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JAN DE RIJK LOGISTICS

Finding out opportunities in Franciscus Ziekenhuis

The influence of a Third-Party Logistics Service within the supply chain

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Preface

After seven years I am now about to complete my studies in Industrial Engineering.

During these years, I have learnt many skills regarding engineering but, above all, different ways of thinking and facing problems. As a matter of fact, the best knowledge I have learnt is that everything is achievable working hard.

Besides, I have challenged myself many times along my studies in order to know my capabilities and always trying to grow up and become a better person, in all aspects of life.

From now on, a new age starts and I am looking forward to face new challenges, live new experiences and never stop learning.

I also would like to use this preface to state a word of thanks. In the first place I would like to thank my parents and sisters- I am really lucky with the incredible family I have. They have supported me always in everything I have done, taught me very good values and helped me to grow up really happy.

I would like to thank all my friends from my childhood, from my university in Barcelona and the ones I met here in Eindhoven. Specially, thanks to Silvia, Cristina, Christian, Maitane, Jose and Carlos because of forming part into my life and for sharing so many nice moments together.

Concerning my study, I would like to thank Pr. Nico Dellaert for the supervision of this master's project, to Marc Bauwens and Frank Huijbregts for their suggestions and advices and for giving me the opportunity to live a traineeship experience within Jan de Rijk. And last, but not least a word of thanks is also made to Marion de Bruijn and Marc Sijsterman for showing kindly to me the working processes within the hospital and facilitating the available data for this investigation.

Summary

The continuous increasing of costs and the limited budgets is translated into a significant operative pressure for the hospitals.

This sector has to deal with patient and material flows every day. Trying not to impair patient care, several healthcare centres have invested in the development of an infrastructure for supply chain and logistics technology since logistics' improvements are translated into quality improvements (Bakker, 2004).

Nowadays, firms are increasingly thinking in terms of competing as part of a supply chain against other supply chains, rather than as a single firm against other individual firms and a good opportunity for improvement is through a better cooperation with their suppliers and customers (Silver, Pyke, & Peterson, 1998).

During the 1990's companies start realizing of the benefits of outsourcing part of the logistics processes to an external service provider. The challenge for Third-Party Logistics providers is to provide their customers with services that add more value to their customers' business than the customers would be able to achieve themselves. In this way, the service provider tries to improve the supply chain, for example, by introducing cross-docking facilities to eliminate unnecessary storage of inventories, or by redesigning the distribution network to optimize customer service levels.

In this thesis it is done an investigation within a hospital –Franciscus Ziekenhuis- in collaboration with a Third-Party Logistics Service –Jan de Rijk Logistics.

There are two main parts in this thesis: The first one is designated to understand and analyze the current situation and in the second one different possibilites of improvement are developed by using a third party logistics service.

From the outcome of these analyses, the reader can realize of the current bottlenecks in the supply chain, the products and procedures that impact mostly the total costs for the hospital and the trends of improvement in short and long term.

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Chapter I. Introduction

The optimization of the logistics flow of goods in the area of the Healthcare means savings in the total costs of the hospital, but also means a better attention for the patients who are the final customers.

When we go within the world of the Healthcare logistics we easily realized the main topics we have to deal with: the patient has a very important role as a final user, the doctors are also our customers who want to choose their own tools to work with, the demand of some products is hard to foresee since some of them are only used in urgent occasions and some products require special conditions of storage and handling.

The aspects mentioned above are only some of the aspects that justify this thesis. Within the project cornerstone (see Chapter II) we develop the theoretical bases for this investigation.

In this project we look for opportunities of improvement in the supply chain management of the Franciscus hospital in Roosendaal, by some form of cooperation with Jan de Rijk Logistics.

The outcome of the analysis will probably lead to possibilities where Jan de Rijk logistics can provide its services, develop new services to add on their service portfolio and cost savings for the hospital.

Since in this thesis we develop our investigation concerning the two main parties mentioned above, we give a brief explanation of them:

- Franciscus hospital was founded in 1968.

  During the next ten years of growing, both the architecture and the specialties areas grew fast. Around the 2000, St. Franciscus improved the patient care through collaboration with partners as nursing organizations and home care. Also, in order to strength the medical specializations St. Franciscus, started relationships with different hospitals, such as Hospital Lievensberg, Amphia Hospital or cancer centres. These collaborations were essential in order to create sufficient scale and functions within the specializations.

  Nowadays, St. Franciscus Hospital is in the maturity stage. The continuity of the organization is assured and on the eve of many new developments. The hospital offers 472 beds, 115 specialist doctors and more than 1500 professionals and support staff large enough to assist almost all the healthcare in-house. But, also small enough for reacting fast in front of new developments and technologies.

- Jan de Rijk Logistics was founded by J.A.M de Rijk and Mrs. J.G.M de Rijk-Heeren in 1971 and both of them are still the two main shareholders and members of the Board of Directors.

> In these 39 years, Jan de Rijk Logistics has become in one of the leading European logistics service providers, which operates an asset based, Pan- European network for international transportation and distribution services. The Group's customer portfolio consists of many leading global and European companies in the various key industries: Air Cargo, aerospace, automotive, high tech, fresh logistics, tobacco, retail and Pharmacy.
>
> The organization is formed by a network of 26 company owned offices in 15 countries, being one of the largest fleet operators in Europe with a daily deployment of nearly 900 vehicles, a warehouse capacity of 90.000 m^2 and state-of-the-art ICT platforms to increase operational efficiencies and to cater for maximum transparency and customer connectivity.

As the reader can realize, this project involves all the supply chain of Franciscus Ziekenhuis, regarding flow of goods, but also information flows and Jan de Rijk Logistics as a third-party logistics service. Therefore, in the starting point we found a very general scenario where it was hard to delimitate and structure the area of study. That is why; it is important here to introduce the structure this thesis follows.

In this report, we explain in a brief way the theoretical bases all the investigation is based in. In other words, it is also a justification of the reason why this thesis it is done. After that, we define and explain the goals we want to achieve.

Along this thesis there are to distinctive parts: In the first one, there is a research of the products which can be analyzed and their data. For those products or parameters from Franciscus Ziekenhuis that data was not available there have been done some assumptions. Once, the scope of products and all the information concerning their analysis is clear, starts the second part of this report, where the analysis is done.

Along the analysis there are also two main parts: One designated for the study of the current situation and the other, where some scenarios and possibilities of improvement are posed and analyzed.

Finally, the report contains the conclusions and some recommendations for the hospital, once the analysis of the results has concluded.

Chapter II. Project Cornerstone

In this chapter I develop the theory, based on literature, this thesis is based on. In other words, it is the justification why this investigation makes sense.

I have divided the chapter in different areas of interest: the first part concerns the importance of the inventory nowadays and the repercussion a good management of the inventory has within the supply chain. The second part mentions the *ABC* items and their influence in the warehousing logistics. There is also a section designated to talk about warehousing as a basic concept. Obviously, another section regards outsourcing: the paper the third-party logistics has in the industry and the add-values it can add in a supply chain. And, last but not least, the last section talks about the alliance in hospitals' savings in the total costs.

1. Importance of the Inventory

Inventory management and production planning and scheduling are something common today. The huge development in information technology and computer networking allows manufacturers to track consumer demand on a daily basis, and thereby more closely match production with demand.

But, why is this inventory management and production planning and scheduling so important within the supply chain? (Viale, 1996), (Coyle, Bardi, & Langley, 2003) and (Silver, Pyke, & Peterson, 1998)

The answer is plural. One of the important aspects is that changes in inventory levels have an impact on return on assets (ROA). Reduction in inventory usually improves ROA, which is a positive indicator of performance for current and potential investors.

When the sales are not as good as expected, it has a double-edged effect on profits since it is translated into lower sales and more costs due to the increase in the inventory levels; but it also has a negative impact on ROA, which decreases. (Coyle, Bardi, & Langley, 2003)

During the 1990s the supply chain management orientation brought attention to the importance of reducing inventory levels in supply chains to reduce landed costs at the end of the supply chain. An example is Ford motor Company, which estimated that they were carrying fifteen times as much work-in-process (WIP) as Toyota, which was a remarkable competitive disadvantage. (Coyle, Bardi, & Langley, 2003)

During the 1990s not only the relative cost of carrying inventory decreased, but also the relative cost of transportation. This combination was a positive aspect promoting economic growth and prosperity.

But, why didn´t firms controlled the inventory level before?

Because the carrying costs associated with the storage of products were hidden costs and most of the times, even the companys did not realize the big impact these costs could have at the end of the supply chain.

It is good to observe the sources which the batching economies or cycle stocks usually arise from: acquisition, production and/ or transportation. And, a very important aspect regards all three: Scale economies.

As follows, I explain the importance of inventory in some functional areas, and which can easily result in the accumulation of stock that will not be used or sold immediately. (Coyle, Bardi, & Langley, 2003)

- In the acquisition area, it is usual to have lower prices for larger quantities purchased. The price per box is lower but, it will be cycle stock and what it is not used immediately will be stored
- In transportation it occurs the same: if the truck is completely full the price per unit is cheaper
- In production, usually, it is also cheaper to produce in long runs. The handicap is the storage of all those items that have to be stored
- In other functional areas such as Marketing desires high customer service levels and well-replenished inventory stocks to assure product availability. In the other side, the finacial department desires low inventory levels to increase inventory turnover, reduce current assets, and receive high capital returns on assets

For all the reasons mentioned above, the decision and managing of inventory is a hard task. But, the major reason to perform it is to reconcile all the following goals: (Coyle, Bardi, & Langley, 2003), (Silver, Pyke, & Peterson, 1998) and (Viale, 1996).

- Maximizing customer service: innacurate customer forecasts, a multitute of changes to the original customer orders, and an overall lack of account management are the major causes of poor customer service performance in terms of on-time delivery- not suppliers, not purchasing. The result is excessive inventory, which ultimately leads to inventory write-offs and high product cost and lower profit margins.
  The more accurate the individual product-sales forecasting is, the smaller the forecast error, and the less inventory needs to be carried to maintain a specified level of customer service.
- Maximizing efficiency of purchasing and production: goods may be purchased in greater quantities than are needed in order to achieve cost efficiencies in purchasing or transportation. Agreements called “volume purchase orders” (blanket POs) may be established. These allow for increasing discounts as volumes increase and, at the same time, specify that deliveries take place as needed.
- Minimizing inventory investment: excess inventory can create a negative cash flow, something that must be avoided
- Maximizing profit: profit can be maximized by increasing revenue or decreasing cost. One of the best ways to do this is by proper management of inventory.

At this point, the importance of a good forecasting is obvious. Nowadays, thank to the information technology development some initiatives allow very precise forecasts - even daily. These initiatives include Electronic Data Interchange (EDI), Efficient Consumer Response (ECR), and Vendor Managed Inventory (VMI).

But, still the inventory management and production planning and scheduling decisions are a hard task, due to the following challenges: (Silver, Pyke, & Peterson, 1998)

- Some large organizations stock more than 500000 distinct items in inventory
- Items produced and held in inventory can differ in many ways: they may be withdrawn from inventory by the thousands, by the dozen or unit by unit
- They may be substituted
- Goods also arrived for inventory by a variety of modes and in quantities that can differ from how they will eventually be demanded
- Some goods arrive damaged, others need special conditions and treatments
- Delivery of an order may take hours, weeks, or even several months, and the delivery time may or may not be known in advance

For, all the reasons describe in this section, it is crucial to make a good selection of a model to approach the pattern of consumption and a good forecasting of the products analyzed in order to be able to manage the inventory level in a precise way.

2. The ABC items

This ABC item classification is useful in order to take warehousing decisions. This concept was invented by Pareto, an Italian economist, who discovered that a small percentage of a population always has the greatest effect. (Viale, 1996) and (Silver, Pyke, & Peterson, 1998).

A items have the highest value. These are relatively few items (15-20 percent) whose value accounts for 75-80 percent of the total value of the inventory. As a general rule, 20 percent of the items constitute 80 percent of the annual requirements.

B items have medium value. These are a larger number in the middle of the list, usually about 30-40 percent of the items, accounting for about 15 percent of the value.

C items have low value. These are the bulk of the inventory, usually about 40-50 percent of the items, whose total inventory value is almost negligible, accounting for only 5-10 percent of the value.

3. Warehousing

This section is related to the first one: the importance of inventory and it is based in (Burton, 1979).

The warehousing organization exists to bridge the gap between the economic methods of production and the needs of the consumer. The task is to provide what is required, when it is required, in the condition in which it is required, and to do all these things economically.

From the financial point of view warehousing is just an overhead, and there is quite a lot to be said to contradict this. It is true that once the warehousing organization has been set up, the throughput does nothing to affect the cost. The size of the building, the levels of stock and the work force dictates the cost and not the amount of work done.

