46,13
Pale Wheat	B	95	Q	-	25,78	10,79	-	36,57
	B		P	40	-	-	34,41	34,41
Oat flakes	B	95	Q	-	24,47	9,72	-	34,20
	B		P	40	-	-	31,00	31,00
Caramunich II	B	95	Q	-	23,57	9,02	-	32,59
	B		P	40	-	-	28,75	28,75
Barley flakes	B	95	Q	-	21,92	7,80	-	29,72
	B		P	40	-	-	24,87	24,87
Melanoidin	B	95	Q	-	21,59	7,57	-	29,17
	B		P	40	-	-	24,14	24,14
Carafa Spec II	B	95	Q	-	20,79	7,02	-	27,81
	B		P	40	-	-	22,38	22,38
Carafa Spec III	C	90	P	40	-	-	19,13	19,13
Roasted barley	C	90	P	40	-	-	15,31	15,31
Golden Naked Oats	C	90	P	40	-	-	7,13	7,13
Dextrose	C	90	P	40	-	-	9,26	9,26
Oat Malt	C	90	P	40	-	-	4,70	4,70
Total (Model Q for B products)	-	-	-	-	-	-	-	2 014,61
Total (Model P for B products)	-	-	-	-	-	-	-	1 991,49
Maximum Capacity	-	-	-	-	-	-	-	15 000,00

Table 15 - Maximum warehouse inventory for controlled temperature SKUs: Optimistic scenario

Hops & Yeast (controlled temperatures)	**Service Level (%)**	**Model**	**Period (days)**	**Target Stock (kg)**	**Maximum Warehouse inventory (Kg)**
Citra	90	P	105	31,23	31,23
Mosaic	90	P	105	26,63	26,63
Columbus	90	P	105	15,98	15,98
Spalter Select	90	P	105	11,52	11,52
Summit	90	P	105	10,69	10,69
SAFALE US-05	90	P	155	13,05	13,05
Tradition	90	P	120	10,39	10,39
SAFLAGER W34/70	90	P	155	11,49	11,49
Simcoe	90	P	130	7,03	7,03
Bullion	90	P	130	4,93	4,93
Fuggles	90	P	130	3,79	3,79
SAFALE S-04	90	P	180	3,84	3,84
Centennial	90	P	130	3,06	3,06

Saaz	90	P	130	2,87	2,87
BSaison	90	P	180	1,55	1,55
Total	-	-	-	-	158,05
Maximum Capacity					10 500,00

Pessimistic: 20% demand deviation

Table 16 - Maximum warehouse inventory for non-controlled temperature SKUs: pessimistic scenario

Malts (non-controlled temperatures)	**ABC Classification**	**Service Level (%)**	**Model**	**Period (days)**	**EOQ (kg)**	**Reorder Point (kg)**	**Target Stock (kg)**	**Maximum Warehouse Inventory (kg)**
Pale Ale Simpson	A	99	Q	-	139,41	344,85	-	484,25
Maris Otter Simpson	A	99	Q	-	105,07	195,88	-	300,94
Pilsner	A	99	Q	-	82,91	121,97	-	204,88
Finest Lager Malt	A	99	Q	-	66,43	78,30	-	144,72
Carahell	A	99	Q	-	58,50	60,73	-	119,23
Munich I	A	99	Q	-	54,49	52,69	-	107,18
Golden Promise	A	99	Q	-	44,20	34,67	-	78,86
Carared	B	95	Q	-	42,56	29,76	-	72,32
	B		P	30	-	-	78,64	78,64
Dextrin Malt	B	95	Q	-	39,06	25,07	-	64,13
	B		P	30	-	-	66,27	66,27
Carapils	B	95	Q	-	36,04	21,35	-	57,39
	B		P	30	-	-	56,43	56,43
Wheat flakes	B	95	Q	-	34,05	19,05	-	53,11
	B		P	30	-	-	50,37	50,37
Acidulated	B	95	Q	-	34,05	19,04	-	53,09
	B		P	30	-	-	50,34	50,34
Vienna	B	95	Q	-	29,85	14,64	-	44,49
	B		P	40	-	-	46,72	46,72
Pale Wheat	B	95	Q	-	25,78	10,92	-	36,71
	B		P	40	-	-	34,85	34,85
Oat flakes	B	95	Q	-	24,47	9,84	-	34,31
	B		P	40	-	-	31,40	31,40
Caramunich II	B	95	Q	-	23,57	9,13	-	32,69
	B		P	40	-	-	29,12	29,12
Barley flakes	B	95	Q	-	21,92	7,90	-	29,82
	B		P	40	-	-	25,19	25,19
Melanoidin	B	95	Q	-	21,59	7,66	-	29,26
	B		P	40	-	-	24,45	24,45
Carafa Spec II	B	95	Q	-	20,79	7,10	-	27,89
	B		P	40	-	-	22,66	22,66

Carafa Spec III	C	90	P	40	-	-	19,33	19,33
Roasted barley	C	90	P	40	-	-	15,46	15,46
Golden Naked Oats	C	90	P	40	-	-	7,2	7,2
Dextrose	C	90	P	40	-	-	9,35	9,35
Oat Malt	C	90	P	40	-	-	4,75	4,75
Total (Model Q for B products)	-	-	-	-	-	-	-	2 031,38
Total (Model P for B products)	-	-	-	-	-	-	-	2 012,60
Maximum Capacity	-	-	-	-	-	-	-	15 000,00

Table 187 - Maximum warehouse inventory for controlled temperature SKUs: pessimistic scenario

Hops & Yeast (controlled temperatures)	**Service Level (%)**	**Model**	**Period (days)**	**Target Stock (kg)**	**Maximum Warehouse inventory (Kg)**
Citra	90	P	105	31,52	31,52
Mosaic	90	P	105	26,88	26,88
Columbus	90	P	105	16,13	16,13
Spalter Select	90	P	105	11,62	11,62
Summit	90	P	105	10,79	10,79
SAFALE US-05	90	P	155	13,16	13,16
Tradition	90	P	120	10,48	10,48
SAFLAGER W34/70	90	P	155	11,59	11,59
Simcoe	90	P	130	7,10	7,10
Bullion	90	P	130	4,97	4,97
Fuggles	90	P	130	3,83	3,83
SAFALE S-04	90	P	180	3,87	3,87
Centennial	90	P	130	3,09	3,09
Saaz	90	P	130	2,89	2,89
BSaison	90	P	180	1,56	1,56
Total	-	-	-	-	159,49
Maximum Capacity					10 500,00

From table 14, it is possible to notice that, for malts, the space is big enough to store them. The maximum kilograms stored are 2014,61 against the area capacity, which is 15000 kg. Also, in a worst scenario there is no problem with space available since the maximum inventory is around 2000 Kg.

In the situation where raw materials have to be under controlled temperature, results are also comfortable for both scenarios, as one can confirm from table 15 and 17, since the maximum weight achieved is approximately 157 kg and 158Kg, respectively, against the 10500 kg capacity. Even if demand registers a double increase, there is still capacity to store all raw materials.

From figure 8 it is possible to state that malts area capacity could handle an increase in annual demand until 6 times higher as one. Hops and yeast maximum capacity area is ready to store this type of SKUs until 60 times more of the actual demand (see figure 9). This would be a more expensive investment but there is no concern about that since the space is far enough.

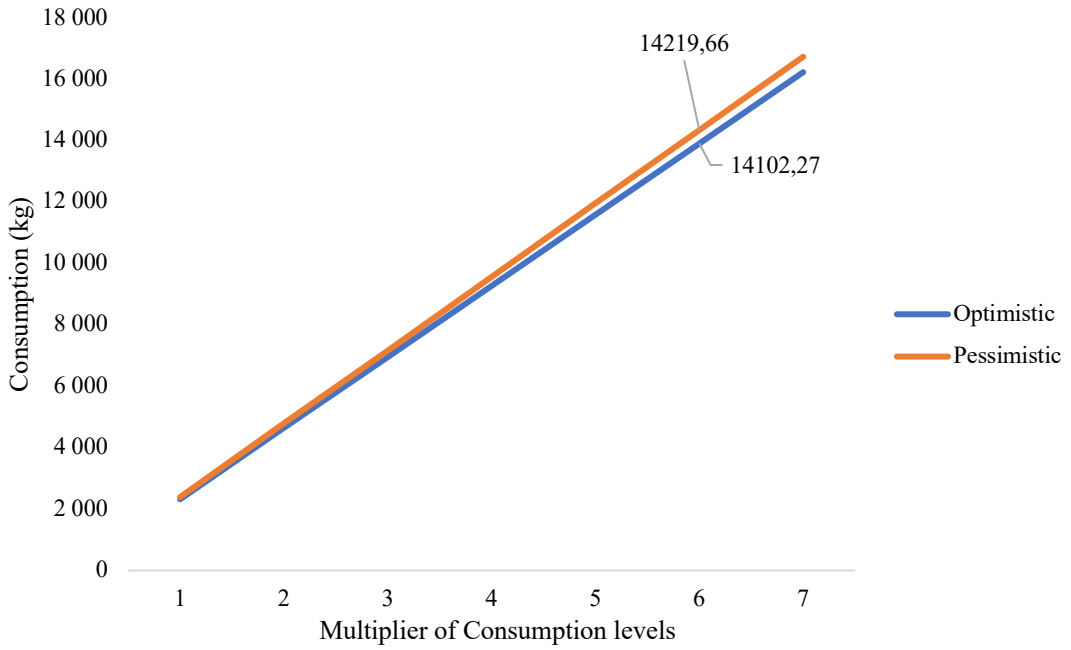

Figure 8 - Number of times malt's' consumption increases

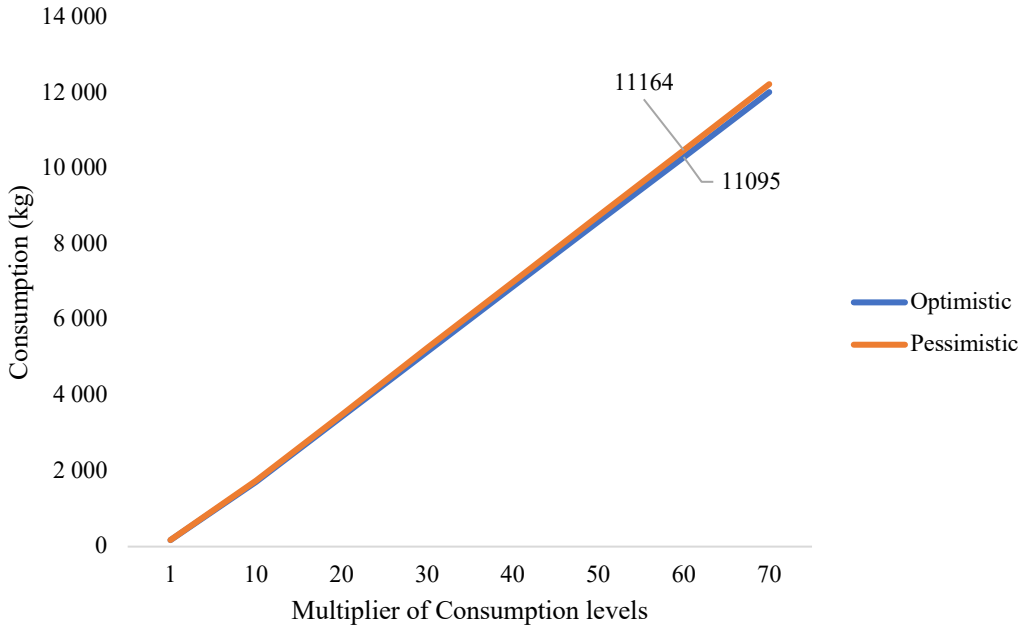

Figure 9 - Number of times hops and yeast consumption increase

Once the company wants to change to a make-to-stock strategy an assessment to the space available to store finished products was also performed. So, in order to understand if the dedicated storage space available for finished product is enough some calculations were performed. First calculations were done in order to get the maximum capacity in liters given the dedicated space available to store these specific products. This was computed based on the following assumptions:

- Each pallet contains 6 layers of 23 boxes (see appendix 1, figure 3). Thus, the maximum boxes capacity per pallet is 138.
- Each box has capacity for 12 bottles. Hence, a pallet carries a total of 1656 bottles.
- Each bottle has 0,33 liters of beer. Therefore, one pallet stores 546,48 liters.

The second step was to compute the maximum stock in the warehouse. Thus, information about sales per beer reference/type for 18 months was retrieved from a non-official document provided by the sales director. From these amounts, each SKU average sales by month was achieved. The number of pallets needed to store this maximum stock per month was calculated based on the following steps:

i. Dividing the total sales liters by 18 months to get the average monthly, which is the maximum stock in warehouse per month.

ii. Dividing the maximum stock by the maximum liters' capacity per pallet (546,48 liters) to compute the number of pallets needed for each SKU.

iii. Multiplying the number of pallets for the maximum liters capacity to get the maximum capacity needed in liters.

As for the case of raw materials, for the finished products optimistic and pessimistic scenarios were also considered. The optimistic was described by a 5% increase of sales and the pessimistic a 20% unexpected sales increase.

The below tables show the results of these calculations.

Table 18 - Finished Products Sales Maximum

Beer Reference	18 Months Sales (liters)	Average Monthly Sales (liters)	Number of pallets	Maximum Capacity (liters)
Born in the IPA	44453,05	2469,61	5	2732,4
Mick Lager	42286,23	2349,24	5	2732,4
Red Zeppelin Ale	23144,43	1285,80	3	1639,44
Twist and Stout	14348,91	797,16	2	1092,96
Saison O'Connor	4338,51	241,03	1	546,48
Frank APA	5349,08	297,17	1	546,48
Blonde Ale	3526,92	195,94	1	546,48
Total	137447,13	7635,95	18	9836,64
References Total	137447,13	7635,95	14	7650,72
Storage Maximum Capacity	-	-	20	10929,6

Table 19 - Finished Products Sales Maximum: Optimistic scenario

Beer Reference	18 Months Sales (liters)	Average Monthly Sales	5 % Sales Increase	Number of pallets	Maximum Capacity (liters)
Born in the IPA	44453,05	2469,61	2593,09	5	2732,4
Mick Lager	42286,23	2349,24	2466,70	5	2732,4
Red Zeppelin Ale	23144,43	1285,80	1350,09	3	1639,44
Twist and Stout	14348,91	797,16	837,02	2	1092,96
Saison O'Connor	4338,51	241,03	253,08	1	546,48

Frank APA	5349,08	297,17	312,03	1	546,48
Blonde Ale	3526,92	195,94	205,74	1	546,48
Total	137447,13	7635,95	8017,75	18	9836,64
References Total	137447,13	7635,95	8017,75	15	8197,2
Storage Maximum Capacity (liters)	-	-	-	20	10929,6

Table 20 - Finished Products Sales Maximum: Pessimistic scenario

Beer Reference	18 Months Sales (liters)	Average Monthly Sales	20 % Sales Increase	Number of pallets	Liters
Born in the IPA	44453,05	2469,61	2963,54	6	3278,88
Mick Lager	42286,23	2349,24	2819,08	6	3278,88
Red Zeppelin Ale	23144,43	1285,80	1542,96	3	1639,44
Twist and Stout	14348,91	797,16	956,59	2	1092,96
Saison O'Connor	4338,51	241,03	289,23	1	546,48
Frank APA	5349,08	297,17	356,61	1	546,48
Blonde Ale	3526,92	195,94	235,13	1	546,48
Total	137447,13	7635,95	9163,14	20	10929,6
References Total	137447,13	7635,95	9163,14	17	9290,16
Storage Maximum Capacity (liters)	-	-	-	20	10929,6

From table 18 it is possible to conclude that 18 pallets which have a total capacity for 9836,64 liters are needed to store these items having the references organized by pallet, without mixing them. Also, the capacity available to store this inventory is sufficient since it can take up to 20 pallets. In a struggle situation where more space is needed boxes can all be stored in 14 pallets, but it has the inconvenient of having references mixed.

If an optimistic scenario (table 19) is considered the total number of pallets needed is also 18 having references organized by pallet. A sales increase of 5% do not affect

finished products storage. Nevertheless, if they considering mixing reference only 15 pallets are needed and hence there is space for more 5 pallets.

If sales register an increase of 20% (table 20) the capacity is used until its limit. This means that higher sales increases lead to further investments in storage space.

In order to summarize the previous analysis, the below table shows the comparison between capacities and maximum stocks for different scenarios and different types of materials.

Table 21 - Stock scenarios comparison against maximum warehouse capacity

	Optimistic	Pessimistic	Warehouse Maximum Capacity
Maximum Malts Stock (kg): Q model/P model	2014,61/1991,49	2032,24/2013,47	15000
Maximum Hops &Yeast Stock (kg)	156,59	158,04	10500
Maximum Finished Products Stock (liters)	8017,75	9163,14	10929,6

From table 21 is possible to conclude that the space available for the two different types of raw materials as well as for finished products is big enough to store maximum capacity. The warehouse maximum capacity for malts, which is a dedicated space with a total capacity of 9,6 square meters (see appendix 6). Translating that space into kilos, it is a total of 15000. This means that malt quantities can be stored even in the pessimistic scenario and adopting the model P (2076,05 kg) and there is still a lot of empty space. Although the space left in the previous case, and as it is a dedicated space in the plant, separated in a specific room, it might not make sense to mix any other kind of products there. The reason behind is the fact that the other two raw materials has to be stored under controlled temperature, unlike malt. Thus, in terms of organization and storage logic this space will be empty until there is a pick of sales. Managers do not have to worry about space allocated for raw materials, which is a positive point. The situation repeats for hops and yeast which are located in the refrigerator area. The total capacity is 10500 Kg and the maximum stock for one year with these average sales is only 158 kg approximately considering the pessimistic scenario.

In the case of finished products results are not that conformable, but it can still handle a pessimistic scenario of 20% sales variation.

Globally concluding, the company can change to a make-to-stock strategy since the warehouse has enough capacity. Nevertheless, if sales record variations beyond 20%, managers could have a problem regarding warehouse space.

4.4. Final Recommendations – step 4

Warehousing and inventory management activities are a fundamental part of the logistics management process as it was mentioned in the Literature Review chapter. Many companies attribute more than fifty percent of their budget on materials which means inventory has to be well managed in order to reduce waste.

A proper inventory analysis was never done before to the company of this project. A proper inventory management analysis always comes associated to a good warehousing management. Thus, based on the stock management policies, warehousing management has to be adjusted accordingly.

Simulations to each SKU were performed using adequate inventory management models linked to the uncertainty level faced by the company. At this phase the first goal was to measure the costs associated to each model. On one hand Q review model has presented better results in terms of costs. On another hand it has disadvantages that could not compensate its adoption. Then, an ABC analysis was performed to classify items by importance. The criteria used was the consumption of each raw material. So, the higher the consumption the higher the importance and the stricter the control. Combining this analysis and based on empirical studies each item has a recommended stock management policy.

Afterwards, a storage space assessment was performed according to these policies. The objective was to evaluate if the current space available is enough or if further investments are needed to answer future demands. The space available to storage does not represent a problem for the company in the next years. It could only be an issue if annual demand increases up to six times more, even in the pessimistic scenario.

Regarding the research question in the first chapter and after an intensive empirical and practical analysis of the case it is possible to conclude that warehousing and inventory management activities at MUSA's company can be improved through an adjustment of the current practices regarding results of the methods tested before. Hence, higher efficiency levels could be achieved.

5. CONCLUSION

In the last years logistics has been much more widely recognized by the companies as one of the most important activities when running a business. This project focused on two of the its key elements, warehousing and inventory management, which are important parts of the logistic management process. The goal was to define inventory management policies to each of the SKUs under uncertainty conditions. Linked to the stock management is the storage of the materials which have to adopted accordingly. The warehousing management includes several warehousing planning levels. For the purpose of this project, the challenge was to assess two of the five levels, the sizing and dimensioning and the operation strategy selection. Thus, an assessment to the current storage space was performed. This allowed to conclude about investment decisions considering different hypothetic scenarios for the future.

The first step of this study was to collect information about the current warehousing and inventory management in MUSA's warehouse. There were some data limitations according to sales registering which do not allowed to perform a more accurate analysis based on forecast. Despite that, information about total sales over a period was collected. Also, list of SKUs by family considered, raw material consumption levels, warehouse plant, acquisition costs, suppliers' lead times and levels of inventory at some time were part of the gathered data. Afterwards, having information about the current situation and based on empirical research, models and specific analysis were performed and tested reflecting different factors and scenarios. The methods used were the continuous and periodic stochastic review models and ABC analysis.

For inventory management scope, a first costs analysis comparison between models showed that continuous review model is always less expensive in terms of inventory costs. This model should be adopted for that reason and if there is no classification on the items. So, a first proposal provided a fixed quantity that should be ordered for each SKU when the stock reaches a specific quantity, also fixed. The period between orders is variable. On another hand, according to products classification by importance different models should be adopted. Then, a final proposal was delivered containing the lower inventory cost possible according to the appropriate service level and model. A manager' decision on which model should be implemented has to be based on the companies' budget, taking into account its implementation costs as well as the advantages and disadvantages of each of the models.

In spite of inventory management activities manager should think in adopting different inventory management policies for the different SKUs due to the fact that each of them has different contributions to sales. Thus, the most important ones require a more accurate and strict control and should follow a continuous review policy while the less important do not and hence a periodic review is enough.

The results in terms of warehousing showed that the company has an appropriate sizing and dimensioning in terms of capacity since the dedicated spaces to each raw material are ready to receive up to six times sales increase measured in litters of beers. This means managers should only rethink their operation strategy when this limit is achieved. Regarding finished products the situation is not that comfortable, but it allows for now to adopt a make-to-stock strategy, since there is enough dedicated space in the warehouse.

After the main results presented and taking into account the research question presented in the first chapter "How to improve MUSA's warehousing and inventory management activities so as to improve its efficiency?" it is possible to answer that an efficiency improvement could be achieved by adopting inventory management policies contemplating the safety stock required regarding the demand uncertainty. This way the company could face unexpected situations and answer customers' orders on time. Namely, proposal B should be implemented for MUSA's inventory management since it considers SKUs importance and attributes the adequate review policy control. Also, invest in more dedicated space to store finished products if sales increase in the near future, which is likely to happen due to growing market trend.

A limitation of this study was the lack of detailed information about monthly, weekly or even daily sales that did not allowed to do more detailed inventory management proposals including the quantity to order for the periodic review model.

Further research on these topics could be done and suggestions are on performing a sales forecast by month in order to have the accurate scenario, allowing to confirm the situation where it fits and take the needed decisions. Furthermore, measure the financial impact of this stock management in the firms' accounts could be interesting due to the fundamental role it plays in the treasury equilibrium, which contributes to the decrease of working capital and hence to the increase of company's liquidity. A detailed analysis about allocation of the different SKUs in order to reduce order picking times could be also relevant.

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APPENDICES

Appendix 1 – Warehouse and equipment pictures

Figure 1 – Conventional racks

Figure 2 – Refrigerator

Figure 3 – Finished product storage

Figure 4 – Finished product storage

Appendix 2 – List of SKUs by family

Malts	Hops	Yeast
Acidulated	Bullion	SAFALE US-05
Barley flakes	Centennial	SAFALE S-04
Carafa Spec II	Citra	SAFLAGER W34/70
Carafa Spec III	Columbus	BSaison
Carahell	Fuggles	
Caramunich II	Mosaic	
Carapils	Simcoe	
Carared	Spalter Select	
Dextrin Malt	Summit	
Finest Lager Malt	Tradition	
Maris Otter Simpson	Saaz	
Melanoidin		
Munich I		
Oat flakes		
Pale Ale Simpson		
Pale Wheat		
Pilsner		
Roasted barley		
Vienna		
Wheat flakes		
Dextrose		
Golden Naked Oats		
Golden Promise		
Oat Malt		

Appendix 3 – Continuous and periodic costs analysis per SKU

Malts

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Acidulated	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	9 467,74	9 483,16	9 542,84	12 072,91	12 103,41	12 218,05	9 516,22	9 561,46	9 727,19	9 623,03	9 677,93	9 875,88
Total Cost (95% Service Level)	9 137,72	9 148,57	9 190,58	11 741,36	11 762,82	11 843,52	9 183,15	9 214,99	9 331,64	9 288,95	9 327,59	9 466,92
Total Cost (90% Service Level)	8 965,54	8 974,01	9 006,79	11 568,38	11 585,13	11 648,11	9 009,37	9 034,23	9 125,27	9 114,64	9 144,80	9 253,55

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Barley flakes	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	13 523,50	13 538,92	13 598,60	24 046,93	24 077,42	24 192,07	15 352,23	15 397,47	15 563,20	13 924,54	13 979,44	14 177,39
Total Cost (95% Service Level)	13 193,47	13 204,33	13 246,33	23 715,38	23 736,84	23 817,53	15 019,16	15 051,00	15 167,65	13 590,46	13 629,10	13 768,43
Total Cost (90% Service Level)	13 021,29	13 029,76	13 062,55	23 542,40	23 559,15	23 622,13	14 845,38	14 870,24	14 961,28	13 416,15	13 446,31	13 555,05

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Carafa Spec II	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	14 172,62	14 188,04	14 247,72	26 372,16	26 402,66	26 517,30	16 506,91	16 552,15	16 717,88	14 786,57	14 841,47	15 039,42
Total Cost (95% Service Level)	13 842,60	13 853,45	13 895,46	26 040,61	26 062,08	26 142,77	16 173,83	16 205,68	16 322,33	14 452,49	14 491,13	14 630,46
Total Cost (90% Service Level)	13 670,41	13 678,89	13 711,67	25 867,63	25 884,38	25 947,36	16 000,06	16 024,91	16 115,95	14 278,19	14 308,35	14 417,09

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Carafa Spec III	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	15 114,68	15 130,10	15 189,78	29 960,89	29 991,38	30 106,03	18 290,81	18 336,05	18 501,78	16 119,27	16 174,17	16 372,12
Total Cost (95% Service Level)	14 784,66	14 795,51	14 837,52	29 629,34	29 650,80	29 731,50	17 957,74	17 989,58	18 106,23	15 785,19	15 823,83	15 963,16
Total Cost (90% Service Level)	14 612,48	14 620,95	14 653,73	29 456,36	29 473,11	29 536,09	17 783,96	17 808,81	17 899,86	15 610,88	15 641,04	15 749,78

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Carahell	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	6 749,38	6 764,80	6 824,48	6 898,80	6 929,29	7 043,93	7 216,97	7 262,21	7 427,94	8 042,50	8 097,40	8 295,34
Total Cost (95% Service Level)	6 419,36	6 430,22	6 472,22	6 567,25	6 588,71	6 669,40	6 883,90	6 915,74	7 032,39	7 708,41	7 747,06	7 886,38
Total Cost (90% Service Level)	6 247,18	6 255,65	6 288,43	6 394,26	6 411,02	6 474,00	6 710,12	6 734,98	6 826,02	7 534,11	7 564,27	7 673,01

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Caramunich II	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	12 666,88	12 682,30	12 741,98	21 217,28	21 247,77	21 362,42	13 936,61	13 981,85	14 147,58	12 862,43	12 917,33	13 115,27
Total Cost (95% Service Level)	12 336,86	12 347,71	12 389,72	20 885,73	20 907,19	20 987,89	13 603,54	13 635,38	13 752,03	12 528,34	12 566,99	12 706,31
Total Cost (90% Service Level)	12 164,67	12 173,14	12 205,93	20 712,75	20 729,50	20 792,48	13 429,76	13 454,62	13 545,66	12 354,04	12 384,20	12 492,94

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Carapils	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	8 951,03	8 966,45	9 026,13	11 055,52	11 086,01	11 200,65	8 967,70	9 012,94	9 178,67	9 191,72	9 246,62	9 444,57
Total Cost (95% Service Level)	8 621,01	8 631,87	8 673,87	10 723,97	10 745,43	10 826,12	8 634,62	8 666,47	8 783,12	8 857,64	8 896,28	9 035,61
Total Cost (90% Service Level)	8 448,83	8 457,30	8 490,08	10 550,98	10 567,74	10 630,72	8 460,85	8 485,70	8 576,74	8 683,33	8 713,49	8 822,24

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Carared	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	8 007,64	8 023,06	8 082,74	9 058,43	9 088,92	9 203,57	8 067,11	8 112,35	8 278,08	8 565,26	8 620,16	8 818,11
Total Cost (95% Service Level)	7 677,62	7 688,47	7 730,48	8 726,88	8 748,34	8 829,03	7 734,04	7 765,88	7 882,53	8 231,18	8 269,82	8 409,15
Total Cost (90% Service Level)	7 505,44	7 513,91	7 546,69	8 553,90	8 570,65	8 633,63	7 560,26	7 585,11	7 676,16	8 056,87	8 087,03	8 195,78

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Dextrin Malt	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	8 284,17	8 299,59	8 359,27	9 811,63	9 842,12	9 956,77	8 299,71	8 344,95	8 510,68	8 667,71	8 722,61	8 920,56
Total Cost (95% Service Level)	7 954,15	7 965,00	8 007,01	9 480,08	9 501,54	9 582,23	7 966,64	7 998,48	8 115,13	8 333,63	8 372,27	8 511,60
Total Cost (90% Service Level)	7 781,97	7 790,44	7 823,22	9 307,10	9 323,85	9 386,83	7 792,86	7 817,71	7 908,76	8 159,32	8 189,48	8 298,23

	The below figures correspond to demand standard deviations											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Finest Lager Malt	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	7 408,04	7 423,46	7 483,14	7 443,86	7 474,35	7 588,99	8 092,36	8 137,61	8 303,33	9 000,47	9 055,37	9 253,32
Total Cost (95% Service Level)	7 078,02	7 088,87	7 130,88	7 112,31	7 133,77	7 214,46	7 759,29	7 791,14	7 907,79	8 666,39	8 705,03	8 844,36
Total Cost (90% Service Level)	6 905,83	6 914,30	6 947,09	6 939,32	6 956,07	7 019,05	7 585,51	7 610,37	7 701,41	8 492,09	8 522,25	8 630,99

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Maris Otter Simpson	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	6 488,63	6 504,05	6 563,73	6 638,71	6 669,21	6 783,85	7 972,66	8 017,90	8 183,63	9 052,13	9 107,03	9 304,98
Total Cost (95% Service Level)	6 158,61	6 169,46	6 211,47	6 307,16	6 328,63	6 409,32	7 639,59	7 671,43	7 788,08	8 718,05	8 756,69	8 896,02
Total Cost (90% Service Level)	5 986,42	5 994,90	6 027,68	6 134,18	6 150,93	6 213,91	7 465,81	7 490,66	7 581,71	8 543,74	8 573,90	8 682,64

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Melanoidin	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	13 673,73	13 689,15	13 748,83	24 651,29	24 681,78	24 796,43	15 636,97	15 682,21	15 847,94	14 129,38	14 184,28	14 382,22
Total Cost (95% Service Level)	13 343,71	13 354,56	13 396,57	24 319,74	24 341,20	24 421,90	15 303,90	15 335,74	15 452,39	13 795,29	13 833,93	13 973,26
Total Cost (90% Service Level)	13 171,52	13 180,00	13 212,78	24 146,76	24 163,51	24 226,49	15 130,12	15 154,98	15 246,02	13 620,99	13 651,15	13 759,89

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Munich I	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	6 824,67	6 840,09	6 899,77	7 086,01	7 116,50	7 231,15	7 179,42	7 224,66	7 390,39	7 948,76	8 003,66	8 201,60
Total Cost (95% Service Level)	6 494,65	6 505,50	6 547,51	6 754,46	6 775,92	6 856,62	6 846,35	6 878,19	6 994,84	7 614,67	7 653,32	7 792,64
Total Cost (90% Service Level)	6 322,47	6 330,94	6 363,72	6 581,48	6 598,23	6 661,21	6 672,57	6 697,43	6 788,47	7 440,37	7 470,53	7 579,27

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Oat flakes	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	12 360,84	12 376,26	12 435,94	20 015,48	20 045,98	20 160,62	13 393,08	13 438,32	13 604,05	12 483,46	12 538,36	12 736,31
Total Cost (95% Service Level)	12 030,82	12 041,68	12 083,68	19 683,93	19 705,40	19 786,09	13 060,01	13 091,85	13 208,50	12 149,37	12 188,02	12 327,34
Total Cost (90% Service Level)	11 858,64	11 867,11	11 899,89	19 510,95	19 527,70	19 590,68	12 886,23	12 911,08	13 002,13	11 975,07	12 005,23	12 113,97

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Pale Ale Simpson	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	7 384,34	7 399,76	7 459,44	7 769,01	7 799,51	7 914,15	9 300,14	9 345,38	9 511,11	10 428,90	10 483,80	10 681,75
Total Cost (95% Service Level)	7 054,32	7 065,17	7 107,18	7 437,46	7 458,92	7 539,62	8 967,06	8 998,91	9 115,56	10 094,82	10 133,46	10 272,79
Total Cost (90% Service Level)	6 882,13	6 890,60	6 923,39	7 264,48	7 281,23	7 344,21	8 793,29	8 818,14	8 909,18	9 920,51	9 950,67	10 059,41

The below percentages correspond to demand standard deviations. Total costs are in euros.