Efficiency in the warehouse, therefore, starts with planning for the need, and this presupposes that the need itself can be forecasted with some accuracy. Clearly, this forecasting process must be subject to review and to the periodic re-setting of the scale of operations.

Within the supply chain there are many links between operations and all of them have to be considered before any decision is taken. The links involved are described as follows:

- Enquiries are prepared and dispatched with a specification to the suppliers
- The suppliers prepare and dispatch their tender, giving a price and a delivery time
- Tenders are received
- A supplier is selected
- An order is placed on the named supplier
- The supplier receives the order and plans production
- The production run is set up and the articles are produced
- Finished goods are dispatched with the invoice
- Goods are received
- Goods are checked for correctness against the invocie and the specification
- Goods are taken on charge and are available for issue
- The bill is paid

Each of the headings represent the passage of time in the supply of the goods.

Another topic that has to be faced is that the warehouse does not want to place orders daily as this takes a lot of time, which is translated into a lot of money. So, orders usually are placed monthly.

However, although we can establish a practical average supply period and can multiply this by an average consumption over a period, these averages, do not exist in practice. Mathematics based upon them, therefore, are themselves doubtful. A safety margin may be required to cover the risk of running out and this too can be expressed in terms of days of average usage.

Lastly, since things can go wrong with the process, for instance when strikes disrupt the supplier's schedule or the transport system a further safety stock may be held as an insurance.

4. Outsourcing

Many firms have directed significant attention toward working more closely with supply chain partners, including not only customers and suppliers but also various types of logistics suppliers. Considering that one of the fundamental objectives of effective supply chain management is to achieve coordination and integration among participating organizations, the development of more meaningful " relationships" through the supply chain has become a high priority.

One way of extending the logistics organization beyond the boundaries of the company is through the use of a supplier of third-party or contract logistics services.

A third-party-logistics firm may be defined as an external supplier that performs all or part of a company's logistics functions.

Third-party logistcs may be thought of as an ·external supplier that performs all or part of a company's logistics functions." It is desirable that these suppliers provide multiple services and that these services are integrated in the way they are managed and delivered.

Based on the results of a study of users of 3PL services in the United States, over 70 percent of the firms studied are, to some extent, users of 3PL services. Approximately two-thirds of the customers suggest 3PL involvement in their global supply chain activities.

But, why does it appear the idea of outsourcing?

The drivers for outsourcing are the following ones: (Berglund, Laarhoven, Sharman, & Wandel, 1999)

- On the demand side: reduction of asset intensity; restructuring of the distribution structure, triggered by a restructuring of the production structure; and, reduction of labour costs by switching to a non-unionized labor force.
- And on the supply side: deregulation of the transportation industry, which made it possible to provide TPL services; declining profit margins in basic services (i.e freight transport); and, availability of capital.

There are two different strategies for the providers: the ones who offer a specific service, for example distribution of spare parts, versus providers that cover a complete range of services and offer their customer logistics solutions; and, the providers that carry out traditional transportation and warehousing activities, such as value-added services.

The two providers' types have different qualities within the industry: the value-added providers have a higher percentage of personnel working in general management and business development and have a higher percentage of value-added services.

Although, the difference with the two types is very big, the difference in each growth expectancy is remarkable: the value-added providers expect their revenues to increase

annually by more than 50%; whereas the basic providers expect their annual growth to be less than 30%. (Berglund, Laarhoven, Sharman, & Wandoel, 1999)

The challenge for TPL providers is to provide their customers with services that add more value to their customers' business than the customers would be able to achieve themselves.

Service providers need to find customers whose requirements neaty fit into the standardized services they offer. This will enable the provider to benefit from increased economies of scale, risk-sharing and volatility smoothing. The new resources from additional clients can be used to improve efficiency and to further improve profit margins and the delivered perfromance/cost ratio.

TPL providers can also add value by sharing resources between customers, for example by running a warehouse for several customers or by operating joint transportation networks for a set of customers. Thus, the driver for value creation is predominantly economies of scale.

Another way to create value for customers is to use conceptual logistics skills to improve the customers' supply chains, for example by introducing cross-docking facilities to eliminate unnecessary storage of inventories, or by redesigning the distribtuion network to optimize customer service levels.

Roughly, half of the providers plan to take ownership of inventories so as to be able to earn money by reducing inventory levels and increase their power in the supply chain.

5. Hospital's Alliance

In June, 2009, an association of hospitals was founded. It is called *Hospital Purchasing Alliance* and is formed by 14 members (one of them is Franciscus Ziekenhuis). The goal of this alliance is to achieve synergy and cost savings in hospitals for needed facility services and goods.

Haga Ziekenhuis (in Den Haag), Reinier de Graaf Gasthuis (in Delft) and Sint Franciscus Gasthuis (in Rooterdam) work together in the association *Service XL,* by means of which they expect to save 10 million euros per year joining their logistics' activities and joining their demand orders.

These are only two examples of hospitals in the Netherlands which are doing recently efforts in order to save money in their logistics' processes using the power of the alliance with other hospitals. See (Hoegsma, 2010).

Chapter III. Goals

In an institution like a hospital there are thousands of products, services and tasks that are being developed in parallel and it is hard to define the area we want the project to be focused on. That is why; here is a chapter designated to describe precisely the goals I want to achieve in this thesis and they are described as follows:

- **To do a market research in order to know how the different supply chain in some hospitals in Netherlands is working**, an investigation about the services that other suppliers are offering to Healthcare and literature review for logistics' solutions, such as outsourcing. Also, it is important on this level to understand the trend of the new methods that are being applied in different hospitals

- **To know and understand the current situation in Franciscus Ziekenhuis**

  In this goal there are many aspects involved:

  - The way the products are stored: rooms for storage, employees implied, flows of goods through all the storage rooms
  - Which products are stored: products' characteristics that are required to be stored in the same area, the area the products that require special conditions are stored and the treatments these products have to receive
  - Policies established in the storage, inbound and outbound of products
  - Develop a mathematical model, based on literature, which can approach the costs in the reality
  - The calculation of the costs per product within the supply chain

- **Choose the most proper products for this investigation**

  - Choose categories of products
  - Classify products into categories by means of similar characteristics
  - Define fundamental parameters in order to define criteria to choose the categories under study
  - Define the criteria and choose the products' categories for this investigation

- **Explore the information sources to realize the data possible to obtain**

  In the study of the possible improvements in the supply chain of Franciscus Ziekenhuis we have to deal with the fact that is not that easy to work with a real situation compared with a theoretical one, since for example, in some cases historical data is

not available and it is really hard to do good stimations. Therefore, it has been needed to redefine the scope of the project several times due to the impossibility to do a precise analysis with real data

  - Obtain the data available by means of interviews with the responsible of Logistics within the hospital and observation of the working methodologies

- **Develop assumptions for the data** we cannot obtain and which is required for the investigation

  - Based on literature and our criteria: creation of assumptions

- **Look for ways of improvement within the supply chain of Franciscus Ziekenhuis by using a third Party Logistics service**

  - Create different scenarios modifying parameters from the current situation in order to compare costs and to realize of possibilities of improvement

  - Create assumptions to approach the mathematical model chosen to the different situations in each scenario

  - Realize the impact of every parameter on the supply chain

- **Be able to find out possible benefits** for Franciscus Ziekenhuis and Jan de Rijk Logistics

  - From the outcome of the analysis and the literature studied, be able to conclude with the possible trends of improvement in short and long term

Chapter IV. Products' delimitation for the investigation

1. Creation of products' categories

The goal of this chapter is to determine the products in scope for this study because the hospital is supplied with thousands of products and it is not possible to study all of them in this investigation. Therefore, the first decision taken is to create categories of products since we want to have a general perspective. Also this methodology helps to have a clearer picture of the situation and a guideline for further possible studies.

We split the products in the next categories, after paying visits to the hospital and observe the way the products are stored:

- Food: The food used in the kitchen and in the different departments
- Textiles: Regarding the medical, nursery and patient clothes and sheets, curtains and all the clothes used in the patient´s accommodation
- Office material: Including all the material such pens, documents, envelops, prescriptions, folders, etc.
- Operation theatre products: This group refers to all the products that are used in the surgeries like: needles, thread, sterile gauzes, etc.
- Pharmacy: Group that includes medicaments and antibiotics used in the hospital
- Auxiliary products for the attendance of the patient: sterile products, specialized fluids, incontinent materials, etc.
- Cleaning products: Basically, the products used by the cleaning department for the maintenance of the hospital, like detergents, soaps, gloves and others
- Household materials: Such as the toilet paper, paper towels, etc.

2. Parameters to build the criteria for choosing the categories of the investigation

Soon, we realized we had to start filtering products for our study. The most important aspects we considered for building the criteria used for the selection of the categories studied, are described as follows:

No urgent need: The hospital does not collect any historical data about products which require urgent needs, so, it makes hard to do their analysis

Long expiry dates: We consider the products which have long expiry dates in scope because it is a required condition in order to analyze some of the scenarios described in chapter VII. Products that have short expire dates cannot be stored for long time, so their treatment has to be different.

No special conditions required: The products which require special conditions are treated different than the others during all the supply chain. This group of products can be included later depending on the outcome of the study. As in the case above, these products need a different treatment from the employees and a distinctive attention.

Products which can be included into a category: It is not interesting for a first analysis to consider a product which cannot be classified into a group because in a hospital we are talking about thousands of products, so, it does not add value in this stage of the analysis to find out an improvement for a product which will represents a very little benefit for the hospital, since this study represents a first approach for the situation within the hospital.

Products which represent a high volume it is related with the case above. In this case as well, we consider more interesting to investigate in the optimization of the products that represent a higher level of improvement regarding volume used for storage and costs savings. We will call these products ***A items***. (See chapter II)

In the next figure, there is a summary about the different criteria developed above and the different categories that are out of scope because of the non requisites' fulfilment:

Criteria	Products out of scope after applying the criteria
No urgent need	Food, operation theatre products, pharmacy
Long expire dates	Food, operation theatre products, pharmacy
No especial conditions required	Operation theatre products, pharmacy
Products which can be included into a category	??
Products which represent a high volume	Office material, cleaning products

Figure IV.1: Products out of scope after applying the criteria

Therefore, considering all these aspects, the products which are still in scope are:

Textiles
Office material
Cleaning products
Household materials

3. Study of the viability of the products' categories chosen

The next step taken in order to choose the products in scope is to discuss these categories with Marion de Bruijn and Marc Sijstermans, responsible for Logistics in Franciscus Ziekenhuis in order to know their opinion and to ask them for the data required.

As an outcome of this meeting, we consider more criteria suggested doing a step more to filter the products in scope:

- The textile products are ***reusable products***, which are cleaned within the hospital and distributed into the departments in roll containers. So these products could not be stored in an external storage. I could not analyze the scenarios where Jan de Rijk Logistics can play a role with these products.
- The office material is a big group that ***does represent a big volume***. In addition, the storage is difficult to modify since it is directly in the drawers in each office or department. So, it would be difficult to optimize for a first analysis and without data about its process of distribution.

Alternatively, we have added two product types in scope after we have been talking to the responsible of logistics in the hospital:

- Dialysis fluids: these products are stored in high volumes in the department where they are used, being the dialysis centre. The demand of these products is quite regular and high
- Sterile products: as in the case above, these products are only stored in one department, the sterile centre and used for wrapping sterile sets for operations. They are also stored in high volumes and their demands are regular and predictable

4. Products in scope

Finally, we can determine the products in scope for this thesis:

Household products
Incontinent material (pads to cover the bed)
Paper for wrapping sterile sets for operations
Dialysis fluids

And, particularly, within each group, there are the following products:

Household products	WC paper tissues	Paper towels Kleenex Ultra 2LGS		
Incontinent material	Onderlegger Tena Bed	Tena Bed Green		
Sterile products	Kimguard one-step KC300, 101x101 cm	Kimguard one-step KC200, 121x121 cm	Kimguard one-step KC300, 76x76 cm	
Dialysis products	Concentraat D294	Bicart 720 gr.	Concentraat D292	Concentraat D296

Figure IV.2: Total of products in scope

5. Union of some categories for their treatment in this report

Because of similar characteristics some of the categories chosen can be studied together. This union is useful to simplify the reading and understanding of this report.

Thus, from now on, in each chapter the information is organized and distributed in three groups: the first one regarding general information that concerns all the products' categories, the second one only concern the household and incontinent materials and the third one is formed by the sterile and dialyze products.

The characteristics that enable this union of categories are the ones regarding same replenishment times, regular demands, same rooms for storage (central warehouse and/ or different departments), etc.

In particular the two selected groups done follow the characteristics explained below:

- For the household and incontinent materials:
    - The products are stored in the central warehouse and in the departments where are used

- The replenishments from the supplier are received once per month
- The replenishments from the central warehouse to the departments are done once per week
- The safety stock is one week demand

- For the sterile and dialyze products:

  - Both type of products are only stored in the department where they are used, sterile and dialyze department respectively
  - The deliveries from the supplier to the central warehouse are once per month
  - The safety stock is one week demand

For these reasons, we assume the products within these two groups mentioned to follow the same patterns of consumption and therefore, they can be managed all together and we can establish the same parameters for the products within each group.

Chapter V: Data acquisition and Assumptions

1. Data obtained

After several visits to the hospital the data obtained for each product is shown as follows and it can be found in tables in the ***Annex A*** of this report. All the information is distinguished by colours and different tables, and everything is described at the beginning of the mentioned annex. As an observation we would like to add, that those tables also contain the results from the assumptions done and which are explained in the section 2 of this chapter.

In this section we explain the utility of the data obtained during further analysis.

1.1. General data for the products in scope

These data is used for all the products because it regards general information from the hospital:

- Rooms for storage in the hospital: to be aware of the number of rooms currently being used as a storage room and their location
- Schedule of the replenishments from the central warehouse to all the departments: this information is used in order to do assumptions of the handling times and other assumptions regarding the employees tasks
- Price of the square meter in the nursery departments, central warehouse and underground storages: information required to calculate costs in every situation
- Cost of men power per hour: Also required to calculate costs in all the different scenarios

1.2. Data for the household products: WC paper tissues and Kleenex Ultra; and incontinent material: Tena bed and Tena bed green

The data available for these products' groups is:

- Supplier: information used to know the distance from the supplier to the hospital
- The last six lead time values: to know the lead time demand on average
- Order quantities per month for the last six months: to get to know the demand of the products
- Net price per item: to understand the products costs' weights throughout the supply chain
- Total consumption per department for last year and two years ago: to know the demand of the products

- Detailed consumption for the last year per month: to be more precise in the approaching of the average demand per product
- Order up to level in each department (S): to know the safety stock in the current situation
- Volume of each box: to calculate the total volume occupied in each storage room per product
- Pallets per year: to confirm the order quantities, the replenishments and the average demands
- Number of boxes per pallet: to know the volume occupied in the case the product is stored in pallets
- Number of items per box: to be able to do calculations with both, boxes and items, it depends on the circumstances and needs
- Handling cost for all the products of the hospital: to calculate the costs in every situation (see next section: assumptions, for the prediction of the handling cost per each product)

1.3. Data for Dialyze fluids and paper for wrapping sterile sets for operations

The data obtained for these products are the same as mentioned in 1.2 with the only exception regarding:

- Lead time: only an approximate average
- Order quantity: only an approximate average
- Detailed consumption for the last year per month
- We do not have in this situation the volume per box, but we can assume the volume occupied by using the demand per month, the number of pallets per month/year and the number of boxes per pallet, as we see in section 2.2.3 of this chapter

2. Data not obtained and Assumptions

Before starting with the analysis it is very important to explain all the assumptions that have been required to do because of: missing data from the hospital, a bad approaching of the reality to the models or just because of the complexity of the information obtained.

This chapter contains general assumptions regarding all the products and specific ones regarding some categories of them. All these assumptions are used in both, the current situation's analysis and in the different scenarios' analysis.

As we mentioned earlier, the assumptions regarding the current situation are enclosed in the tables of Annex A.

2.1. General assumptions

Some of the assumptions done are used for all the products in study; so, we explain them in this first part of the analysis. These assumptions are general because mostly refer to aspects about the central warehouse in the hospital, where almost all the products are stored.

All the results of these assumptions can be found in the Annex A of this report, distinguished by the colour:

Below a detailed description of the assumptions made.

2.1.1. SQUARE METER'S DEPRECIATION RATE

The square meter's depreciation rate is assumed as an 8% of the building price per year taking as a reference other examples in the health care market in Netherlands. Thus, the final cost per square meter, making use of the depreciation rate, is:

	Depreciation rate	euros/m2 at the nursery departments	euros/m2 at the central warehouse	euros/m2 at the underground storage
Cost per square meter per 20 years only taking in account the original price of the building.	0,00	1620,00	1150,00	1150,00
Cost per square meter per year, taking in account renewals, bank interests,… .	0,08	129,60	92,00	92,00

Table V.1: Costs per square meter in each location room taking in account the square meter's depreciation rate

2.1.2. MEN POWER COST PER HOUR (ON AVERAGE)

The information obtained from the hospital is the salary received by employee and the number of working hours per Labour Day. So, we have made some assumptions to be able to predict the handling cost in every situation.

Taking as a reference the employee's cost per hour in the case of Jan de Rijk Logistics during the weekends, we have used the proportion of the cost's difference to calculate the labour cost per hour in the case of Franciscus Ziekenhuis during the weekends.

	handling cost per hour, laboral days [euros]	handling cost per hour on Saturdays [euros]	handling cost per hour on Sundays [euros]
Jan de Rijk	25,00	38,00	51,00
Franciscus Ziekenhuis	20,00	30,40	40,80

Table V.2: Labour cost per hour during the weekends

To calculate the handling cost per hour on average we have decided to calculate a weighted average. Only the cleaning department is working the weekends in the central warehouse or distributing products in the hospital. Thus, the cost of the handling cost is estimated as:

nº employees for distribution labour days (%)	nº employees for distribution saturdays (%)	nº employees for distribution sundays (%)	handling cost per hour on average [euros]
90,00	5,00	5,00	20,78

Table V.3: Handling cost per hour on average

2.2. Assumptions for the household products and incontinent materials

For the study of the products in scope it has been required to do different individually assumptions for each of them. In this chapter, we combine two groups of products, household products and incontinent materials; since these groups have many characteristics in common that facilitates their study together. (See section 5 of chapter IV).

2.2.1. SAFETY STOCK

- **Central warehouse**

The safety stock in the central warehouse, in the current situation, is assumed to be, for each product, one week demand of the mentioned product.
In the different scenarios considered the safety stock is explained and calculated usually based on the expected number of stock outs per replenishment.

- **Departments**

In the current situation, the safety stock size in the departments is assumed to be as big as one week of the average consumption per department.
Each department receives the products from the central warehouse, once per week and the order-up-to-level is equal to two weeks consumption.
In the different scenarios posed the safety stock is explained and calculated based in the lead time established in each scenario and the expected number of stock outs per replenishment cycle.

2.2.2. CONSUMPTION AVERAGE

In order to be able to predict the level of consumption of each product, it has been required to analyze the situation carefully, due to the following reasons:

- The difference between the order quantities on average and the amounts consumed per department was quite high
- The historical data about the order quantities from the central warehouse was only available for the last 6 months
- The data available per department was the total consumption per product for the last year and two years ago
- The data about consumption per month is only for the last 12 months considering only one department, 3C

So, the way we predict a realistic consumption average is:

- We calculate the average of the order quantities available
- We calculate the average of consumption per month of the 3C department
- We calculate the average of consumption per department with the two years available
- Finally, we take a global average of all the averages mentioned below, giving more importance to the consumption averages of last year rather than two years ago, and also taking into account the number of pallets per year consumed per product.

2.2.3. VOLUME OCCUPIED

- **Central warehouse**

In the central warehouse the products are stored in pallets. We use the next formula to calculate the volume occupied:

$$\left\lceil \frac{Q+s}{b_p} \right\rceil * p_s$$

Where,
Q: order quantity per month, on average
s: safety stock
b_p: boxes per pallet
p_s: pallet size

The variables implied in this formula, can be described as follows:

- The order quantities per product is based on an average consumption of the monthly demands
- The safety stock in the central warehouse is estimated as the same size as one week demand
- In each scenario we can change the time of replenishments, the order quantities, and consequently the safety stock, or all of them
- The maximum stock level is estimated as the sum of the order quantity received and the safety stock
- In this case, it is not needed to add a safety stock factor because the areas around the pallets do not have to be used to manipulate the products

- **Departments**

For each department and product we have calculated the volume occupied using the next algorithm V.1 showed in the next page.

If $S_{ij} > 0$,

If $n_{ij} > 0$,

l *w*n_{ij} +

if($n_{ijd} > 0,5$),

l *w*1,2

if not ($n_{ijd} > 0,5$),

(l/2)*w*1,2

If not ($n_{ij} > 0$),

if($n_{ijd} > 0,5$),

l *w*1,2

if not ($n_{ijd} > 0,5$),

(l/2)*w*1,2

Algorithm V.1: Volume occupied per department

Where,

S_{ij}: maximum stock in the department i per product j,

n_{ij}: number of boxes per department i per product j, it is the integer part of S_{ij},

n_{ijd}: decimal part of the boxes per product j in the department i,

l: length of the box,

w: width of the box,

Safety factor: 1,2

By using this algorithm, if the maximum stock in the department is higher than one box we multiply the number of boxes by the size of the box. For the volume occupied by the maximum stock's decimal part we apply the next rule: if the decimal part is higher than half a box, then we assume a volume occupied equal as if it was an entire box because we assume than half a box is the limit from which the products can be stored one on each other, occupying then a same volume. In case, the maximum stock is lower than half a box, we consider a volume occupied of half the length multiplied by the width.

In both cases, we multiply the result by a factor of 1,2 because during my visits in the hospital it could be observed that, within each department, the items of each product are randomly stored in the shelves instead of being stored in boxes. So, the safety factor is justifying this difference of volume.

The last assumption related with the volume is that: the volume occupied, in all the cases, is measured with the maximum volume occupied.

The reason that explains this assumption is that the volume designated for a product cannot be used for another purpose or product. Even when the total stock left of that product is the safety stock, the area designated for the product has to be empty and available for the receiving of future replenishments.

2.2.4. HANDLING COST

The estimation of the handling cost is not an easy task. Due to the current situation of distributing the products from the central warehouse to the departments it is very hard to assess the time spent in the management of each product individually.
In the Annex B of this report there is the weekly schedule of goods' distribution per departments. And it is here the handicap for the handling cost prediction: every day each department is replenished until the order-up-to-level for all the products.
The ideal situation to predict in a precise way the handling cost would be that one day of the week is chosen to replenish all the departments by one product. So, you can measure the time required from the beginning to the end of the replenishing, multiplied by the number of employees who are doing the mentioned replenishment.
But, the real situation is quite different. The distribution is made by departments instead of by products. So, every day, there are different groups of employees and each group is the responsible of the replenishment of some departments and with a high probability that all of them are replenishing toilet paper.
So, we paid another visit to the hospital to follow and time one of the employees during all the process of replenishing. The purpose was to predict the proportion of time spent for the products in our study within the hundreds of products that are replenished every day. Once, we had the prediction of the time in those days and those departments we extrapolated the results to all the departments in order to do a closer approximation of the reality on average, using the consumption of all the departments and the schedule of distribution per day found in the Annex B.
Once we calculated the total time spent for the household and incontinent materials, we split up the total time in the individual times for each product taking in account the consumption's weight of each product within the total.

The results obtained after all the above assumptions are shown in table V.4.

The values referring time are expressed in hours, the costs in Euros and the consumptions in boxes. The same is applied for the table V.6 and V.7.

Product	Percentage of the total handling [%]	Time for unloading the truck per month	Time for handling: scanning, picking, replenishing per month	Total time for handling per month	Total time for handling per year	Handling cost per month	handling cost per year and unit	Average Consumption per year
Total 4 products	1,00	0,69	7,00	7,69	92,25	159,75		
WC paper tissues	0,35	0,24	2,45	2,69	32,29	55,91	0,90	744,00
Kleenex	0,20	0,14	1,40	1,54	18,45	31,95	0,45	852,00
Tena Bed	0,30	0,21	2,10	2,31	27,68	47,92	1,45	396,00
Tena Bed Green	0,15	0,10	1,05	1,15	13,84	23,96	2,66	108,00

Table V.4: Handling cost per year and unit per product in the current situation

*Obs. - The handling cost is calculated multiplying the handling time by the handling cost per hour, explained in section 2.1.2.

2.3. Assumptions for sterile and dialyze products

We can also study together the two groups of products left due to their common characteristics.

The assumptions done for this kind of products are explained as follows:

2.3.1. SAFETY STOCK

- **Departments**

In the current situation, the safety´s stock size is one week demand

- **Central warehouse**

These products are not stored in the central warehouse

2.3.2. CONSUMPTION AVERAGE

To predict the order quantity per month and product the next formula has been used:

$$p_{mj} \cdot \frac{p_{yi}}{p_{yj} \cdot 1{,}2} \cdot b_p$$

Where,

p_{mj}: number of pallets per month for the group j; j: sterile or dialyze products
p_{yi}: number of pallets per year per product i; i: products within the categories sterile or dialyze
p_{yj}: number of pallets per year ordered per all the category sterile or dialyze
b_p: number of boxes per pallet
Safety factor: 1,2

Obs. - The safety factor in this case is required to make the result more realistic since the pallets are not always full and it is determined after observations of the order quantities and the consumptions of several months.