	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Pale Wheat	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	11 688,78	11 704,19	11 763,87	18 234,11	18 264,60	18 379,25	12 444,80	12 490,04	12 655,77	11 743,45	11 798,35	11 996,30
Total Cost (95% Service Level)	11 358,75	11 369,61	11 411,61	17 902,56	17 924,02	18 004,71	12 111,72	12 143,57	12 260,22	11 409,37	11 448,01	11 587,34
Total Cost (90% Service Level)	11 186,57	11 195,04	11 227,82	17 729,58	17 746,33	17 809,31	11 937,95	11 962,80	12 053,84	11 235,06	11 265,22	11 373,97

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Pilsner	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	6 106,60	6 122,02	6 181,70	6 127,47	6 157,97	6 272,61	7 184,85	7 230,09	7 395,82	8 195,18	8 250,08	8 448,02
Total Cost (95% Service Level)	5 776,58	5 787,43	5 829,44	5 795,92	5 817,39	5 898,08	6 851,78	6 883,62	7 000,27	7 861,09	7 899,74	8 039,06
Total Cost (90% Service Level)	5 604,39	5 612,86	5 645,65	5 622,94	5 639,69	5 702,67	6 678,00	6 702,85	6 793,90	7 686,79	7 716,95	7 825,69

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Roasted barley	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	16 727,09	16 742,51	16 802,19	36 666,97	36 697,46	36 812,11	21 631,77	21 677,01	21 842,74	18 618,95	18 673,85	18 871,80
Total Cost (95% Service Level)	16 397,07	16 407,92	16 449,92	36 335,42	36 356,88	36 437,58	21 298,70	21 330,54	21 447,19	18 284,87	18 323,51	18 462,84
Total Cost (90% Service Level)	16 224,88	16 233,35	16 266,14	36 162,44	36 179,19	36 242,17	21 124,92	21 149,78	21 240,82	18 110,57	18 140,73	18 249,47

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Vienna	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	10 334,19	10 349,61	10 409,29	14 446,84	14 477,33	14 591,98	10 582,93	10 628,17	10 793,90	10 362,94	10 417,84	10 615,78
Total Cost (95% Service Level)	10 004,17	10 015,02	10 057,03	14 115,29	14 136,75	14 217,45	10 249,86	10 281,70	10 398,35	10 028,85	10 067,50	10 206,82
Total Cost (90% Service Level)	9 831,98	9 840,46	9 873,24	13 942,31	13 959,06	14 022,04	10 076,08	10 100,94	10 191,98	9 854,55	9 884,71	9 993,45

The below percentages correspond to demand standard deviations. Total costs are in euros.

	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Wheat flakes	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	9 488,22	9 503,64	9 563,32	12 090,98	12 121,47	12 236,12	9 536,49	9 581,73	9 747,46	9 643,85	9 698,75	9 896,70
Total Cost (95% Service Level)	9 158,19	9 169,05	9 211,05	11 759,43	11 780,89	11 861,59	9 203,42	9 235,26	9 351,91	9 309,77	9 348,41	9 487,74
Total Cost (90% Service Level)	8 986,01	8 994,48	9 027,27	11 586,45	11 603,20	11 666,18	9 029,64	9 054,49	9 145,54	9 135,46	9 165,62	9 274,36

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Dextrose	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	26 365,48	26 380,90	26 440,58	58 609,97	58 640,46	58 755,11	32 576,42	32 621,66	32 787,39	26 814,02	26 868,92	27 066,86
Total Cost (95% Service Level)	26 035,45	26 046,31	26 088,31	58 278,42	58 299,88	58 380,57	32 243,35	32 275,19	32 391,84	26 479,93	26 518,58	26 657,90
Total Cost (90% Service Level)	25 863,27	25 871,74	25 904,53	58 105,44	58 122,19	58 185,17	32 069,57	32 094,43	32 185,47	26 305,63	26 335,79	26 444,53

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Golden Naked Oats	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	23 970,77	23 986,19	24 045,87	75 267,81	75 298,31	75 412,95	40 950,48	40 995,72	41 161,45	33 117,13	33 172,03	33 369,98
Total Cost (95% Service Level)	23 640,75	23 651,60	23 693,61	74 936,26	74 957,72	75 038,42	40 617,41	40 649,25	40 765,90	32 783,05	32 821,69	32 961,02
Total Cost (90% Service Level)	23 468,56	23 477,03	23 509,82	74 763,28	74 780,03	74 843,01	40 443,63	40 468,49	40 559,53	32 608,74	32 638,90	32 747,65

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Golden Promise	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	7 739,02	7 754,44	7 814,12	8 618,49	8 648,98	8 763,63	7 829,76	7 875,00	8 040,73	8 378,55	8 433,45	8 631,40
Total Cost (95% Service Level)	7 409,00	7 419,85	7 461,86	8 286,94	8 308,40	8 389,10	7 496,68	7 528,53	7 645,18	8 044,47	8 083,11	8 222,44
Total Cost (90% Service Level)	7 236,81	7 245,28	7 278,07	8 113,96	8 130,71	8 193,69	7 322,91	7 347,76	7 438,80	7 870,16	7 900,32	8 009,07

The below percentages correspond to demand standard deviations. Total costs are in euros.

	Q Model			P Model (P=15 days)			P Model (P=30 days)			P Model (P=40 days)		
Oat Malt	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	29 115,17	29 130,59	29 190,27	112 464,28	112 494,78	112 609,42	59 492,14	59 537,38	59 703,11	46 995,08	47 049,98	47 247,93
Total Cost (95% Service Level)	28 785,15	28 796,00	28 838,01	112 132,73	112 154,20	112 234,89	59 159,07	59 190,91	59 307,56	46 661,00	46 699,64	46 838,97
Total Cost (90% Service Level)	28 612,97	28 621,44	28 654,22	111 959,75	111 976,50	112 039,48	58 985,29	59 010,14	59 101,19	46 486,70	46 516,86	46 625,60

Hops

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=105 days)			P Model (P=120 days)			P Model (P=130 days)		
Bullion	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	45 252,70	45 263,46	45 305,53	51 399,52	51 514,42	51 897,86	48 643,34	48 771,98	49 194,60	47 398,49	47 536,16	47 984,00
Total Cost (95% Service Level)	44 909,21	44 916,78	44 946,40	51 045,00	51 125,87	51 395,76	48 287,27	48 377,82	48 675,29	47 041,40	47 138,30	47 453,51
Total Cost (90% Service Level)	44 730,00	44 735,91	44 759,02	50 860,03	50 923,15	51 133,80	48 101,50	48 172,17	48 404,34	46 855,09	46 930,72	47 176,74

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=105 days)			P Model (P=120 days)			P Model (P=130 days)		
Centennial	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	57 024,60	57 035,36	57 077,43	73 964,76	74 079,66	74 463,10	68 380,00	68 508,64	68 931,26	65 612,07	65 749,74	66 197,57
Total Cost (95% Service Level)	56 681,11	56 688,68	56 718,29	73 610,25	73 691,12	73 961,01	68 023,93	68 114,48	68 411,95	65 254,97	65 351,87	65 667,09
Total Cost (90% Service Level)	56 501,89	56 507,80	56 530,92	73 425,28	73 488,40	73 699,05	67 838,16	67 908,83	68 141,00	65 068,66	65 144,29	65 390,32

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=105 days)			P Model (P=120 days)			P Model (P=130 days)		
Citra	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	19 665,57	19 676,33	19 718,40	21 912,73	22 027,63	22 411,07	23 177,48	23 306,12	23 728,74	24 097,74	24 235,41	24 683,25
Total Cost (95% Service Level)	19 322,08	19 329,65	19 359,26	21 558,21	21 639,09	21 908,98	22 821,41	22 911,96	23 209,42	23 740,65	23 837,55	24 152,76
Total Cost (90% Service Level)	19 142,86	19 148,77	19 171,88	21 373,25	21 436,37	21 647,01	22 635,64	22 706,31	22 938,48	23 554,34	23 629,97	23 875,99

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=105 days)			P Model (P=120 days)			P Model (P=130 days)		
Columbus	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	24 056,92	24 067,68	24 109,75	24 388,60	24 503,49	24 886,93	25 079,27	25 207,91	25 630,53	25 690,42	25 828,09	26 275,93
Total Cost (95% Service Level)	23 713,43	23 721,00	23 750,61	24 034,08	24 114,95	24 384,84	24 723,20	24 813,75	25 111,22	25 333,32	25 430,23	25 745,44
Total Cost (90% Service Level)	23 534,21	23 540,12	23 563,24	23 849,11	23 912,23	24 122,88	24 537,43	24 608,10	24 840,27	25 147,01	25 222,65	25 468,67

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=105 days)			P Model (P=120 days)			P Model (P=130 days)		
Fuggles	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	51 356,23	51 366,99	51 409,06	62 443,59	62 558,49	62 941,93	58 300,68	58 429,33	58 851,95	56 309,14	56 446,81	56 894,65
Total Cost (95% Service Level)	51 012,74	51 020,31	51 049,92	62 089,07	62 169,94	62 439,83	57 944,62	58 035,17	58 332,63	55 952,04	56 048,95	56 364,16
Total Cost (90% Service Level)	50 833,52	50 839,43	50 862,55	61 904,10	61 967,22	62 177,87	57 758,84	57 829,52	58 061,68	55 765,73	55 841,37	56 087,39

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=105 days)			P Model (P=120 days)			P Model (P=130 days)		
Mosaic	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	20 227,34	20 238,10	20 280,17	22 188,77	22 303,67	22 687,11	23 349,67	23 478,32	23 900,93	24 214,02	24 351,69	24 799,53
Total Cost (95% Service Level)	19 883,85	19 891,42	19 921,03	21 834,25	21 915,13	22 185,02	22 993,61	23 084,15	23 381,62	23 856,92	23 953,83	24 269,04
Total Cost (90% Service Level)	19 704,63	19 710,54	19 733,66	21 649,29	21 712,41	21 923,05	22 807,83	22 878,50	23 110,67	23 670,61	23 746,25	23 992,27

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=105 days)			P Model (P=120 days)			P Model (P=130 days)		
Simcoe	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	38 414,13	38 424,89	38 466,96	40 646,27	40 761,17	41 144,61	39 272,94	39 401,58	39 824,20	38 772,70	38 910,38	39 358,21
Total Cost (95% Service Level)	38 070,64	38 078,21	38 107,82	40 291,75	40 372,62	40 642,51	38 916,87	39 007,42	39 304,89	38 415,61	38 512,51	38 827,73
Total Cost (90% Service Level)	37 891,42	37 897,33	37 920,45	40 106,79	40 169,91	40 380,55	38 731,10	38 801,77	39 033,94	38 229,30	38 304,93	38 550,95

The below percentages correspond to demand standard deviations. Total costs are in euros.

	Q Model			P Model (P=105 days)			P Model (P=120 days)			P Model (P=130 days)		
Spalter Select	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	27 548,31	27 559,07	27 601,14	28 683,81	28 798,71	29 182,15	28 918,79	29 047,43	29 470,05	29 284,56	29 422,23	29 870,07
Total Cost (95% Service Level)	27 204,81	27 212,39	27 242,00	28 329,29	28 410,16	28 680,05	28 562,72	28 653,27	28 950,73	28 927,47	29 024,37	29 339,59
Total Cost (90% Service Level)	27 025,60	27 031,51	27 054,62	28 144,32	28 207,44	28 418,09	28 376,95	28 447,62	28 679,79	28 741,16	28 816,79	29 062,81

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=105 days)			P Model (P=120 days)			P Model (P=130 days)		
Summit	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	29 170,74	29 181,50	29 223,57	29 227,44	29 342,34	29 725,78	29 336,93	29 465,58	29 888,19	29 635,13	29 772,81	30 220,64
Total Cost (95% Service Level)	28 827,25	28 834,82	28 864,43	28 872,93	28 953,80	29 223,69	28 980,87	29 071,41	29 368,88	29 278,04	29 374,94	29 690,16
Total Cost (90% Service Level)	28 648,03	28 653,94	28 677,06	28 687,96	28 751,08	28 961,73	28 795,09	28 865,76	29 097,93	29 091,73	29 167,36	29 413,39

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=105 days)			P Model (P=120 days)			P Model (P=130 days)		
Tradition	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	30 613,84	30 624,59	30 666,67	30 835,60	30 950,50	31 333,94	30 662,77	30 791,41	31 214,03	30 808,95	30 946,62	31 394,46
Total Cost (95% Service Level)	30 270,34	30 277,92	30 307,53	30 481,08	30 561,95	30 831,84	30 306,70	30 397,25	30 694,71	30 451,86	30 548,76	30 863,97
Total Cost (90% Service Level)	30 091,13	30 097,04	30 120,15	30 296,12	30 359,24	30 569,88	30 120,93	30 191,60	30 423,77	30 265,55	30 341,18	30 587,20

	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=105 days)			P Model (P=120 days)			P Model (P=130 days)		
Saaz	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	58 857,81	58 868,57	58 910,64	77 951,34	78 066,24	78 449,68	71 868,05	71 996,69	72 419,31	68 831,68	68 969,35	69 417,18
Total Cost (95% Service Level)	58 514,31	58 521,89	58 551,50	77 596,83	77 677,70	77 947,59	71 511,98	71 602,53	71 900,00	68 474,58	68 571,48	68 886,70
Total Cost (90% Service Level)	58 335,10	58 341,01	58 364,12	77 411,86	77 474,98	77 685,62	71 326,21	71 396,88	71 629,05	68 288,27	68 363,90	68 609,93

Yeast

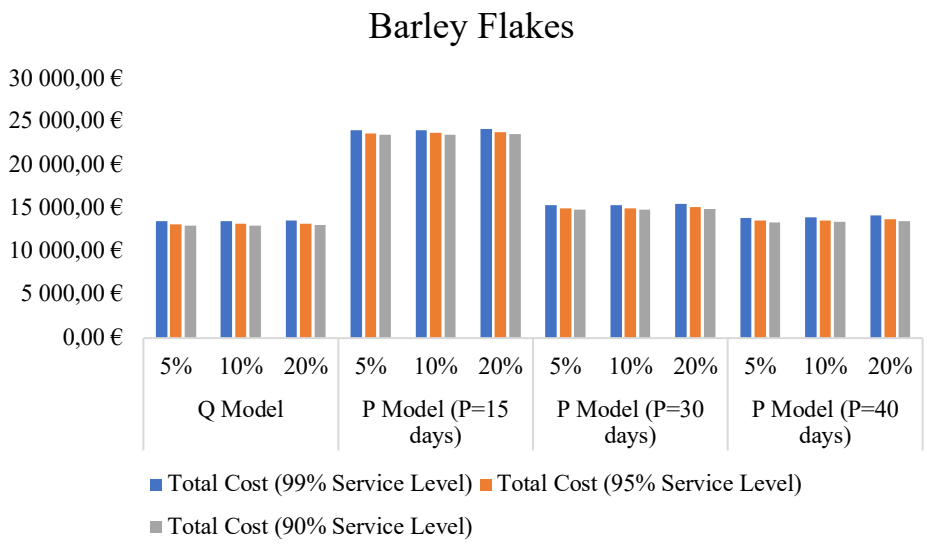
	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=155 days)			P Model (P=170days)			P Model (P=180 days)		
SAFALE US-05	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	31 443,59	31 454,35	31 496,42	33 701,33	33 861,12	34 369,20	34 586,25	34 759,01	35 301,51	35 267,04	35 448,33	36 013,12
Total Cost (95% Service Level)	31 100,10	31 107,67	31 137,29	33 341,68	33 454,15	33 811,77	34 225,08	34 346,68	34 728,52	34 904,85	35 032,46	35 429,99
Total Cost (90% Service Level)	30 920,89	30 926,79	30 949,91	33 154,04	33 241,82	33 520,94	34 036,64	34 131,55	34 429,57	34 715,89	34 815,48	35 125,75

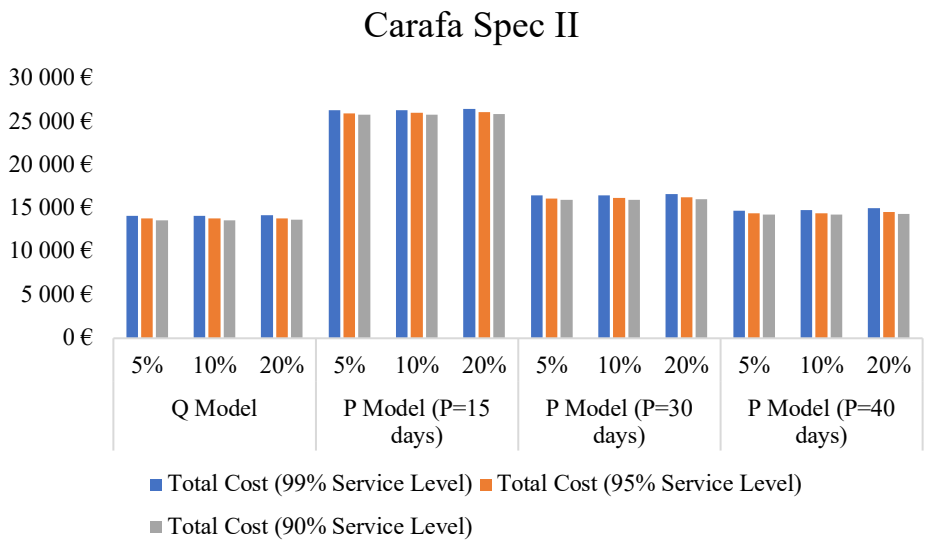
	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=155 days)			P Model (P=170days)			P Model (P=180 days)		
SAFALE S-04	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	53 625,30	53 636,06	53 678,13	64 417,07	64 576,86	65 084,93	62 451,98	62 624,74	63 167,23	61 496,65	61 677,94	62 242,73
Total Cost (95% Service Level)	53 281,81	53 289,38	53 318,99	64 057,42	64 169,89	64 527,50	62 090,80	62 212,40	62 594,24	61 134,46	61 262,06	61 659,60
Total Cost (90% Service Level)	53 102,59	53 108,50	53 131,62	63 869,78	63 957,56	64 236,67	61 902,36	61 997,27	62 295,29	60 945,49	61 045,09	61 355,36

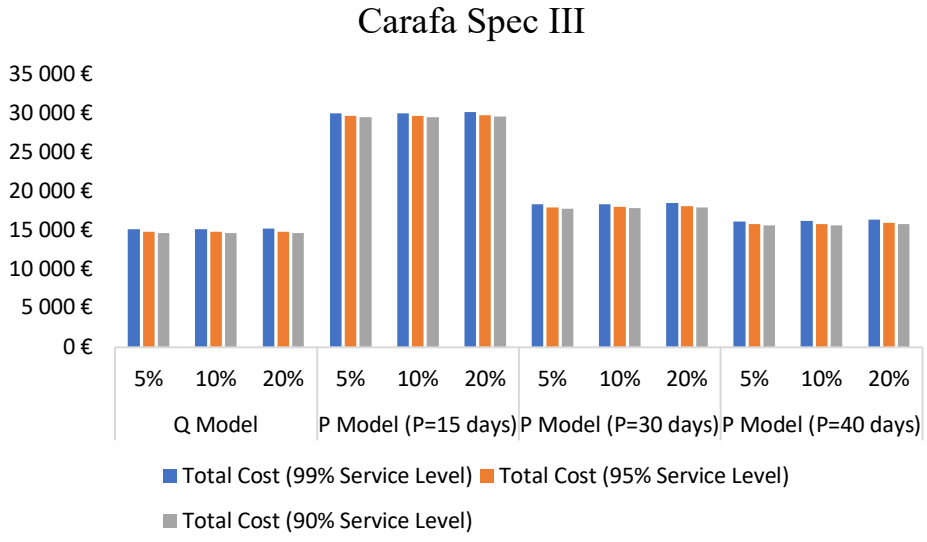
	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=155 days)			P Model (P=170days)			P Model (P=180 days)		
SAFLAGER W34/70	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	35 462,46	35 473,22	35 515,29	36 208,42	36 368,21	36 876,29	36 960,25	37 133,02	37 675,51	37 564,64	37 745,93	38 310,72
Total Cost (95% Service Level)	35 118,97	35 126,54	35 156,15	35 848,77	35 961,24	36 318,86	36 599,08	36 720,68	37 102,52	37 202,45	37 330,06	37 727,59
Total Cost (90% Service Level)	34 939,75	34 945,66	34 968,77	35 661,13	35 748,91	36 028,03	36 410,64	36 505,55	36 803,57	37 013,49	37 113,08	37 423,35

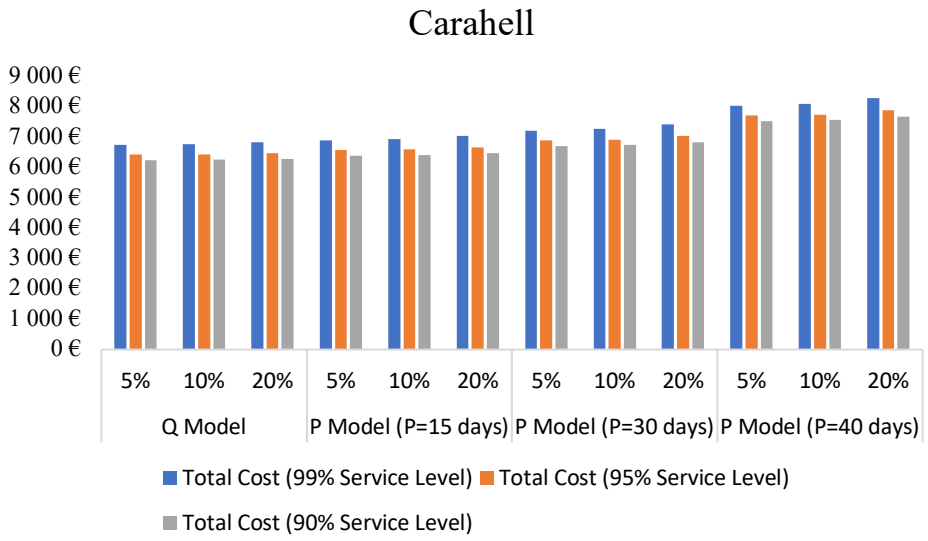
	The below percentages correspond to demand standard deviations. Total costs are in euros.											
	Q Model			P Model (P=155 days)			P Model (P=170days)			P Model (P=180 days)		
BSaison	5%	10%	20%	5%	10%	20%	5%	10%	20%	5%	10%	20%
Total Cost (99% Service Level)	92 311,51	92 322,27	92 364,34	128 280,62	128 440,41	128 948,49	120 643,35	120 816,11	121 358,61	116 431,77	116 613,06	117 177,85
Total Cost (95% Service Level)	91 968,02	91 975,59	92 005,20	127 920,97	128 033,44	128 391,06	120 282,18	120 403,78	120 785,62	116 069,58	116 197,19	116 594,72
Total Cost (90% Service Level)	91 788,80	91 794,71	91 817,83	127 733,33	127 821,11	128 100,22	120 093,74	120 188,64	120 486,67	115 880,62	115 980,21	116 290,48

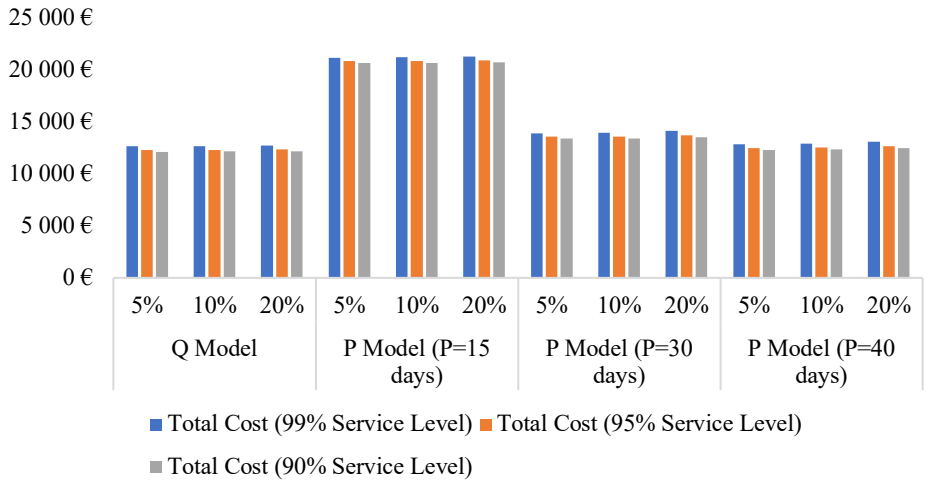
Appendix 4 – Models' costs comparison

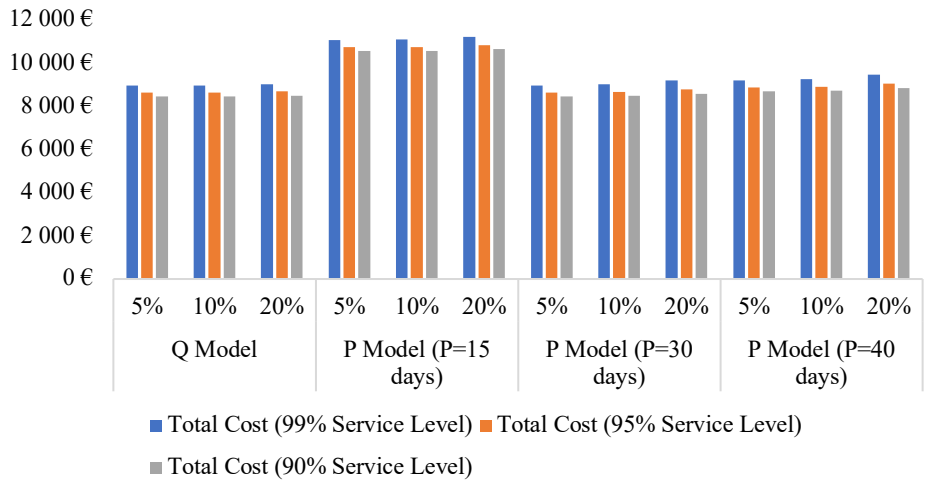


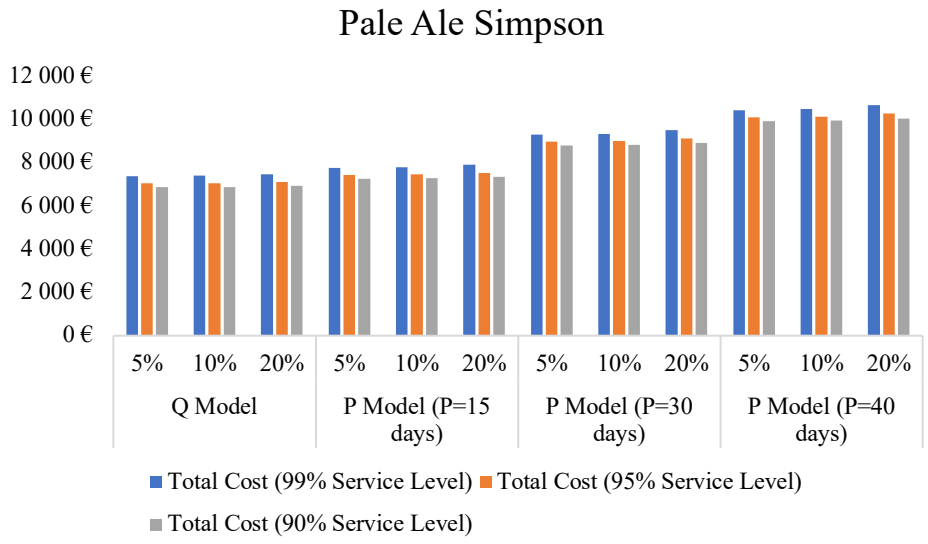


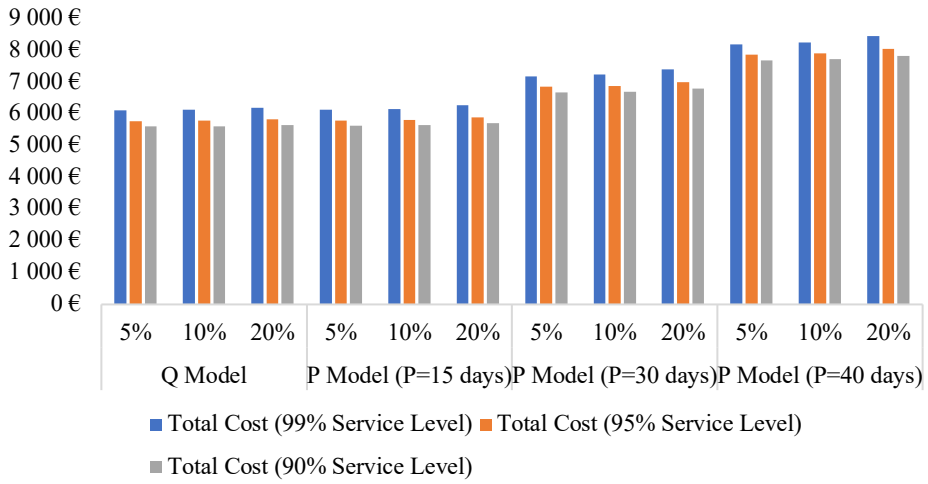


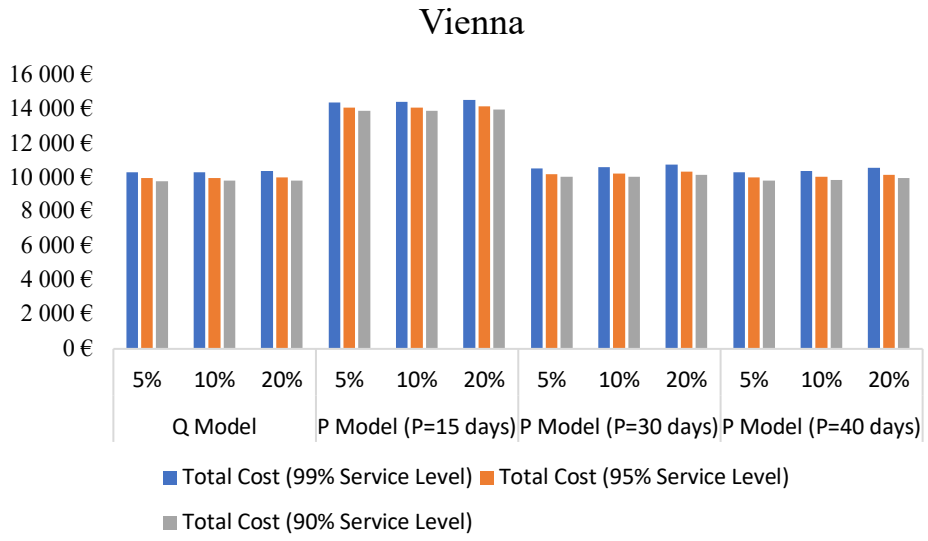

Carahell
9 000 €
8 000 €
7 000 €
6 000 €
5 000 €
4 000 €
3 000 €
2 000 €
1 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

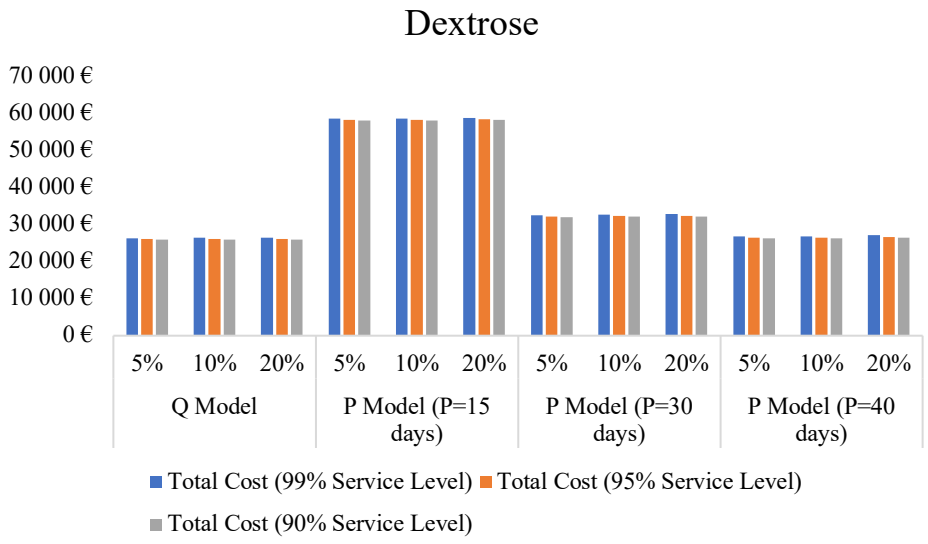

Caramunich II
25 000 €
20 000 €
15 000 €
10 000 €
5 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

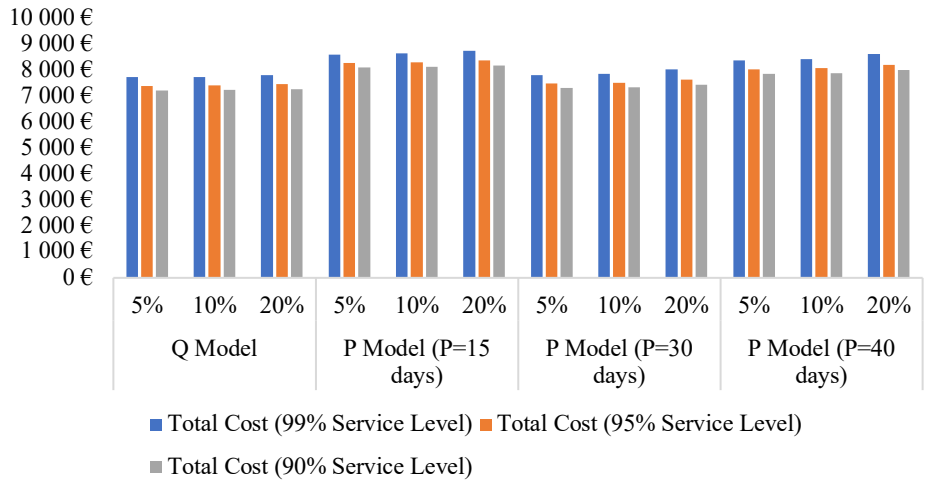

Carapils
12 000 €
10 000 €
8 000 €
6 000 €
4 000 €
2 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