2.3.3. VOLUME OCCUPIED

As we mentioned before, in this group category the products are only stored in their respective department, sterile or dialyze centre. Therefore, in each of these departments there are the pallets of products for one month consumption and the safety stock.

The formula used to predict the volume occupied is the following one:

$$\left\lceil \frac{Q+s}{b_p} \right\rceil * p_s$$

Where,
Q: order quantity per month, on average
s: safety stock
b_p: boxes per pallet
p_s: pallet size

2.3.4. MEN POWER COST PER HOUR (ON AVERAGE)

In the hospital's current situation, the employees responsible of the manipulation and distribution of these products from the central warehouse to the sterile and dialyses' department are only working on labour days. So, the handling cost will result:

nº employees for distribution laboral days (%)	nº employees for distribution saturdays (%)	nº employees for distribution sundays (%)	handling cost per hour on average [euros]
100,00	0,00	0,00	20,00

Table V.5 Handling cost per hour on average

2.3.5. HANDLING COST

As we explained in the section 2.2.4 to predict the handling cost, some assumptions have to be done because its approximation is not an easy task.

For this group category we use the same method explained in section 2.2.4 but taking in account the times associated to dialyze and sterile products. In these times we consider that the handling of the products includes the unloading of the truck and the replenishment from the central warehouse to the department. Also, we have to add some time for scanning once per week and the respective time to order the product quantities, but it is important to realize that in this situation the products are not stored in the central warehouse, so, the replenishments once per week are not needed. In this case, on the one hand the handling cost decrease, but on the other the volume occupied in the departments increase.

Applying the same method explained earlier, the results for the handling cost per year and unit of these products' groups are:

Sterile products:

Product	Percentage of the total handling [%]	Time for unloading the truck per month	Time for handling: scanning, replenishing per month	Total time for handling per month	Total time for handling per year	Handling cost per month	handling cost per year and unit	Average Consumption per year
Total 4 products	1,00	0,38	1,00	1,38	16,50	27,50		
Kimguard one-step KC 300 (101x10	0,14	0,05	0,14	0,19	2,23	3,72	0,29	156,00
Kimguard one-step KC 200	0,82	0,31	0,82	1,13	13,60	22,67	0,27	996,00
Kimguard one-step KC 300 (76x76)	0,04	0,02	0,04	0,06	0,67	1,11	0,14	96,00

Table V.6: Handling cost per year and unit

Dialysis products:

Product	Percentage of the total handling	Time for unloading the truck per month	Time for handling: scanning,replenishing per month	Total time for handling per month	Total time for handling per year	Handling cost per month	handling cost per year and unit	Average Consumption per month
Total 4 products	0,97	0,38	1,00	1,38	16,50	27,50		
Concentraat D 29	0,69	0,26	0,69	0,95	11,38	18,97	0,66	345,00
Bicart 720 gr.	0,16	0,06	0,16	0,22	2,66	4,43	1,04	51,00
Concentraat D 29	0,11	0,04	0,11	0,16	1,90	3,16	1,00	38,00
Concentraat D 29	0,03	0,01	0,03	0,05	0,57	0,95	1,03	11,00

Table V.7: Handling cost per year and unit

*Obs. - The handling cost is calculated multiplying the handling time by the men power cost per hour, explained in the section 2.3.4.

Chapter VI. Analysis of the Current situation

The goal of this chapter is to analyze the costs in the current situation of the products in scope within the hospital. There are several reasons why these calculations are important, such as realizing how the improvements in the supply chain of the products in study will affect the entire hospital and being able to analyze the results of all the scenarios studied in further chapters. The outcomes of this chapter are the inventory costs per year of all the products in the current situation.

1. Current situation in the hospital for the products in study

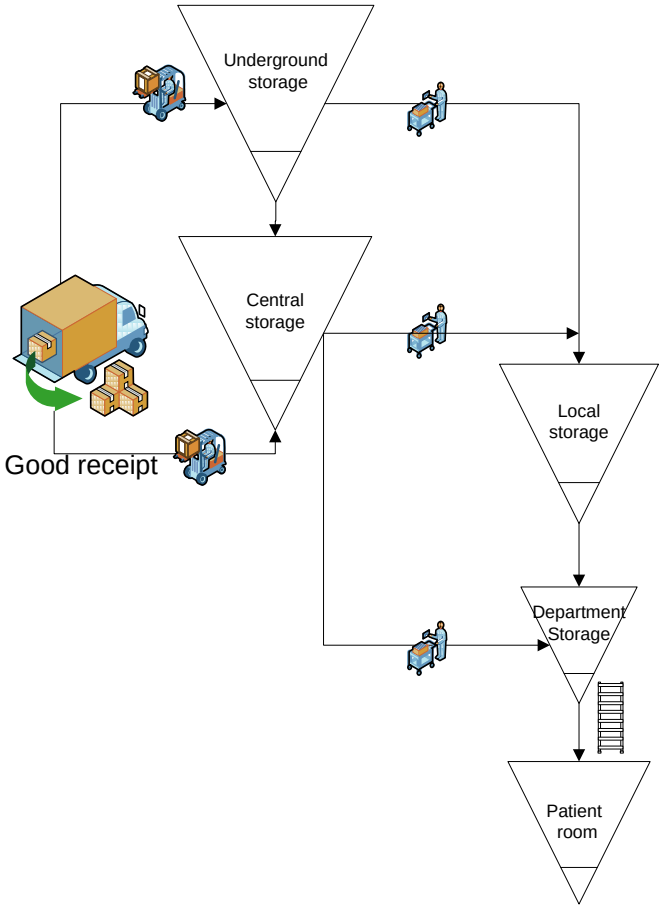


Figure VI.1: Schema of the materials' flows in the current situation

In the current situation, in the departments, the employees from the hospital scan the inventory levels once per week and replenish until the stock up-to-level for those products which inventory level is below the order point s. All the inventory levels of all the departments are collected in the computers of the central warehouse and once per week the responsible of logistics checks which products have to be ordered by using the software's suggestions which

informs about the products which inventory levels are below the reorder point in the central warehouse.

Usually for the products in this study the demand is pretty stable and the replenishment cycle in the central warehouse uses to be one month.

Only for the sterile and dialyze products the procedure is different. The reason is that these products are only stored in the department where they are used. So, the replenishments are done once per month, when the shipment from the supplier arrives. The review period, scanning, in the departments for these products, is also one week, but since the demand is quite stable the orders are usually done once per month. Therefore, a big stock is stored in those departments.

2. Mathematical model for the costs' calculations in the current situation

In this section we explain the methods used for the costs' calculations in the analysis in a general way and based on literature (Silver, Pyke, & Peterson, 1998) (Coyle, Bardi, & Langley, 2003) (Viale, 1996) (Witzier, 1986)

Since the real cases always differ from the theoretical models the first challenge for the analysis is to look for a way to approximate the costs in the reality as best as possible.

The supply chain of the products in study follows an arborescent situation with stock at the Central warehouse (Silver, Pyke, & Peterson, 1998), where there are three types of decisions: the amount the warehouse should order from its supplier, the amount to ship from the warehouse to the departments each period, and the amount to allocate to each department when stock runs short.

We assume that each department ($_i$) orders from a single warehouse according to an (R_i, s_i, S_i) policy, and that the warehouse employs also an (R_w,s_w, S_w). All the locations use the same review period, R. These policies are reasonable because the warehouse orders on a regular basis from their supplier. In the current situation, trucks are dispatched every month approximately, and the departments must determine how much to order each week. Demand is assumed to follow a Gamma distribution and a shortage cost is applied.

We would like to clarify that the (R,s,S) system is a combination of (s,S) and (R,S) systems. The concept is that every R units of time the inventory position is checked. If it is at or below the order point s, it is ordered enough to rise to S. If the position is above s, nothing is done until at least the next review.

Throughout this report we consider different models of calculations according the different scenarios posed. In each scenario we fix some variables and we modify others. In the case of the current situation, we are facing a fixed reorder cycle inventory model.

We establish this model to approach the current situation because the replenishments follow fixed time periods (R). That is to say, the replenishments are always done once per week and the order quantity is the variable which amount varies to achieve the order-up-to-level in each review period.

3. Costs per product

In order to calculate the inventory costs for all the products, some intermediate calculations are required for obtaining some variables implied in the formulas. The rest of the values used in the formulas are the result of the assumptions explained in chapter 4 and shown in tables in the Annex A.

Obviously, next to the tables expressed in this chapter we write the basic steps done in the calculations in order to clarify the process. However, since the process followed is the same for all the products we only explain the steps done in the case of the first product: WC toilet paper, for the rest we only mention some information if it is needed. Moreover the development of the costs is only developed in the case of the toilet paper in the report, for the developments of the rest of the products see Annex D.

The intermediate calculations are done to calculate the lead times, the probability of stock outs and the reorders points for all the locations, which are used in the costs formulas.

We would like to remind that the models are approached by a (R,s,S) system, explained in the section above and in general all the variables that appear in this chapter are explained in the chapter above.

All the values of all the tables of chapters VI and VII are expressed in different units which are summarized in the following tables. In this table, we also show the symbols to express the different magnitudes.

Parameters in intermediate tables	Measured in
Lead time	days
Lead time demand	boxes
Safety Stock (SS)	boxes
Standard deviation (σ), Variances(sq(σ))	-
α,β	boxes
Probability of stocking out (1-P_1)	-
Order quantities (Q), demands (D)	boxes
Sizes, volumes occupied	m^2
Reorder points	boxes
Expected shortages per replenishment cycle (ESPRC)	boxes

Table VI.1: Units the parameters are expressed in

Parameters in costs' calculations	Measured in
Expected shortages	boxes
Costs	Euros
Average inventory on-hand	boxes
Value holding cost	percentage

3.1. Toilet paper

3.1.1. INTERMEDIATE CALCULATIONS

- **Central warehouse**:

lead time demand	SS	Reorder point	Lead time demand	σLead time demand	sq(σ) lead time demand	α	β	1-P1	ESPRC	Q per month	D departments per month	Pallet's size	Volume occupied
12,14	16,00	28,00	12,14	7,29	53,21	2,77	4,38	0,04	0,20	62,00	61,85	0,96	2,88

Table VI.2: Calculations of order quantity, volume occupied, reorder point, safety stock and stock outs for the Toilet paper per replenishment cycle

The first step to fill this table in is to determine the demand from the departments per month, on average, to know the order quantities per month the central warehouse has to order to the suppliers. To do not be redundant we do not explain again how we have got these values, since it is explained in the 2.2 of chapter V.

In the same way, the volume occupied the safety stock and the lead time demand is also explained in chapter V, regarding assumptions.

However, we have to explain more carefully the steps taken in order to calculate the probability of stock outs:

As we mentioned before, the lead time in the departments vary accordingly with the expected shortages per replenishment in the central warehouse. That is why the lead time in the departments is zero if the central warehouse has stock, if it does not; the departments have to wait until the next review in the central warehouse plus the time until the shipment from the supplier arrives.

Since the lead time from the supplier to the central warehouse is data from the hospital, we can calculate the lead time demand. On the other side, we can assess α and β, which are the parameters for the Gamma distribution and are explained in Annex C. With all this information we can calculate the probability of stocking out and the expected shortages per cycle. (See 2.3 of Annex C).

- **Departments**:

In the next table, we determine the lead time in the departments, the reorder point and the number of units short.

lead time	Lead time demand	probability	number of units short	Reorder point
0,00	0,00	0,964	-28,14	16,00
6,00	12,14	0,005	-16,00	28,14
7,00	14,16	0,005	-13,98	30,16
8,00	16,19	0,005	-11,95	32,19
9,00	18,21	0,005	-9,93	34,21
10,00	20,23	0,005	-7,91	36,23
11,00	22,26	0,005	-5,88	38,26
12,00	24,28	0,005	-3,86	40,28

Table VI.3: Calculation of Reorder point for the different Lead time demands

The first column of this table refers to all the possible values of the lead time.

The lead time is zero when the warehouse has enough stock for replenishing the departments. In this case it is done in less than few hours. This is the most probable case (96,4%) since the probability that the central warehouse has any stock out is 4%.

The lead time which is 6 days, is the case one department stocks out on Tuesday and the central warehouse orders also on Tuesday, so, the total lead time would be 6 days which correspond to the average time that the supplier takes to arrive to the hospital.