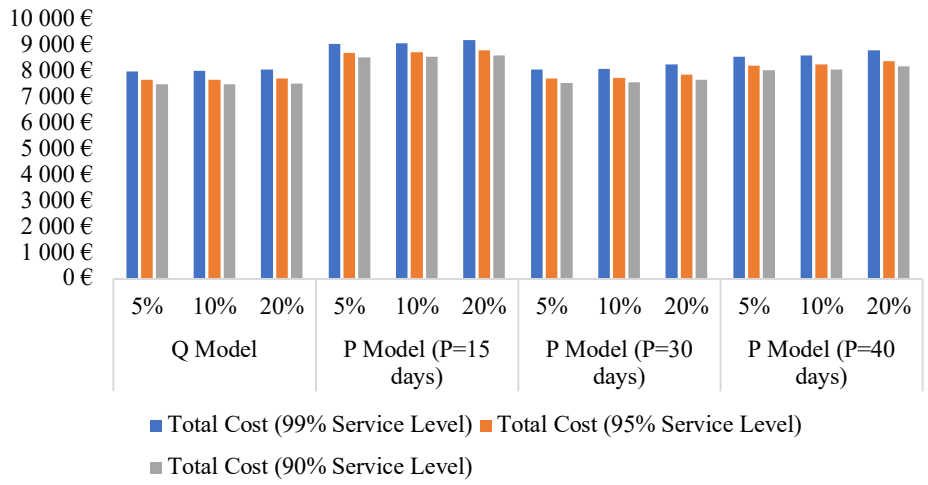

Pale Ale Simpson
12 000 €
10 000 €
8 000 €
6 000 €
4 000 €
2 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)


Pilsner
9 000 €
8 000 €
7 000 €
6 000 €
5 000 €
4 000 €
3 000 €
2 000 €
1 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

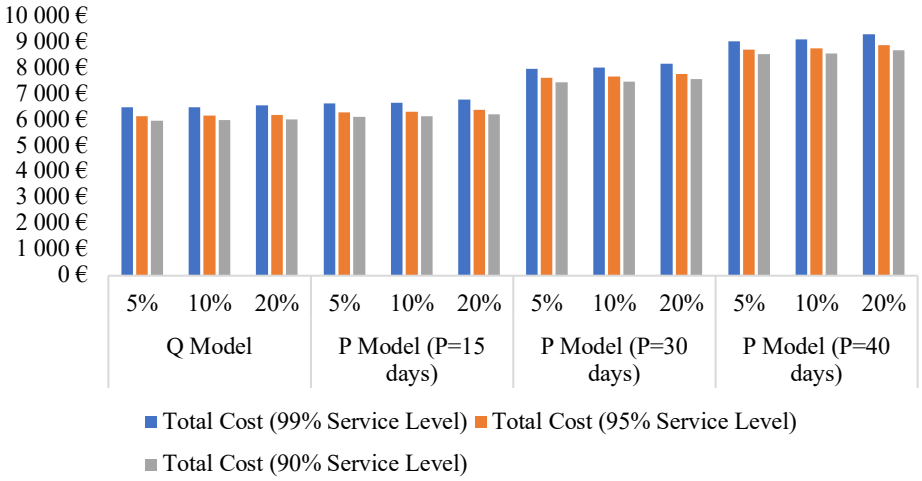

Vienna
16 000 €
14 000 €
12 000 €
10 000 €
8 000 €
6 000 €
4 000 €
2 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)


Dextrose
70 000 €
60 000 €
50 000 €
40 000 €
30 000 €
20 000 €
10 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

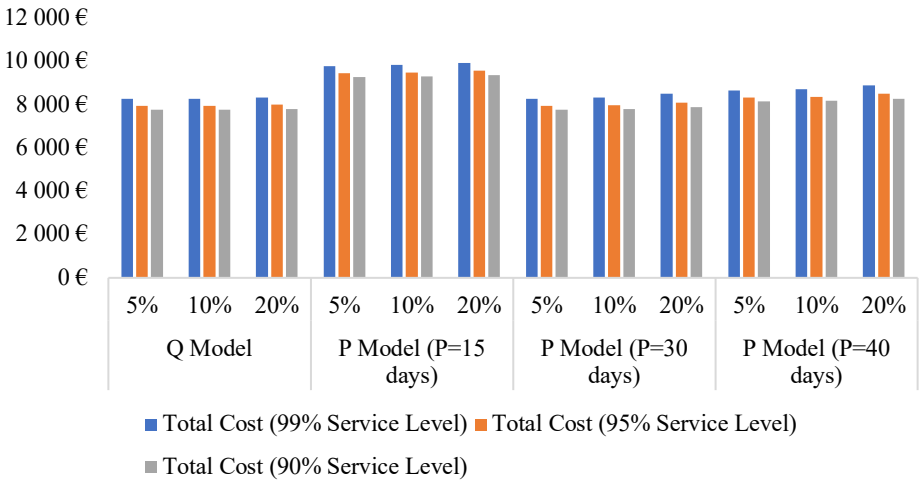

Golden Promise
10 000 €
9 000 €
8 000 €
7 000 €
6 000 €
5 000 €
4 000 €
3 000 €
2 000 €
1 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)


Carared
10 000 €
9 000 €
8 000 €
7 000 €
6 000 €
5 000 €
4 000 €
3 000 €
2 000 €
1 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

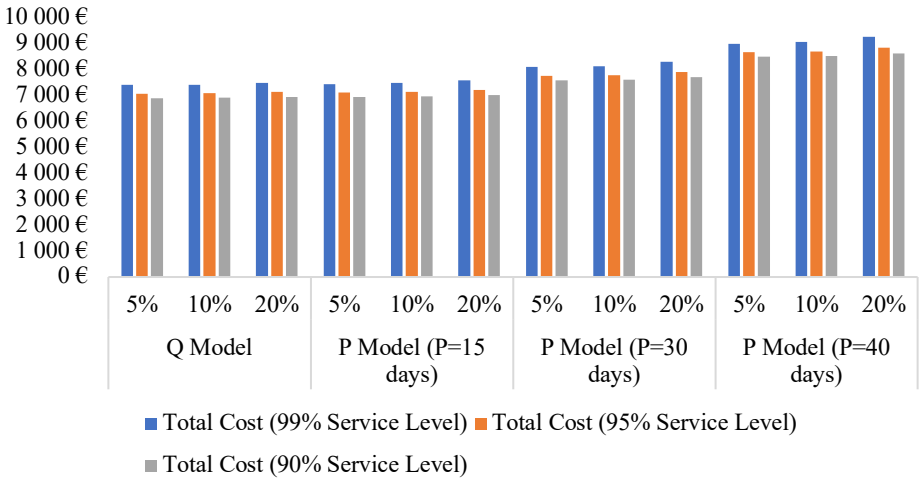
Maris Otter Simpson

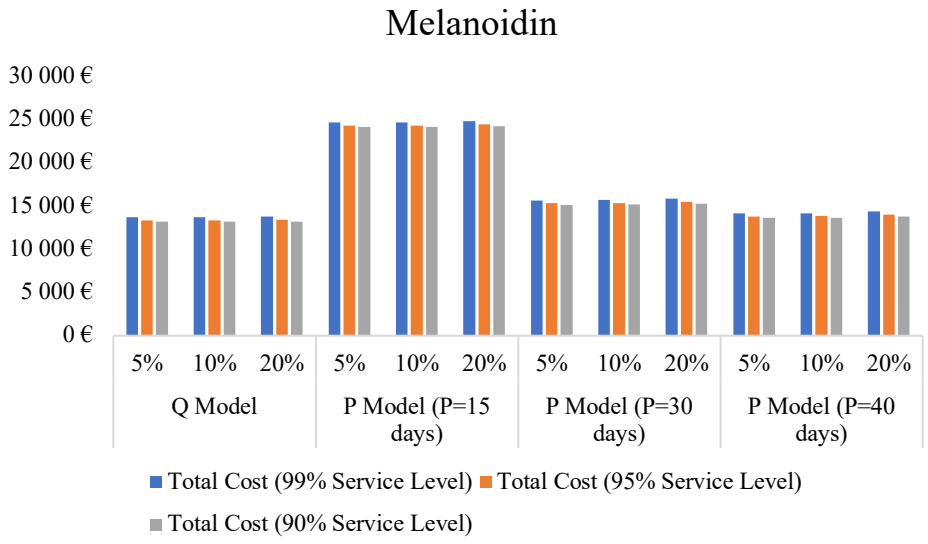


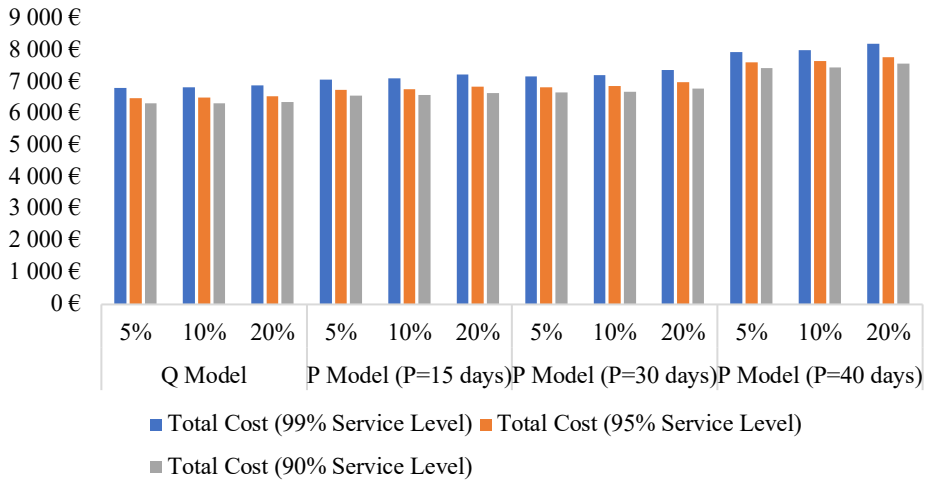
Dextrin Malt

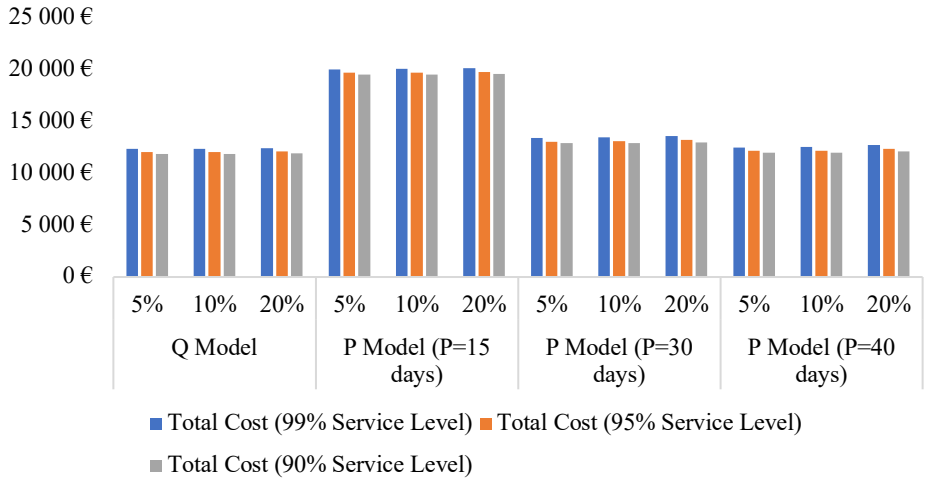


Finest Lager Malt

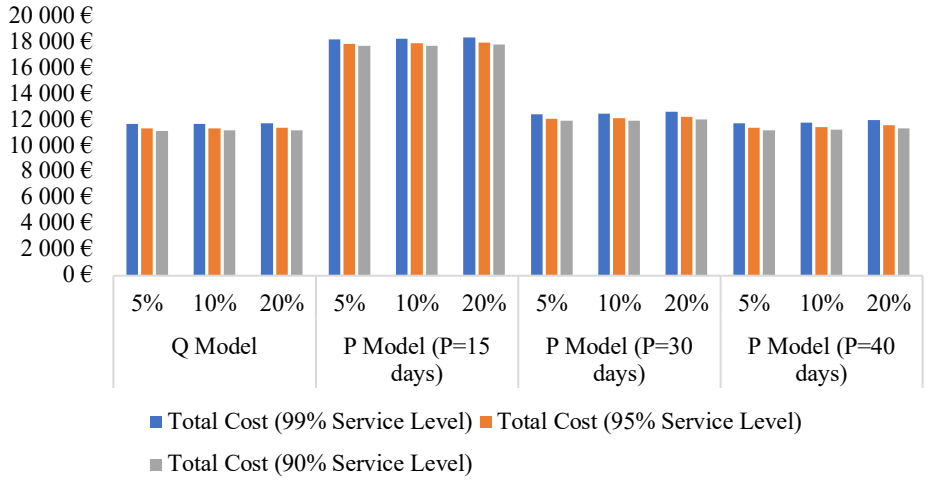



Melanoidin
30 000 €
25 000 €
20 000 €
15 000 €
10 000 €
5 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

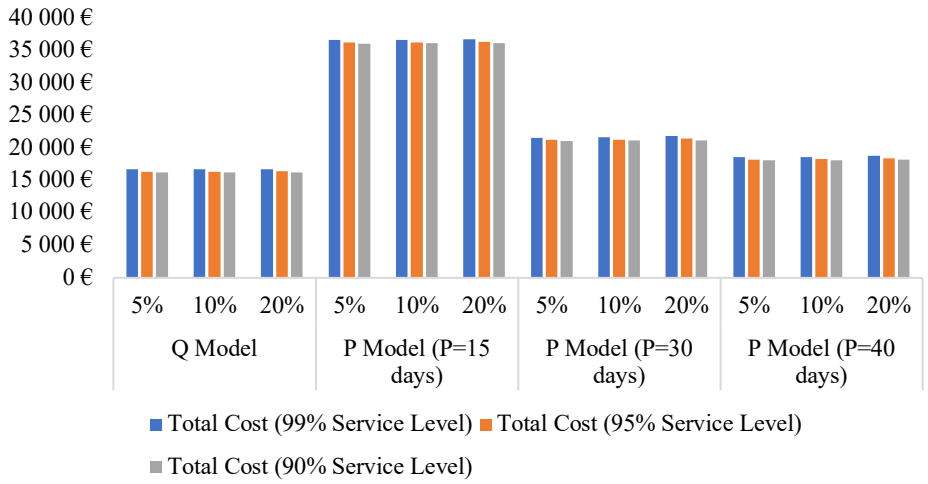

Munich I
9 000 €
8 000 €
7 000 €
6 000 €
5 000 €
4 000 €
3 000 €
2 000 €
1 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)


Oat Flakes
25 000 €
20 000 €
15 000 €
10 000 €
5 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

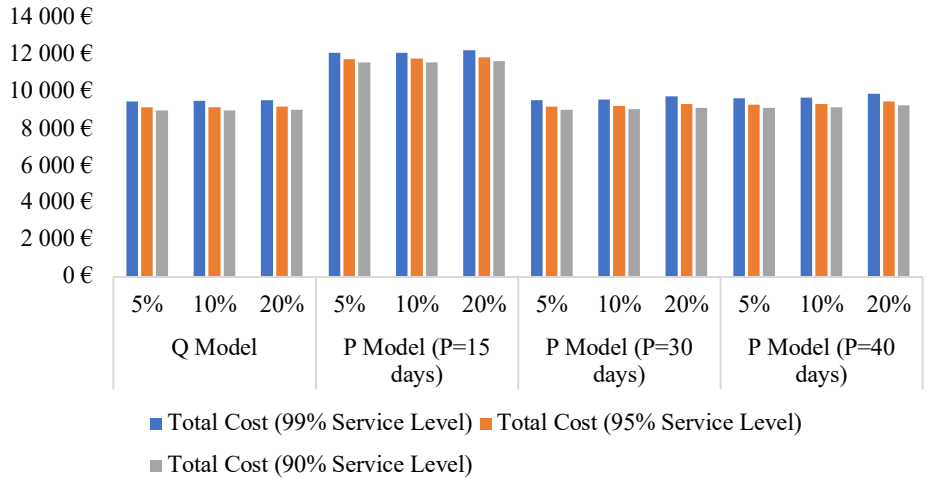
Pale Wheat

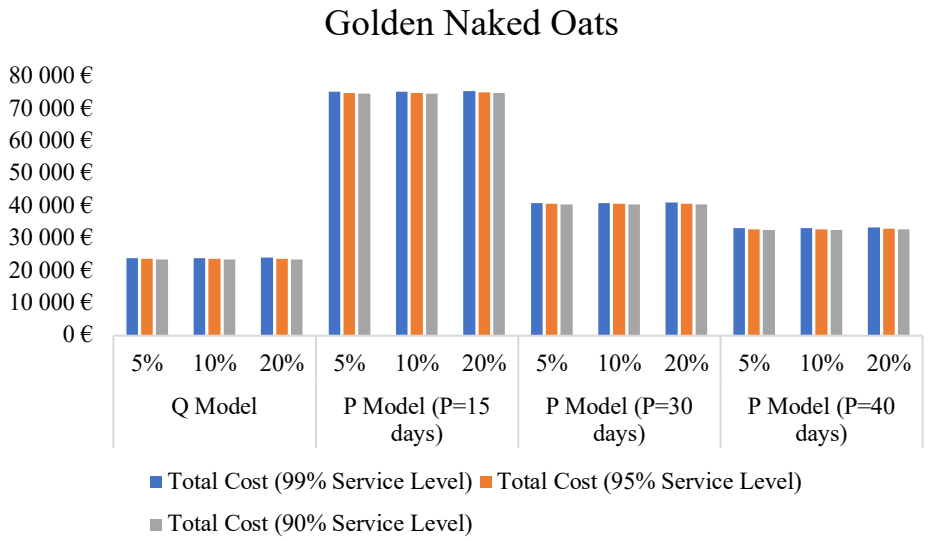


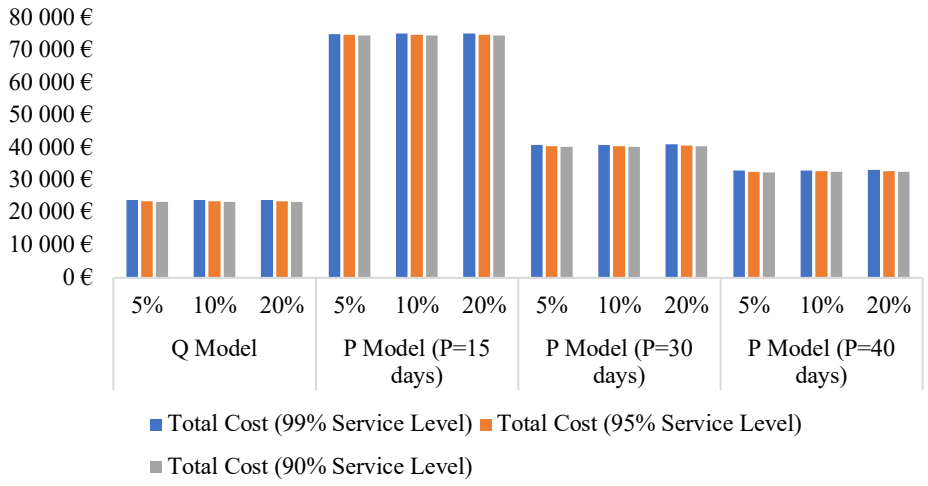
Roasted Barley

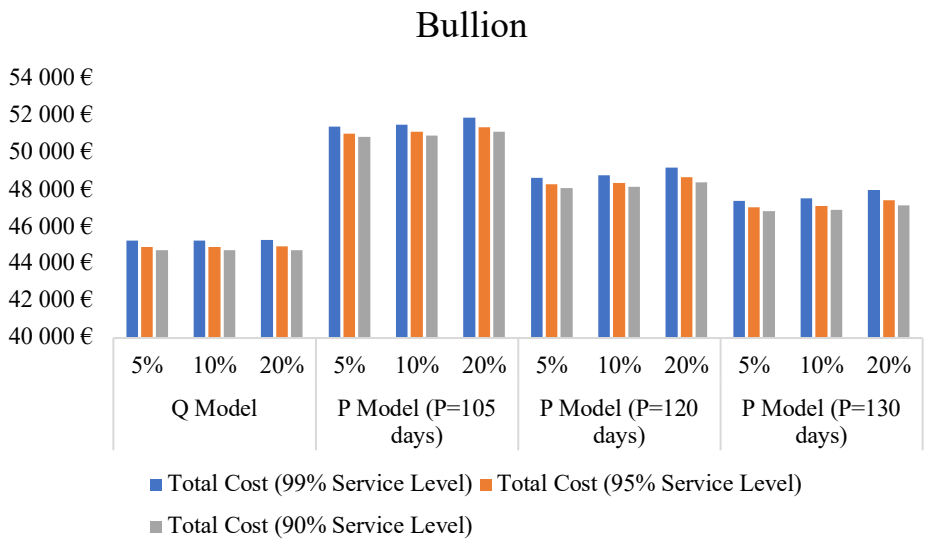


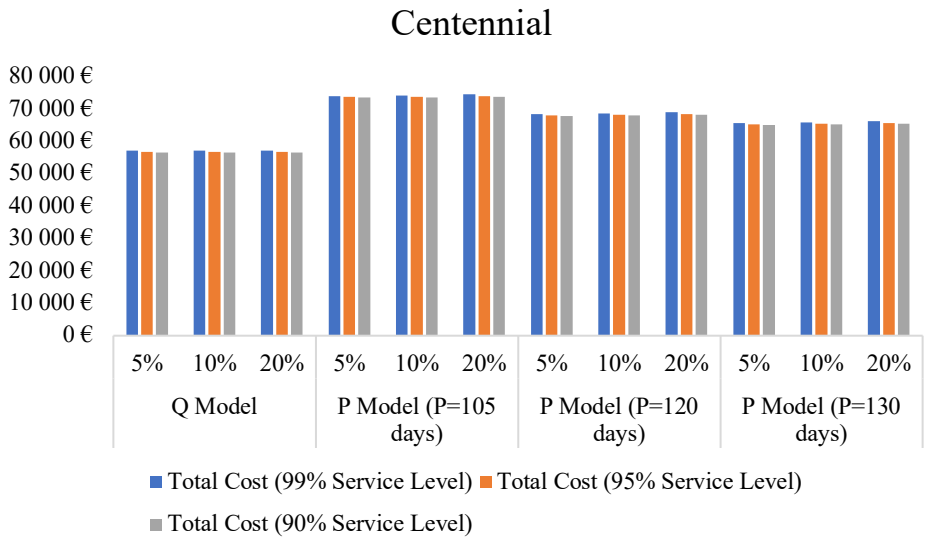
Wheat Flakes

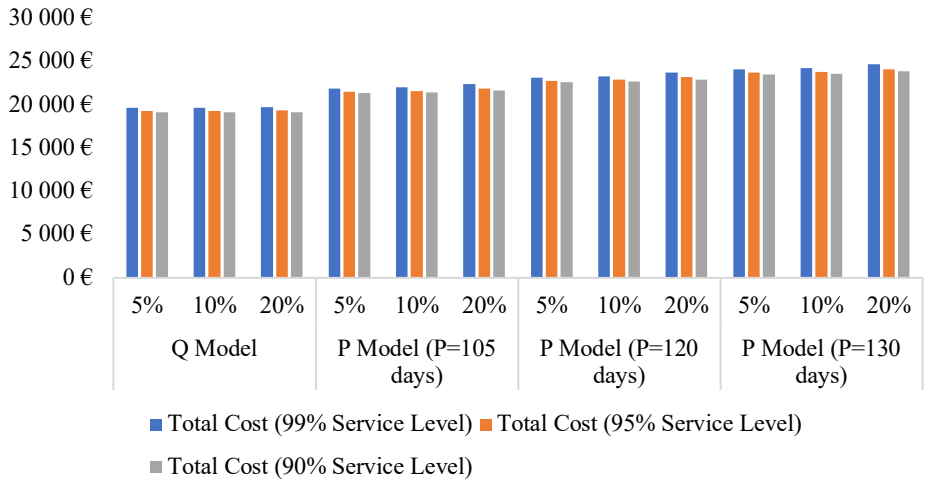


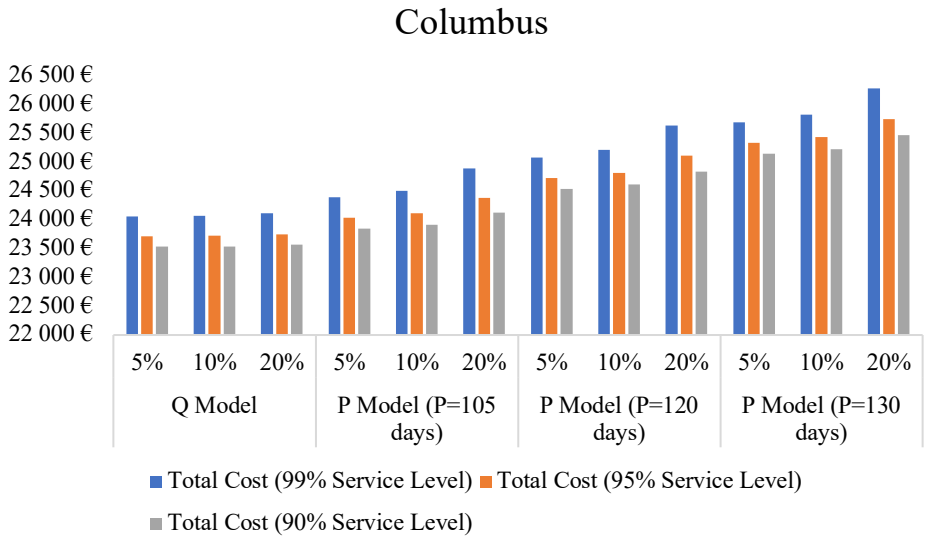

Golden Naked Oats
80 000 €
70 000 €
60 000 €
50 000 €
40 000 €
30 000 €
20 000 €
10 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

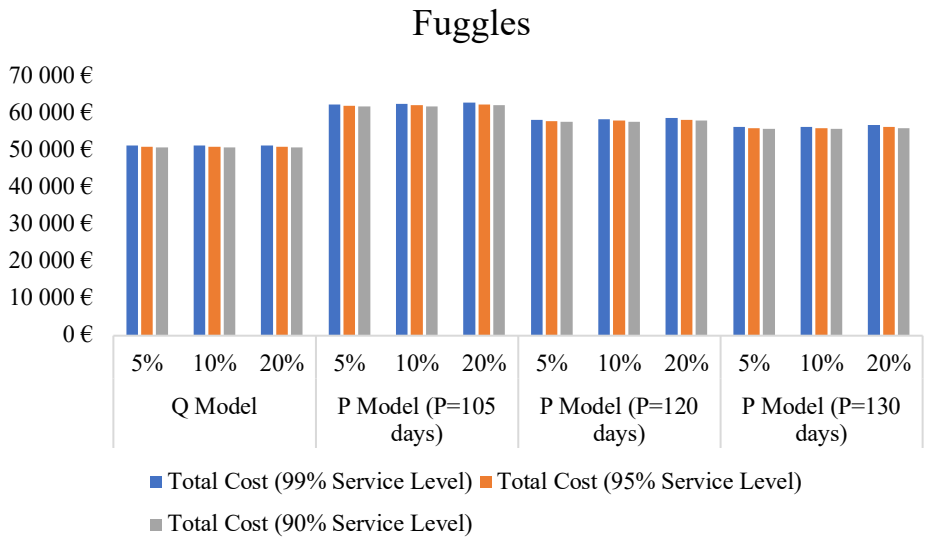

Oat Malt
80 000 €
70 000 €
60 000 €
50 000 €
40 000 €
30 000 €
20 000 €
10 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

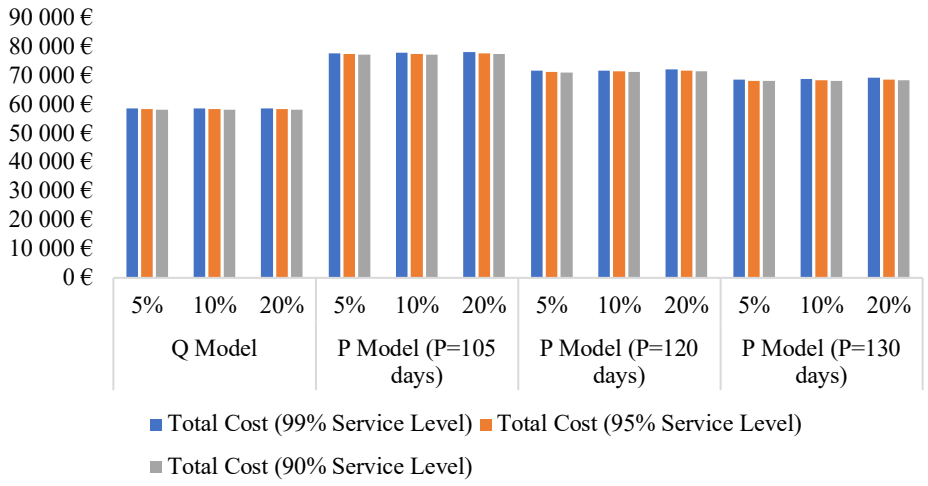

Bullion
54 000 €
52 000 €
50 000 €
48 000 €
46 000 €
44 000 €
42 000 €
40 000 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=105 days)
P Model (P=120 days)
P Model (P=130 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

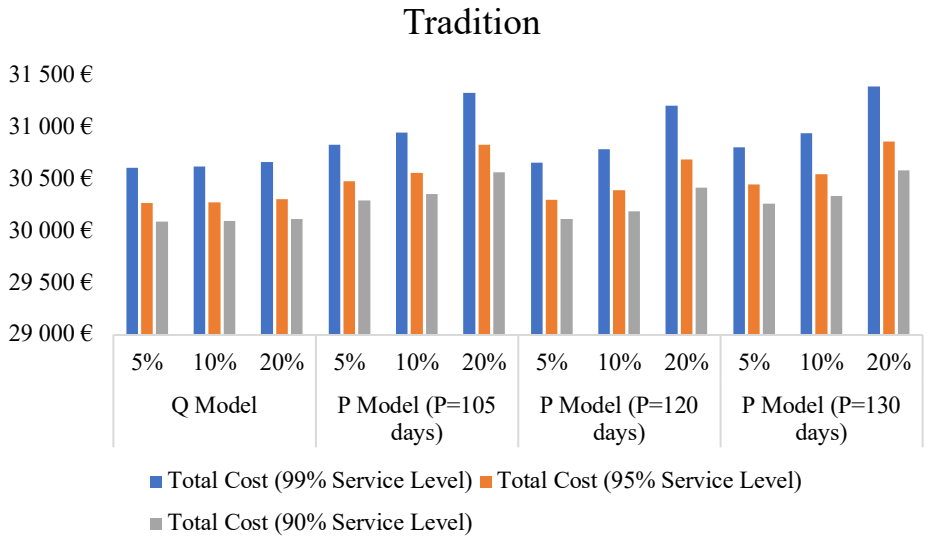

Centennial
80 000 €
70 000 €
60 000 €
50 000 €
40 000 €
30 000 €
20 000 €
10 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=105 days)
P Model (P=120 days)
P Model (P=130 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)


Citra
30 000 €
25 000 €
20 000 €
15 000 €
10 000 €
5 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=105 days)
P Model (P=120 days)
P Model (P=130 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

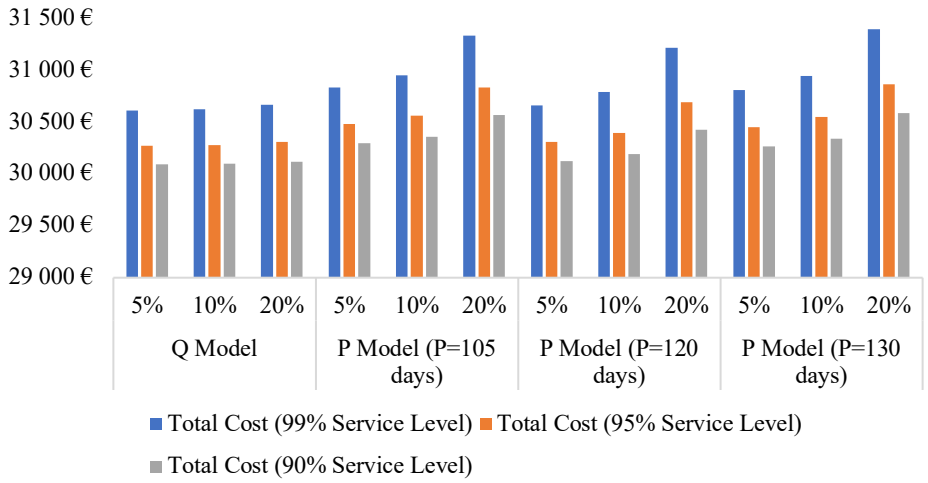

Columbus
26 500 €
26 000 €
25 500 €
25 000 €
24 500 €
24 000 €
23 500 €
23 000 €
22 500 €
22 000 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=105 days)
P Model (P=120 days)
P Model (P=130 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)


Fuggles
70 000 €
60 000 €
50 000 €
40 000 €
30 000 €
20 000 €
10 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=105 days)
P Model (P=120 days)
P Model (P=130 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

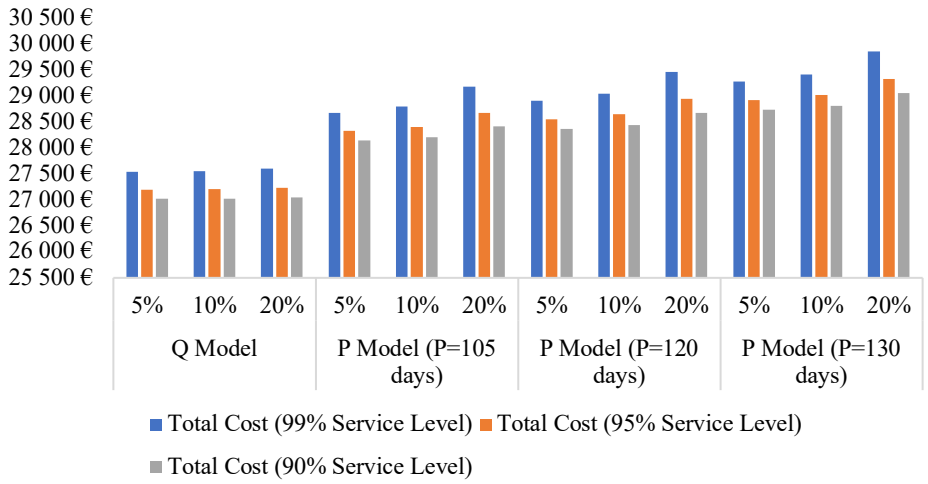

Sazz
90 000 €
80 000 €
70 000 €
60 000 €
50 000 €
40 000 €
30 000 €
20 000 €
10 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=105 days)
P Model (P=120 days)
P Model (P=130 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)


Tradition
31 500 €
31 000 €
30 500 €
30 000 €
29 500 €
29 000 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=105 days)
P Model (P=120 days)
P Model (P=130 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

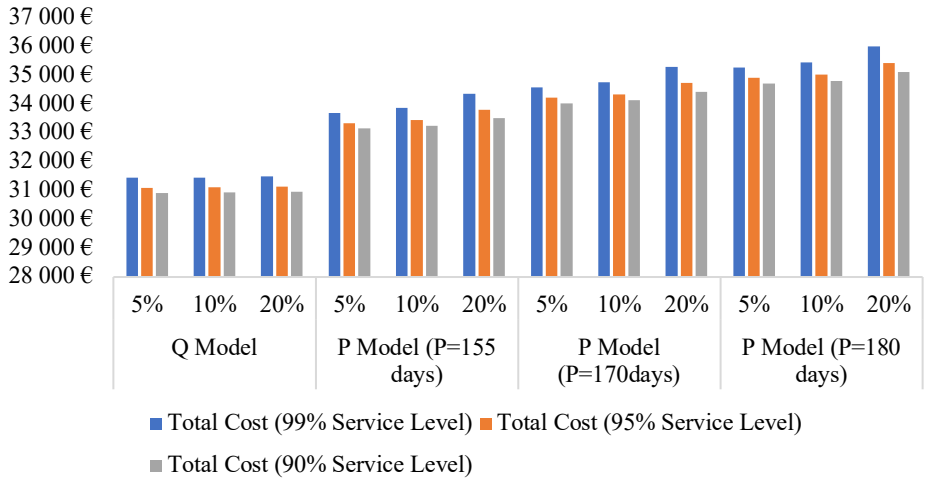
Summit



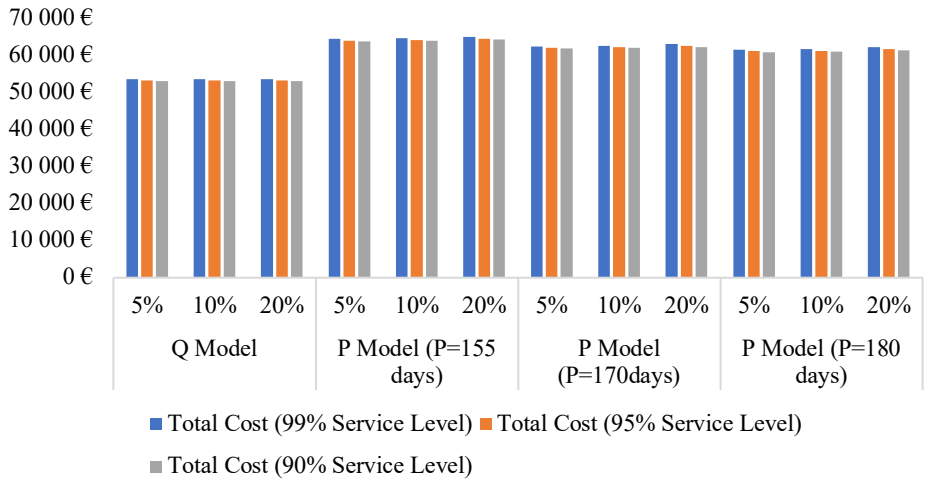
Spalter Select



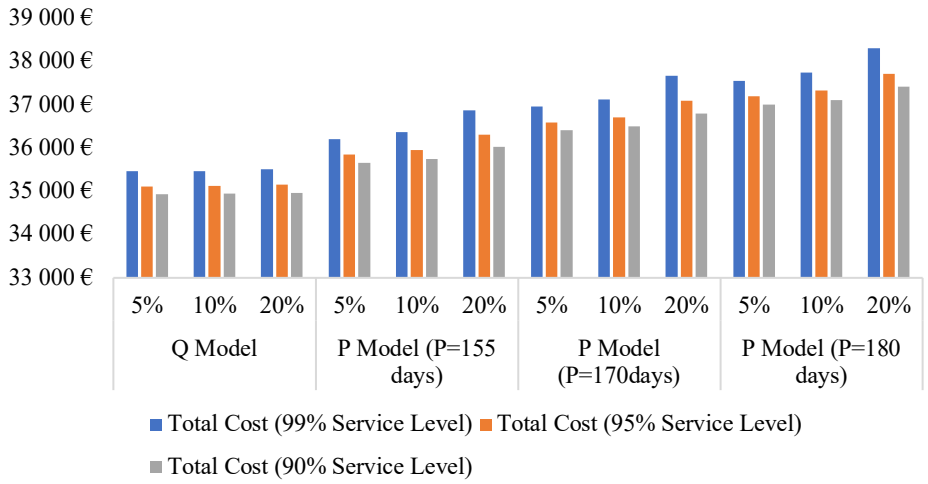
SAFALE US-05

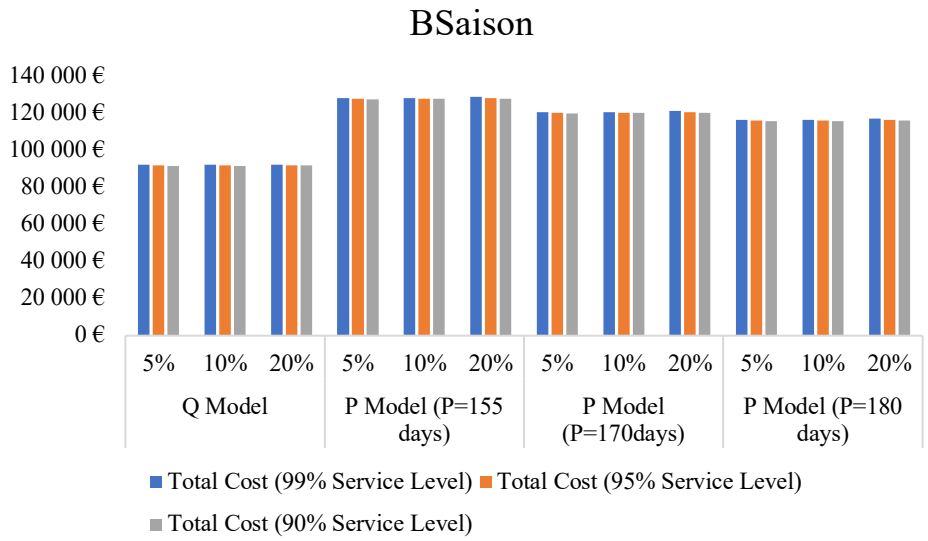


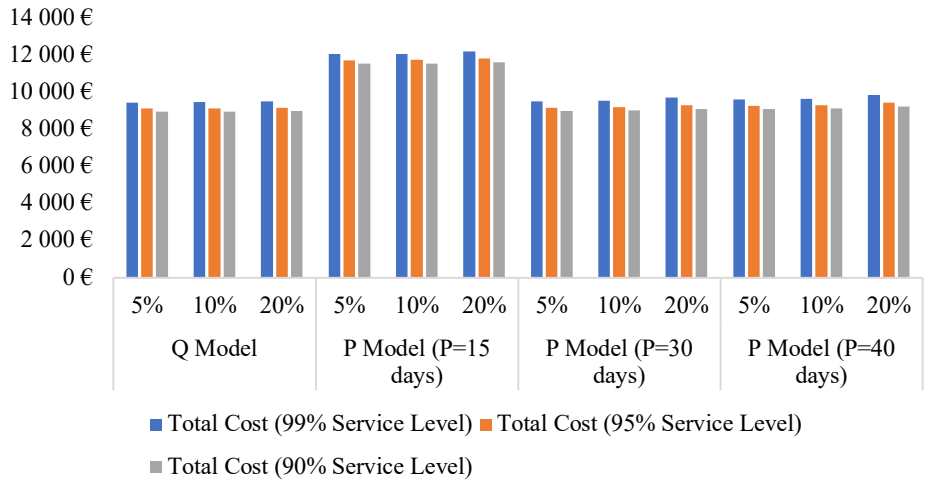
SAFALE S-04



SAFLAGER W34/70




BSaison
140 000 €
120 000 €
100 000 €
80 000 €
60 000 €
40 000 €
20 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=155 days)
P Model (P=170days)
P Model (P=180 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)


Acidulated
14 000 €
12 000 €
10 000 €
8 000 €
6 000 €
4 000 €
2 000 €
0 €
5% 10% 20% 5% 10% 20% 5% 10% 20% 5% 10% 20%
Q Model
P Model (P=15 days)
P Model (P=30 days)
P Model (P=40 days)
Total Cost (99% Service Level)
Total Cost (95% Service Level)
Total Cost (90% Service Level)

Appendix 5 – ABC analysis

Raw Materials	Anual Demand (Kg)	Annual Demand Weight (%)	Annual Demand Cumulative Weight (%)	Number of items	Number of items Weight (%)	Number of items Cummulaitve weight (%)	ABC
Pale Ale Simpson	6 208,08	30,56%	30,56%	1	2,56%	2,56%	A
Maris Otter Simpson	3 526,25	17,36%	47,91%	1	2,56%	5,13%	A
Pilsner	2 195,78	10,81%	58,72%	1	2,56%	7,69%	A
Finest Lager Malt	1 409,54	6,94%	65,66%	1	2,56%	10,26%	A
Carahell	1 093,27	5,38%	71,04%	1	2,56%	12,82%	A
Munich I	948,47	4,67%	75,71%	1	2,56%	15,38%	A
Golden Promise	624,06	3,07%	78,78%	1	2,56%	17,95%	A
Carared	578,61	2,85%	81,63%	1	2,56%	20,51%	B
Dextrin Malt	487,39	2,40%	84,03%	1	2,56%	23,08%	B
Carapils	415,02	2,04%	86,07%	1	2,56%	25,64%	B
Wheat flakes	370,44	1,82%	87,90%	1	2,56%	28,21%	B
Acidulated	370,25	1,82%	89,72%	1	2,56%	30,77%	B
Vienna	284,66	1,40%	91,12%	1	2,56%	33,33%	B
Pale Wheat	212,35	1,05%	92,16%	1	2,56%	35,90%	B
Oat flakes	191,32	0,94%	93,11%	1	2,56%	38,46%	B
Caramunich II	177,44	0,87%	93,98%	1	2,56%	41,03%	B
Barley flakes	153,51	0,76%	94,73%	1	2,56%	43,59%	B
Melanoidin	148,97	0,73%	95,47%	1	2,56%	46,15%	B
Carafa Spec II	138,09	0,68%	96,15%	1	2,56%	48,72%	B
Carafa Spec III	119,57	0,59%	96,74%	1	2,56%	51,28%	C
Citra	99,67	0,49%	97,23%	1	2,56%	53,85%	C
Roasted barley	95,66	0,47%	97,70%	1	2,56%	56,41%	C
Mosaic	87,11	0,43%	98,13%	1	2,56%	58,97%	C
Columbus	48,90	0,24%	98,37%	1	2,56%	61,54%	C
Golden Naked Oats	44,58	0,22%	98,59%	1	2,56%	64,10%	C
Spalter Select	38,85	0,19%	98,78%	1	2,56%	66,67%	C
Dextrose	36,15	0,18%	98,96%	1	2,56%	69,23%	C
Summit	32,72	0,16%	99,12%	1	2,56%	71,79%	C
SAFALE US-05	30,69	0,15%	99,27%	1	2,56%	74,36%	C
Oat Malt	29,39	0,14%	99,41%	1	2,56%	76,92%	C
Tradition	28,19	0,14%	99,55%	1	2,56%	79,49%	C
SAFLAGER W34/70	24,67	0,12%	99,67%	1	2,56%	82,05%	C
Simcoe	17,74	0,09%	99,76%	1	2,56%	84,62%	C
Bullion	12,44	0,06%	99,82%	1	2,56%	87,18%	C

Fuggles	9,57	0,05%	99,87%	1	2,56%	89,74%	C
SAFALE S-04	8,94	0,04%	99,91%	1	2,56%	92,31%	C
Centennial	7,71	0,04%	99,95%	1	2,56%	94,87%	C
Saaz	7,23	0,04%	99,99%	1	2,56%	97,44%	C
BSaison	2,89	0,01%	100,00%	1	2,56%	100,00%	C
Total	20 316,15	100,00%	-	39	-	-	-

Appendix 6 – Dedicated Company Areas

Dedicated Area	Assigned Plant Area	Area (square meters)
Tap Room	A	82,41
bar's warehouse	A	10,96
kitchen	A	3,79
Male toilet	A	2,43
Female toilet	A	1,23
Antechamber	A	2,2
Circulation area	B	2,37
Staff toilet	B	1,26
Men's clothing	B	1,51
Women's clothing	B	1,2
Shower	B	1,56
Malt storage	B	9,6
Hops and yeast storage	B	7,2
Keg storage	B	7,2
Finished bottle	B	19,2
Empty bottle	B	8,64
Production	B	214,49
Bottling area	B	27,2
Offices	C	24,33
Garbage	C	6,15
Total	-	434,93

Appendix 7 – Case Study Sources

Input information	**Source**
Finished product sales volume	Data provided by Commercial Director
Raw materials consumptions	Data provided by the Quality Manager
Suppliers' lead time	Interview to managers
Suppliers' lead time deviation	Interview to managers
SKUs' Acquisition cost	Data provided by Quality Manager
Warehouse ordering costs	Data retrieved from Samuels et al. (2016)
Warehouse holding costs	Data retrieved from Samuels et al. (2016)
Warehouse plant	Official document

Appendix 8 – Continuous Review model calculations for three raw materials families considering different standard demand deviations

Table 1 - 5 % Demand Standard Deviation for malts

Malts	Annual Demand (Kg)	LT (days)	Acquisition Cost per kg (euros)	Annual Holding Cost (euros)	Holding Cost per Kg/year (euros)	Annual Ordering Cost (euros)	Ordering Cost per Kg/year	σ_d (units)	σ_LT (days)	μ (average demand during LT) (units)	z (99% service level)	z (95% service level)	z (90% service level)	σ (demand standard deviation during LT) (units)	Annual Acquisition Cost (euros)
Acidulated	370,255	15	1,28	85691,89	231,44	134127,13	362,26	0,05	2	15,43	2,33	1,64	1,28	2,07	473,93
Barley flakes	153,506	15	1,12	85691,89	558,23	134127,13	873,76	0,02	2	6,40	2,33	1,64	1,28	0,86	171,93
Carafa Spec II	138,090	15	1,13	85691,89	620,55	134127,13	971,30	0,02	2	5,75	2,33	1,64	1,28	0,77	156,04
Carafa Spec III	119,574	15	1,13	85691,89	716,64	134127,13	1121,71	0,02	2	4,98	2,33	1,64	1,28	0,67	135,12
Carahell	1093,269	15	0,96	85691,89	78,38	134127,13	122,68	0,15	2	45,55	2,33	1,64	1,28	6,10	1049,54
Caramunich II	177,435	15	0,96	85691,89	482,95	134127,13	755,92	0,02	2	7,39	2,33	1,64	1,28	0,99	170,34
Carapils	415,018	15	0,95	85691,89	206,48	134127,13	323,18	0,06	2	17,29	2,33	1,64	1,28	2,32	394,27
Carared	578,611	15	1,02	85691,89	148,10	134127,13	231,81	0,08	2	24,11	2,33	1,64	1,28	3,23	590,18
Dextrin Malt	487,394	15	0,62	85691,89	175,82	134127,13	275,19	0,07	2	20,31	2,33	1,64	1,28	2,72	302,18
Finest Lager Malt	1409,541	15	1,60	85691,89	60,79	134127,13	95,16	0,20	2	58,73	2,33	1,64	1,28	7,87	2255,27
Maris Otter Simpson	3526,250	15	0,80	85691,89	24,30	134127,13	38,04	0,49	2	146,93	2,33	1,64	1,28	19,68	2821,00
Melanoidin	148,965	15	0,92	85691,89	575,25	134127,13	900,39	0,02	2	6,21	2,33	1,64	1,28	0,83	137,05
Munich I	948,468	15	0,83	85691,89	90,35	134127,13	141,41	0,13	2	39,52	2,33	1,64	1,28	5,29	787,23
Oat flakes	191,319	15	1,49	85691,89	447,90	134127,13	701,07	0,03	2	7,97	2,33	1,64	1,28	1,07	285,07
Pale Ale Simpson	6208,077	15	0,70	85691,89	13,80	134127,13	21,61	0,86	2	258,67	2,33	1,64	1,28	34,65	4345,65
Pale Wheat	212,347	15	0,80	85691,89	403,55	134127,13	631,64	0,03	2	8,85	2,33	1,64	1,28	1,19	169,88
Pilsner	2195,777	15	0,80	85691,89	39,03	134127,13	61,08	0,30	2	91,49	2,33	1,64	1,28	12,26	1756,62

Roasted barley	95,659	15	1,16	85691,89	895,80	134127,13	1402,13	0,01	2	3,99	2,33	1,64	1,28	0,53	110,96
Vienna	284,655	15	0,82	85691,89	301,04	134127,13	471,19	0,04	2	11,86	2,33	1,64	1,28	1,59	233,42
Wheat flakes	370,442	15	1,34	85691,89	231,32	134127,13	362,07	0,05	2	15,44	2,33	1,64	1,28	2,07	496,39
Dextrose	36,154	15	0,99	85691,89	2370,17	134127,13	3709,86	0,01	2	1,51	2,33	1,64	1,28	0,20	35,79
Golden Naked Oats	44,576	15	3,31	85691,89	1922,39	134127,13	3008,98	0,01	2	1,86	2,33	1,64	1,28	0,25	147,55
Golden Promise	624,059	15	0,89	85691,89	137,31	134127,13	214,93	0,09	2	26,00	2,33	1,64	1,28	3,48	555,41
Oat Malt	29,391	15	1,17	85691,89	2915,58	134127,13	4563,54	0,00	2	1,22	2,33	1,64	1,28	0,16	34,39

Table 1 - 5 % Demand Standard Deviation for malts - continuation

Malts	EOQ	Annual Ordering Cost	Safety Stock (99%)	Safety Stock (95%)	Safety Stock (90%)	Stock Holding Annual Cost (99%)	Stock Holding Annual Cost (95%)	Stock Holding Annual Cost (90%)	Reorder Point (99%)	Reorder Point (95%)	Reorder Point (90%)	TC (99%)	TC (95%)	TC (90%)	Average order period
Acidulated	34,05	3939,70	4,82	3,39	2,65	5054,12	4724,10	4551,91	20,24	18,82	18,07	9467,74	9137,72	8965,54	33
Barley flakes	21,92	6118,57	2,00	1,41	1,10	7233,00	6902,97	6730,79	8,39	7,80	7,49	13523,50	13193,47	13021,29	51
Carafa Spec II	20,79	6451,08	1,80	1,26	0,99	7565,50	7235,48	7063,29	7,55	7,02	6,74	14172,62	13842,60	13670,41	54
Carafa Spec III	19,35	6932,57	1,56	1,09	0,85	8046,99	7716,97	7544,79	6,54	6,08	5,84	15114,68	14784,66	14612,48	58
Carahell	58,50	2292,71	14,22	10,01	7,81	3407,13	3077,11	2904,93	59,77	55,56	53,36	6749,38	6419,36	6247,18	19
Caramunich II	23,57	5691,06	2,31	1,62	1,27	6805,48	6475,46	6303,27	9,70	9,02	8,66	12666,88	12336,86	12164,67	48
Carapils	36,04	3721,17	5,40	3,80	2,97	4835,59	4505,57	4333,39	22,69	21,09	20,26	8951,03	8621,01	8448,83	31
Carared	42,56	3151,52	7,52	5,30	4,13	4265,94	3935,92	3763,73	31,63	29,41	28,24	8007,64	7677,62	7505,44	26
Dextrin Malt	39,06	3433,78	6,34	4,46	3,48	4548,20	4218,18	4046,00	26,65	24,77	23,79	8284,17	7954,15	7781,97	29
Finest Lager Malt	66,43	2019,18	18,33	12,90	10,07	3133,60	2803,58	2631,39	77,06	71,63	68,80	7408,04	7078,02	6905,83	17
Maris Otter Simpson	105,07	1276,61	45,86	32,28	25,19	2391,03	2061,00	1888,82	192,79	179,21	172,12	6488,63	6158,61	5986,42	11
Melanoidin	21,59	6211,13	1,94	1,36	1,06	7325,55	6995,53	6823,35	8,14	7,57	7,27	13673,73	13343,71	13171,52	52
Munich I	54,49	2461,51	12,33	8,68	6,78	3575,93	3245,91	3073,73	51,85	48,20	46,30	6824,67	6494,65	6322,47	21
Oat flakes	24,47	5480,68	2,49	1,75	1,37	6595,10	6265,08	6092,89	10,46	9,72	9,34	12360,84	12030,82	11858,64	46

Pale Ale Simpson	139,41	962,13	80,74	56,83	44,35	2076,55	1746,53	1574,35	339,41	315,50	303,02	7384,34	7054,32	6882,13	8
Pale Wheat	25,78	5202,24	2,76	1,94	1,52	6316,66	5986,64	5814,45	11,61	10,79	10,36	11688,78	11358,75	11186,57	44
Pilsner	82,91	1617,78	28,56	20,10	15,69	2732,20	2402,18	2229,99	120,05	111,59	107,18	6106,60	5776,58	5604,39	14
Roasted barley	17,30	7750,85	1,24	0,88	0,68	8865,27	8535,25	8363,06	5,23	4,86	4,67	16727,09	16397,07	16224,88	65
Vienna	29,85	4493,18	3,70	2,61	2,03	5607,60	5277,58	5105,39	15,56	14,47	13,89	10334,19	10004,17	9831,98	38
Wheat flakes	34,05	3938,70	4,82	3,39	2,65	5053,12	4723,10	4550,92	20,25	18,83	18,08	9488,22	9158,19	8986,01	33
Dextrose	10,64	12607,63	0,47	0,33	0,26	13722,05	13392,03	13219,85	1,98	1,84	1,76	26365,48	26035,45	25863,27	106
Golden Naked Oats	11,81	11354,40	0,58	0,41	0,32	12468,82	12138,80	11966,62	2,44	2,27	2,18	23970,77	23640,75	23468,56	95
Golden Promise	44,20	3034,59	8,12	5,71	4,46	4149,01	3818,99	3646,81	34,12	31,71	30,46	7739,02	7409,00	7236,81	25
Oat Malt	9,59	13983,18	0,38	0,27	0,21	15097,60	14767,58	14595,40	1,61	1,49	1,43	29115,17	28785,15	28612,97	117

Table 2 - 5 % Demand Standard Deviation for hops and yeast

Hops	**Annual Demand (Kg)**	**LT (days)**	**Acquisition Cost**	**Holding Cost (including refrig)**	**Holding Cost per Kg/year**	**Ordering Cost**	**Ordering Cost per Kg/year**	**σ_d**	**σ_LT**	**μ (average demand during LT)**	**z (99% service level)**	**z (95% service level)**	**z (90% service level)**	**σ (demand standard deviation during LT)**	**Annual Acquisition Cost**
Bullion	12,436	10	15,76	89328,52	7183,22	134127,1	10785,63	0,00	2	0,345	2,33	1,64	1,28	0,07	195,99
Centennial	7,715	10	17,18	89328,52	11578,84	134127,1	17385,67	0,001	2	0,214	2,33	1,64	1,28	0,04	132,54
Citra	99,668	10	30,1	89328,52	896,26	134127,1	1345,73	0,014	2	2,769	2,33	1,64	1,28	0,56	3000,02
Columbus	48,898	10	15,54	89328,52	1826,82	134127,1	2742,98	0,007	2	1,358	2,33	1,64	1,28	0,27	759,88
Fuggles	9,566	10	15,29	89328,52	9338,19	134127,1	14021,32	0,001	2	0,266	2,33	1,64	1,28	0,05	146,26
Mosaic	87,111	10	28,49	89328,52	1025,46	134127,1	1539,73	0,012	2	2,420	2,33	1,64	1,28	0,49	2481,79
Simcoe	17,744	10	28,49	89328,52	5034,28	134127,1	7558,99	0,002	2	0,493	2,33	1,64	1,28	0,10	505,53
Spalter Select	38,854	10	40	89328,52	2299,08	134127,1	3452,08	0,005	2	1,079	2,33	1,64	1,28	0,22	1554,16
Summit	32,721	10	29,01	89328,52	2729,98	134127,1	4099,08	0,005	2	0,909	2,33	1,64	1,28	0,18	949,24

Tradition	28,191	10	10,6	89328,52	3168,71	134127,1	4757,83	0,004	2	0,783	2,33	1,64	1,28	0,16	298,82
Saaz	7,231	10	18,1	89328,52	12353,81	134127,1	18549,29	0,001	2	0,201	2,33	1,64	1,28	0,04	130,88
Yeast															
SAFALE US-05	30,687	10	76,24	89328,52	2910,94	134127,1	4370,79	0,004	2	0,852	2,33	1,64	1,28	0,17	2339,59
SAFALE S-04	8,938	10	76,84	89328,52	9994,34	134127,1	15006,53	0,001	2	0,248	2,33	1,64	1,28	0,05	686,79
SAFLAGER W34/70	24,667	10	127,07	89328,52	3621,38	134127,1	5437,52	0,003	2	0,68519	2,33	1,64	1,28	0,13747	3134,4316
BSaison	2,89234	10	45	89328,52	30884,5	134127,1	46373,2	4E-04	2	0,08034	2,33	1,64	1,28	0,01612	130,1553

Table 2 - 5 % Demand Standard Deviation for hops and yeast - continuation

Hops	**EOQ**	**Annual Order Cost**	**Safety Stock (99%)**	**Safety Stock (95%)**	**Safety Stock (90%)**	**Stock Holding Annual Cost (99%)**	**Stock Holding Annual Cost (95%)**	**Stock Holding Annual Cost (90%)**	**Reorder Point (99%)**	**Reorder Point (95%)**	**Reorder Point (90%)**	**TC (99%)**	**TC (95%)**	**TC (90%)**	**Average order period**
Bullion	6,11	21948,40	0,16	0,11	0,09	23108,32	22764,82	22585,61	0,51	0,46	0,43	45252,70	44909,21	44730,00	177
Centennial	4,81	27866,07	0,10	0,07	0,06	29025,99	28682,49	28503,28	0,31	0,28	0,27	57024,60	56681,11	56501,89	225
Citra	17,30	7752,82	1,29	0,91	0,71	8912,73	8569,24	8390,02	4,06	3,68	3,48	19665,57	19322,08	19142,86	62
Columbus	12,12	11068,56	0,63	0,45	0,35	12228,48	11884,99	11705,77	1,99	1,81	1,71	24056,92	23713,43	23534,21	89
Fuggles	5,36	25025,03	0,12	0,09	0,07	26184,94	25841,45	25662,23	0,39	0,35	0,33	51356,23	51012,74	50833,52	202
Mosaic	16,17	8292,82	1,13	0,80	0,62	9452,73	9109,24	8930,03	3,55	3,22	3,04	20227,34	19883,85	19704,63	67
Simcoe	7,30	18374,34	0,23	0,16	0,13	19534,26	19190,77	19011,55	0,72	0,66	0,62	38414,13	38070,64	37891,42	148
Spalter Select	10,80	12417,12	0,50	0,36	0,28	13577,03	13233,54	13054,32	1,58	1,43	1,36	27548,31	27204,81	27025,60	100
Summit	9,91	13530,79	0,42	0,30	0,23	14690,71	14347,21	14168,00	1,33	1,21	1,14	29170,74	28827,25	28648,03	109
Tradition	9,20	14577,55	0,37	0,26	0,20	15737,47	15393,97	15214,76	1,15	1,04	0,98	30613,84	30270,34	30091,13	117
Saaz	4,66	28783,51	0,09	0,07	0,05	29943,42	29599,93	29420,71	0,29	0,27	0,25	58857,81	58514,31	58335,10	232

Yeast															
SAFALE US-05	9,60	13972,04	0,40	0,28	0,22	15131,96	14788,47	14609,25	1,25	1,13	1,07	31443,59	31100,10	30920,89	113
SAFALE S-04	5,18	25889,30	0,12	0,08	0,06	27049,21	26705,72	26526,51	0,36	0,33	0,31	53625,30	53281,81	53102,59	209
SAFLAGER W34/70	8,607	15584,1	0,32	0,225	0,176	16743,97	16400,48	16221,263	1,0055	0,9106	0,86115	35462,5	35119	34939,8	125,61
BSaison	2,947	45510,7	0,038	0,026	0,021	46670,64	46327,14	46147,928	0,1179	0,1068	0,10097	92311,5	91968	91788,8	366,82

Table 3 - 10 % Demand Standard Deviation for malts

Malts	**Anual Demand (Kg)**	**LT (days)**	**Acquisition Cost per kg**	**Annual Holding Cost**	**Holding Cost per Kg/year**	**Annual Ordering Cost**	**Ordering Cost per Kg/year**	**σ_d (units)**	**σ_LT (days)**	**μ (average demand during LT)**	**z (99% service level)**	**z (95% service level)**	**z (90% service level)**	**σ (demand standard deviation during LT)**	**Annual Acquisition Cost**
Acidulated	370,255	15	1,28	85691,89	231,44	134127,13	362,26	0,10	2	15,43	2,33	1,64	1,28	2,10	473,93
Barley flakes	153,506	15	1,12	85691,89	558,23	134127,13	873,76	0,04	2	6,40	2,33	1,64	1,28	0,87	171,93
Carafa Spec II	138,090	15	1,13	85691,89	620,55	134127,13	971,30	0,04	2	5,75	2,33	1,64	1,28	0,78	156,04
Carafa Spec III	119,574	15	1,13	85691,89	716,64	134127,13	1121,71	0,03	2	4,98	2,33	1,64	1,28	0,68	135,12
Carahell	1093,269	15	0,96	85691,89	78,38	134127,13	122,68	0,30	2	45,55	2,33	1,64	1,28	6,19	1049,54
Caramunich II	177,435	15	0,96	85691,89	482,95	134127,13	755,92	0,05	2	7,39	2,33	1,64	1,28	1,00	170,34
Carapils	415,018	15	0,95	85691,89	206,48	134127,13	323,18	0,12	2	17,29	2,33	1,64	1,28	2,35	394,27
Carared	578,611	15	1,02	85691,89	148,10	134127,13	231,81	0,16	2	24,11	2,33	1,64	1,28	3,27	590,18
Dextrin Malt	487,394	15	0,62	85691,89	175,82	134127,13	275,19	0,14	2	20,31	2,33	1,64	1,28	2,76	302,18
Finest Lager Malt	1409,541	15	1,60	85691,89	60,79	134127,13	95,16	0,39	2	58,73	2,33	1,64	1,28	7,98	2255,27
Maris Otter Simpson	3526,250	15	0,80	85691,89	24,30	134127,13	38,04	0,98	2	146,93	2,33	1,64	1,28	19,95	2821,00
Melanoidin	148,965	15	0,92	85691,89	575,25	134127,13	900,39	0,04	2	6,21	2,33	1,64	1,28	0,84	137,05
Munich I	948,468	15	0,83	85691,89	90,35	134127,13	141,41	0,26	2	39,52	2,33	1,64	1,28	5,37	787,23
Oat flakes	191,319	15	1,49	85691,89	447,90	134127,13	701,07	0,05	2	7,97	2,33	1,64	1,28	1,08	285,07

Pale Ale Simpson	6208,077	15	0,70	85691,89	13,80	134127,13	21,61	1,72	2	258,67	2,33	1,64	1,28	35,13	4345,65
Pale Wheat	212,347	15	0,80	85691,89	403,55	134127,13	631,64	0,06	2	8,85	2,33	1,64	1,28	1,20	169,88
Pilsner	2195,777	15	0,80	85691,89	39,03	134127,13	61,08	0,61	2	91,49	2,33	1,64	1,28	12,43	1756,62
Roasted barley	95,659	15	1,16	85691,89	895,80	134127,13	1402,13	0,03	2	3,99	2,33	1,64	1,28	0,54	110,96
Vienna	284,655	15	0,82	85691,89	301,04	134127,13	471,19	0,08	2	11,86	2,33	1,64	1,28	1,61	233,42
Wheat flakes	370,442	15	1,34	85691,89	231,32	134127,13	362,07	0,10	2	15,44	2,33	1,64	1,28	2,10	496,39
Dextrose	36,154	15	0,99	85691,89	2370,17	134127,13	3709,86	0,01	2	1,51	2,33	1,64	1,28	0,20	35,79
Golden Naked Oats	44,576	15	3,31	85691,89	1922,39	134127,13	3008,98	0,01	2	1,86	2,33	1,64	1,28	0,25	147,55
Golden Promise	624,059	15	0,89	85691,89	137,31	134127,13	214,93	0,17	2	26,00	2,33	1,64	1,28	3,53	555,41
Oat Malt	29,391	15	1,17	85691,89	2915,58	134127,13	4563,54	0,01	2	1,22	2,33	1,64	1,28	0,17	34,39