The probability of this lead time is 0,5%, because we multiply the 4% of probability of stock out in the central warehouse by 14% of probability that a department stocks out on Tuesday. The time between replenishments is one week, so, every different lead time, within the departments, has a probability of 1/7, which equals 14%.

In the same way, the lead time of 7 days represent a review of a department made on Monday. In this situation the lead time is 7, because the order won´t be done from the central warehouse until next Tuesday and then it takes 6 days more for the replenishment to arrive. The probability in this case, is also 0,5% for the same reason explicated above.

The rest of the values of the first and third column are filling it in using the same method.

The reorder point is calculated summing the lead time demand and the safety stock in the departments, which data is known. The value coloured in red is the reorder point chosen to guarantee not stocking outs in the departments.

We can guarantee it because the value in red is higher than the lead time demands in every situation.

An important observation is that the reorder point has been calculated considering that all the departments have approximately the same average consumption per month, so, are being calculated with the total consumption of all the departments. For this reason, the reorder point chosen would correspond to 28,14 divided by the number of departments. In the reality we should do it in a more precise way determining each reorder point taking in account the weight of each department. In this report, we do it in a general way, because there are too many characteristics to be precise in all of them.

Finally, the number of unit short is filled in, using the reorder point in red. And as we can see in the table all the values are negative what means there is no shortage in any case.

In the following table we summarize all the values from the outcome of the previous calculations. The only observation is that the lead time and the lead time demand are a weighted sum and for the expected shortage per cycle see section 2.3 of Annex C.

lead time	SS	Reorder point	Lead time demand	σLead time demand	sq(σ) lead time demand	α	β	1-P1	ESPRC
0,30	16,00	29,00	0,61	7,60	57,82	0,08	7,60	0,00	0,00

Table VI.4: Determination of the lead time demand and expected shortages per replenishment cycle

3.1.2. COSTS

After the intermediate parameters calculated above we can continue the analysis with the different costs' approaches.

3.1.2.1. Ordering Cost

Orders per year (hospital info.)	Orders per Year (calculated)	Cost per order	Ordering cost per year
12,00	11,97	1,73	20,78

Table VI.5: Annual *ordering cost per year of Toilet paper*

3.1.2.2. Shortage Cost

I make a distinction between central warehouse and departments because the probabilities of stock out are different in each location. Obviously, the cost per unit short is also different in both cases due to the differences in the holding costs accordingly the location.

- **Central warehouse**:

ESPRC	Cost perunit short	Number of cycles per year	Expected annual shortage cost
0,20	6,51	12,00	15,49

The expected shortage per replenishment cycle is an outcome from *Figure VI.1*

The cost per unit short is explained in section 2.3 in Annex C.

Table VI.6: Shortage annual cost in the central warehouse of Toilet paper

The number of cycles per year is data from the hospital. The shipments arrive once per month.

The expected annual shortage cost is the result of multiplying all the columns of the table.

- **Departments**:

ESPRC	Cost per unit short	Number of cycles per year	Expected annual shortage cost
0,00	22,21	48,00	3,11

Table VI.7: Shortage annual cost in the depts. of Toilet paper.

The expected shortage per replenishment cycle is an outcome from Figure VI.3.

The number of cycles per year corresponds to 48, since the departments are replenished once per week.

The explanations in Table VI:5 for the rest of the columns are also valid to fill n this table.

3.1.2.3. Handling cost

Product	Percentage of the total handling	Time for unloading the truck per month	Time for handling: scanning, picking, replenishing per month	Total time for handling per month	Total time for handling per year	Handling cost per month	handling cost per year and unit	Average Consumption per year	Labour cost per year for replenishing into depts.	Labour cost per year for replenishing into depts. with same cost per hour as Jan de Rijk
Total 4 products	1,00	0,69	7,00	7,69	92,25	159,75			######	2396,19
WC paper tissues	0,35	0,24	2,45	2,69	32,29	55,91	0,90	744,00	670,93	838,67
Kleenex	0,20	0,14	1,40	1,54	18,45	31,95	0,45	852,00	383,39	479,24
Tena Bed	0,30	0,21	2,10	2,31	27,68	47,92	1,45	396,00	575,09	718,86
Tena Bed Green	0,15	0,10	1,05	1,15	13,84	23,96	2,66	108,00	287,54	359,43

3.1.2.4. Holding cost

Average inventory on-hand in the central warehouse (boxes)	Average inventory on-hand in the departments (boxes)	v (unit variable cost)	value holding cost per unit and year	Holding cost
47,00	23,75	26,71	0,07	1091,56

Table VI.8: Holding annual cost of Toilet paper

The average inventory on-hand in the central warehouse is the order quantity on average (Q/2) plus the safety stock (SS) in the central warehouse.

The average inventory on-hand in the departments is the average consumption in the replenishment cycle (Q/4)/2 plus the safety stock in the departments.

The unit variable cost and the value holding cost per unit are explained in section 2.1 of Annex C, where it can also be found the formula used for the calculation of the holding cost and its explanation.

3.1.2.5. Total cost *per year*

The total cost per year is the addition of all the costs previously calculated: ordering cost, holding cost and shortage cost.

Cost per year [€]	1802,11
Cost per year with Jan de Rijk's labour costs [€]	1969,84

3.2. Kleenex tissues 2LGS

3.2.1. INTERMEDIATE CALCULATIONS

- **Central warehouse**:

lead time	SS	Reorder point	Lead time demand	σLead time demand	sq(σ) lead time demand	α	β	1-P1	ESPRC	Qper month	Ddept.per month	Pallet's size	Volume occupied
14,00	14,00	28,00	25,67	12,21	149,01	4,42	5,81	0,37	3,84	55,00	46,00	0,96	2,88

Table VI.9: Intermediate calculations in the central warehouse for Kleenex tissues

We can observe in the table that there is a pretty high probability of stocking out. This is due to the high standard deviation, and consequently the variance too, of the lead time demand. (See Annex A: Data obtained to see information about the lead times of this supplier).

- **Departments**

lead time	Lead time demand	probability	number of units short	Reorder point
0,00	0,00	0,635	-14,00	14,00
6,00	11,00	0,052	-3,00	25,00
7,00	12,83	0,052	-1,17	26,83
8,00	14,67	0,052	0,67	28,67
9,00	16,50	0,052	2,50	30,50
10,00	18,33	0,052	4,33	32,33
11,00	20,17	0,052	6,17	34,17
12,00	22,00	0,052	8,00	36,00

Table VI.10: Calculation of the Reorder point for the different Lead time demands

As a consequence of the high probability of stock out in the central warehouse, the probability of stocking out when the lead time in the departments increase, it also increases.

The reorder point which would reduce the number of units short per cycle would be 25 units, but it is not possible to choose that number, because if we look in the Annex A, we

can notice that the maximum stock per cycle for the total of departments is 17,56. Therefore, it does not make sense to determine a reorder point that it does not describe the current situation.

lead time	SS	Reorder point	Lead time demand	σLead time demand	sq(σ)lead time demand	α	β	1-P1	ESPRC
3,29	14,00	14,00	6,03	6,89	47,48	0,88	6,89	0,11	0,70

Following the same procedure as it has done for the toilet paper, all this table has been filled it in

Table VI.11: Intermediate calculations in the depts. for Kleenex tissues

3.3. Onderlegger Tena Bed

3.3.1. INTERMEDIATE CALCULATIONS

- ***Central warehouse:***

Lead time	SS	Reorder point	Lead time demand	σLead time demand	sq(σ)lead time demand	α	β	1-P1	ESPRC	Qmonth	Ddept.month	Pallet's size	Volume occupied
4,00	8,00	12,00	4,27	1,23	1,52	12,00	0,36	0,00	0,00	32,00	31,00	0,96	1,92

Table VI.12: Intermediate calculations in the central warehouse for Kleenex tissues

- ***Departments:***

lead time	Lead time demand	probability	number of units short	Reorder point
0,00	0,00	1,000	-8,00	8,00

Table VI.13: Calculation of the reorder point

We can see in Table VI.12 that in this situation there is not any stock out in the central warehouse. That is the reason why in the next table the only lead time is zero: every time we do replenishment there is enough amounts in the central warehouse.

Therefore, the reorder point it is equal to the safety stock.

Lead time	SS	Reorder point	Lead time demand	σLead time demand	sq(σ)lead time demand	α	β	1-P1	ESPRC	Volume occupied
0,00	8,00	8,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	5,90

Table VI.14: Intermediate calculations in the depts. for Onderlegger Tena Bed

Since the central warehouse has always enough stock to provide the departments. The stock outs are zero.

3.4. Onderlegger Tena Bed Green

3.4.1. INTERMEDIATE CALCULATIONS

- **Central warehouse:**

Lead time	SS	Reorder point	Lead time demand	σLead time demand	sq(σ)lead time demand	α	β	1-P1	ESPRC	Qmonth	Ddept.month	Pallet's size	Volume occupied
4,00	3,00	7,00	1,33	0,38	0,15	12,00	0,11	0,00	0,00	10,00	11,08	0,96	0,96

Table VI.15: Intermediate calculations in the central warehouse for Onderlegger Tena Bed Green

One of the handicaps we find in the data from the hospital in order to do a precise analysis is that Franciscus Ziekenhuis does not have many historical data. For this reason, the order quantities are not so precise at it should be and in this table we can see an example. In section 2.3 in chapter V we explain the assumptions in order to predict the best consumption average as possible, but still there is a gap of one box between the order quantity and the average consumption. For the calculations, we look carefully to each case, and in this one, we take the consumption average as the order quantity, because there is more recent data.

- ***Departments:***

lead time	Lead time demand	probability	number of units short	Reorder point
0,00	0,00	1,000	-3,00	3,00

Table VI.16: Calculation of the reorder point

As in the case above, the probability of stocking out in the central warehouse is zero, so, the lead time in the departments is also zero.

The reorder point equals to the safety stock.

Lead time	SS	Reorder point	Lead time demand	σLead time demand	sq(σ)lead time demand	α	β	1-P1	ESPRC	Volume occupied
0,00	3,00	3,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,64

Table VI.17: Intermediate calculations in the depts. for Onderlegger Tena Bed Green

3.5. Sterile products

The sterile products are only stored in the sterile center. The review of the mentioned department is done every Wednesday (see Annex B), and the orders are scheduled every Tuesday from the central warehouse, so, the lead time demand is the sum of these 6 days (from Wednesday to Tuesday) plus the lead time from the supplier to the hospital, which for all the sterile products is 3 days on average.

Since, for all the sterile products we applied the same rules and policies, we grouped all of them in this chapter to make the results more visual.

3.5.1. INTERMEDIATE CALCULATIONS

	SS in central warehouse	SS in dept.	Volume occupied	Pallet's size	Lead time	Lead time demand	σlead time demand	sq(σ)lead time demand	Reorder point s	α	β	1-P1	ESPRC	Qmonth	Ddept.month
Kimguard 1step, KC 300, 101x101	0,00	4,00	1,92	0,96	15,00	7,00	0,38	0,15	11,00	337,50	0,02	0,00	0,00	14,00	13,00
Kimguard 1step, KC 200, 121x121	0,00	21,00	6,72	0,96	15,00	41,50	2,26	5,10	62,50	337,50	0,12	0,00	0,00	83,00	83,00
Kimguard 1step, KC 300, 76x76	0,00	3,00	0,96	0,96	15,00	5,00	0,27	0,07	8,00	337,50	0,01	0,00	0,00	10,00	8,00

Table VI.18: Intermediate calculations for sterile products

For any of the products there isn´t any stock out. This occurs because the reorder point has been chosen covering all the lead time demand.

3.6. Dialysis products

As we did with the sterile products, we also group the dialysis ones to make it more visual due to similar characteristics.

All the dialysis products are stored in the dialysis centre without any stock in the central warehouse. The reviewing day is on Monday and the orders from the central warehouse are on Tuesday, so, in this situation the lead time for all these products is one day plus the time from the supplier to Franciscus Ziekenhuis.

The safety stock is one week average consumption and the volume occupied is established by the number of pallets where the boxes are stored. (See section 2.3 of chapter V)

3.6.1. INTERMEDIATE CALCULATIONS

	SS in Cw	SS in depts.	Volume occupied	Pallet's size	Lead tme	Lead time demand	σLead time demand	sq(σ)lead time demand	Reorder point s	α	β	1-P1	ESPRC	Qmonth	Ddept.month
Concentraat D294	0,00	74,00	6,72	0,96	3,00	29,50	8,03	64,46	103,50	13,50	2,19	0,00	0,00	295,00	295,00
Bicart 720 gr.	0,00	20,00	1,92	0,96	3,00	8,00	2,18	4,74	28,00	13,50	0,59	0,00	0,00	80,00	71,00
Concentraat D292	0,00	15,00	1,92	0,96	3,00	5,70	1,55	2,41	20,70	13,50	0,42	0,00	0,00	57,00	52,00
Concentraat D296	0,00	4,00	0,96	0,96	3,00	1,40	0,38	0,15	5,40	13,50	0,10	0,00	0,00	14,00	13,00

Table VI.19: Intermediate calculations for Dialysis products

It is remarkable in this table to see the differences between the order quantities and the demand from the departments per month. In the Annex A it can be noticed that the order quantity for the first dialysis product (Concentraat D294) is 345 boxes, we have chosen the same order quantity than the demand, in this case, because the data obtained regarding the order quantities is not very precise in the case of sterile and dialysis products. We would like to remember that the assumptions regarding this situation are in section 2.3 of chapter V. As in the case of the sterile products, the probabilities of stocking out are zero. That is due to the reorder point chosen that covers the lead time demand and also due to the big amount of safety stock.