Table 3 - 10 % Demand Standard Deviation for malts - continuation

Malts	EOQ	Annual Ordering Cost	Safety Stock (99%)	Safety Stock (95%)	Safety Stock (90%)	Stock Holding Annual Cost (99%)	Stock Holding Annual Cost (95%)	Stock Holding Annual Cost (90%)	Reorder Point (99%)	Reorder Point (95%)	Reorder Point (90%)	TC (99%)	TC (95%)	TC (90%)	Average order period
Acidulated	34,05	3939,70	4,88	3,44	2,68	5069,54	4734,95	4560,38	20,31	18,86	18,11	9483,16	9148,57	8974,01	33
Barley flakes	21,92	6118,57	2,02	1,42	1,11	7248,41	6913,83	6739,26	8,42	7,82	7,51	13538,92	13204,33	13029,76	51
Carafa Spec II	20,79	6451,08	1,82	1,28	1,00	7580,92	7246,33	7071,76	7,57	7,04	6,75	14188,04	13853,45	13678,89	54
Carafa Spec III	19,35	6932,57	1,58	1,11	0,87	8062,41	7727,82	7553,26	6,56	6,09	5,85	15130,10	14795,51	14620,95	58
Carahell	58,50	2292,71	14,41	10,15	7,92	3422,55	3087,97	2913,40	59,97	55,70	53,47	6764,80	6430,22	6255,65	19
Caramunich II	23,57	5691,06	2,34	1,65	1,29	6820,90	6486,31	6311,74	9,73	9,04	8,68	12682,30	12347,71	12173,14	48
Carapils	36,04	3721,17	5,47	3,85	3,01	4851,01	4516,43	4341,86	22,76	21,14	20,30	8966,45	8631,87	8457,30	31
Carared	42,56	3151,52	7,63	5,37	4,19	4281,36	3946,77	3772,20	31,74	29,48	28,30	8023,06	7688,47	7513,91	26
Dextrin Malt	39,06	3433,78	6,43	4,52	3,53	4563,62	4229,04	4054,47	26,73	24,83	23,84	8299,59	7965,00	7790,44	29
Finest Lager Malt	66,43	2019,18	18,58	13,08	10,21	3149,02	2814,43	2639,86	77,32	71,81	68,94	7423,46	7088,87	6914,30	17
Maris Otter Simpson	105,07	1276,61	46,49	32,72	25,54	2406,45	2071,86	1897,29	193,42	179,65	172,47	6504,05	6169,46	5994,90	11

Melanoidin	21,59	6211,13	1,96	1,38	1,08	7340,97	7006,38	6831,82	8,17	7,59	7,29	13689,15	13354,56	13180,00	52
Munich I	54,49	2461,51	12,51	8,80	6,87	3591,35	3256,76	3082,20	52,02	48,32	46,39	6840,09	6505,50	6330,94	21
Oat flakes	24,47	5480,68	2,52	1,78	1,39	6610,52	6275,93	6101,36	10,49	9,75	9,36	12376,26	12041,68	11867,11	46
Pale Ale Simpson	139,41	962,13	81,85	57,61	44,97	2091,97	1757,38	1582,82	340,52	316,28	303,64	7399,76	7065,17	6890,60	8
Pale Wheat	25,78	5202,24	2,80	1,97	1,54	6332,08	5997,49	5822,92	11,65	10,82	10,39	11704,19	11369,61	11195,04	44
Pilsner	82,91	1617,78	28,95	20,38	15,90	2747,62	2413,03	2238,46	120,44	111,87	107,40	6122,02	5787,43	5612,86	14
Roasted barley	17,30	7750,85	1,26	0,89	0,69	8880,69	8546,10	8371,54	5,25	4,87	4,68	16742,51	16407,92	16233,35	65
Vienna	29,85	4493,18	3,75	2,64	2,06	5623,02	5288,43	5113,86	15,61	14,50	13,92	10349,61	10015,02	9840,46	38
Wheat flakes	34,05	3938,70	4,88	3,44	2,68	5068,54	4733,95	4559,39	20,32	18,87	18,12	9503,64	9169,05	8994,48	33
Dextrose	10,64	12607,63	0,48	0,34	0,26	13737,47	13402,88	13228,32	1,98	1,84	1,77	26380,90	26046,31	25871,74	106
Golden Naked Oats	11,81	11354,40	0,59	0,41	0,32	12484,24	12149,65	11975,09	2,45	2,27	2,18	23986,19	23651,60	23477,03	95
Golden Promise	44,20	3034,59	8,23	5,79	4,52	4164,43	3829,84	3655,28	34,23	31,79	30,52	7754,44	7419,85	7245,28	25
Oat Malt	9,59	13983,18	0,39	0,27	0,21	15113,02	14778,43	14603,87	1,61	1,50	1,44	29130,59	28796,00	28621,44	117

Table 4 - 10 % Demand Standard Deviation for hops and yeast

Hops	**Annual Demand (Kg)**	**LT (days)**	**Acquisition Cost per kg**	**Annual Holding Cost (including refrigeration)**	**Holding Cost per Kg/year**	**Ordering Cost**	**Ordering Cost per Kg/year**	**σ_d**	**σ_LT**	**μ (average demand during LT)**	**z (99% service level)**	**z (95% service level)**	**z (90% service level)**	**σ (demand standard deviation during LT)**	**Annual Acquisition Cost**
Bullion	12,436	10	15,76	89328,52	7183,22	134127,1	10785,63	0,00	2	0,345	2,33	1,64	1,28	0,07	195,99
Centennial	7,715	10	17,18	89328,52	11578,84	134127,1	17385,67	0,002	2	0,214	2,33	1,64	1,28	0,04	132,54
Citra	99,668	10	30,1	89328,52	896,26	134127,1	1345,73	0,028	2	2,769	2,33	1,64	1,28	0,56	3000,02
Columbus	48,898	10	15,54	89328,52	1826,82	134127,1	2742,98	0,014	2	1,358	2,33	1,64	1,28	0,28	759,88
Fuggles	9,566	10	15,29	89328,52	9338,19	134127,1	14021,32	0,003	2	0,266	2,33	1,64	1,28	0,05	146,26
Mosaic	87,111	10	28,49	89328,52	1025,46	134127,1	1539,73	0,024	2	2,420	2,33	1,64	1,28	0,49	2481,79

Simcoe	17,744	10	28,49	89328,52	5034,28	134127,1	7558,99	0,005	2	0,493	2,33	1,64	1,28	0,10	505,53
Spalter Select	38,854	10	40	89328,52	2299,08	134127,1	3452,08	0,011	2	1,079	2,33	1,64	1,28	0,22	1554,16
Summit	32,721	10	29,01	89328,52	2729,98	134127,1	4099,08	0,009	2	0,909	2,33	1,64	1,28	0,18	949,24
Tradition	28,191	10	10,6	89328,52	3168,71	134127,1	4757,83	0,008	2	0,783	2,33	1,64	1,28	0,16	298,82
Saaz	7,231	10	18,1	89328,52	12353,81	134127,1	18549,29	0,002	2	0,201	2,33	1,64	1,28	0,04	130,88
Yeast															
SAFALE US-05	30,687	10	76,24	89328,52	2910,94	134127,1	4370,79	0,009	2	0,852	2,33	1,64	1,28	0,17	2339,59
SAFALE S-04	8,938	10	76,84	89328,52	9994,34	134127,1	15006,53	0,002	2	0,248	2,33	1,64	1,28	0,05	686,79
SAFLAGER W34/70	24,667	10	127,07	89328,52	3621,38	134127,1	5437,52	0,007	2	0,685	2,33	1,64	1,28	0,14	3134,43
BSaison	2,89234	10	45	89328,52	30884,5	134127,1	46373,2	8E-04	2	0,08034	2,33	1,64	1,28	0,01627	130,1553

Table 4 - 10 % Demand Standard Deviation for hops and yeast - continuation

Hops	**EOQ**	**Annual Order Cost**	**Safety Stock (99%)**	**Safety Stock (95%)**	**Safety Stock (90%)**	**Stock Holding Annual Cost (99%)**	**Stock Holding Annual Cost (95%)**	**Stock Holding Annual Cost (90%)**	**Reorder Point (99%)**	**Reorder Point (95%)**	**Reorder Point (90%)**	**TC (99%)**	**TC (95%)**	**TC (90%)**	**Average order period**
Bullion	6,11	21948,40	0,16	0,11	0,09	23119,07	22772,39	22591,52	0,51	0,46	0,43	45263,46	44916,78	44735,91	177
Centennial	4,81	27866,07	0,10	0,07	0,06	29036,75	28690,07	28509,19	0,32	0,29	0,27	57035,36	56688,68	56507,80	225
Citra	17,30	7752,82	1,31	0,92	0,72	8923,49	8576,81	8395,93	4,07	3,69	3,49	19676,33	19329,65	19148,77	62
Columbus	12,12	11068,56	0,64	0,45	0,35	12239,24	11892,56	11711,68	2,00	1,81	1,71	24067,68	23721,00	23540,12	89
Fuggles	5,36	25025,03	0,13	0,09	0,07	26195,70	25849,02	25668,14	0,39	0,35	0,33	51366,99	51020,31	50839,43	202
Mosaic	16,17	8292,82	1,14	0,80	0,63	9463,49	9116,81	8935,93	3,56	3,22	3,05	20238,10	19891,42	19710,54	67
Simcoe	7,30	18374,34	0,23	0,16	0,13	19545,02	19198,34	19017,46	0,73	0,66	0,62	38424,89	38078,21	37897,33	148
Spalter Select	10,80	12417,12	0,51	0,36	0,28	13587,79	13241,11	13060,23	1,59	1,44	1,36	27559,07	27212,39	27031,51	100

Summit	9,91	13530,79	0,43	0,30	0,24	14701,46	14354,78	14173,91	1,34	1,21	1,14	29181,50	28834,82	28653,94	109
Tradition	9,20	14577,55	0,37	0,26	0,20	15748,22	15401,54	15220,67	1,15	1,04	0,99	30624,59	30277,92	30097,04	117
Saaz	4,66	28783,51	0,09	0,07	0,05	29954,18	29607,50	29426,62	0,30	0,27	0,25	58868,57	58521,89	58341,01	232
Yeast															
SAFALE US-05	9,60	13972,04	0,40	0,28	0,22	15142,72	14796,04	14615,16	1,25	1,14	1,07	31454,35	31107,67	30926,79	113
SAFALE S-04	5,18	25889,30	0,12	0,08	0,06	27059,97	26713,29	26532,41	0,37	0,33	0,31	53636,06	53289,38	53108,50	209
SAFLAGER W34/70	8,61	15584,06	0,32	0,23	0,18	16754,73	16408,05	16227,17	1,01	0,91	0,86	35473,22	35126,54	34945,66	126
BSaison	2,947	45510,7	0,038	0,027	0,021	46681,39	46334,71	46153,837	0,1182	0,107	0,10117	92322,3	91975,6	91794,7	366,82

Table 5 - 20 % Demand Standard Deviation for malts

Malts	**Annual Demand (Kg)**	**LT (days)**	**Acquisition Cost per kg**	**Annual Holding Cost**	**Holding Cost per Kg/year**	**Annual Ordering Cost**	**Ordering Cost per Kg/year**	**σ_d (units)**	**σ_LT (days)**	**μ (average demand during LT)**	**z (99% service level)**	**z (95% service level)**	**z (90% service level)**	**σ (demand standard deviation during LT)**	**Annual Acquisition Cost**
Acidulated	370,255	15	1,28	85691,89	231,44	134127,13	362,26	0,21	2	15,43	2,33	1,64	1,28	2,21	473,93
Barley flakes	153,506	15	1,12	85691,89	558,23	134127,13	873,76	0,09	2	6,40	2,33	1,64	1,28	0,91	171,93
Carafa Spec II	138,090	15	1,13	85691,89	620,55	134127,13	971,30	0,08	2	5,75	2,33	1,64	1,28	0,82	156,04
Carafa Spec III	119,574	15	1,13	85691,89	716,64	134127,13	1121,71	0,07	2	4,98	2,33	1,64	1,28	0,71	135,12
Carahell	1093,269	15	0,96	85691,89	78,38	134127,13	122,68	0,61	2	45,55	2,33	1,64	1,28	6,51	1049,54
Caramunich II	177,435	15	0,96	85691,89	482,95	134127,13	755,92	0,10	2	7,39	2,33	1,64	1,28	1,06	170,34
Carapils	415,018	15	0,95	85691,89	206,48	134127,13	323,18	0,23	2	17,29	2,33	1,64	1,28	2,47	394,27
Carared	578,611	15	1,02	85691,89	148,10	134127,13	231,81	0,32	2	24,11	2,33	1,64	1,28	3,45	590,18
Dextrin Malt	487,394	15	0,62	85691,89	175,82	134127,13	275,19	0,27	2	20,31	2,33	1,64	1,28	2,90	302,18
Finest Lager Malt	1409,541	15	1,60	85691,89	60,79	134127,13	95,16	0,78	2	58,73	2,33	1,64	1,28	8,40	2255,27

Maris Otter Simpson	3526,250	15	0,80	85691,89	24,30	134127,13	38,04	1,96	2	146,93	2,33	1,64	1,28	21,01	2821,00
Melanoidin	148,965	15	0,92	85691,89	575,25	134127,13	900,39	0,08	2	6,21	2,33	1,64	1,28	0,89	137,05
Munich I	948,468	15	0,83	85691,89	90,35	134127,13	141,41	0,53	2	39,52	2,33	1,64	1,28	5,65	787,23
Oat flakes	191,319	15	1,49	85691,89	447,90	134127,13	701,07	0,11	2	7,97	2,33	1,64	1,28	1,14	285,07
Pale Ale Simpson	6208,077	15	0,70	85691,89	13,80	134127,13	21,61	3,45	2	258,67	2,33	1,64	1,28	36,99	4345,65
Pale Wheat	212,347	15	0,80	85691,89	403,55	134127,13	631,64	0,12	2	8,85	2,33	1,64	1,28	1,27	169,88
Pilsner	2195,777	15	0,80	85691,89	39,03	134127,13	61,08	1,22	2	91,49	2,33	1,64	1,28	13,08	1756,62
Roasted barley	95,659	15	1,16	85691,89	895,80	134127,13	1402,13	0,05	2	3,99	2,33	1,64	1,28	0,57	110,96
Vienna	284,655	15	0,82	85691,89	301,04	134127,13	471,19	0,16	2	11,86	2,33	1,64	1,28	1,70	233,42
Wheat flakes	370,442	15	1,34	85691,89	231,32	134127,13	362,07	0,21	2	15,44	2,33	1,64	1,28	2,21	496,39
Dextrose	36,154	15	0,99	85691,89	2370,17	134127,13	3709,86	0,02	2	1,51	2,33	1,64	1,28	0,22	35,79
Golden Naked Oats	44,576	15	3,31	85691,89	1922,39	134127,13	3008,98	0,02	2	1,86	2,33	1,64	1,28	0,27	147,55
Golden Promise	624,059	15	0,89	85691,89	137,31	134127,13	214,93	0,35	2	26,00	2,33	1,64	1,28	3,72	555,41
Oat Malt	29,391	15	1,17	85691,89	2915,58	134127,13	4563,54	0,02	2	1,22	2,33	1,64	1,28	0,18	34,39

Table 5 - 20 % Demand Standard Deviation for malts - comtimuation

Malts	EOQ	Annual Ordering Cost	Safety Stock (99%)	Safety Stock (95%)	Safety Stock (90%)	Stock Holding Annual Cost (99%)	Stock Holding Annual Cost (95%)	Stock Holding Annual Cost (90%)	Reorder Point (99%)	Reorder Point (95%)	Reorder Point (90%)	TC (99%)	TC (95%)	TC (90%)	Average order period
Acidulated	34,05	3939,70	5,14	3,62	2,82	5129,22	4776,96	4593,17	20,57	19,04	18,25	9542,84	9190,58	9006,79	33
Barley flakes	21,92	6118,57	2,13	1,50	1,17	7308,09	6955,83	6772,04	8,53	7,90	7,57	13598,60	13246,33	13062,55	51
Carafa Spec II	20,79	6451,08	1,92	1,35	1,05	7640,60	7288,34	7104,55	7,67	7,10	6,81	14247,72	13895,46	13711,67	54
Carafa Spec III	19,35	6932,57	1,66	1,17	0,91	8122,09	7769,83	7586,04	6,64	6,15	5,89	15189,78	14837,52	14653,73	58
Carahell	58,50	2292,71	15,18	10,68	8,34	3482,23	3129,97	2946,18	60,73	56,23	53,89	6824,48	6472,22	6288,43	19

Caramunich II	23,57	5691,06	2,46	1,73	1,35	6880,58	6528,32	6344,53	9,86	9,13	8,75	12741,98	12389,72	12205,93	48
Carapils	36,04	3721,17	5,76	4,05	3,16	4910,69	4558,43	4374,64	23,05	21,35	20,46	9026,13	8673,87	8490,08	31
Carared	42,56	3151,52	8,03	5,65	4,41	4341,04	3988,78	3804,99	32,14	29,76	28,52	8082,74	7730,48	7546,69	26
Dextrin Malt	39,06	3433,78	6,77	4,76	3,72	4623,30	4271,04	4087,25	27,07	25,07	24,02	8359,27	8007,01	7823,22	29
Finest Lager Malt	66,43	2019,18	19,57	13,77	10,75	3208,70	2856,44	2672,65	78,30	72,50	69,48	7483,14	7130,88	6947,09	17
Maris Otter Simpson	105,07	1276,61	48,95	34,45	26,89	2466,13	2113,86	1930,08	195,88	181,38	173,82	6563,73	6211,47	6027,68	11
Melanoidin	21,59	6211,13	2,07	1,46	1,14	7400,65	7048,39	6864,60	8,27	7,66	7,34	13748,83	13396,57	13212,78	52
Munich I	54,49	2461,51	13,17	9,27	7,23	3651,03	3298,77	3114,98	52,69	48,79	46,75	6899,77	6547,51	6363,72	21
Oat flakes	24,47	5480,68	2,66	1,87	1,46	6670,20	6317,94	6134,15	10,63	9,84	9,43	12435,94	12083,68	11899,89	46
Pale Ale Simpson	139,41	962,13	86,18	60,66	47,34	2151,65	1799,39	1615,60	344,85	319,33	306,01	7459,44	7107,18	6923,39	8
Pale Wheat	25,78	5202,24	2,95	2,07	1,62	6391,76	6039,50	5855,71	11,80	10,92	10,47	11763,87	11411,61	11227,82	44
Pilsner	82,91	1617,78	30,48	21,45	16,74	2807,30	2455,04	2271,25	121,97	112,94	108,24	6181,70	5829,44	5645,65	14
Roasted barley	17,30	7750,85	1,33	0,93	0,73	8940,37	8588,11	8404,32	5,31	4,92	4,72	16802,19	16449,92	16266,14	65
Vienna	29,85	4493,18	3,95	2,78	2,17	5682,70	5330,44	5146,65	15,81	14,64	14,03	10409,29	10057,03	9873,24	38
Wheat flakes	34,05	3938,70	5,14	3,62	2,82	5128,22	4775,96	4592,17	20,58	19,05	18,26	9563,32	9211,05	9027,27	33
Dextrose	10,64	12607,63	0,50	0,35	0,28	13797,15	13444,89	13261,10	2,01	1,86	1,78	26440,58	26088,31	25904,53	106
Golden Naked Oats	11,81	11354,40	0,62	0,44	0,34	12543,92	12191,66	12007,87	2,48	2,29	2,20	24045,87	23693,61	23509,82	95
Golden Promise	44,20	3034,59	8,66	6,10	4,76	4224,11	3871,85	3688,06	34,67	32,10	30,76	7814,12	7461,86	7278,07	25
Oat Malt	9,59	13983,18	0,41	0,29	0,22	15172,70	14820,44	14636,65	1,63	1,51	1,45	29190,27	28838,01	28654,22	117

Table 6 - 20 % Demand Standard Deviation for hops and yeast

Hops	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrigeration)	Holding Cost per Kg/year	Ordering Cost	Ordering Cost per Kg/year	σ_d	σ_LT	μ (average demand during LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ (demand standard deviation during LT)	Annual Acquisition Cost
Bullion	12,436	10	15,76	89328,52	7183,22	134127,1	10785,63	0,01	2	0,345	2,33	1,64	1,28	0,07	195,99
Centennial	7,715	10	17,18	89328,52	11578,84	134127,1	17385,67	0,004	2	0,214	2,33	1,64	1,28	0,04	132,54
Citra	99,668	10	30,1	89328,52	896,26	134127,1	1345,73	0,055	2	2,769	2,33	1,64	1,28	0,58	3000,02
Columbus	48,898	10	15,54	89328,52	1826,82	134127,1	2742,98	0,027	2	1,358	2,33	1,64	1,28	0,28	759,88
Fuggles	9,566	10	15,29	89328,52	9338,19	134127,1	14021,32	0,005	2	0,266	2,33	1,64	1,28	0,06	146,26
Mosaic	87,111	10	28,49	89328,52	1025,46	134127,1	1539,73	0,048	2	2,420	2,33	1,64	1,28	0,51	2481,79
Simcoe	17,744	10	28,49	89328,52	5034,28	134127,1	7558,99	0,010	2	0,493	2,33	1,64	1,28	0,10	505,53
Spalter Select	38,854	10	40	89328,52	2299,08	134127,1	3452,08	0,022	2	1,079	2,33	1,64	1,28	0,23	1554,16
Summit	32,721	10	29,01	89328,52	2729,98	134127,1	4099,08	0,018	2	0,909	2,33	1,64	1,28	0,19	949,24
Tradition	28,191	10	10,6	89328,52	3168,71	134127,1	4757,83	0,016	2	0,783	2,33	1,64	1,28	0,16	298,82
Saaz	7,231	10	18,1	89328,52	12353,81	134127,1	18549,29	0,004	2	0,201	2,33	1,64	1,28	0,04	130,88
Yeast															
SAFALE US-05	30,687	10	76,24	89328,52	2910,94	134127,1	4370,79	0,017	2	0,852	2,33	1,64	1,28	0,18	2339,59
SAFALE S-04	8,938	10	76,84	89328,52	9994,34	134127,1	15006,53	0,005	2	0,248	2,33	1,64	1,28	0,05	686,79
SAFLAGER W34/70	24,667	10	127,07	89328,52	3621,38	134127,1	5437,52	0,014	2	0,685	2,33	1,64	1,28	0,14	3134,43
BSaison	2,892	10	45	89328,52	30884,52	134127,1	46373,22	0,002	2	0,080	2,33	1,64	1,28	0,02	130,16

Table 6 - 20 % Demand Standard Deviation for hops and yeast - continuation

Hops	EOQ	Annual Order Cost	Safety Stock (99%)	Safety Stock (95%)	Safety Stock (90%)	Stock Holding Annual Cost (99%)	Stock Holding Annual Cost (95%)	Stock Holding Annual Cost (90%)	Reorder Point (99%)	Reorder Point (95%)	Reorder Point (90%)	TC (99%)	TC (95%)	TC (90%)	Average order period
Bullion	6,11	21948,40	0,17	0,12	0,09	23161,15	22802,01	22614,63	0,51	0,46	0,44	45305,53	44946,40	44759,02	177
Centennial	4,81	27866,07	0,10	0,07	0,06	29078,82	28719,68	28532,30	0,32	0,29	0,27	57077,43	56718,29	56530,92	225
Citra	17,30	7752,82	1,35	0,95	0,74	8965,56	8606,42	8419,05	4,12	3,72	3,51	19718,40	19359,26	19171,88	62
Columbus	12,12	11068,56	0,66	0,47	0,36	12281,31	11922,17	11734,79	2,02	1,83	1,72	24109,75	23750,61	23563,24	89
Fuggles	5,36	25025,03	0,13	0,09	0,07	26237,77	25878,63	25691,26	0,40	0,36	0,34	51409,06	51049,92	50862,55	202
Mosaic	16,17	8292,82	1,18	0,83	0,65	9505,56	9146,42	8959,05	3,60	3,25	3,07	20280,17	19921,03	19733,66	67
Simcoe	7,30	18374,34	0,24	0,17	0,13	19587,09	19227,95	19040,57	0,73	0,66	0,63	38466,96	38107,82	37920,45	148
Spalter Select	10,80	12417,12	0,53	0,37	0,29	13629,86	13270,72	13083,35	1,61	1,45	1,37	27601,14	27242,00	27054,62	100
Summit	9,91	13530,79	0,44	0,31	0,24	14743,54	14384,40	14197,02	1,35	1,22	1,15	29223,57	28864,43	28677,06	109
Tradition	9,20	14577,55	0,38	0,27	0,21	15790,30	15431,16	15243,78	1,17	1,05	0,99	30666,67	30307,53	30120,15	117
Saaz	4,66	28783,51	0,10	0,07	0,05	29996,25	29637,11	29449,74	0,30	0,27	0,25	58910,64	58551,50	58364,12	232
Yeast															
SAFALE US-05	9,60	13972,04	0,42	0,29	0,23	15184,79	14825,65	14638,27	1,27	1,15	1,08	31496,42	31137,29	30949,91	113
SAFALE S-04	5,18	25889,30	0,12	0,09	0,07	27102,04	26742,90	26555,53	0,37	0,33	0,31	53678,13	53318,99	53131,62	209
SAFLAGER W34/70	8,61	15584,06	0,33	0,24	0,18	16796,80	16437,66	16250,29	1,02	0,92	0,87	35515,29	35156,15	34968,77	126
BSaison	2,95	45510,72	0,04	0,03	0,02	46723,47	46364,33	46176,95	0,12	0,11	0,10	92364,34	92005,20	91817,83	367

Appendix 9 – Periodic Review model calculations for three raw materials families considering different standard demand deviations

Table 1 - 5% Demand Standard Deviation and 15 days order period

Malt	Annual Demand (Kg)	LT (days)	Acquisition Cost per kg	Annual Holding Cost	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
Acidulated	370,25	15	1,28	85691,89	231,44	134127,13	362,26	0,05	2	15	30,85	2,33	1,64	1,28	2,08
Barley flakes	153,51	15	1,12	85691,89	558,23	134127,13	873,76	0,02	2	15	12,79	2,33	1,64	1,28	0,86
Carafa Spec II	138,09	15	1,13	85691,89	620,55	134127,13	971,30	0,02	2	15	11,51	2,33	1,64	1,28	0,77
Carafa Spec III	119,57	15	1,13	85691,89	716,64	134127,13	1121,71	0,02	2	15	9,96	2,33	1,64	1,28	0,67
Carahell	1093,27	15	0,96	85691,89	78,38	134127,13	122,68	0,15	2	15	91,11	2,33	1,64	1,28	6,13
Caramunich II	177,44	15	0,96	85691,89	482,95	134127,13	755,92	0,02	2	15	14,79	2,33	1,64	1,28	0,99
Carapils	415,02	15	0,95	85691,89	206,48	134127,13	323,18	0,06	2	15	34,58	2,33	1,64	1,28	2,33
Carared	578,61	15	1,02	85691,89	148,10	134127,13	231,81	0,08	2	15	48,22	2,33	1,64	1,28	3,24
Dextrin Malt	487,39	15	0,62	85691,89	175,82	134127,13	275,19	0,07	2	15	40,62	2,33	1,64	1,28	2,73
Finest Lager Malt	1409,54	15	1,6	85691,89	60,79	134127,13	95,16	0,20	2	15	117,46	2,33	1,64	1,28	7,90
Maris Otter Simpson	3526,25	15	0,8	85691,89	24,30	134127,13	38,04	0,49	2	15	293,85	2,33	1,64	1,28	19,77
Melanoidin	148,97	15	0,92	85691,89	575,25	134127,13	900,39	0,02	2	15	12,41	2,33	1,64	1,28	0,84
Munich I	948,47	15	0,83	85691,89	90,35	134127,13	141,41	0,13	2	15	79,04	2,33	1,64	1,28	5,32
Oat flakes	191,32	15	1,49	85691,89	447,90	134127,13	701,07	0,03	2	15	15,94	2,33	1,64	1,28	1,07
Pale Ale Simpson	6208,08	15	0,7	85691,89	13,80	134127,13	21,61	0,86	2	15	517,34	2,33	1,64	1,28	34,81
Pale Wheat	212,35	15	0,8	85691,89	403,55	134127,13	631,64	0,03	2	15	17,70	2,33	1,64	1,28	1,19
Pilsner	2195,78	15	0,8	85691,89	39,03	134127,13	61,08	0,30	2	15	182,98	2,33	1,64	1,28	12,31
Roasted barley	95,66	15	1,16	85691,89	895,80	134127,13	1402,13	0,01	2	15	7,97	2,33	1,64	1,28	0,54

Vienna	284,66	15	0,82	85691,89	301,04	134127,13	471,19	0,04	2	15	23,72	2,33	1,64	1,28	1,60
Wheat flakes	370,44	15	1,34	85691,89	231,32	134127,13	362,07	0,05	2	15	30,87	2,33	1,64	1,28	2,08
Dextrose	57,85	15	0,99	85691,89	1481,36	134127,13	2318,66	0,01	2	15	4,82	2,33	1,64	1,28	0,32
Golden Naked Oats	44,58	15	3,31	85691,89	1922,39	134127,13	3008,98	0,01	2	15	3,71	2,33	1,64	1,28	0,25
Golden Promise	624,059	15	0,89	85691,89	137,31	134127,13	214,93	0,09	2	15	52,00	2,33	1,64	1,28	3,50

Table 1 - 5% Demand Standard Deviation and 15 days order period – continuation

Malt	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Acidulated	4,84	3,40	2,66	35,69	34,26	33,51	-	-	-	-	12072,91	11741,36	11568,38
Barley flakes	2,01	1,41	1,10	14,80	14,20	13,89	-	-	-	-	24046,93	23715,38	23542,40
Carafa Spec II	1,80	1,27	0,99	13,31	12,78	12,50	-	-	-	-	26372,16	26040,61	25867,63
Carafa Spec III	1,56	1,10	0,86	11,53	11,06	10,82	-	-	-	-	29960,89	29629,34	29456,36
Carahell	14,28	10,05	7,85	105,39	101,16	98,95	-	-	-	-	6898,80	6567,25	6394,26
Caramunich II	2,32	1,63	1,27	17,10	16,42	16,06	-	-	-	-	21217,28	20885,73	20712,75
Carapils	5,42	3,82	2,98	40,01	38,40	37,56	-	-	-	-	11055,52	10723,97	10550,98
Carared	7,56	5,32	4,15	55,78	53,54	52,37	-	-	-	-	9058,43	8726,88	8553,90
Dextrin Malt	6,37	4,48	3,50	46,98	45,10	44,11	-	-	-	-	9811,63	9480,08	9307,10
Finest Lager Malt	18,42	12,96	10,12	135,88	130,42	127,58	-	-	-	-	7443,86	7112,31	6939,32
Maris Otter Simpson	46,07	32,43	25,31	339,93	326,28	319,16	-	-	-	-	6638,71	6307,16	6134,18
Melanoidin	1,95	1,37	1,07	14,36	13,78	13,48	-	-	-	-	24651,29	24319,74	24146,76
Munich I	12,39	8,72	6,81	91,43	87,76	85,85	-	-	-	-	7086,01	6754,46	6581,48
Oat flakes	2,50	1,76	1,37	18,44	17,70	17,32	-	-	-	-	20015,48	19683,93	19510,95
Pale Ale Simpson	81,11	57,09	44,56	598,45	574,43	561,90	-	-	-	-	7769,01	7437,46	7264,48
Pale Wheat	2,77	1,95	1,52	20,47	19,65	19,22	-	-	-	-	18234,11	17902,56	17729,58
Pilsner	28,69	20,19	15,76	211,67	203,17	198,74	-	-	-	-	6127,47	5795,92	5622,94

Roasted barley	1,25	0,88	0,69	9,22	8,85	8,66	-	-	-	-	36666,97	36335,42	36162,44
Vienna	3,72	2,62	2,04	27,44	26,34	25,76	-	-	-	-	14446,84	14115,29	13942,31
Wheat flakes	4,84	3,41	2,66	35,71	34,28	33,53	-	-	-	-	12090,98	11759,43	11586,45
Dextrose	0,76	0,53	0,42	5,58	5,35	5,24	-	-	-	-	58609,97	58278,42	58105,44
Golden Naked Oats	0,58	0,41	0,32	4,30	4,12	4,03	-	-	-	-	75267,81	74936,26	74763,28
Golden Promise	8,15	5,74	4,48	60,16	57,74	56,48	-	-	-	-	8618,49	8286,94	8113,96
Oat Malt	0,38	0,27	0,21	2,83	2,72	2,66	-	-	-	-	112464,28	112132,73	111959,75

Table 2 - 10% Demand Standard Deviation and 15 days order period

Malt	**Annual Demand (Kg)**	**LT (days)**	**Acquisition Cost per kg**	**Annual Holding Cost**	**Holding Cost per kg/year**	**Annual Ordering Cost**	**Ordering Cost per kg/year**	**σ_d**	**σ_LT**	**P (days)**	**μ (average demand during P+LT)**	**z (99% service level)**	**z (95% service level)**	**z (90% service level)**	**σ_P+LT**
Acidulated	370,25	15	1,28	85691,89	231,44	134127,13	362,26	0,10	2	15	30,85	2,33	1,64	1,28	2,13
Barley flakes	153,51	15	1,12	85691,89	558,23	134127,13	873,76	0,04	2	15	12,79	2,33	1,64	1,28	0,88
Carafa Spec II	138,09	15	1,13	85691,89	620,55	134127,13	971,30	0,04	2	15	11,51	2,33	1,64	1,28	0,80
Carafa Spec III	119,57	15	1,13	85691,89	716,64	134127,13	1121,71	0,03	2	15	9,96	2,33	1,64	1,28	0,69
Carahell	1093,27	15	0,96	85691,89	78,38	134127,13	122,68	0,30	2	15	91,11	2,33	1,64	1,28	6,30
Caramunich II	177,44	15	0,96	85691,89	482,95	134127,13	755,92	0,05	2	15	14,79	2,33	1,64	1,28	1,02
Carapils	415,02	15	0,95	85691,89	206,48	134127,13	323,18	0,12	2	15	34,58	2,33	1,64	1,28	2,39
Carared	578,61	15	1,02	85691,89	148,10	134127,13	231,81	0,16	2	15	48,22	2,33	1,64	1,28	3,33
Dextrin Malt	487,39	15	0,62	85691,89	175,82	134127,13	275,19	0,14	2	15	40,62	2,33	1,64	1,28	2,81
Finest Lager Malt	1409,54	15	1,6	85691,89	60,79	134127,13	95,16	0,39	2	15	117,46	2,33	1,64	1,28	8,12
Maris Otter Simpson	3526,25	15	0,8	85691,89	24,30	134127,13	38,04	0,98	2	15	293,85	2,33	1,64	1,28	20,31
Melanoidin	148,97	15	0,92	85691,89	575,25	134127,13	900,39	0,04	2	15	12,41	2,33	1,64	1,28	0,86