4. Total costs and observations

In this section we show the total inventory costs per product. The goal of this information is to enable the comparison between the current situation and further scenarios that are considered and analyzed along this report.

Products	Ordering Cost	Shortage Cost	Holding Cost	Replenishments into depts.	Total Inventory Cost [€]	Replenishments into depts. with jan de Rijk's labour costs	Total inventory costs with Jan de Rijk's labour costs [€]
WC toilet paper	**20,78**	**0,00**	**1091,56**	**670,93**	**1783,27**	**838,67**	**1951,01**
Kleenex Tissues 2LGS	**20,78**	**228,25**	**1082,14**	**383,39**	**1714,56**	**479,24**	**1810,40**
Onderlegger Tena Bed	**20,78**	**0,00**	**737,02**	**575,09**	**1332,89**	**718,86**	**1476,66**
Onderlegger Tena Bed Green	**20,78**	**0,00**	**385,01**	**287,54**	**693,34**	**359,43**	**765,22**
Kimguard 1step, KC 300, 101x101	**20,00**	**0,00**	**216,89**	**44,59**	**281,48**	**44,59**	**281,48**
Kimguard 1step, KC 200, 121x121	**20,00**	**0,00**	**704,30**	**272,03**	**996,33**	**272,03**	**996,33**
Kimguard 1step, KC 300, 76x76	**20,00**	**0,00**	**119,71**	**13,38**	**153,09**	**13,38**	**153,09**
Concentraat D294	**20,00**	**0,00**	**597,05**	**227,59**	**844,63**	**284,48**	**901,53**
Bicart 720 gr.	**20,00**	**0,00**	**249,39**	**53,10**	**322,49**	**66,38**	**335,77**
Concentraat D292	**20,00**	**0,00**	**173,72**	**37,93**	**231,65**	**47,41**	**241,13**
Concentraat D296	**20,00**	**0,00**	**81,97**	**11,38**	**113,35**	**14,22**	**116,20**
TOTAL COSTS	223,12	228,25	5438,76	2576,96	8467,08	3138,69	9028,82

Table VI.20: Total inventory costs for all the products in scope

Again, as we have done during the report, we can observe different groups which follow similar characteristics.

The group formed by WC toilet paper, Kleenex tissues 2LGS, Onderlegger Tena Bed and Onderlegger Tena Bed Green are the ones which represent a higher costs per year in proportion with the total consumption. We specify the main reasons we have observed as an outcome of the results:

- These products occupy more volume since they are stored in the central warehouse and in the departments
- For the same reason, these products have a higher amount of safety stock. (In the central warehouse and in the departments)
- These products are stored in many different departments and this has consequences as: a higher cost for handling the products (from the central warehouse to the departments and within the department level), a higher volume occupied and the need of scanning, picking and replenish each review period.
- Moreover, in the case of Kleenex Ultra 2LGS, the shortage costs are also remarkable and it is due to a high standard deviation of the lead time demand.

Alternatively, the group formed by the sterile and dialysis products represents lower costs regarding the total costs due to the next observations:

- These products are only stored in the department where are used: sterile and dialysis respectively. This means a lower volume occupied and less effort from the employees of Franciscus Ziekenhuis for their handling
- The lead time is more precise since only one department has to be controlled. For the same reason, the safety stock is more precise and covers the lead time demand which does not have much deviation and the combination of all this, also implies no shortage costs

Chapter VII: Possibilities using a Third Party Logistics Service

In this chapter we describe and analyze different possibilities using a third party logistics service: Jan de Rijk Logistics. The goal of this analysis is to consider different ways of optimization changing different variables and applying different models to see how they impact the total costs per year.

The structure used during this process follows a tree shape. We pose different scenarios and for all of them we do a description, we calculate the variables bounded and we analyze the results. So, why does it have a tree shape? Because all the scenarios are related between them, and each of it, gives you many other possibilities, branches, to continue investigating.

In this investigation we have to delimitate the scenarios posed since we have limited time to finish the report. But, all our analysis can give a general idea of how can be the way of improvement within the supply chain of the hospital and keys for further studies.

We try to be as much precise as possible with our analysis and that is why in all the scenarios we compare each one with the current situation splitting the costs which are clearer from those ones which are more subjective.

In section A.2.1 of this chapter, we made hypothesis to try to approximate some costs to the reality, once chosen the best approximation we add the result to the inventory costs to have the total costs. But, it is shown in a separate way to distinguish the more objective parts to the other that can be more subjective. In this way, the reader can realize which would be the impact applying these scenarios to the reality.

Along these scenarios we use several times the prices established by Jan de Rijk and they can be found in the Annex F of this report.

Known or Unknown Inventory Level

These scenarios represent the starting point and determine the way Jan de Rijk can do the replenishments. This is the first node of the tree and within each scenario there are many other scenarios. Therefore, we start with the scenario which represents the global idea, unknown or known inventories, and within it we study different branches where we change different variables to compare the final costs. Known inventory implies that the inventory level is measured before the replenishment takes place (either by a hospital employee or by a Jan de Rijk employee) and unknown inventory implies that the inventory level is measured only when replenishing.

A. Unknown Inventory Level

This case is based in the idea that Jan de Rijk making use of the historical data available assume an average quantity of consumption each T units of time and go to the hospital with the mentioned amounts of products to supply for the next T units of time.

The same employee from Jan de Rijk, carry the products into the departments and in each department scan the stock level of the products and replenish the quantity enough to the stock up-to-level, S. When, the employee has finished replenishing the last department comes back to Jan de Rijk with the products left.

In this scenario the replenishments can only be considered by product. It does not make sense to do this kind of replenishments by departments because it would be a huge waste of time. Furthermore, within the same department the products there are stored have different replenishment times.

We have to consider that in this situation, a pretty big safety stock is required because the stock level has the opportunity to drop appreciably between review instants without any reordering action being possible in the interim. Another reason that supports the idea of a big safety stock is that the replenishments are based on averages, so if one month the consumption increases suddenly, the safety stock has to cover, at least partially, this peak of demand.

This scenario is quite close to the current situation, but with the next advantages:

- No more volume occupied in the central warehouse
- No need of an employee to scan, order, pick and replenish. Therefore, there is a reduction of the handling time within Franciscus Ziekenhuis.

A.1. SCENARIO 1: UNKNOWN INVENTORY LEVEL AND JAN DE RIJK DELIVERS INTO THE DEPARTMENTS ONCE PER WEEK

The schema that represents this scenario is the next one:

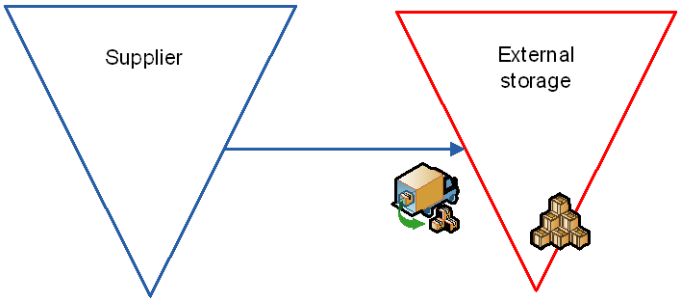


Figure VII.1

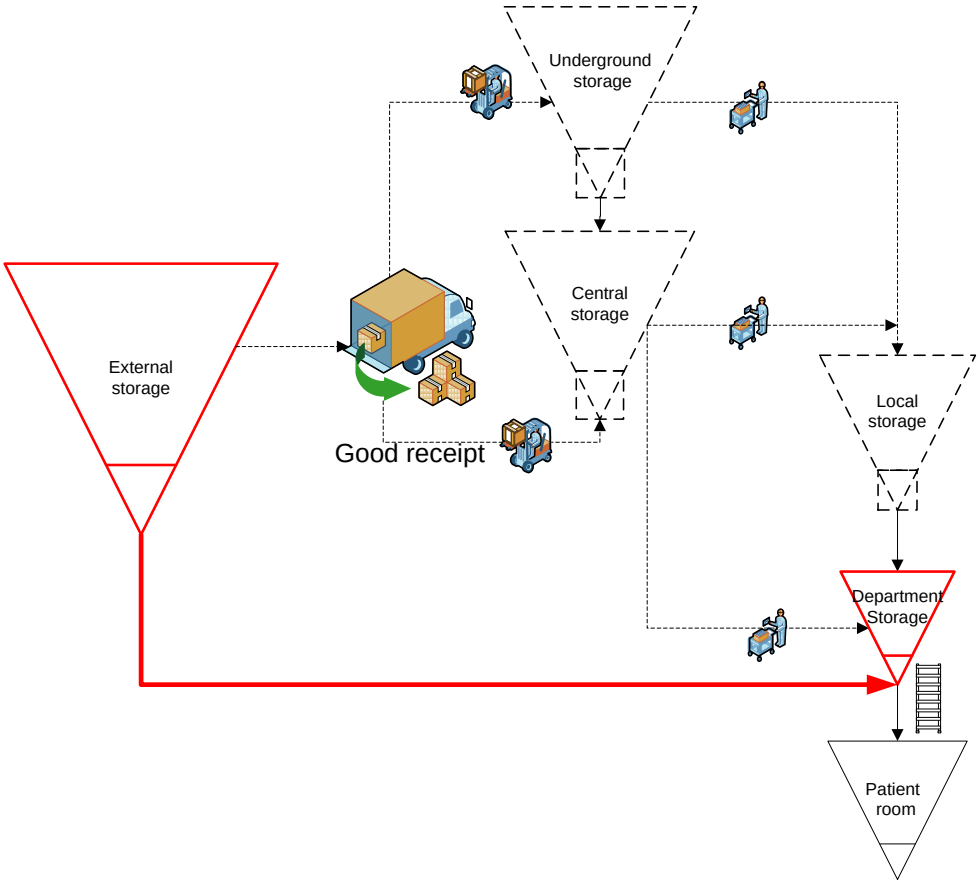


Figure VII.2

- ***Assumptions***:

- The central warehouse do not play any role
- The model which approaches the reality in the departments is an (R, S) system
- For this scenario, R equals 1 week and the stock-up-to-level is decided for each product
- There is not any lead time because there is not any order point, Jan de Rijk goes directly into the departments without no orders
- We define a protection interval which is formed by the time between replenishments and the lead time. As we mentioned earlier, the lead time in this situation is zero
- The stock up-to-level S, consists in the expected demand during the protection interval plus the safety stock
- The quantity carried by Jan de Rijk every week is the average weekly demand plus a safety stock, which has to be estimated. This goal of carrying also the safety stock is to cover any possible peak of demand or to get the safety stock in the department to its maximum level, in case the safety stock level decreased during the last R period. But, once the order-up-to-level is achieved, the truck comes back to Jan de Rijk with the products left
- To determine the safety stock in the departments we apply the next formula: k (safety factor) ·standard deviation of protection interval demand
- We assume a safety factor of 3. It is quite high because although the demand for all the products is pretty stable, the historical data available is not very precise and this fact is more remarkable in the case of dialysis products, for which products is required a safety factor of 4
- A safety stock is also carried every week next to the average quantity and it is calculated considering the expected shortages per cycle for each product
- Jan de Rijk also stores a safety stock which is calculated for each product following the next formula: $k \cdot \sigma(\text{weekly demand}) \cdot n$, where k is a safety factor and n is the number of weeks between the replenishments from the supplier to Jan de Rijk

Once the description of the scenario has been made we describe the inventory costs in this new situation. To make it clearer, first we report the costs related with the storage within the hospital, secondly the costs regarding the storage in Jan de Rijk Logistics, finally we add the costs for the replenishing by Jan de Rijk into the departments and the transport costs. These last two costs are added at posterior since can be analyzed also from a subjective point of view. Therefore, we consider that showing these costs separately it is easier to have a more realistic map of the scenario in the mind of the reader.

A.1.1. COSTS WITHIN THE HOSPITAL

For showing the results, we show also the intermediate tables of calculations. For each scenario it is required to show these tables because we change some parameters and assumptions from the Data obtained, so, the tables that appear in Annex A, are modified.

Here, I only do it for the first product, because I apply the same method for the rest. Therefore, for the others products, next to the results I only do some observations if the method differs from the first product which has more specified explanations and their tables can be found in Annex E.

A.1.1.1. WC Toilet paper

Department	Consumption last year[rols]	Consumption two years ago[rols]	Consumption average per month, last year (boxes)	Consumption average per month, two years ago (boxes)	Consumption average per week [boxes]	standard deviation	Inventory level desired in each replenishment (boxes) (once per week)	Safety stock (boxes)	Stock max.in depts. integer part	Stock max. in depts. decimal part	Volume occupied in each department
1. 6A	982	1061	2,27	2,46	0,59	0,13	0,78	0,19	0,00	0,78	0,22
2. 6B	320	390	0,74	0,90	0,21	0,11	0,27	0,07	0,00	0,27	0,11
3. 5A	605	790	1,40	1,83	0,40	0,30	0,53	0,13	0,00	0,53	0,22
4. 5B	670	704	1,55	1,63	0,40	0,06	0,53	0,13	0,00	0,53	0,22
5. 4A	1078	1082	2,50	2,50	0,63	0,01	0,83	0,20	0,00	0,83	0,22
6. 4C	1220	1220	2,82	2,82	0,71	0,00	0,93	0,23	0,00	0,93	0,22
7. 1E	28	222	0,06	0,51	0,07	0,32	0,10	0,02	0,00	0,10	0,11
8. 3A	1874	1060	4,34	2,45	0,85	1,33	1,12	0,27	1,00	0,12	0,29
9. 3B	0	820	0,00	1,90	0,24	1,34	0,31	0,08	0,00	0,31	0,11
10. 3C	854	744	1,98	1,72	0,46	0,18	0,61	0,15	0,00	0,61	0,22
11. 2A	0	314	0,00	0,73	0,09	0,51	0,12	0,03	0,00	0,12	0,11
12. 2B	1548	1630	3,58	3,77	0,92	0,13	1,21	0,29	1,00	0,21	0,29
13. KINDERAFDELING	824	836	1,91	1,94	0,48	0,02	0,63	0,15	0,00	0,63	0,22
14. ZIEKENHUIS ALGEMEEN	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
15. RUIMTENBEHEER	504	108	1,17	0,25	0,18	0,65	0,23	0,06	0,00	0,23	0,11
16. KOSTEN SCHOONMAAK	12660	10866	29,31	25,15	6,81	2,94	8,99	2,18	8,00	0,99	1,66
17. KEUKEN	64	60	0,15	0,14	0,04	0,01	0,05	0,01	0,00	0,05	0,11
18. BLOKKADE FLAT	0	432	0,00	1,00	0,13	0,71	0,17	0,04	0,00	0,17	0,11
19. AFDELING 2A	78	10	0,18	0,02	0,03	0,11	0,03	0,01	0,00	0,03	0,11
20. OPERATIE	777	826	1,80	1,91	0,46	0,08	0,61	0,15	0,00	0,61	0,22
21. FUNKTIE	8	30	0,02	0,07	0,01	0,04	0,01	0,00	0,00	0,01	0,11
22. FYSIOTHERAPIE	12	26	0,03	0,06	0,01	0,02	0,01	0,00	0,00	0,01	0,11
23. APOTHEEK	154	128	0,36	0,30	0,08	0,04	0,11	0,03	0,00	0,11	0,11
24. KLINISCH	386	398	0,89	0,92	0,23	0,02	0,30	0,07	0,00	0,30	0,11
25. MICROBIOLOGISCH	1	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11
26. NUCLEAIRE	14	42	0,03	0,10	0,02	0,05	0,02	0,01	0,00	0,02	0,11
27. ST. HUISARTSENPOST	108	0	0,25	0,00	0,03	0,18	0,04	0,01	0,00	0,04	0,11
28. POLI ETTEN LEUR	155	0	0,36	0,00	0,04	0,25	0,06	0,01	0,00	0,06	0,11
29. MED.CENTR.	452	474	1,05	1,10	0,27	0,04	0,35	0,09	0,00	0,35	0,11
30. BEHANDELCENTRUM	412	282	0,95	0,65	0,20	0,21	0,27	0,06	0,00	0,27	0,11
31. SPODEISENDE HULP	504	446	1,17	1,03	0,27	0,09	0,36	0,09	0,00	0,36	0,11
32. HEMODIALYSE	254	300	0,59	0,69	0,16	0,08	0,21	0,05	0,00	0,21	0,11
33. 1B	31	142	0,07	0,33	0,05	0,18	0,07	0,02	0,00	0,07	0,11
34. 4B	150	272	0,35	0,63	0,12	0,20	0,16	0,04	0,00	0,16	0,11
SUM	26727	25715	61,87	59,53	15,17		20,04	4,87	10,00		6,34
AVERAGE						0,30					

Table VII.1: Inventory level desired, safety stock and volume occupied in departments in scenario 1 for Toilet paper

In the Table VII.1 we calculate the stock up-to-level every week in every department and the safety stock and volume occupied.

As we mention in the assumptions at the beginning of this chapter, for calculating the safety stock we use the standard deviation of the protection interval and this protection interval equals to the review period. But, the consumptions available in this table are the total consumption of last year and two years ago. It means that if we calculate the standard deviation weekly, we would have an average of the weekly demand of two different years. So, we do not use this information because of the lack of precision. Alternatively, we have the consumption per month of last year. So, we work in parallel with Tables VII.1, VII.2 and VII.3.

Thus, in Table VII.3 we calculate the standard deviation of the protection interval (1 week) using Table VII.2 with this information we can fill in the entire Table VII.3.

Once, we know the total safety stock we fill the corresponding column in the Table VII.1. We assign to each department its safety stock accordingly to its weight.

With this information we can fill the entire Table VII.1:

The inventory level desired per replenishment is the sum of the weekly demand plus the safety stock per department.

The volume occupied is calculated following the same formula as in the current situation. (See section 2.2.3 of chapter V.

Consumption per month last year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Apr	May	Average
Monthly demand [rols]	2350,00	1980,00	2053,00	2280,00	2104,00	2314,00	2687,00	1998,00	2382,00	2623,00	2047,00	2250,00	2255,67
Weekly demand [boxes]	16,32	13,75	14,26	15,83	14,61	16,07	18,66	13,88	16,54	18,22	14,22	15,63	15,66

Table VII.2: Weekly demand for Toilet paper

Weekly demand	SS in depts.	Q carried by Jan de Rijk per week	Volume occupied	Protection interval demand	σprotection interval	sq(σ)protection interval demand	Reorder point s	α	β	1-P1	ESPRC	Qweek	Ddepts.week
15,17	4,87	21,00	6,34	15,17	1,62	2,63	20,04	87,55	0,17	0,00	0,00	16,00	15,17

Table VII.3: Intermediate calculations in scenario 1 for Toilet paper

We have also to do some observations in this Table VII.3:

Someone could ask why we have calculated the reorder point if in the assumptions we specified that in this scenario would not be any orders and consequently any lead time. The answer is that it is only a theoretical reorder point. Jan de Rijk replenishes every week until the stock up-to-level and it carries the weekly demand plus the safety stock. The reorder point is only an indication of the stock level when Jan de Rijk replenishes, in order to calculate the expected shortages per replenishment cycle in this situation. We can observe that the expected shortage per replenishment cycle is quite low but still it is not zero due to the variance of the protection interval demand. We should take a major security factor to avoid

any stock outs but then, the volume occupied would increase. We have always to deal between a bigger volume occupied and a bigger shortage costs. So, in each scenario there are always choices by my criteria trying to give realistic results.

With all these calculations we know all the variables implied in the costs' formulas, and we show the result as follows:

A.1.1.1.1. Ordering cost

Orders per year	Orders per year (calculated)	Cost per order	Ordering cost per year
48,00	46,40	0,00	0,00

The order cost is zero, because Franciscus Ziekenhuis does not have to scan the inventory level and order quantities because Jan de Rijk is responsible of all the replenishment process.

Table VII.4: Ordering cost in scenario 1 for Toilet paper

A.1.1.1.2. Shortage cost

ESPRC	Cost per unit short	Number of cycles per year	Expected annual shortage cost
0,00	22,21	48,00	0,00

The number of cycles per year in this situation is 48 because the replenishments are effective once per week. And the expected annual shortage cost is the result of multiplying all the columns.

Table VII.5: Shortage cost in scenario 1 for Toilet paper

A.1.1.1.3. Handling cost

Within the hospital the handling cost is zero! It is Jan de Rijk the responsible of the replenishments.

A.1.1.1.4. Holding cost

Average inventory on-hand in Cw	Average inventory on-hand in all the departments	v (unit variable cost)	Holding cost
0,00	10,11	25,81	438,66

Table VII.6: Holding cost for Toilet paper in scenario 1

A.1.1.1.5. Total inventory costs

468,08 €

A.1.1.2. All the products

As the reader could observe along this chapter, the process to arrive to the results is quite long for every product. So, to make it more readable and not to be lost within so many tables we have enclosed the intermediate tables of all the products in the Annex E: all of them follow the same procedure than in the case of the toilet paper. And in this section we show the results for all of them.

	Weekly demand	SS in depts.	Qcarried by Jan de Rijk weekly	Volume occupied	Protection interval demand	Standard deviation of the protection interval	sq(σ)protection interval demand	Reorder point s	α	β	1-P1	ESPRC	Qweek
WC toilet paper	**15,17**	**4,87**	**17,00**	**6,34**	**15,17**	**1,62**	**2,63**	**20,04**	**87,55**	**0,17**	**0,003**	**0,00**	**16,00**
Kleenex Ultra 2LGS	**10,06**	**6,70**	**12,00**	**3,96**	**10,06**	**2,23**	**4,99**	**16,76**	**20,26**	**0,50**	**0,005**	**0,00**	**11,00**
Tena Bed	**7,74**	**1,81**	**9,00**	**4,79**	**7,74**	**0,60**	**0,36**	**9,55**	**164,20**	**0,05**	**0,002**	**0,00**	**8,00**
Tena Bed Green	**2,77**	**1,56**	**4,00**	**1,62**	**2,77**	**0,52**	**0,27**	**4,33**	**28,30**	**0,10**	**0,004**	**0,00**	**3,00**
Kimguard 1step, KC 300, 101x101	4,00	1,85	5,00	0,96	4,00	0,62	0,38	5,85	42,24	0,09	0,004	0,00	4,00
Kimguard 1step, KC 200, 121x121	21,00	16,51	23,00	2,88	21,00	5,50	30,30	37,51	14,55	1,44	0,006	0,02	22,00
Kimguard 1step, KC 300, 76x76	1,77	1,43	3,00	0,96	1,77	0,48	0,23	3,20	13,63	0,13	0,006	0,00	2,00
Concentraat D294	74,00	86,13	75,00	2,88	74,00	21,53	463,64	160,13	11,81	6,27	0,001	0,01	74,00
Bicart 720 gr.	18,00	28,55	19,00	0,96	18,00	7,14	50,93	46,55	6,36	2,83	0,002	0,01	18,00
Concentraat D292	13,00	11,11	14,00	0,96	13,00	2,78	7,72	24,11	21,89	0,59	0,001	0,00	13,00
Concentraat D296	2,24	4,10	4,00	0,96	2,24	1,03	1,05	6,34	4,77	0,47	0,002	0,00	3,00

Table VII.7: Intermediate calculations for all the products in scenario 1

In this figure, we can observe and compare the main characteristics of the supply chain of all the products in study. We would like to do the next observations regarding these results:

- It is remarkable the expected shortage per replenishments in the case of the dialysis product: Concentraat D294. The reason of this high result is the big deviation of its demand. In fact, this product is also the one with highest consumption, so it needs a big amount of safety stock in the departments to compensate these aspects
- Even thought the highest volume occupied is due to the toilet paper. This can be explained because the toilet paper's sizes are bigger (28 boxes per pallet against 60 boxes per pallet in the case of the Concentraat D294: see Annex A) and because the sterile and dialysis products are stored in pallets in a compact way while the toilet paper and the rest of household or incontinent material are stored independently in boxes split in shelves at different departments
- The second and third biggest safeties stocks correspond to Bicart 720gr. and Kimguard 1step KC200 121x121, which are also the ones that have biggest variance in their demand
- In general aspects, the sterile and dialysis products occupy less volume because of their smaller boxes' sizes but they need a higher safety stock to compensate the variability of their demand. On the opposite, the household and incontinent materials occupy more volume but they need less safety stock since there is not much risk of suffering stock outs because of their stable demand

A.1.2.1.1. Ordering cost

All the ordering costs are zero because all the replenishments are under Jan de Rijk responsibility. In case of urgency, the hospital would call to the company but for this study that time would be neglected in front of the rest.