Munich I	948,47	15	0,83	85691,89	90,35	134127,13	141,41	0,26	2	15	79,04	2,33	1,64	1,28	5,46
Oat flakes	191,32	15	1,49	85691,89	447,90	134127,13	701,07	0,05	2	15	15,94	2,33	1,64	1,28	1,10
Pale Ale Simpson	6208,08	15	0,7	85691,89	13,80	134127,13	21,61	1,72	2	15	517,34	2,33	1,64	1,28	35,76
Pale Wheat	212,35	15	0,8	85691,89	403,55	134127,13	631,64	0,06	2	15	17,70	2,33	1,64	1,28	1,22
Pilsner	2195,78	15	0,8	85691,89	39,03	134127,13	61,08	0,61	2	15	182,98	2,33	1,64	1,28	12,65
Roasted barley	95,66	15	1,16	85691,89	895,80	134127,13	1402,13	0,03	2	15	7,97	2,33	1,64	1,28	0,55
Vienna	284,66	15	0,82	85691,89	301,04	134127,13	471,19	0,08	2	15	23,72	2,33	1,64	1,28	1,64
Wheat flakes	370,44	15	1,34	85691,89	231,32	134127,13	362,07	0,10	2	15	30,87	2,33	1,64	1,28	2,13
Dextrose	57,85	15	0,99	85691,89	1481,36	134127,13	2318,66	0,02	2	15	4,82	2,33	1,64	1,28	0,33
Golden Naked Oats	44,58	15	3,31	85691,89	1922,39	134127,13	3008,98	0,01	2	15	3,71	2,33	1,64	1,28	0,26
Golden Promise	624,059	15	0,89	85691,89	137,31	134127,13	214,93	0,17	2	15	52,00	2,33	1,64	1,28	3,59
Oat Malt	29,39	15	1,17	85691,89	2915,58	134127,13	4563,54	0,01	2	15	2,45	2,33	1,64	1,28	0,17

Table 2 - 10% Demand Standard Deviation and 15 days order period - continuation

Malt	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Acidulated	4,97	3,50	2,73	35,82	34,35	33,58	-	-	-	-	12103,41	11762,82	11585,13
Barley flakes	2,06	1,45	1,13	14,85	14,24	13,92	-	-	-	-	24077,42	23736,84	23559,15
Carafa Spec II	1,85	1,30	1,02	13,36	12,81	12,53	-	-	-	-	26402,66	26062,08	25884,38
Carafa Spec III	1,60	1,13	0,88	11,57	11,09	10,85	-	-	-	-	29991,38	29650,80	29473,11
Carahell	14,67	10,33	8,06	105,78	101,43	99,17	-	-	-	-	6929,29	6588,71	6411,02
Caramunich II	2,38	1,68	1,31	17,17	16,46	16,09	-	-	-	-	21247,77	20907,19	20729,50
Carapils	5,57	3,92	3,06	40,15	38,51	37,64	-	-	-	-	11086,01	10745,43	10567,74
Carared	7,77	5,47	4,27	55,98	53,68	52,48	-	-	-	-	9088,92	8748,34	8570,65
Dextrin Malt	6,54	4,60	3,59	47,16	45,22	44,21	-	-	-	-	9842,12	9501,54	9323,85
Finest Lager Malt	18,92	13,32	10,39	136,38	130,78	127,85	-	-	-	-	7474,35	7133,77	6956,07

Maris Otter Simpson	47,33	33,31	26,00	341,18	327,17	319,85	-	-	-	-	6669,21	6328,63	6150,93
Melanoidin	2,00	1,41	1,10	14,41	13,82	13,51	-	-	-	-	24681,78	24341,20	24163,51
Munich I	12,73	8,96	6,99	91,77	88,00	86,03	-	-	-	-	7116,50	6775,92	6598,23
Oat flakes	2,57	1,81	1,41	18,51	17,75	17,35	-	-	-	-	20045,98	19705,40	19527,70
Pale Ale Simpson	83,32	58,65	45,77	600,66	575,98	563,11	-	-	-	-	7799,51	7458,92	7281,23
Pale Wheat	2,85	2,01	1,57	20,55	19,70	19,26	-	-	-	-	18264,60	17924,02	17746,33
Pilsner	29,47	20,74	16,19	212,45	203,72	199,17	-	-	-	-	6157,97	5817,39	5639,69
Roasted barley	1,28	0,90	0,71	9,26	8,88	8,68	-	-	-	-	36697,46	36356,88	36179,19
Vienna	3,82	2,69	2,10	27,54	26,41	25,82	-	-	-	-	14477,33	14136,75	13959,06
Wheat flakes	4,97	3,50	2,73	35,84	34,37	33,60	-	-	-	-	12121,47	11780,89	11603,20
Dextrose	0,78	0,55	0,43	5,60	5,37	5,25	-	-	-	-	58640,46	58299,88	58122,19
Golden Naked Oats	0,60	0,42	0,33	4,31	4,14	4,04	-	-	-	-	75298,31	74957,72	74780,03
Golden Promise	8,38	5,90	4,60	60,38	57,90	56,61	-	-	-	-	8648,98	8308,40	8130,71
Oat Malt	0,39	0,28	0,22	2,84	2,73	2,67	-	-	-	-	112494,78	112154,20	111976,50

Table 3 - 20% Demand Standard Deviation and 15 days order period

Malt	Annual Demand (Kg)	LT (days)	Acquisition Cost per kg	Annual Holding Cost	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
Acidulated	370,25	15	1,28	85691,89	231,44	134127,13	362,26	0,21	2	15	30,85	2,33	1,64	1,28	2,35
Barley flakes	153,51	15	1,12	85691,89	558,23	134127,13	873,76	0,09	2	15	12,79	2,33	1,64	1,28	0,97
Carafa Spec II	138,09	15	1,13	85691,89	620,55	134127,13	971,30	0,08	2	15	11,51	2,33	1,64	1,28	0,87
Carafa Spec III	119,57	15	1,13	85691,89	716,64	134127,13	1121,71	0,07	2	15	9,96	2,33	1,64	1,28	0,76
Carahell	1093,27	15	0,96	85691,89	78,38	134127,13	122,68	0,61	2	15	91,11	2,33	1,64	1,28	6,93
Caramunich II	177,44	15	0,96	85691,89	482,95	134127,13	755,92	0,10	2	15	14,79	2,33	1,64	1,28	1,12
Carapils	415,02	15	0,95	85691,89	206,48	134127,13	323,18	0,23	2	15	34,58	2,33	1,64	1,28	2,63

Carared	578,61	15	1,02	85691,89	148,10	134127,13	231,81	0,32	2	15	48,22	2,33	1,64	1,28	3,67
Dextrin Malt	487,39	15	0,62	85691,89	175,82	134127,13	275,19	0,27	2	15	40,62	2,33	1,64	1,28	3,09
Finest Lager Malt	1409,54	15	1,6	85691,89	60,79	134127,13	95,16	0,78	2	15	117,46	2,33	1,64	1,28	8,93
Maris Otter Simpson	3526,25	15	0,8	85691,89	24,30	134127,13	38,04	1,96	2	15	293,85	2,33	1,64	1,28	22,34
Melanoidin	148,97	15	0,92	85691,89	575,25	134127,13	900,39	0,08	2	15	12,41	2,33	1,64	1,28	0,94
Munich I	948,47	15	0,83	85691,89	90,35	134127,13	141,41	0,53	2	15	79,04	2,33	1,64	1,28	6,01
Oat flakes	191,32	15	1,49	85691,89	447,90	134127,13	701,07	0,11	2	15	15,94	2,33	1,64	1,28	1,21
Pale Ale Simpson	6208,08	15	0,7	85691,89	13,80	134127,13	21,61	3,45	2	15	517,34	2,33	1,64	1,28	39,32
Pale Wheat	212,35	15	0,8	85691,89	403,55	134127,13	631,64	0,12	2	15	17,70	2,33	1,64	1,28	1,35
Pilsner	2195,78	15	0,8	85691,89	39,03	134127,13	61,08	1,22	2	15	182,98	2,33	1,64	1,28	13,91
Roasted barley	95,66	15	1,16	85691,89	895,80	134127,13	1402,13	0,05	2	15	7,97	2,33	1,64	1,28	0,61
Vienna	284,66	15	0,82	85691,89	301,04	134127,13	471,19	0,16	2	15	23,72	2,33	1,64	1,28	1,80
Wheat flakes	370,44	15	1,34	85691,89	231,32	134127,13	362,07	0,21	2	15	30,87	2,33	1,64	1,28	2,35
Dextrose	57,85	15	0,99	85691,89	1481,36	134127,13	2318,66	0,03	2	15	4,82	2,33	1,64	1,28	0,37
Golden Naked Oats	44,58	15	3,31	85691,89	1922,39	134127,13	3008,98	0,02	2	15	3,71	2,33	1,64	1,28	0,28
Golden Promise	624,059	15	0,89	85691,89	137,31	134127,13	214,93	0,35	2	15	52,00	2,33	1,64	1,28	3,95
Oat Malt	29,39	15	1,17	85691,89	2915,58	134127,13	4563,54	0,02	2	15	2,45	2,33	1,64	1,28	0,19

Table 3 - 20% Demand Standard Deviation and 15 days order period - continuation

Malt	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Acidulated	5,46	3,85	3,00	36,32	34,70	33,86	-	-	-	-	12218,05	11843,52	11648,11
Barley flakes	2,27	1,59	1,24	15,06	14,39	14,04	-	-	-	-	24192,07	23817,53	23622,13
Carafa Spec II	2,04	1,43	1,12	13,55	12,94	12,63	-	-	-	-	26517,30	26142,77	25947,36
Carafa Spec III	1,76	1,24	0,97	11,73	11,21	10,93	-	-	-	-	30106,03	29731,50	29536,09
Carahell	16,14	11,36	8,86	107,24	102,46	99,97	-	-	-	-	7043,93	6669,40	6474,00

Caramunich II	2,62	1,84	1,44	17,41	16,63	16,22	-	-	-	-	21362,42	20987,89	20792,48
Carapils	6,13	4,31	3,36	40,71	38,90	37,95	-	-	-	-	11200,65	10826,12	10630,72
Carared	8,54	6,01	4,69	56,76	54,23	52,91	-	-	-	-	9203,57	8829,03	8633,63
Dextrin Malt	7,19	5,06	3,95	47,81	45,68	44,57	-	-	-	-	9956,77	9582,23	9386,83
Finest Lager Malt	20,80	14,64	11,43	138,27	132,10	128,89	-	-	-	-	7588,99	7214,46	7019,05
Maris Otter Simpson	52,04	36,63	28,59	345,90	330,49	322,44	-	-	-	-	6783,85	6409,32	6213,91
Melanoidin	2,20	1,55	1,21	14,61	13,96	13,62	-	-	-	-	24796,43	24421,90	24226,49
Munich I	14,00	9,85	7,69	93,04	88,89	86,73	-	-	-	-	7231,15	6856,62	6661,21
Oat flakes	2,82	1,99	1,55	18,77	17,93	17,49	-	-	-	-	20160,62	19786,09	19590,68
Pale Ale Simpson	91,62	64,49	50,33	608,96	581,83	567,67	-	-	-	-	7914,15	7539,62	7344,21
Pale Wheat	3,13	2,21	1,72	20,83	19,90	19,42	-	-	-	-	18379,25	18004,71	17809,31
Pilsner	32,41	22,81	17,80	215,39	205,79	200,78	-	-	-	-	6272,61	5898,08	5702,67
Roasted barley	1,41	0,99	0,78	9,38	8,97	8,75	-	-	-	-	36812,11	36437,58	36242,17
Vienna	4,20	2,96	2,31	27,92	26,68	26,03	-	-	-	-	14591,98	14217,45	14022,04
Wheat flakes	5,47	3,85	3,00	36,34	34,72	33,87	-	-	-	-	12236,12	11861,59	11666,18
Dextrose	0,85	0,60	0,47	5,67	5,42	5,29	-	-	-	-	58755,11	58380,57	58185,17
Golden Naked Oats	0,66	0,46	0,36	4,37	4,18	4,08	-	-	-	-	75412,95	75038,42	74843,01
Golden Promise	9,21	6,48	5,06	61,22	58,49	57,06	-	-	-	-	8763,63	8389,10	8193,69
Oat Malt	0,43	0,31	0,24	2,88	2,75	2,69	-	-	-	-	112609,42	112234,89	112039,48

Table 4 - 5% Demand Standard Deviation and 30 days order period

Malt	**Annual Demand (Kg)**	**LT (days)**	**Acquisition Cost per kg**	**Annual Holding Cost**	**Holding Cost per kg/year**	**Annual Ordering Cost**	**Ordering Cost per kg/year**	**σ_d**	**σ_LT**	**P (days)**	**μ (average demand during P+LT)**	**z (99% service level)**	**z (95% service level)**	**z (90% service level)**	**σ_P+LT**
Acidulated	370,25	15	1,28	85691,89	231,44	134127,13	362,26	0,05	2	30	46,28	2,33	1,64	1,28	2,09
Barley flakes	153,51	15	1,12	85691,89	558,23	134127,13	873,76	0,02	2	30	19,19	2,33	1,64	1,28	0,86

Carafa Spec II	138,09	15	1,13	85691,89	620,55	134127,13	971,30	0,02	2	30	17,26	2,33	1,64	1,28	0,78
Carafa Spec III	119,57	15	1,13	85691,89	716,64	134127,13	1121,71	0,02	2	30	14,95	2,33	1,64	1,28	0,67
Carahell	1093,27	15	0,96	85691,89	78,38	134127,13	122,68	0,15	2	30	136,66	2,33	1,64	1,28	6,16
Caramunich II	177,44	15	0,96	85691,89	482,95	134127,13	755,92	0,02	2	30	22,18	2,33	1,64	1,28	1,00
Carapils	415,02	15	0,95	85691,89	206,48	134127,13	323,18	0,06	2	30	51,88	2,33	1,64	1,28	2,34
Carared	578,61	15	1,02	85691,89	148,10	134127,13	231,81	0,08	2	30	72,33	2,33	1,64	1,28	3,26
Dextrin Malt	487,39	15	0,62	85691,89	175,82	134127,13	275,19	0,07	2	30	60,92	2,33	1,64	1,28	2,75
Finest Lager Malt	1409,54	15	1,6	85691,89	60,79	134127,13	95,16	0,20	2	30	176,19	2,33	1,64	1,28	7,94
Maris Otter Simpson	3526,25	15	0,8	85691,89	24,30	134127,13	38,04	0,49	2	30	440,78	2,33	1,64	1,28	19,86
Melanoidin	148,97	15	0,92	85691,89	575,25	134127,13	900,39	0,02	2	30	18,62	2,33	1,64	1,28	0,84
Munich I	948,47	15	0,83	85691,89	90,35	134127,13	141,41	0,13	2	30	118,56	2,33	1,64	1,28	5,34
Oat flakes	191,32	15	1,49	85691,89	447,90	134127,13	701,07	0,03	2	30	23,91	2,33	1,64	1,28	1,08
Pale Ale Simpson	6208,08	15	0,7	85691,89	13,80	134127,13	21,61	0,86	2	30	776,01	2,33	1,64	1,28	34,97
Pale Wheat	212,35	15	0,8	85691,89	403,55	134127,13	631,64	0,03	2	30	26,54	2,33	1,64	1,28	1,20
Pilsner	2195,78	15	0,8	85691,89	39,03	134127,13	61,08	0,30	2	30	274,47	2,33	1,64	1,28	12,37
Roasted barley	95,66	15	1,16	85691,89	895,80	134127,13	1402,13	0,01	2	30	11,96	2,33	1,64	1,28	0,54
Vienna	284,66	15	0,82	85691,89	301,04	134127,13	471,19	0,04	2	30	35,58	2,33	1,64	1,28	1,60
Wheat flakes	370,44	15	1,34	85691,89	231,32	134127,13	362,07	0,05	2	30	46,31	2,33	1,64	1,28	2,09
Dextrose	57,85	15	0,99	85691,89	1481,36	134127,13	2318,66	0,01	2	30	7,23	2,33	1,64	1,28	0,33
Golden Naked Oats	44,58	15	3,31	85691,89	1922,39	134127,13	3008,98	0,01	2	30	5,57	2,33	1,64	1,28	0,25
Golden Promise	624,059	15	0,89	85691,89	137,31	134127,13	214,93	0,09	2	30	78,01	2,33	1,64	1,28	3,52
Oat Malt	29,39	15	1,17	85691,89	2915,58	134127,13	4563,54	0,00	2	30	3,67	2,33	1,64	1,28	0,17

Table 4 - 5% Demand Standard Deviation and 30 days order period - continuation

Malt	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Acidulated	4,86	3,42	2,67	51,14	49,70	48,95	-	-	-	-	9516,22	9183,15	9009,37
Barley flakes	2,01	1,42	1,11	21,20	20,61	20,30	-	-	-	-	15352,23	15019,16	14845,38
Carafa Spec II	1,81	1,28	1,00	19,07	18,54	18,26	-	-	-	-	16506,91	16173,83	16000,06
Carafa Spec III	1,57	1,10	0,86	16,52	16,05	15,81	-	-	-	-	18290,81	17957,74	17783,96
Carahell	14,35	10,10	7,88	151,01	146,76	144,54	-	-	-	-	7216,97	6883,90	6710,12
Caramunich II	2,33	1,64	1,28	24,51	23,82	23,46	-	-	-	-	13936,61	13603,54	13429,76
Carapils	5,45	3,83	2,99	57,32	55,71	54,87	-	-	-	-	8967,70	8634,62	8460,85
Carared	7,59	5,35	4,17	79,92	77,67	76,50	-	-	-	-	8067,11	7734,04	7560,26
Dextrin Malt	6,40	4,50	3,51	67,32	65,43	64,44	-	-	-	-	8299,71	7966,64	7792,86
Finest Lager Malt	18,50	13,02	10,16	194,69	189,21	186,36	-	-	-	-	8092,36	7759,29	7585,51
Maris Otter Simpson	46,28	32,58	25,43	487,06	473,36	466,21	-	-	-	-	7972,66	7639,59	7465,81
Melanoidin	1,96	1,38	1,07	20,58	20,00	19,69	-	-	-	-	15636,97	15303,90	15130,12
Munich I	12,45	8,76	6,84	131,01	127,32	125,40	-	-	-	-	7179,42	6846,35	6672,57
Oat flakes	2,51	1,77	1,38	26,43	25,68	25,29	-	-	-	-	13393,08	13060,01	12886,23
Pale Ale Simpson	81,48	57,35	44,76	857,49	833,36	820,77	-	-	-	-	9300,14	8967,06	8793,29
Pale Wheat	2,79	1,96	1,53	29,33	28,51	28,07	-	-	-	-	12444,80	12111,72	11937,95
Pilsner	28,82	20,29	15,83	303,29	294,76	290,30	-	-	-	-	7184,85	6851,78	6678,00
Roasted barley	1,26	0,88	0,69	13,21	12,84	12,65	-	-	-	-	21631,77	21298,70	21124,92
Vienna	3,74	2,63	2,05	39,32	38,21	37,63	-	-	-	-	10582,93	10249,86	10076,08
Wheat flakes	4,86	3,42	2,67	51,17	49,73	48,98	-	-	-	-	9536,49	9203,42	9029,64
Dextrose	0,76	0,53	0,42	7,99	7,77	7,65	-	-	-	-	32576,42	32243,35	32069,57
Golden Naked Oats	0,59	0,41	0,32	6,16	5,98	5,89	-	-	-	-	40950,48	40617,41	40443,63
Golden Promise	8,19	5,77	4,50	86,20	83,77	82,51	-	-	-	-	7829,76	7496,68	7322,91
Oat Malt	0,39	0,27	0,21	4,06	3,95	3,89	-	-	-	-	59492,14	59159,07	58985,29

Table 5 - 10% Demand Standard Deviation and 30 days order period

Malt	Annual Demand (Kg)	LT (days)	Acquisition Cost per kg	Annual Holding Cost	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
Acidulated	370,25	15	1,28	85691,89	231,44	134127,13	362,26	0,10	2	30	46,28	2,33	1,64	1,28	2,17
Barley flakes	153,51	15	1,12	85691,89	558,23	134127,13	873,76	0,04	2	30	19,19	2,33	1,64	1,28	0,90
Carafa Spec II	138,09	15	1,13	85691,89	620,55	134127,13	971,30	0,04	2	30	17,26	2,33	1,64	1,28	0,81
Carafa Spec III	119,57	15	1,13	85691,89	716,64	134127,13	1121,71	0,03	2	30	14,95	2,33	1,64	1,28	0,70
Carahell	1093,27	15	0,96	85691,89	78,38	134127,13	122,68	0,30	2	30	136,66	2,33	1,64	1,28	6,41
Caramunich II	177,44	15	0,96	85691,89	482,95	134127,13	755,92	0,05	2	30	22,18	2,33	1,64	1,28	1,04
Carapils	415,02	15	0,95	85691,89	206,48	134127,13	323,18	0,12	2	30	51,88	2,33	1,64	1,28	2,43
Carared	578,61	15	1,02	85691,89	148,10	134127,13	231,81	0,16	2	30	72,33	2,33	1,64	1,28	3,39
Dextrin Malt	487,39	15	0,62	85691,89	175,82	134127,13	275,19	0,14	2	30	60,92	2,33	1,64	1,28	2,86
Finest Lager Malt	1409,54	15	1,6	85691,89	60,79	134127,13	95,16	0,39	2	30	176,19	2,33	1,64	1,28	8,26
Maris Otter Simpson	3526,25	15	0,8	85691,89	24,30	134127,13	38,04	0,98	2	30	440,78	2,33	1,64	1,28	20,66
Melanoidin	148,97	15	0,92	85691,89	575,25	134127,13	900,39	0,04	2	30	18,62	2,33	1,64	1,28	0,87
Munich I	948,47	15	0,83	85691,89	90,35	134127,13	141,41	0,26	2	30	118,56	2,33	1,64	1,28	5,56
Oat flakes	191,32	15	1,49	85691,89	447,90	134127,13	701,07	0,05	2	30	23,91	2,33	1,64	1,28	1,12
Pale Ale Simpson	6208,08	15	0,7	85691,89	13,80	134127,13	21,61	1,72	2	30	776,01	2,33	1,64	1,28	36,38
Pale Wheat	212,35	15	0,8	85691,89	403,55	134127,13	631,64	0,06	2	30	26,54	2,33	1,64	1,28	1,24
Pilsner	2195,78	15	0,8	85691,89	39,03	134127,13	61,08	0,61	2	30	274,47	2,33	1,64	1,28	12,87
Roasted barley	95,66	15	1,16	85691,89	895,80	134127,13	1402,13	0,03	2	30	11,96	2,33	1,64	1,28	0,56
Vienna	284,66	15	0,82	85691,89	301,04	134127,13	471,19	0,08	2	30	35,58	2,33	1,64	1,28	1,67
Wheat flakes	370,44	15	1,34	85691,89	231,32	134127,13	362,07	0,10	2	30	46,31	2,33	1,64	1,28	2,17
Dextrose	57,85	15	0,99	85691,89	1481,36	134127,13	2318,66	0,02	2	30	7,23	2,33	1,64	1,28	0,34
Golden Naked Oats	44,58	15	3,31	85691,89	1922,39	134127,13	3008,98	0,01	2	30	5,57	2,33	1,64	1,28	0,26
Golden Promise	624,059	15	0,89	85691,89	137,31	134127,13	214,93	0,17	2	30	78,01	2,33	1,64	1,28	3,66

Oat Malt	29,39	15	1,17	85691,89	2915,58	134127,13	4563,54	0,01	2	30	3,67	2,33	1,64	1,28	0,17

Table 5 - 10% Demand Standard Deviation and 30 days order period – continuation

Malt	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Acidulated	5,06	3,56	2,78	51,34	49,84	49,06	-	-	-	-	9561,46	9214,99	9034,23
Barley flakes	2,10	1,48	1,15	21,28	20,66	20,34	-	-	-	-	15397,47	15051,00	14870,24
Carafa Spec II	1,89	1,33	1,04	19,15	18,59	18,30	-	-	-	-	16552,15	16205,68	16024,91
Carafa Spec III	1,63	1,15	0,90	16,58	16,10	15,84	-	-	-	-	18336,05	17989,58	17808,81
Carahell	14,93	10,51	8,20	151,59	147,16	144,86	-	-	-	-	7262,21	6915,74	6734,98
Caramunich II	2,42	1,71	1,33	24,60	23,88	23,51	-	-	-	-	13981,85	13635,38	13454,62
Carapils	5,67	3,99	3,11	57,54	55,87	54,99	-	-	-	-	9012,94	8666,47	8485,70
Carared	7,90	5,56	4,34	80,23	77,89	76,67	-	-	-	-	8112,35	7765,88	7585,11
Dextrin Malt	6,65	4,68	3,66	67,58	65,61	64,58	-	-	-	-	8344,95	7998,48	7817,71
Finest Lager Malt	19,24	13,55	10,57	195,44	189,74	186,76	-	-	-	-	8137,61	7791,14	7610,37
Maris Otter Simpson	48,14	33,89	26,45	488,93	474,67	467,23	-	-	-	-	8017,90	7671,43	7490,66
Melanoidin	2,03	1,43	1,12	20,65	20,05	19,74	-	-	-	-	15682,21	15335,74	15154,98
Munich I	12,95	9,11	7,11	131,51	127,67	125,67	-	-	-	-	7224,66	6878,19	6697,43
Oat flakes	2,61	1,84	1,43	26,53	25,75	25,35	-	-	-	-	13438,32	13091,85	12911,08
Pale Ale Simpson	84,76	59,66	46,56	860,77	835,67	822,57	-	-	-	-	9345,38	8998,91	8818,14
Pale Wheat	2,90	2,04	1,59	29,44	28,58	28,14	-	-	-	-	12490,04	12143,57	11962,80
Pilsner	29,98	21,10	16,47	304,45	295,57	290,94	-	-	-	-	7230,09	6883,62	6702,85
Roasted barley	1,31	0,92	0,72	13,26	12,88	12,67	-	-	-	-	21677,01	21330,54	21149,78
Vienna	3,89	2,74	2,14	39,47	38,32	37,72	-	-	-	-	10628,17	10281,70	10100,94
Wheat flakes	5,06	3,56	2,78	51,36	49,87	49,08	-	-	-	-	9581,73	9235,26	9054,49
Dextrose	0,79	0,56	0,43	8,02	7,79	7,66	-	-	-	-	32621,66	32275,19	32094,43

Golden Naked Oats	0,61	0,43	0,33	6,18	6,00	5,91	-	-	-	-	40995,72	40649,25	40468,49
Golden Promise	8,52	6,00	4,68	86,53	84,00	82,69	-	-	-	-	7875,00	7528,53	7347,76
Oat Malt	0,40	0,28	0,22	4,08	3,96	3,89	-	-	-	-	59537,38	59190,91	59010,14

Table 6 - 20% Demand Standard Deviation and 30 days order period

Malt	Annual Demand (Kg)	LT (days)	Acquisition Cost per kg	Annual Holding Cost	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
Acidulated	370,25	15	1,28	85691,89	231,44	134127,13	362,26	0,21	2	30	46,28	2,33	1,64	1,28	2,48
Barley flakes	153,51	15	1,12	85691,89	558,23	134127,13	873,76	0,09	2	30	19,19	2,33	1,64	1,28	1,03
Carafa Spec II	138,09	15	1,13	85691,89	620,55	134127,13	971,30	0,08	2	30	17,26	2,33	1,64	1,28	0,92
Carafa Spec III	119,57	15	1,13	85691,89	716,64	134127,13	1121,71	0,07	2	30	14,95	2,33	1,64	1,28	0,80
Carahell	1093,27	15	0,96	85691,89	78,38	134127,13	122,68	0,61	2	30	136,66	2,33	1,64	1,28	7,31
Caramunich II	177,44	15	0,96	85691,89	482,95	134127,13	755,92	0,10	2	30	22,18	2,33	1,64	1,28	1,19
Carapils	415,02	15	0,95	85691,89	206,48	134127,13	323,18	0,23	2	30	51,88	2,33	1,64	1,28	2,78
Carared	578,61	15	1,02	85691,89	148,10	134127,13	231,81	0,32	2	30	72,33	2,33	1,64	1,28	3,87
Dextrin Malt	487,39	15	0,62	85691,89	175,82	134127,13	275,19	0,27	2	30	60,92	2,33	1,64	1,28	3,26
Finest Lager Malt	1409,54	15	1,6	85691,89	60,79	134127,13	95,16	0,78	2	30	176,19	2,33	1,64	1,28	9,43
Maris Otter Simpson	3526,25	15	0,8	85691,89	24,30	134127,13	38,04	1,96	2	30	440,78	2,33	1,64	1,28	23,59
Melanoidin	148,97	15	0,92	85691,89	575,25	134127,13	900,39	0,08	2	30	18,62	2,33	1,64	1,28	1,00
Munich I	948,47	15	0,83	85691,89	90,35	134127,13	141,41	0,53	2	30	118,56	2,33	1,64	1,28	6,35
Oat flakes	191,32	15	1,49	85691,89	447,90	134127,13	701,07	0,11	2	30	23,91	2,33	1,64	1,28	1,28
Pale Ale Simpson	6208,08	15	0,7	85691,89	13,80	134127,13	21,61	3,45	2	30	776,01	2,33	1,64	1,28	41,53
Pale Wheat	212,35	15	0,8	85691,89	403,55	134127,13	631,64	0,12	2	30	26,54	2,33	1,64	1,28	1,42
Pilsner	2195,78	15	0,8	85691,89	39,03	134127,13	61,08	1,22	2	30	274,47	2,33	1,64	1,28	14,69
Roasted barley	95,66	15	1,16	85691,89	895,80	134127,13	1402,13	0,05	2	30	11,96	2,33	1,64	1,28	0,64

Vienna	284,66	15	0,82	85691,89	301,04	134127,13	471,19	0,16	2	30	35,58	2,33	1,64	1,28	1,90
Wheat flakes	370,44	15	1,34	85691,89	231,32	134127,13	362,07	0,21	2	30	46,31	2,33	1,64	1,28	2,48
Dextrose	57,85	15	0,99	85691,89	1481,36	134127,13	2318,66	0,03	2	30	7,23	2,33	1,64	1,28	0,39
Golden Naked Oats	44,58	15	3,31	85691,89	1922,39	134127,13	3008,98	0,02	2	30	5,57	2,33	1,64	1,28	0,30
Golden Promise	624,059	15	0,89	85691,89	137,31	134127,13	214,93	0,35	2	30	78,01	2,33	1,64	1,28	4,17
Oat Malt	29,39	15	1,17	85691,89	2915,58	134127,13	4563,54	0,02	2	30	3,67	2,33	1,64	1,28	0,20

Table 6 - 20% Demand Standard Deviation and 30 days order period - continuation

Malt	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Acidulated	5,77	4,06	3,17	52,05	50,34	49,45	-	-	-	-	9727,19	9331,64	9125,27
Barley flakes	2,39	1,68	1,31	21,58	20,87	20,50	-	-	-	-	15563,20	15167,65	14961,28
Carafa Spec II	2,15	1,52	1,18	19,41	18,78	18,44	-	-	-	-	16717,88	16322,33	16115,95
Carafa Spec III	1,86	1,31	1,02	16,81	16,26	15,97	-	-	-	-	18501,78	18106,23	17899,86
Carahell	17,04	11,99	9,36	153,70	148,65	146,02	-	-	-	-	7427,94	7032,39	6826,02
Caramunich II	2,77	1,95	1,52	24,95	24,13	23,70	-	-	-	-	14147,58	13752,03	13545,66
Carapils	6,47	4,55	3,55	58,35	56,43	55,43	-	-	-	-	9178,67	8783,12	8576,74
Carared	9,02	6,35	4,95	81,35	78,67	77,28	-	-	-	-	8278,08	7882,53	7676,16
Dextrin Malt	7,60	5,35	4,17	68,52	66,27	65,10	-	-	-	-	8510,68	8115,13	7908,76
Finest Lager Malt	21,97	15,46	12,07	198,16	191,66	188,26	-	-	-	-	8303,33	7907,79	7701,41
Maris Otter Simpson	54,96	38,69	30,19	495,75	479,47	470,98	-	-	-	-	8183,63	7788,08	7581,71
Melanoidin	2,32	1,63	1,28	20,94	20,25	19,90	-	-	-	-	15847,94	15452,39	15246,02
Munich I	14,78	10,41	8,12	133,34	128,96	126,68	-	-	-	-	7390,39	6994,84	6788,47
Oat flakes	2,98	2,10	1,64	26,90	26,01	25,55	-	-	-	-	13604,05	13208,50	13002,13
Pale Ale Simpson	96,77	68,11	53,16	872,78	844,12	829,17	-	-	-	-	9511,11	9115,56	8909,18
Pale Wheat	3,31	2,33	1,82	29,85	28,87	28,36	-	-	-	-	12655,77	12260,22	12053,84

Pilsner	34,23	24,09	18,80	308,70	298,56	293,27	-	-	-	-	7395,82	7000,27	6793,90
Roasted barley	1,49	1,05	0,82	13,45	13,01	12,78	-	-	-	-	21842,74	21447,19	21240,82
Vienna	4,44	3,12	2,44	40,02	38,70	38,02	-	-	-	-	10793,90	10398,35	10191,98
Wheat flakes	5,77	4,06	3,17	52,08	50,37	49,48	-	-	-	-	9747,46	9351,91	9145,54
Dextrose	0,90	0,63	0,50	8,13	7,87	7,73	-	-	-	-	32787,39	32391,84	32185,47
Golden Naked Oats	0,69	0,49	0,38	6,27	6,06	5,95	-	-	-	-	41161,45	40765,90	40559,53
Golden Promise	9,73	6,85	5,34	87,73	84,85	83,35	-	-	-	-	8040,73	7645,18	7438,80
Oat Malt	0,46	0,32	0,25	4,13	4,00	3,93	-	-	-	-	59703,11	59307,56	59101,19

Table 7 - 5% Demand Standard Deviation and 40 days order period

Malt	Annual Demand (Kg)	LT (days)	Acquisition Cost per kg	Annual Holding Cost	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
Acidulated	370,25	15	1,28	85691,89	231,44	134127,1	362,26	0,05	2	40	56,57	2,33	1,64	1,28	2,09
Barley flakes	153,51	15	1,12	85691,89	558,23	134127,1	873,76	0,02	2	40	23,45	2,33	1,64	1,28	0,87
Carafa Spec II	138,09	15	1,13	85691,89	620,55	134127,1	971,30	0,02	2	40	21,10	2,33	1,64	1,28	0,78
Carafa Spec III	119,57	15	1,13	85691,89	716,64	134127,1	1121,71	0,02	2	40	18,27	2,33	1,64	1,28	0,68
Carahell	1093,27	15	0,96	85691,89	78,38	134127,1	122,68	0,15	2	40	167,03	2,33	1,64	1,28	6,18
Caramunich II	177,44	15	0,96	85691,89	482,95	134127,1	755,92	0,02	2	40	27,11	2,33	1,64	1,28	1,00
Carapils	415,02	15	0,95	85691,89	206,48	134127,1	323,18	0,06	2	40	63,41	2,33	1,64	1,28	2,34
Carared	578,61	15	1,02	85691,89	148,10	134127,1	231,81	0,08	2	40	88,40	2,33	1,64	1,28	3,27
Dextrin Malt	487,39	15	0,62	85691,89	175,82	134127,1	275,19	0,07	2	40	74,46	2,33	1,64	1,28	2,75
Finest Lager Malt	1409,54	15	1,6	85691,89	60,79	134127,1	95,16	0,20	2	40	215,35	2,33	1,64	1,28	7,96
Maris Otter Simpson	3526,25	15	0,8	85691,89	24,30	134127,1	38,04	0,49	2	40	538,73	2,33	1,64	1,28	19,92
Melanoidin	148,97	15	0,92	85691,89	575,25	134127,1	900,39	0,02	2	40	22,76	2,33	1,64	1,28	0,84
Munich I	948,47	15	0,83	85691,89	90,35	134127,1	141,41	0,13	2	40	144,90	2,33	1,64	1,28	5,36

Oat flakes	191,32	15	1,49	85691,89	447,90	134127,1	701,07	0,03	2	40	29,23	2,33	1,64	1,28	1,08
Pale Ale Simpson	6208,08	15	0,7	85691,89	13,80	134127,1	21,61	0,86	2	40	948,46	2,33	1,64	1,28	35,08
Pale Wheat	212,35	15	0,8	85691,89	403,55	134127,1	631,64	0,03	2	40	32,44	2,33	1,64	1,28	1,20
Pilsner	2195,78	15	0,8	85691,89	39,03	134127,1	61,08	0,30	2	40	335,47	2,33	1,64	1,28	12,41
Roasted barley	95,66	15	1,16	85691,89	895,80	134127,1	1402,13	0,01	2	40	14,61	2,33	1,64	1,28	0,54
Vienna	284,66	15	0,82	85691,89	301,04	134127,1	471,19	0,04	2	40	43,49	2,33	1,64	1,28	1,61
Wheat flakes	370,44	15	1,34	85691,89	231,32	134127,1	362,07	0,05	2	40	56,60	2,33	1,64	1,28	2,09
Dextrose	57,85	15	0,99	85691,89	1481,36	134127,1	2318,66	0,01	2	40	8,84	2,33	1,64	1,28	0,33
Golden Naked Oats	44,58	15	3,31	85691,89	1922,39	134127,1	3008,98	0,01	2	40	6,81	2,33	1,64	1,28	0,25
Golden Promise	624,059	15	0,89	85691,89	137,31	134127,1	214,93	0,09	2	40	95,34	2,33	1,64	1,28	3,53
Oat Malt	29,39	15	1,17	85691,89	2915,58	134127,1	4563,54	0,00	2	40	4,49	2,33	1,64	1,28	0,17

Table 7 - 5% Demand Standard Deviation and 40 days order period - continuation

Malt	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Acidulated	4,87	3,43	2,68	61,44	60,00	59,24	-	-	-	-	9623,03	9288,95	9114,64
Barley flakes	2,02	1,42	1,11	25,47	24,87	24,56	-	-	-	-	13924,54	13590,46	13416,15
Carafa Spec II	1,82	1,28	1,00	22,92	22,38	22,10	-	-	-	-	14786,57	14452,49	14278,19
Carafa Spec III	1,57	1,11	0,86	19,84	19,38	19,13	-	-	-	-	16119,27	15785,19	15610,88
Carahell	14,39	10,13	7,91	181,42	177,16	174,93	-	-	-	-	8042,50	7708,41	7534,11
Caramunich II	2,34	1,64	1,28	29,44	28,75	28,39	-	-	-	-	12862,43	12528,34	12354,04
Carapils	5,46	3,85	3,00	68,87	67,25	66,41	-	-	-	-	9191,72	8857,64	8683,33
Carared	7,62	5,36	4,18	96,02	93,76	92,58	-	-	-	-	8565,26	8231,18	8056,87
Dextrin Malt	6,42	4,52	3,52	80,88	78,98	77,99	-	-	-	-	8667,71	8333,63	8159,32
Finest Lager Malt	18,56	13,06	10,19	233,90	228,41	225,54	-	-	-	-	9000,47	8666,39	8492,09
Maris Otter Simpson	46,42	32,68	25,50	585,16	571,41	564,24	-	-	-	-	9052,13	8718,05	8543,74

Melanoidin	1,96	1,38	1,08	24,72	24,14	23,84	-	-	-	-	14129,38	13795,29	13620,99
Munich I	12,49	8,79	6,86	157,39	153,69	151,76	-	-	-	-	7948,76	7614,67	7440,37
Oat flakes	2,52	1,77	1,38	31,75	31,00	30,61	-	-	-	-	12483,46	12149,37	11975,07
Pale Ale Simpson	81,73	57,53	44,90	1030,19	1005,98	993,35	-	-	-	-	10428,90	10094,82	9920,51
Pale Wheat	2,80	1,97	1,54	35,24	34,41	33,98	-	-	-	-	11743,45	11409,37	11235,06
Pilsner	28,91	20,35	15,88	364,37	355,81	351,35	-	-	-	-	8195,18	7861,09	7686,79
Roasted barley	1,26	0,89	0,69	15,87	15,50	15,31	-	-	-	-	18618,95	18284,87	18110,57
Vienna	3,75	2,64	2,06	47,24	46,13	45,55	-	-	-	-	10362,94	10028,85	9854,55
Wheat flakes	4,88	3,43	2,68	61,47	60,03	59,27	-	-	-	-	9643,85	9309,77	9135,46
Dextrose	0,76	0,54	0,42	9,60	9,37	9,26	-	-	-	-	26814,02	26479,93	26305,63
Golden Naked Oats	0,59	0,41	0,32	7,40	7,22	7,13	-	-	-	-	33117,13	32783,05	32608,74
Golden Promise	8,22	5,78	4,51	103,56	101,13	99,86	-	-	-	-	8378,55	8044,47	7870,16
Oat Malt	0,39	0,27	0,21	4,88	4,76	4,70	-	-	-	-	46995,08	46661,00	46486,70

Table 8 - 10% Demand Standard Deviation and 40 days order period

Malt	**Annual Demand (Kg)**	**LT (days)**	**Acquisition Cost per kg**	**Annual Holding Cost**	**Holding Cost per kg/year**	**Annual Ordering Cost**	**Ordering Cost per kg/year**	**σ_d**	**σ_LT**	**P (days)**	**μ (average demand during P+LT)**	**z (99% service level)**	**z (95% service level)**	**z (90% service level)**	**σ_P+LT**
Acidulated	370,25	15	1,28	85691,89	231,44	134127,1	362,26	0,10	2	40	56,57	2,33	1,64	1,28	2,19
Barley flakes	153,51	15	1,12	85691,89	558,23	134127,1	873,76	0,04	2	40	23,45	2,33	1,64	1,28	0,91
Carafa Spec II	138,09	15	1,13	85691,89	620,55	134127,1	971,30	0,04	2	40	21,10	2,33	1,64	1,28	0,82
Carafa Spec III	119,57	15	1,13	85691,89	716,64	134127,1	1121,71	0,03	2	40	18,27	2,33	1,64	1,28	0,71
Carahell	1093,27	15	0,96	85691,89	78,38	134127,1	122,68	0,30	2	40	167,03	2,33	1,64	1,28	6,48
Caramunich II	177,44	15	0,96	85691,89	482,95	134127,1	755,92	0,05	2	40	27,11	2,33	1,64	1,28	1,05
Carapils	415,02	15	0,95	85691,89	206,48	134127,1	323,18	0,12	2	40	63,41	2,33	1,64	1,28	2,46

Carared	578,61	15	1,02	85691,89	148,10	134127,1	231,81	0,16	2	40	88,40	2,33	1,64	1,28	3,43
Dextrin Malt	487,39	15	0,62	85691,89	175,82	134127,1	275,19	0,14	2	40	74,46	2,33	1,64	1,28	2,89
Finest Lager Malt	1409,54	15	1,6	85691,89	60,79	134127,1	95,16	0,39	2	40	215,35	2,33	1,64	1,28	8,35
Maris Otter Simpson	3526,25	15	0,8	85691,89	24,30	134127,1	38,04	0,98	2	40	538,73	2,33	1,64	1,28	20,89
Melanoidin	148,97	15	0,92	85691,89	575,25	134127,1	900,39	0,04	2	40	22,76	2,33	1,64	1,28	0,88
Munich I	948,47	15	0,83	85691,89	90,35	134127,1	141,41	0,26	2	40	144,90	2,33	1,64	1,28	5,62
Oat flakes	191,32	15	1,49	85691,89	447,90	134127,1	701,07	0,05	2	40	29,23	2,33	1,64	1,28	1,13
Pale Ale Simpson	6208,08	15	0,7	85691,89	13,80	134127,1	21,61	1,72	2	40	948,46	2,33	1,64	1,28	36,78
Pale Wheat	212,35	15	0,8	85691,89	403,55	134127,1	631,64	0,06	2	40	32,44	2,33	1,64	1,28	1,26
Pilsner	2195,78	15	0,8	85691,89	39,03	134127,1	61,08	0,61	2	40	335,47	2,33	1,64	1,28	13,01
Roasted barley	95,66	15	1,16	85691,89	895,80	134127,1	1402,13	0,03	2	40	14,61	2,33	1,64	1,28	0,57
Vienna	284,66	15	0,82	85691,89	301,04	134127,1	471,19	0,08	2	40	43,49	2,33	1,64	1,28	1,69
Wheat flakes	370,44	15	1,34	85691,89	231,32	134127,1	362,07	0,10	2	40	56,60	2,33	1,64	1,28	2,19
Dextrose	57,85	15	0,99	85691,89	1481,36	134127,1	2318,66	0,02	2	40	8,84	2,33	1,64	1,28	0,34
Golden Naked Oats	44,58	15	3,31	85691,89	1922,39	134127,1	3008,98	0,01	2	40	6,81	2,33	1,64	1,28	0,26
Golden Promise	624,059	15	0,89	85691,89	137,31	134127,1	214,93	0,17	2	40	95,34	2,33	1,64	1,28	3,70
Oat Malt	29,39	15	1,17	85691,89	2915,58	134127,1	4563,54	0,01	2	40	4,49	2,33	1,64	1,28	0,17

Table 8 - 10% Demand Standard Deviation and 40 days order period - continuation

Malt	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Acidulated	5,11	3,60	2,81	61,68	60,16	59,37	-	-	-	-	9677,93	9327,59	9144,80
Barley flakes	2,12	1,49	1,16	25,57	24,94	24,62	-	-	-	-	13979,44	13629,10	13446,31
Carafa Spec II	1,91	1,34	1,05	23,00	22,44	22,14	-	-	-	-	14841,47	14491,13	14308,35
Carafa Spec III	1,65	1,16	0,91	19,92	19,43	19,18	-	-	-	-	16174,17	15823,83	15641,04
Carahell	15,09	10,62	8,29	182,12	177,65	175,32	-	-	-	-	8097,40	7747,06	7564,27

Caramunich II	2,45	1,72	1,35	29,56	28,83	28,45	-	-	-	-	12917,33	12566,99	12384,20
Carapils	5,73	4,03	3,15	69,14	67,44	66,55	-	-	-	-	9246,62	8896,28	8713,49
Carared	7,99	5,62	4,39	96,39	94,02	92,79	-	-	-	-	8620,16	8269,82	8087,03
Dextrin Malt	6,73	4,74	3,70	81,19	79,20	78,16	-	-	-	-	8722,61	8372,27	8189,48
Finest Lager Malt	19,46	13,70	10,69	234,81	229,04	226,04	-	-	-	-	9055,37	8705,03	8522,25
Maris Otter Simpson	48,68	34,27	26,74	587,42	573,00	565,48	-	-	-	-	9107,03	8756,69	8573,90
Melanoidin	2,06	1,45	1,13	24,82	24,21	23,89	-	-	-	-	14184,28	13833,93	13651,15
Munich I	13,09	9,22	7,19	158,00	154,12	152,10	-	-	-	-	8003,66	7653,32	7470,53
Oat flakes	2,64	1,86	1,45	31,87	31,09	30,68	-	-	-	-	12538,36	12188,02	12005,23
Pale Ale Simpson	85,71	60,33	47,08	1034,16	1008,78	995,54	-	-	-	-	10483,80	10133,46	9950,67
Pale Wheat	2,93	2,06	1,61	35,37	34,51	34,05	-	-	-	-	11798,35	11448,01	11265,22
Pilsner	30,31	21,34	16,65	365,78	356,80	352,12	-	-	-	-	8250,08	7899,74	7716,95
Roasted barley	1,32	0,93	0,73	15,94	15,54	15,34	-	-	-	-	18673,85	18323,51	18140,73
Vienna	3,93	2,77	2,16	47,42	46,26	45,65	-	-	-	-	10417,84	10067,50	9884,71
Wheat flakes	5,11	3,60	2,81	61,71	60,20	59,40	-	-	-	-	9698,75	9348,41	9165,62
Dextrose	0,80	0,56	0,44	9,64	9,40	9,28	-	-	-	-	26868,92	26518,58	26335,79
Golden Naked Oats	0,62	0,43	0,34	7,43	7,24	7,15	-	-	-	-	33172,03	32821,69	32638,90
Golden Promise	8,62	6,06	4,73	103,96	101,41	100,08	-	-	-	-	8433,45	8083,11	7900,32
Oat Malt	0,41	0,29	0,22	4,90	4,78	4,71	-	-	-	-	47049,98	46699,64	46516,86

Table 9 - 20% Demand Standard Deviation and 40 days order period

Malt	Annual Demand (Kg)	LT (days)	Acquisition Cost per kg	Annual Holding Cost	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
Acidulated	370,25	15	1,28	85691,89	231,44	134127,1	362,26	0,21	2	40	56,57	2,33	1,64	1,28	2,56
Barley flakes	153,51	15	1,12	85691,89	558,23	134127,1	873,76	0,09	2	40	23,45	2,33	1,64	1,28	1,06

Carafa Spec II	138,09	15	1,13	85691,89	620,55	134127,1	971,30	0,08	2	40	21,10	2,33	1,64	1,28	0,96
Carafa Spec III	119,57	15	1,13	85691,89	716,64	134127,1	1121,71	0,07	2	40	18,27	2,33	1,64	1,28	0,83
Carahell	1093,27	15	0,96	85691,89	78,38	134127,1	122,68	0,61	2	40	167,03	2,33	1,64	1,28	7,56
Caramunich II	177,44	15	0,96	85691,89	482,95	134127,1	755,92	0,10	2	40	27,11	2,33	1,64	1,28	1,23
Carapils	415,02	15	0,95	85691,89	206,48	134127,1	323,18	0,23	2	40	63,41	2,33	1,64	1,28	2,87
Carared	578,61	15	1,02	85691,89	148,10	134127,1	231,81	0,32	2	40	88,40	2,33	1,64	1,28	4,00
Dextrin Malt	487,39	15	0,62	85691,89	175,82	134127,1	275,19	0,27	2	40	74,46	2,33	1,64	1,28	3,37
Finest Lager Malt	1409,54	15	1,6	85691,89	60,79	134127,1	95,16	0,78	2	40	215,35	2,33	1,64	1,28	9,75
Maris Otter Simpson	3526,25	15	0,8	85691,89	24,30	134127,1	38,04	1,96	2	40	538,73	2,33	1,64	1,28	24,39
Melanoidin	148,97	15	0,92	85691,89	575,25	134127,1	900,39	0,08	2	40	22,76	2,33	1,64	1,28	1,03
Munich I	948,47	15	0,83	85691,89	90,35	134127,1	141,41	0,53	2	40	144,90	2,33	1,64	1,28	6,56
Oat flakes	191,32	15	1,49	85691,89	447,90	134127,1	701,07	0,11	2	40	29,23	2,33	1,64	1,28	1,32
Pale Ale Simpson	6208,08	15	0,7	85691,89	13,80	134127,1	21,61	3,45	2	40	948,46	2,33	1,64	1,28	42,94
Pale Wheat	212,35	15	0,8	85691,89	403,55	134127,1	631,64	0,12	2	40	32,44	2,33	1,64	1,28	1,47
Pilsner	2195,78	15	0,8	85691,89	39,03	134127,1	61,08	1,22	2	40	335,47	2,33	1,64	1,28	15,19
Roasted barley	95,66	15	1,16	85691,89	895,80	134127,1	1402,13	0,05	2	40	14,61	2,33	1,64	1,28	0,66
Vienna	284,66	15	0,82	85691,89	301,04	134127,1	471,19	0,16	2	40	43,49	2,33	1,64	1,28	1,97
Wheat flakes	370,44	15	1,34	85691,89	231,32	134127,1	362,07	0,21	2	40	56,60	2,33	1,64	1,28	2,56
Dextrose	57,85	15	0,99	85691,89	1481,36	134127,1	2318,66	0,03	2	40	8,84	2,33	1,64	1,28	0,40
Golden Naked Oats	44,58	15	3,31	85691,89	1922,39	134127,1	3008,98	0,02	2	40	6,81	2,33	1,64	1,28	0,31
Golden Promise	624,059	15	0,89	85691,89	137,31	134127,1	214,93	0,35	2	40	95,34	2,33	1,64	1,28	4,32
Oat Malt	29,39	15	1,17	85691,89	2915,58	134127,1	4563,54	0,02	2	40	4,49	2,33	1,64	1,28	0,20

Table 9 - 20% Demand Standard Deviation and 40 days order period - continuation

Malt	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Acidulated	5,97	4,20	3,28	62,53	60,77	59,84	-	-	-	-	9875,88	9466,92	9253,55
Barley flakes	2,47	1,74	1,36	25,93	25,19	24,81	-	-	-	-	14177,39	13768,43	13555,05
Carafa Spec II	2,23	1,57	1,22	23,32	22,66	22,32	-	-	-	-	15039,42	14630,46	14417,09
Carafa Spec III	1,93	1,36	1,06	20,20	19,62	19,33	-	-	-	-	16372,12	15963,16	15749,78
Carahell	17,62	12,40	9,68	184,65	179,43	176,71	-	-	-	-	8295,34	7886,38	7673,01
Caramunich II	2,86	2,01	1,57	29,97	29,12	28,68	-	-	-	-	13115,27	12706,31	12492,94
Carapils	6,69	4,71	3,67	70,09	68,11	67,08	-	-	-	-	9444,57	9035,61	8822,24
Carared	9,32	6,56	5,12	97,72	94,96	93,52	-	-	-	-	8818,11	8409,15	8195,78
Dextrin Malt	7,85	5,53	4,32	82,32	79,99	78,78	-	-	-	-	8920,56	8511,60	8298,23
Finest Lager Malt	22,72	15,99	12,48	238,06	231,34	227,83	-	-	-	-	9253,32	8844,36	8630,99
Maris Otter Simpson	56,83	40,00	31,22	595,56	578,73	569,95	-	-	-	-	9304,98	8896,02	8682,64
Melanoidin	2,40	1,69	1,32	25,16	24,45	24,08	-	-	-	-	14382,22	13973,26	13759,89
Munich I	15,29	10,76	8,40	160,19	155,66	153,30	-	-	-	-	8201,60	7792,64	7579,27
Oat flakes	3,08	2,17	1,69	32,31	31,40	30,92	-	-	-	-	12736,31	12327,34	12113,97
Pale Ale Simpson	100,05	70,42	54,96	1048,50	1018,88	1003,42	-	-	-	-	10681,75	10272,79	10059,41
Pale Wheat	3,42	2,41	1,88	35,86	34,85	34,32	-	-	-	-	11996,30	11587,34	11373,97
Pilsner	35,39	24,91	19,44	370,85	360,37	354,91	-	-	-	-	8448,02	8039,06	7825,69
Roasted barley	1,54	1,09	0,85	16,16	15,70	15,46	-	-	-	-	18871,80	18462,84	18249,47
Vienna	4,59	3,23	2,52	48,08	46,72	46,01	-	-	-	-	10615,78	10206,82	9993,45
Wheat flakes	5,97	4,20	3,28	62,57	60,80	59,87	-	-	-	-	9896,70	9487,74	9274,36
Dextrose	0,93	0,66	0,51	9,77	9,49	9,35	-	-	-	-	27066,86	26657,90	26444,53
Golden Naked Oats	0,72	0,51	0,39	7,53	7,32	7,20	-	-	-	-	33369,98	32961,02	32747,65

Golden Promise	10,06	7,08	5,52	105,40	102,42	100,87	-	-	-	-	8631,40	8222,44	8009,07
Oat Malt	0,47	0,33	0,26	4,96	4,82	4,75	-	-	-	-	47247,93	46838,97	46625,60

Table 10 - 5% Demand Standard Deviation and 105 days order period

Hops	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
Bullion	12,44	10	15,76	89328,52	7183,22	134127,1	10785,63	0,002	2	105	3,97	2,33	1,64	1,28	0,07
Centennial	7,71	10	17,18	89328,52	11578,84	134127,1	17385,67	0,001	2	105	2,46	2,33	1,64	1,28	0,04
Citra	95,57	10	30,1	89328,52	934,72	134127,1	1403,48	0,013	2	105	30,53	2,33	1,64	1,28	0,55
Columbus	48,90	10	15,54	89328,52	1826,82	134127,1	2742,98	0,007	2	105	15,62	2,33	1,64	1,28	0,28
Fuggles	9,57	10	15,29	89328,52	9338,19	134127,1	14021,32	0,001	2	105	3,06	2,33	1,64	1,28	0,06
Mosaic	81,50	10	28,49	89328,52	1096,09	134127,1	1645,79	0,011	2	105	26,03	2,33	1,64	1,28	0,47
Simcoe	17,74	10	28,49	89328,52	5034,28	134127,1	7558,99	0,002	2	105	5,67	2,33	1,64	1,28	0,10
Spalter Select	35,24	10	40,00	89328,52	2534,97	134127,1	3806,26	0,005	2	105	11,26	2,33	1,64	1,28	0,20
Summit	32,72	10	29,01	89328,52	2729,98	134127,1	4099,08	0,005	2	105	10,45	2,33	1,64	1,28	0,19
Tradition	28,19	10	10,6	89328,52	3168,71	134127,1	4757,83	0,004	2	105	9,01	2,33	1,64	1,28	0,16
Saaz	7,23	10	18,1	89328,52	12353,55	134127,1	18548,90	0,001	2	105	2,31	2,33	1,64	1,28	0,04

Table 10 - 5% Demand Standard Deviation and 105 days order period - continuation

Hops	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Bullion	0,17	0,12	0,09	4,14	4,09	4,06	-	-	-	-	51399,52	51045,00	50860,03
Centennial	0,10	0,07	0,06	2,57	2,54	2,52	-	-	-	-	73964,76	73610,25	73425,28

Citra	1,28	0,90	0,70	31,81	31,43	31,23	-	-	-	-	21912,73	21558,21	21373,25
Columbus	0,66	0,46	0,36	16,28	16,08	15,98	-	-	-	-	24388,60	24034,08	23849,11
Fuggles	0,13	0,09	0,07	3,18	3,15	3,13	-	-	-	-	62443,59	62089,07	61904,10
Mosaic	1,09	0,77	0,60	27,13	26,80	26,63	-	-	-	-	22188,77	21834,25	21649,29
Simcoe	0,24	0,17	0,13	5,91	5,84	5,80	-	-	-	-	40646,27	40291,75	40106,79
Spalter Select	0,47	0,33	0,26	11,73	11,59	11,52	-	-	-	-	28683,81	28329,29	28144,32
Summit	0,44	0,31	0,24	10,89	10,76	10,69	-	-	-	-	29227,44	28872,93	28687,96
Tradition	0,38	0,27	0,21	9,38	9,27	9,21	-	-	-	-	30835,60	30481,08	30296,12
Saaz	0,10	0,07	0,05	2,41	2,38	2,36	-	-	-	-	77951,34	77596,83	77411,86

Table 11 - 10% Demand Standard Deviation and 105 days order period

Hops	**Annual Demand (Kg)**	**LT (days)**	**Acquisition Cost**	**Holding Cost (including refrig)**	**Holding Cost per kg/year**	**Annual Ordering Cost**	**Ordering Cost per kg/year**	**σ_d**	**σ_LT**	**P (days)**	**μ (average demand during P+LT)**	**z (99% service level)**	**z (95% service level)**	**z (90% service level)**	**σ_P+LT**
Bullion	12,44	10	15,76	89328,52	7183,22	134127,1	10785,63	0,003	2	105	3,97	2,33	1,64	1,28	0,08
Centennial	7,71	10	17,18	89328,52	11578,84	134127,1	17385,67	0,002	2	105	2,46	2,33	1,64	1,28	0,05
Citra	95,57	10	30,1	89328,52	934,72	134127,1	1403,48	0,027	2	105	30,53	2,33	1,64	1,28	0,60
Columbus	48,90	10	15,54	89328,52	1826,82	134127,1	2742,98	0,014	2	105	15,62	2,33	1,64	1,28	0,31
Fuggles	9,57	10	15,29	89328,52	9338,19	134127,1	14021,32	0,003	2	105	3,06	2,33	1,64	1,28	0,06
Mosaic	81,50	10	28,49	89328,52	1096,09	134127,1	1645,79	0,023	2	105	26,03	2,33	1,64	1,28	0,51
Simcoe	17,74	10	28,49	89328,52	5034,28	134127,1	7558,99	0,005	2	105	5,67	2,33	1,64	1,28	0,11
Spalter Select	35,24	10	40,00	89328,52	2534,97	134127,1	3806,26	0,010	2	105	11,26	2,33	1,64	1,28	0,22
Summit	32,72	10	29,01	89328,52	2729,98	134127,1	4099,08	0,009	2	105	10,45	2,33	1,64	1,28	0,21
Tradition	28,19	10	10,6	89328,52	3168,71	134127,1	4757,83	0,008	2	105	9,01	2,33	1,64	1,28	0,18
Saaz	7,23	10	18,1	89328,52	12353,55	134127,1	18548,90	0,002	2	105	2,31	2,33	1,64	1,28	0,05

Table 11 - 10% Demand Standard Deviation and 105 days order period – continuation

Hops	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Bullion	0,18	0,13	0,10	4,16	4,10	4,07	-	-	-	-	51514,42	51125,87	50923,15
Centennial	0,11	0,08	0,06	2,58	2,54	2,53	-	-	-	-	74079,66	73691,12	73488,40
Citra	1,40	0,99	0,77	31,93	31,52	31,30	-	-	-	-	22027,63	21639,09	21436,37
Columbus	0,72	0,51	0,39	16,34	16,13	16,01	-	-	-	-	24503,49	24114,95	23912,23
Fuggles	0,14	0,10	0,08	3,20	3,15	3,13	-	-	-	-	62558,49	62169,94	61967,22
Mosaic	1,20	0,84	0,66	27,23	26,88	26,69	-	-	-	-	22303,67	21915,13	21712,41
Simcoe	0,26	0,18	0,14	5,93	5,85	5,81	-	-	-	-	40761,17	40372,62	40169,91
Spalter Select	0,52	0,36	0,28	11,77	11,62	11,54	-	-	-	-	28798,71	28410,16	28207,44
Summit	0,48	0,34	0,26	10,93	10,79	10,72	-	-	-	-	29342,34	28953,80	28751,08
Tradition	0,41	0,29	0,23	9,42	9,30	9,23	-	-	-	-	30950,50	30561,95	30359,24
Saaz	0,11	0,07	0,06	2,42	2,38	2,37	-	-	-	-	78066,24	77677,70	77474,98

Table 12 - 20% Demand Standard Deviation and 105 days order period

Hops	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrigeration)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
Bullion	12,44	10	15,76	89328,52	7183,22	134127,1	10785,63	0,007	2	105	3,97	2,33	1,64	1,28	0,10
Centennial	7,71	10	17,18	89328,52	11578,84	134127,1	17385,67	0,004	2	105	2,46	2,33	1,64	1,28	0,06
Citra	95,57	10	30,1	89328,52	934,72	134127,1	1403,48	0,053	2	105	30,53	2,33	1,64	1,28	0,78
Columbus	48,90	10	15,54	89328,52	1826,82	134127,1	2742,98	0,027	2	105	15,62	2,33	1,64	1,28	0,40
Fuggles	9,57	10	15,29	89328,52	9338,19	134127,1	14021,32	0,005	2	105	3,06	2,33	1,64	1,28	0,08

Mosaic	81,50	10	28,49	89328,52	1096,09	134127,1	1645,79	0,045	2	105	26,03	2,33	1,64	1,28	0,66
Simcoe	17,74	10	28,49	89328,52	5034,28	134127,1	7558,99	0,010	2	105	5,67	2,33	1,64	1,28	0,14
Spalter Select	35,24	10	40,00	89328,52	2534,97	134127,1	3806,26	0,020	2	105	11,26	2,33	1,64	1,28	0,29
Summit	32,72	10	29,01	89328,52	2729,98	134127,1	4099,08	0,018	2	105	10,45	2,33	1,64	1,28	0,27
Tradition	28,19	10	10,6	89328,52	3168,71	134127,1	4757,83	0,016	2	105	9,01	2,33	1,64	1,28	0,23
Saaz	7,23	10	18,1	89328,52	12353,55	134127,1	18548,90	0,004	2	105	2,31	2,33	1,64	1,28	0,06

Table 12 - 20% Demand Standard Deviation and 105 days order period – continuation

Hops	**SS (99%)**	**SS (95%)**	**SS (90%)**	**T (99%)**	**T (95%)**	**T (90%)**	**Available Stock (at the moment)**	**EOQ (99%)**	**EOQ (95%)**	**EOQ (90%)**	**TC (99%)**	**TC (95%)**	**TC (90%)**
Bullion	0,24	0,17	0,13	4,21	4,14	4,10	-	-	-	-	51897,86	51395,76	51133,80
Centennial	0,15	0,10	0,08	2,61	2,57	2,54	-	-	-	-	74463,10	73961,01	73699,05
Citra	1,81	1,28	1,00	32,34	31,81	31,52	-	-	-	-	22411,07	21908,98	21647,01
Columbus	0,93	0,65	0,51	16,55	16,27	16,13	-	-	-	-	24886,93	24384,84	24122,88
Fuggles	0,18	0,13	0,10	3,24	3,18	3,16	-	-	-	-	62941,93	62439,83	62177,87
Mosaic	1,55	1,09	0,85	27,58	27,12	26,88	-	-	-	-	22687,11	22185,02	21923,05
Simcoe	0,34	0,24	0,19	6,01	5,91	5,85	-	-	-	-	41144,61	40642,51	40380,55
Spalter Select	0,67	0,47	0,37	11,93	11,73	11,62	-	-	-	-	29182,15	28680,05	28418,09
Summit	0,62	0,44	0,34	11,07	10,89	10,79	-	-	-	-	29725,78	29223,69	28961,73
Tradition	0,54	0,38	0,29	9,54	9,38	9,30	-	-	-	-	31333,94	30831,84	30569,88
Saaz	0,14	0,10	0,08	2,45	2,41	2,39	-	-	-	-	78449,68	77947,59	77685,62

Table 13 - 5% Demand Standard Deviation and 120 days order period

Hops	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (dysa)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
Bullion	12,44	10	15,76	89328,52	7183,22	134127,1	10785,63	0,002	2	120	4,49	2,33	1,64	1,28	0,07
Centennial	7,71	10	17,18	89328,52	11578,84	134127,1	17385,67	0,001	2	120	2,79	2,33	1,64	1,28	0,04
Citra	95,57	10	30,1	89328,52	934,72	134127,1	1403,48	0,013	2	120	34,51	2,33	1,64	1,28	0,55
Columbus	48,90	10	15,54	89328,52	1826,82	134127,1	2742,98	0,007	2	120	17,66	2,33	1,64	1,28	0,28
Fuggles	9,57	10	15,29	89328,52	9338,19	134127,1	14021,32	0,001	2	120	3,45	2,33	1,64	1,28	0,06
Mosaic	81,50	10	28,49	89328,52	1096,09	134127,1	1645,79	0,011	2	120	29,43	2,33	1,64	1,28	0,47
Simcoe	17,74	10	28,49	89328,52	5034,28	134127,1	7558,99	0,002	2	120	6,41	2,33	1,64	1,28	0,10
Spalter Select	35,24	10	40,00	89328,52	2534,97	134127,1	3806,26	0,005	2	120	12,73	2,33	1,64	1,28	0,20
Summit	32,72	10	29,01	89328,52	2729,98	134127,1	4099,08	0,005	2	120	11,82	2,33	1,64	1,28	0,19
Tradition	28,19	10	10,6	89328,52	3168,71	134127,1	4757,83	0,004	2	120	10,18	2,33	1,64	1,28	0,16
Saaz	7,23	10	18,1	89328,52	12353,55	134127,1	18548,90	0,001	2	120	2,61	2,33	1,64	1,28	0,04

Table 13 - 5% Demand Standard Deviation and 120 days order period – continuation

Hops	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Bullion	0,17	0,12	0,09	4,66	4,61	4,58	-	-	-	-	48643,34	48287,27	48101,50
Centennial	0,10	0,07	0,06	2,89	2,86	2,84	-	-	-	-	68380,00	68023,93	67838,16
Citra	1,29	0,91	0,71	35,80	35,42	35,22	-	-	-	-	23177,48	22821,41	22635,64
Columbus	0,66	0,46	0,36	18,32	18,12	18,02	-	-	-	-	25079,27	24723,20	24537,43
Fuggles	0,13	0,09	0,07	3,58	3,54	3,53	-	-	-	-	58300,68	57944,62	57758,84

Mosaic	1,10	0,77	0,60	30,53	30,20	30,03	-	-	-	-	23349,67	22993,61	22807,83
Simcoe	0,24	0,17	0,13	6,65	6,58	6,54	-	-	-	-	39272,94	38916,87	38731,10
Spalter Select	0,47	0,33	0,26	13,20	13,06	12,99	-	-	-	-	28918,79	28562,72	28376,95
Summit	0,44	0,31	0,24	12,26	12,13	12,06	-	-	-	-	29336,93	28980,87	28795,09
Tradition	0,38	0,27	0,21	10,56	10,45	10,39	-	-	-	-	30662,77	30306,70	30120,93
Saaz	0,10	0,07	0,05	2,71	2,68	2,66	-	-	-	-	71868,05	71511,98	71326,21

Table 14 - 10% Demand Standard Deviation and 120 days order period

Hops	**Annual Demand (Kg)**	**LT (days)**	**Acquisition Cost**	**Holding Cost (including refrig)**	**Holding Cost per kg/year**	**Annual Ordering Cost**	**Ordering Cost per kg/year**	**σ_d**	**σ_LT**	**P (days)**	**μ (average demand during P+LT)**	**z (99% service level)**	**z (95% service level)**	**z (90% service level)**	**σ_P+LT**
Bullion	12,44	10	15,76	89328,52	7183,22	134127,1	10785,63	0,003	2	120	4,49	2,33	1,64	1,28	0,08
Centennial	7,71	10	17,18	89328,52	11578,84	134127,1	17385,67	0,002	2	120	2,79	2,33	1,64	1,28	0,05
Citra	95,57	10	30,1	89328,52	934,72	134127,1	1403,48	0,027	2	120	34,51	2,33	1,64	1,28	0,61
Columbus	48,90	10	15,54	89328,52	1826,82	134127,1	2742,98	0,014	2	120	17,66	2,33	1,64	1,28	0,31
Fuggles	9,57	10	15,29	89328,52	9338,19	134127,1	14021,32	0,003	2	120	3,45	2,33	1,64	1,28	0,06
Mosaic	81,50	10	28,49	89328,52	1096,09	134127,1	1645,79	0,023	2	120	29,43	2,33	1,64	1,28	0,52
Simcoe	17,74	10	28,49	89328,52	5034,28	134127,1	7558,99	0,005	2	120	6,41	2,33	1,64	1,28	0,11
Spalter Select	35,24	10	40,00	89328,52	2534,97	134127,1	3806,26	0,010	2	120	12,73	2,33	1,64	1,28	0,23
Summit	32,72	10	29,01	89328,52	2729,98	134127,1	4099,08	0,009	2	120	11,82	2,33	1,64	1,28	0,21
Tradition	28,19	10	10,6	89328,52	3168,71	134127,1	4757,83	0,008	2	120	10,18	2,33	1,64	1,28	0,18
Saaz	7,23	10	18,1	89328,52	12353,55	134127,1	18548,90	0,002	2	120	2,61	2,33	1,64	1,28	0,05

Table 14 - 10% Demand Standard Deviation and 120 days order period – continuation

Hops	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Bullion	0,19	0,13	0,10	4,68	4,62	4,59	-	-	-	-	48771,98	48377,82	48172,17
Centennial	0,11	0,08	0,06	2,90	2,87	2,85	-	-	-	-	68508,64	68114,48	67908,83
Citra	1,42	1,00	0,78	35,93	35,51	35,29	-	-	-	-	23306,12	22911,96	22706,31
Columbus	0,73	0,51	0,40	18,39	18,17	18,06	-	-	-	-	25207,91	24813,75	24608,10
Fuggles	0,14	0,10	0,08	3,60	3,55	3,53	-	-	-	-	58429,33	58035,17	57829,52
Mosaic	1,21	0,85	0,67	30,64	30,28	30,10	-	-	-	-	23478,32	23084,15	22878,50
Simcoe	0,26	0,19	0,15	6,67	6,59	6,55	-	-	-	-	39401,58	39007,42	38801,77
Spalter Select	0,53	0,37	0,29	13,25	13,09	13,01	-	-	-	-	29047,43	28653,27	28447,62
Summit	0,49	0,34	0,27	12,30	12,16	12,08	-	-	-	-	29465,58	29071,41	28865,76
Tradition	0,42	0,30	0,23	10,60	10,48	10,41	-	-	-	-	30791,41	30397,25	30191,60
Saaz	0,11	0,08	0,06	2,72	2,69	2,67	-	-	-	-	71996,69	71602,53	71396,88

Table 15 - 20% Demand Standard Deviation and 120 days order period

Hops	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
Bullion	12,44	10	15,76	89328,52	7183,22	134127,1	10785,63	0,007	2	120	4,49	2,33	1,64	1,28	0,10
Centennial	7,71	10	17,18	89328,52	11578,84	134127,1	17385,67	0,004	2	120	2,79	2,33	1,64	1,28	0,07
Citra	95,57	10	30,1	89328,52	934,72	134127,1	1403,48	0,053	2	120	34,51	2,33	1,64	1,28	0,81
Columbus	48,90	10	15,54	89328,52	1826,82	134127,1	2742,98	0,027	2	120	17,66	2,33	1,64	1,28	0,41
Fuggles	9,57	10	15,29	89328,52	9338,19	134127,1	14021,32	0,005	2	120	3,45	2,33	1,64	1,28	0,08

Mosaic	81,50	10	28,49	89328,52	1096,09	134127,1	1645,79	0,045	2	120	29,43	2,33	1,64	1,28	0,69
Simcoe	17,74	10	28,49	89328,52	5034,28	134127,1	7558,99	0,010	2	120	6,41	2,33	1,64	1,28	0,15
Spalter Select	35,24	10	40,00	89328,52	2534,97	134127,1	3806,26	0,020	2	120	12,73	2,33	1,64	1,28	0,30
Summit	32,72	10	29,01	89328,52	2729,98	134127,1	4099,08	0,018	2	120	11,82	2,33	1,64	1,28	0,28
Tradition	28,19	10	10,6	89328,52	3168,71	134127,1	4757,83	0,016	2	120	10,18	2,33	1,64	1,28	0,24
Saaz	7,23	10	18,1	89328,52	12353,55	134127,1	18548,90	0,004	2	120	2,61	2,33	1,64	1,28	0,06

Table 15 - 20% Demand Standard Deviation and 120 days order period - continuation

Hops	**SS (99%)**	**SS (95%)**	**SS (90%)**	**T (99%)**	**T (95%)**	**T (90%)**	**Available Stock (at the moment)**	**EOQ (99%)**	**EOQ (95%)**	**EOQ (90%)**	**TC (99%)**	**TC (95%)**	**TC (90%)**
Bullion	0,24	0,17	0,13	4,73	4,66	4,62	-	-	-	-	49194,60	48675,29	48404,34
Centennial	0,15	0,11	0,08	2,94	2,89	2,87	-	-	-	-	68931,26	68411,95	68141,00
Citra	1,88	1,32	1,03	36,39	35,83	35,54	-	-	-	-	23728,74	23209,42	22938,48
Columbus	0,96	0,68	0,53	18,62	18,33	18,19	-	-	-	-	25630,53	25111,22	24840,27
Fuggles	0,19	0,13	0,10	3,64	3,59	3,56	-	-	-	-	58851,95	58332,63	58061,68
Mosaic	1,60	1,13	0,88	31,03	30,56	30,31	-	-	-	-	23900,93	23381,62	23110,67
Simcoe	0,35	0,25	0,19	6,76	6,65	6,60	-	-	-	-	39824,20	39304,89	39033,94
Spalter Select	0,69	0,49	0,38	13,42	13,21	13,11	-	-	-	-	29470,05	28950,73	28679,79
Summit	0,64	0,45	0,35	12,46	12,27	12,17	-	-	-	-	29888,19	29368,88	29097,93
Tradition	0,55	0,39	0,30	10,73	10,57	10,48	-	-	-	-	31214,03	30694,71	30423,77
Saaz	0,14	0,10	0,08	2,75	2,71	2,69	-	-	-	-	72419,31	71900,00	71629,05

Table 16 - 5% Demand Standard Deviation and 130 days order period

Hops	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
Bullion	12,44	10	15,76	89328,52	7183,22	134127,1	10785,63	0,002	2	130	4,84	2,33	1,64	1,28	0,07
Centennial	7,71	10	17,18	89328,52	11578,84	134127,1	17385,67	0,001	2	130	3,00	2,33	1,64	1,28	0,04
Citra	95,57	10	30,1	89328,52	934,72	134127,1	1403,48	0,013	2	130	37,17	2,33	1,64	1,28	0,55
Columbus	48,90	10	15,54	89328,52	1826,82	134127,1	2742,98	0,007	2	130	19,02	2,33	1,64	1,28	0,28
Fuggles	9,57	10	15,29	89328,52	9338,19	134127,1	14021,32	0,001	2	130	3,72	2,33	1,64	1,28	0,06
Mosaic	81,50	10	28,49	89328,52	1096,09	134127,1	1645,79	0,011	2	130	31,69	2,33	1,64	1,28	0,47
Simcoe	17,74	10	28,49	89328,52	5034,28	134127,1	7558,99	0,002	2	130	6,90	2,33	1,64	1,28	0,10
Spalter Select	35,24	10	40,00	89328,52	2534,97	134127,1	3806,26	0,005	2	130	13,70	2,33	1,64	1,28	0,20
Summit	32,72	10	29,01	89328,52	2729,98	134127,1	4099,08	0,005	2	130	12,72	2,33	1,64	1,28	0,19
Tradition	28,19	10	10,6	89328,52	3168,71	134127,1	4757,83	0,004	2	130	10,96	2,33	1,64	1,28	0,16
Saaz	7,23	10	18,1	89328,52	12353,55	134127,1	18548,90	0,001	2	130	2,81	2,33	1,64	1,28	0,04

Table 16 - 5% Demand Standard Deviation and 130 days order period - continuation

Hops	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Bullion	0,17	0,12	0,09	5,00	4,95	4,93	-	-	-	-	47398,49	47041,40	46855,09
Centennial	0,10	0,07	0,06	3,10	3,07	3,06	-	-	-	-	65612,07	65254,97	65068,66
Citra	1,29	0,91	0,71	38,46	38,07	37,87	-	-	-	-	24097,74	23740,65	23554,34
Columbus	0,66	0,46	0,36	19,68	19,48	19,38	-	-	-	-	25690,42	25333,32	25147,01
Fuggles	0,13	0,09	0,07	3,85	3,81	3,79	-	-	-	-	56309,14	55952,04	55765,73

Mosaic	1,10	0,77	0,60	32,79	32,47	32,30	-	-	-	-	24214,02	23856,92	23670,61
Simcoe	0,24	0,17	0,13	7,14	7,07	7,03	-	-	-	-	38772,70	38415,61	38229,30
Spalter Select	0,48	0,33	0,26	14,18	14,04	13,97	-	-	-	-	29284,56	28927,47	28741,16
Summit	0,44	0,31	0,24	13,17	13,04	12,97	-	-	-	-	29635,13	29278,04	29091,73
Tradition	0,38	0,27	0,21	11,34	11,23	11,17	-	-	-	-	30808,95	30451,86	30265,55
Saaz	0,10	0,07	0,05	2,91	2,88	2,87	-	-	-	-	68831,68	68474,58	68288,27

Table 17 - 10% Demand Standard Deviation and 130 days order period

Hops	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
Bullion	12,44	10	15,76	89328,52	7183,22	134127,1	10785,63	0,003	2	130	4,84	2,33	1,64	1,28	0,08
Centennial	7,71	10	17,18	89328,52	11578,84	134127,1	17385,67	0,002	2	130	3,00	2,33	1,64	1,28	0,05
Citra	95,57	10	30,1	89328,52	934,72	134127,1	1403,48	0,027	2	130	37,17	2,33	1,64	1,28	0,62
Columbus	48,90	10	15,54	89328,52	1826,82	134127,1	2742,98	0,014	2	130	19,02	2,33	1,64	1,28	0,32
Fuggles	9,57	10	15,29	89328,52	9338,19	134127,1	14021,32	0,003	2	130	3,72	2,33	1,64	1,28	0,06
Mosaic	81,50	10	28,49	89328,52	1096,09	134127,1	1645,79	0,023	2	130	31,69	2,33	1,64	1,28	0,53
Simcoe	17,74	10	28,49	89328,52	5034,28	134127,1	7558,99	0,005	2	130	6,90	2,33	1,64	1,28	0,11
Spalter Select	35,24	10	40,00	89328,52	2534,97	134127,1	3806,26	0,010	2	130	13,70	2,33	1,64	1,28	0,23
Summit	32,72	10	29,01	89328,52	2729,98	134127,1	4099,08	0,009	2	130	12,72	2,33	1,64	1,28	0,21
Tradition	28,19	10	10,6	89328,52	3168,71	134127,1	4757,83	0,008	2	130	10,96	2,33	1,64	1,28	0,18
Saaz	7,23	10	18,1	89328,52	12353,55	134127,1	18548,90	0,002	2	130	2,81	2,33	1,64	1,28	0,05

Table 17 - 10% Demand Standard Deviation and 130 days order period - continuation

Hops	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Bullion	0,19	0,13	0,10	5,02	4,97	4,94	-	-	-	-	47536,16	47138,30	46930,72
Centennial	0,12	0,08	0,06	3,12	3,08	3,06	-	-	-	-	65749,74	65351,87	65144,29
Citra	1,44	1,01	0,79	38,60	38,18	37,95	-	-	-	-	24235,41	23837,55	23629,97
Columbus	0,74	0,52	0,40	19,75	19,53	19,42	-	-	-	-	25828,09	25430,23	25222,65
Fuggles	0,14	0,10	0,08	3,86	3,82	3,80	-	-	-	-	56446,81	56048,95	55841,37
Mosaic	1,23	0,86	0,67	32,92	32,56	32,37	-	-	-	-	24351,69	23953,83	23746,25
Simcoe	0,27	0,19	0,15	7,17	7,09	7,05	-	-	-	-	38910,38	38512,51	38304,93
Spalter Select	0,53	0,37	0,29	14,23	14,08	14,00	-	-	-	-	29422,23	29024,37	28816,79
Summit	0,49	0,35	0,27	13,22	13,07	13,00	-	-	-	-	29772,81	29374,94	29167,36
Tradition	0,42	0,30	0,23	11,39	11,26	11,20	-	-	-	-	30946,62	30548,76	30341,18
Saaz	0,11	0,08	0,06	2,92	2,89	2,87	-	-	-	-	68969,35	68571,48	68363,90

Table 18 - 20% Demand Standard Deviation and 130 days order period

Hops	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
Bullion	12,44	10	15,76	89328,52	7183,22	134127,1	10785,63	0,007	2	130	4,84	2,33	1,64	1,28	0,11
Centennial	7,71	10	17,18	89328,52	11578,84	134127,1	17385,67	0,004	2	130	3,00	2,33	1,64	1,28	0,07
Citra	95,57	10	30,1	89328,52	934,72	134127,1	1403,48	0,053	2	130	37,17	2,33	1,64	1,28	0,82
Columbus	48,90	10	15,54	89328,52	1826,82	134127,1	2742,98	0,027	2	130	19,02	2,33	1,64	1,28	0,42
Fuggles	9,57	10	15,29	89328,52	9338,19	134127,1	14021,32	0,005	2	130	3,72	2,33	1,64	1,28	0,08

Mosaic	81,50	10	28,49	89328,52	1096,09	134127,1	1645,79	0,045	2	130	31,69	2,33	1,64	1,28	0,70
Simcoe	17,74	10	28,49	89328,52	5034,28	134127,1	7558,99	0,010	2	130	6,90	2,33	1,64	1,28	0,15
Spalter Select	35,24	10	40,00	89328,52	2534,97	134127,1	3806,26	0,020	2	130	13,70	2,33	1,64	1,28	0,30
Summit	32,72	10	29,01	89328,52	2729,98	134127,1	4099,08	0,018	2	130	12,72	2,33	1,64	1,28	0,28
Tradition	28,19	10	10,6	89328,52	3168,71	134127,1	4757,83	0,016	2	130	10,96	2,33	1,64	1,28	0,24
Saaz	7,23	10	18,1	89328,52	12353,55	134127,1	18548,90	0,004	2	130	2,81	2,33	1,64	1,28	0,06

Table 18 - 20% Demand Standard Deviation and 130 days order period - continuation

Hops	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
Bullion	0,25	0,18	0,14	5,09	5,01	4,97	-	-	-	-	47984,00	47453,51	47176,74
Centennial	0,15	0,11	0,08	3,15	3,11	3,09	-	-	-	-	66197,57	65667,09	65390,32
Citra	1,92	1,35	1,05	39,08	38,51	38,22	-	-	-	-	24683,25	24152,76	23875,99
Columbus	0,98	0,69	0,54	20,00	19,71	19,55	-	-	-	-	26275,93	25745,44	25468,67
Fuggles	0,19	0,14	0,11	3,91	3,86	3,83	-	-	-	-	56894,65	56364,16	56087,39
Mosaic	1,63	1,15	0,90	33,33	32,84	32,59	-	-	-	-	24799,53	24269,04	23992,27
Simcoe	0,36	0,25	0,20	7,26	7,15	7,10	-	-	-	-	39358,21	38827,73	38550,95
Spalter Select	0,71	0,50	0,39	14,41	14,20	14,09	-	-	-	-	29870,07	29339,59	29062,81
Summit	0,66	0,46	0,36	13,38	13,19	13,09	-	-	-	-	30220,64	29690,16	29413,39
Tradition	0,57	0,40	0,31	11,53	11,36	11,27	-	-	-	-	31394,46	30863,97	30587,20
Saaz	0,15	0,10	0,08	2,96	2,91	2,89	-	-	-	-	69417,18	68886,70	68609,93

Table 19 - 5% Demand Standard Deviation and 155 days order period

Yeast	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
SAFALE US-05	28,01	10	76,24	89328,52	3188,87	134127,13	4788,09	0,0039	2	155	12,84	2,33	1,64	1,28	0,16
SAFALE S-04	7,17	10	76,84	89328,52	12450,91	134127,13	18695,10	0,0010	2	155	3,29	2,33	1,64	1,28	0,04
SAFLAGER W34/70	24,67	10	127,07	89328,52	3621,38	134127,13	5437,52	0,0034	2	155	11,31	2,33	1,64	1,28	0,14
BSaison	2,89	10	45	89328,52	30884,52	134127,13	46373,22	0,0004	2	155	1,33	2,33	1,64	1,28	0,02

Table 19 - 5% Demand Standard Deviation and 155 days order period - continuation

Yeast	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
SAFALE US-05	0,38	0,27	0,21	13,22	13,11	13,05	-	-	-	-	33701,33	33341,68	33154,04
SAFALE S-04	0,10	0,07	0,05	3,39	3,36	3,34	-	-	-	-	64417,07	64057,42	63869,78
SAFLAGER W34/70	0,34	0,24	0,18	11,64	11,54	11,49	-	-	-	-	36208,42	35848,77	35661,13
BSaison	0,04	0,03	0,02	1,36	1,35	1,35	-	-	-	-	128280,62	127920,97	127733,33

Table 20 - 10% Demand Standard Deviation and 155 days order period

Yeast	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
SAFALE US-05	28,01	10	76,24	89328,52	3188,87	134127,13	4788,09	0,0078	2	155	12,84	2,33	1,64	1,28	0,18
SAFALE S-04	7,17	10	76,84	89328,52	12450,91	134127,13	18695,10	0,0020	2	155	3,29	2,33	1,64	1,28	0,05
SAFLAGER W34/70	24,67	10	127,07	89328,52	3621,38	134127,13	5437,52	0,0069	2	155	11,31	2,33	1,64	1,28	0,16
BSaison	2,89	10	45	89328,52	30884,52	134127,13	46373,22	0,0008	2	155	1,33	2,33	1,64	1,28	0,02

Table 20 - 10% Demand Standard Deviation and 155 days order period - continuation

Yeast	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
SAFALE US-05	0,43	0,30	0,24	13,27	13,14	13,08	-	-	-	-	33861,12	33454,15	33241,82
SAFALE S-04	0,11	0,08	0,06	3,40	3,37	3,35	-	-	-	-	64576,86	64169,89	63957,56
SAFLAGER W34/70	0,38	0,27	0,21	11,69	11,57	11,51	-	-	-	-	36368,21	35961,24	35748,91
BSaison	0,04	0,03	0,02	1,37	1,36	1,35	-	-	-	-	128440,41	128033,44	127821,11

Table 21 - 20% Demand Standard Deviation and 155 days order period

Yeast	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
SAFALE US-05	28,01	10	76,24	89328,52	3188,87	134127,13	4788,09	0,0156	2	155	12,84	2,33	1,64	1,28	0,25
SAFALE S-04	7,17	10	76,84	89328,52	12450,91	134127,13	18695,10	0,0040	2	155	3,29	2,33	1,64	1,28	0,06
SAFLAGER W34/70	24,67	10	127,07	89328,52	3621,38	134127,13	5437,52	0,0137	2	155	11,31	2,33	1,64	1,28	0,22
BSaison	2,89	10	45	89328,52	30884,52	134127,13	46373,22	0,0016	2	155	1,33	2,33	1,64	1,28	0,03

Table 21 - 20% Demand Standard Deviation and 155 days order period - continuation

Yeast	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
SAFALE US-05	0,59	0,42	0,32	13,43	13,25	13,16	-	-	-	-	34369,20	33811,77	33520,94
SAFALE S-04	0,15	0,11	0,08	3,44	3,39	3,37	-	-	-	-	65084,93	64527,50	64236,67
SAFLAGER W34/70	0,52	0,37	0,29	11,83	11,67	11,59	-	-	-	-	36876,29	36318,86	36028,03
BSaison	0,06	0,04	0,03	1,39	1,37	1,36	-	-	-	-	128948,49	128391,06	128100,22

Table 22 - 5% Demand Standard Deviation and 170 days order period

Yeast	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
SAFALE US-05	28,01	10	76,24	89328,52	3188,87	134127,13	4788,09	0,0039	2	170	14,01	2,33	1,64	1,28	0,16
SAFALE S-04	7,17	10	76,84	89328,52	12450,91	134127,13	18695,10	0,0010	2	170	3,59	2,33	1,64	1,28	0,04
SAFLAGER W34/70	24,67	10	127,07	89328,52	3621,38	134127,13	5437,52	0,0034	2	170	12,33	2,33	1,64	1,28	0,14
BSaison	2,89	10	45	89328,52	30884,52	134127,13	46373,22	0,0004	2	170	1,45	2,33	1,64	1,28	0,02

Table 22 - 5% Demand Standard Deviation and 170 days order period - continuation

Yeast	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
SAFALE US-05	0,38	0,27	0,21	14,39	14,28	14,22	-	-	-	-	34586,25	34225,08	34036,64
SAFALE S-04	0,10	0,07	0,05	3,69	3,66	3,64	-	-	-	-	62451,98	62090,80	61902,36
SAFLAGER W34/70	0,34	0,24	0,19	12,67	12,57	12,52	-	-	-	-	36960,25	36599,08	36410,64
BSaison	0,04	0,03	0,02	1,49	1,47	1,47	-	-	-	-	120643,35	120282,18	120093,74

Table 23 - 10% Demand Standard Deviation and 170 days order period

Yeast	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
SAFALE US-05	28,01	10	76,24	89328,52	3188,87	134127,13	4788,09	0,0078	2	170	14,01	2,33	1,64	1,28	0,19
SAFALE S-04	7,17	10	76,84	89328,52	12450,91	134127,13	18695,10	0,0020	2	170	3,59	2,33	1,64	1,28	0,05
SAFLAGER W34/70	24,67	10	127,07	89328,52	3621,38	134127,13	5437,52	0,0069	2	170	12,33	2,33	1,64	1,28	0,17
BSaison	2,89	10	45	89328,52	30884,52	134127,13	46373,22	0,0008	2	170	1,45	2,33	1,64	1,28	0,02

Table 23 - 10% Demand Standard Deviation and 170 days order period - continuation

Yeast	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
SAFALE US-05	0,44	0,31	0,24	14,44	14,31	14,25	-	-	-	-	34759,01	34346,68	34131,55
SAFALE S-04	0,11	0,08	0,06	3,70	3,67	3,65	-	-	-	-	62624,74	62212,40	61997,27
SAFLAGER W34/70	0,38	0,27	0,21	12,72	12,60	12,54	-	-	-	-	37133,02	36720,68	36505,55
BSaison	0,05	0,03	0,02	1,49	1,48	1,47	-	-	-	-	120816,11	120403,78	120188,64

Table 24 - 20% Demand Standard Deviation and 170 days order period

Yeast	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
SAFALE US-05	28,01	10	76,24	89328,52	3188,87	134127,13	4788,09	0,0156	2	170	14,01	2,33	1,64	1,28	0,26
SAFALE S-04	7,17	10	76,84	89328,52	12450,91	134127,13	18695,10	0,0040	2	170	3,59	2,33	1,64	1,28	0,07
SAFLAGER W34/70	24,67	10	127,07	89328,52	3621,38	134127,13	5437,52	0,0137	2	170	12,33	2,33	1,64	1,28	0,23
BSaison	2,89	10	45	89328,52	30884,52	134127,13	46373,22	0,0016	2	170	1,45	2,33	1,64	1,28	0,03

Table 24 - 20% Demand Standard Deviation and 170 days order period - continuation

Yeast	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
SAFALE US-05	0,61	0,43	0,33	14,61	14,43	14,34	-	-	-	-	35301,51	34728,52	34429,57
SAFALE S-04	0,16	0,11	0,09	3,74	3,70	3,67	-	-	-	-	63167,23	62594,24	62295,29
SAFLAGER W34/70	0,53	0,38	0,29	12,87	12,71	12,63	-	-	-	-	37675,51	37102,52	36803,57
BSaison	0,06	0,04	0,03	1,51	1,49	1,48	-	-	-	-	121358,61	120785,62	120486,67

Table 25 - 5% Demand Standard Deviation and 180 days order period

Yeast	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
SAFALE US-05	28,01	10	76,24	89328,52	3188,87	134127,13	4788,09	0,0039	2	180	14,78	2,33	1,64	1,28	0,16
SAFALE S-04	7,17	10	76,84	89328,52	12450,91	134127,13	18695,10	0,0010	2	180	3,79	2,33	1,64	1,28	0,04
SAFLAGER W34/70	24,67	10	127,07	89328,52	3621,38	134127,13	5437,52	0,0034	2	180	13,02	2,33	1,64	1,28	0,14
BSaison	2,89	10	45	89328,52	30884,52	134127,13	46373,22	0,0004	2	180	1,53	2,33	1,64	1,28	0,02

Table 25 - 5% Demand Standard Deviation and 180 days order period - continuation

Yeast	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
SAFALE US-05	0,38	0,27	0,21	15,17	15,05	15,00	-	-	-	-	35267,04	34904,85	34715,89
SAFALE S-04	0,10	0,07	0,05	3,88	3,86	3,84	-	-	-	-	61496,65	61134,46	60945,49
SAFLAGER W34/70	0,34	0,24	0,19	13,36	13,26	13,20	-	-	-	-	37564,64	37202,45	37013,49
BSaison	0,04	0,03	0,02	1,57	1,55	1,55	-	-	-	-	116431,77	116069,58	115880,62

Table 26 - 10% Demand Standard Deviation and 180 days order period

Yeast	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
SAFALE US-05	28,01	10	76,24	89328,52	3188,87	134127,13	4788,09	0,0078	2	180	14,78	2,33	1,64	1,28	0,19
SAFALE S-04	7,17	10	76,84	89328,52	12450,91	134127,13	18695,10	0,0020	2	180	3,79	2,33	1,64	1,28	0,05
SAFLAGER W34/70	24,67	10	127,07	89328,52	3621,38	134127,13	5437,52	0,0069	2	180	13,02	2,33	1,64	1,28	0,17
BSaison	2,89	10	45	89328,52	30884,52	134127,13	46373,22	0,0008	2	180	1,53	2,33	1,64	1,28	0,02

Table 26 - 10% Demand Standard Deviation and 180 days order period - continuation

Yeast	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
SAFALE US-05	0,44	0,31	0,24	15,22	15,09	15,03	-	-	-	-	35448,33	35032,46	34815,48
SAFALE S-04	0,11	0,08	0,06	3,90	3,87	3,85	-	-	-	-	61677,94	61262,06	61045,09
SAFLAGER W34/70	0,39	0,27	0,21	13,41	13,29	13,23	-	-	-	-	37745,93	37330,06	37113,08
BSaison	0,05	0,03	0,02	1,57	1,56	1,55	-	-	-	-	116613,06	116197,19	115980,21

Table 27 - 20% Demand Standard Deviation and 180 days order period

Yeast	Annual Demand (Kg)	LT (days)	Acquisition Cost	Holding Cost (including refrig)	Holding Cost per kg/year	Annual Ordering Cost	Ordering Cost per kg/year	σ_d	σ_LT	P (days)	μ (average demand during P+LT)	z (99% service level)	z (95% service level)	z (90% service level)	σ_P+LT
SAFALE US-05	28,01	10	76,24	89328,52	3188,87	134127,13	4788,09	0,0156	2	180	14,78	2,33	1,64	1,28	0,27
SAFALE S-04	7,17	10	76,84	89328,52	12450,91	134127,13	18695,10	0,0040	2	180	3,79	2,33	1,64	1,28	0,07
SAFLAGER W34/70	24,67	10	127,07	89328,52	3621,38	134127,13	5437,52	0,0137	2	180	13,02	2,33	1,64	1,28	0,23
BSaison	2,89	10	45	89328,52	30884,52	134127,13	46373,22	0,0016	2	180	1,53	2,33	1,64	1,28	0,03

Table 27 - 20% Demand Standard Deviation and 180 days order period - continuation

Yeast	σ_P+LT	SS (99%)	SS (95%)	SS (90%)	T (99%)	T (95%)	T (90%)	Available Stock (at the moment)	EOQ (99%)	EOQ (95%)	EOQ (90%)	TC (99%)	TC (95%)	TC (90%)
SAFALE US-05	0,27	0,62	0,43	0,34	15,40	15,22	15,12	-	-	-	-	36013,12	35429,99	35125,75
SAFALE S-04	0,07	0,16	0,11	0,09	3,94	3,90	3,87	-	-	-	-	62242,73	61659,60	61355,36
SAFLAGER W34/70	0,23	0,54	0,38	0,30	13,56	13,40	13,32	-	-	-	-	38310,72	37727,59	37423,35
BSaison	0,03	0,06	0,04	0,04	1,59	1,57	1,56	-	-	-	-	117177,85	116594,72	116290,48

Appendix 10 – Interview Guide

1. Raw Materials	Malt	Hops	Yeast
2. SS per SKU	To be defined		
3. Service level por SKU	~95%	~95%	~95%
4. Supplier Lead times per SKU (fixed/variable)	15-17 days	10-12 days	10-12 days
5. ABC anlysis criteria	To be defined		
6. Warehouse and SKUs dimensions	Information to be provided by email: -warehouse plant - volume per SKU		

7. Layout type	To be defined		
8. Demand per SKU (fixed/variable)	Variable for all SKUs, approximately		
9. Types of picking (number of pickers)	By aggregated customer order (could be redefined)		
10. Stock reposition	Instantaneous	Instantaneous	Inst. (could be changed)
11. Warehousing system	Europallets; Conventional racks; Forklift		
12. Warehousing typology -temperature	Room temperature	Room temperature	Controlled temperature
-Flow -Automation level	Broken	Manual	Permanent

13. Order quantity and period between orders (fix or variable)	Both fixed at the start
14. Criteria used for products location in the warehouse	To be defined
15. Main objectives, other notes	Trade-off analysis between cost, warehouse space and stockout risk. Build different demand scenarios (more aggressive and softly) Produce accurate forecasts to achieve high levels of response capacity to customers E.g. Knowing that for the next month I have an order of 1000 liters of beer how could we guarantee that the product is ready at the first day of the month.

Appendix 11 – Interview Report

- What are the products used to produce the final product?

Different types of malts, hops and yeasts. Also, there are also the semi-finished products that are glass bottles, cap bottles, labels, card boxes, and kegs.

- What is the safety stock for each SKU?

To be defined.

- What is the service level actually provided?

I tis around 95% and the goal is to achieve 99%

- How is suppliers' answers capacity? Namely lead times?

It is enough taking into account the current demand. Around 15 days for malts and 10 days for hops and yeast.

- Do you categorize your SKUs following any criteria?

No.

- What are the warehousing dimensions?

To provide an official warehouse plant.

- What is the layout type?

To be defined.

- What is the type of picking used?

By aggregated customer order but could be redefined.

- How is the stock reposition?

Instantaneous for all the SKUs.

- How is constitutes the storage system?

Raw materials stored in europallets; conventional racks; forklift.

- What is the warehouse typology in terms of temperature?

Controlled for hopes and yeast and room temperature for malts.

- How is the flow and automation level of production per SKU?

Malt – broken; hops – manual; yeast – permanent.

- How do you currently organize the orders?

Usually order between 100 and 150 kilos are done by month, but this period can vary.

- What is the criterion for products location in the warehouse?

To be defined.

- What are your main objectives?

Trade-off analysis between cost, warehouse space and stockout risk.
Build different demand scenarios (more aggressive and softly)
Produce accurate forecasts to achieve high levels of response capacity to customers
E.g. Knowing that for the next month I have an order of 1000 liters of beer how could we guarantee that the product is ready at the first day of the month.