A.1.2.1.2. Shortage costs

In this figure we have some examples where the number of shortages per cycle is being compensated by the cost of holding that product per year.

We would like to remind that the cost per unit short is calculated as twenty times the holding cost per year. Thus, the most expensive one regarding shortages is Kimguard 1step KC 200 121X121 but it does not coincide with the most number of expected units short. On the opposite, the one which had highest number of expected units short is not that expensive per year, since its holding cost is pretty cheap.

	ESPRC	Cost per unit short	Number of cycles per year	Expected annual shortage cost
WC paper tissues	0,00	22,21	48,00	1,82
Kleenex	0,00	25,89	48,00	6,21
Tena Bed	0,00	31,02	48,00	0,75
Tena Bed Green	0,00	52,21	48,00	2,39
Kimguard 1step, KC 300, 101x101	0,00	25,22	48,00	1,10
Kimguard 1step, KC 200, 121x121	0,02	13,85	48,00	10,08
Kimguard 1step, KC 300, 76x76	0,00	19,47	48,00	1,28
Concentraat D294	0,01	3,30	48,00	1,38
Bicart 720 gr.	0,01	5,09	48,00	1,46
Concentraat D292	0,00	4,97	48,00	0,14
Concentraat D296	0,00	9,53	48,00	0,55
				27,16

Table VII.8 : Shortage costs for all the products in scenario 1

A.1.2.1.3. Handling costs

The handling costs within the hospital in this scenario are considered zero, because they are contemplated in the costs within Jan de Rijk.

A.1.2.1.4. Holding costs

	Average inventory on-hand in Cw (boxes)	Average inventory on-hand in all the departments (boxes)	Net price per unit	v (unit variable cost)	Holding cost
WC toilet paper	0,00	12,87	25,81	25,81	466,26
Kleenex Ultra 2LGS	0,00	12,20	26,17	26,17	331,91
Tena Bed	0,00	5,81	16,20	16,20	328,20
Tena Bed Green	0,00	3,06	71,98	71,98	138,74
Kimguard 1step, KC 300, 101x101	0,00	3,85	83,90	83,90	94,21
Kimguard 1step, KC 200, 121x121	0,00	27,51	41,08	41,08	312,44
Kimguard 1step, KC 300, 76x76	0,00	2,43	76,91	76,91	90,28
Concentraat D294	0,00	123,13	4,13	4,13	286,72
Bicart 720 gr.	0,00	37,55	22,79	22,79	147,71
Concentraat D292	0,00	17,61	6,68	6,68	87,76
Concentraat D296	0,00	5,60	6,68	6,68	88,49
					2372,72

Table VII.9: Holding costs for all the products in scenario 1

In this scenario is remarkable to see the huge decrease in the holding costs for all the products. (See Table VI.20 in the current situation).

A.1.2. COSTS WITHIN JAN DE RIJK

We have to distinguish three kind of different costs within Jan de Rijk.

Firstly, the costs regarding storage and handling time within the company. Secondly, the costs related with periodic shipments to the hospital (transport costs) and lastly the replenishments into the departments.

A.1.2.1. Costs within the company

A.1.2.1.1. Toilet paper

	items per pallet	Safety stock	Frequency	nº of boxes	nº of pallets	Cost per pallet and year	Cost [euros]
Inbound	28,00	7,00	12,00	71,00	3,00	3,00	108,00
Outbound			48,00	23,00	1,00	5,00	240,00
Storage			12,00	42,50	2,00	55,00	110,00
Total							458,00

Table VII.10: Costs for the storage of Toilet paper in Jan de Rijk

In this scenario we could consider many other possibilities. We have assumed here than the supplier delivers to Jan de Rijk once per month, as in the current situation, because in this case is the only one where we can be

objective, since we do not know the transport cost in the supplier's side. In this case it is not needed because it is exactly the same as in the current situation: In the current situation it is Franciscus Ziekenhuis the one supplied and in this scenario it is Jan de Rijk, but in both cases they are supplied once per month and the distance from the supplier to Jan de Rijk or the hospital only differs 5 km, which can be neglected for the result of this project.

We have done it like this, to be able to compare the results easier, but in further analysis we modify the number of inbounds in Jan de Rijk to open new ways of investigation.

Before going deep in the different values of the table we should explain the meaning of Inbound and Outbound:

- In the inbound are included: unload the truck from the supplier, check the quantities, visual verification of the pallet, transport from the truck to the expedition floor, label the pallet and transport from the expedition floor to the pallet location
- In the outbound are included: the order picking plus the outbound that consists in the same process as in the inbound but the final step is to load the pallets into the truck to go to Franciscus Ziekenhuis

The criteria for choosing the different values represented in the table are:

- The safety stock in Jan de Rijk is calculated following the next formula:

$$SS = k * \sigma(weekly.consumption) * n$$

  Where,
  k= security factor to procure as less shortages as possible (for all the products, in this case, equals 1 unless for the dialysis products that is equal to 2)
  n= number of weeks between replenishments from the supplier to Jan de Rijk, in this situation equals 4 weeks.

- The inbound contains enough boxes to cover the consumption of the hospital for one month
- The outbound size equals the quantity Jan de Rijk has to transport to the hospital weekly. So, includes the weekly consumption from the hospital plus the safety stock in the departments in the hospital, in case it has to be replenished. In this example of toilet paper the security stock transported is assessed considering the number of expected stock outs per replenishment, which is 0,09. Jan the Rijk does the replenishments once per week and carry one extra security box more in case the safety stock in the departments of the hospital has to be recovered
- The frequencies are established in the basis of this scenario
- In the storage is assumed the half of the inbound, because along the month, the stock will decrease due to the replenishments to the hospital, so it is

considered that the average of products stored are the half of one month's consumption

- The number of pallets is the number of boxes divided by the items per pallet and rounding up the result
- Finally the costs are the result of multiplying the number of pallets by the cost per pallet and year

A.1.2.1.2. All the products

In order to calculate the costs that imply storing the products in Jan de Rijk, we have grouped the products by supplier because in the inbound of these products we can assume that they are transported in the same pallet and they can also be stored together.

In the following tables, we show the results:

- WC toilet paper & Kleenex Ultra 2LGS (Supplier: Bunzl)

	items per pallet	Safety stock	Frequency	nº of boxes	nº of pallets	Cost per pallet and year	Cost [euros]
Inbound	28,00	16,00	12,00	116,00	5,00	3,00	180,00
Outbound			48,00	29,00	2,00	5,00	480,00
Storage			12,00	74,00	3,00	55,00	165,00
Total							825,00

Table VII.11: Storage in Jan de Rijk of the products coming from Bunzl

The number of pallets is calculated with the number of items per pallet and considering that the two products can be mixed in the same pallet.

The costs per pallet and year are predetermined information from Jan de Rijk (See Appendix E)

- Tena Bed & Tena Bed Green (Supplier: SCA)

	items per pallet	Safety stock	Frequency	nº of boxes	nº of pallets	Cost per pallet and year	Cost [euros]
Inbound	**28,00**	**6,00**	**12,00**	**52,00**	**2,00**	**3,00**	**72,00**
Outbound			**48,00**	**13,00**	**1,00**	**5,00**	**240,00**
Storage			**12,00**	**32,00**	**2,00**	**55,00**	**110,00**
Total							**422,00**

Table VII.12: Storage in Jan de Rijk of the products coming from SCA

- Sterile products (Supplier: Kimberly-Clark)

	items per pallet	Safety stock	Frequency	nº of boxes	nº of pallets	Cost per pallet and year	Cost [euros]
Inbound	15,00	28,00	12,00	128,00	9,00	3,00	324,00
Outbound	15,00		48,00	32,00	3,00	5,00	720,00
Storage	30,00		12,00	92,00	7,00	55,00	385,00
Total							1429,00

Table VII.13: Storage in Jan de Rijk of the products coming from Kimberly-Clark

– Dialysis products (Supplier: Gambro)

	items per pallet	Safety stock	Frequency	nº of boxes	nº of pallets	Cost per pallet and year	Cost [euros]
Inbound	60,00	263,00	12,00	485,00	9,00	3,00	324,00
Outbound			48,00	120,00	2,00	5,00	480,00
Storage			12,00	505,50	9,00	55,00	495,00
Total							1299,00

Table VII.14: Storage in Jan de Rijk of the products coming from Gambro

So, the total price due to the storage in Jan de Rijk is:

Total cost [euros]	3975,00

A.1.2.2. Replenishments into the departments' costs

A.1.2.2.1. Toilet paper

As information from Jan de Rijk we now that the price for delivering into the departments represents 1euro/min.

We have also to determine for this scenario the handling costs, which are forecasted by using the same criteria as the explained in the assumptions, section 2.2.4 of chapter V.

Product	Percentage of the total handling	Time for unloading the truck per month	Time for handling: replenishing per week (hours)	handling time per year and unit	Average Consumption per year (boxes)
WC paper tissues	0,35	0,00	0,35	0,02	768,00
Kleenex	0,20	0,00	0,20	0,01	852,00
Tena Bed	0,30	0,00	0,30	0,04	396,00
Tena Bed Green	0,15	0,00	0,15	0,07	108,00
Kimguard one-step KC 300 (101x101)	0,14	0,00	0,05	0,54	4,00
Kimguard one-step KC 200	0,82	0,00	0,27	0,16	83,00
Kimguard one-step KC 300 (76x76)	0,04	0,00	0,01	0,08	8,00
Concentraat D 294	0,69	0,00	0,69	0,40	83,00
Bicart 720 gr.	0,16	0,00	0,16	0,15	51,00
Concentraat D 292	0,11	0,00	0,11	0,15	38,00
Concentraat D 296	0,03	0,00	0,03	0,15	11,00

Table VII.15: Handling costs for all the products in scenario 1 by Jan de Rijk

Therefore, the replenishments' costs into the departments by Jan de Rijk for the Toilet paper are:

	handling time per week [hours]	handling time per year [hours]	Cost per minut [euros]	Cost per year [euros]
Replenishments into departments by Jan de Rijk	0,35	16,80	1,00	1008,00

Table VII.16: Replenishments' costs into depts. of Toilet paper by Jan de Rijk

Just, as complementary information, we enclose as follows, the impact that it would be for the hospital if the replenishments would be done by the employees of the hospital. Although in this scenario it does not make sense, because the carriers from Jan de Rijk have to come back to the company with the products left. Otherwise, the stock left would be stored in the hospital, increasing the volume occupied, and ruining the basis of this scenario.

	handling time per week [hours]	handling time per year [hours]	Cost per minut [euros]	Cost per year [euros]
Replenishments into departments by Franciscus Ziekenhuis	0,35	16,80	0,35	349,10

Table VII.17: Replenishments' costs into depts. of Toilet paper by Franciscus Ziekenhuis

Also this result of in Table VII.19, is useful to be able to analyze the results by Jan de Rijk in a more critical way.

A.1.2.2.2. All the products

For this calculation is important to assess the handling time spent by Jan de Rijk for replenishing each product to each department. These handling times are specified in Table VII.17.

	handling time per week [hours]	handling time per year [hours]	Cost per minut [euros]	Cost per year [euros]
Replenishments into departments by Jan de Rijk	1,42	68,00	1,00	4080,00

Table VII.18: Replenishments' costs into depts. of all the products by Jan de Rijk

A.1.2.3. Shortages costs in Jan de Rijk

	lead time	SS	Reorder point	Lead time demand	σLead time demand	sq(σ)lead time demand	α	β	1-P1	ESPRC
WC toilet paper	6,00	7,00	20,00	12,14	1,62	2,63	56,03	0,22	0,00	0,00
Kleenex tissues	14,00	9,00	26,00	16,39	2,23	4,99	53,81	0,30	0,00	0,00
Onderlegger Tena Bed	4,00	3,00	5,00	1,03	0,60	0,36	2,92	0,35	0,00	0,00
Onderlegger Tena Bed Green	4,00	3,00	8,00	4,71	0,52	0,27	81,82	0,06	0,00	0,00
Sterile 1	9,00	3,00	4,00	0,57	0,62	0,38	0,86	0,66	0,00	0,00
Sterile 2	3,00	23,00	32,00	9,00	5,50	30,30	2,67	3,37	0,00	0,01
Sterile 3	3,00	2,00	3,00	0,25	0,48	0,23	0,26	0,93	0,00	0,00
Dialysis 1	3,00	173,00	184,00	10,57	21,53	463,64	0,24	43,86	0,00	0,05
Dialysis 2	2,00	58,00	61,00	2,57	7,14	50,93	0,13	19,81	0,00	0,03
Dialysis 3	2,00	23,00	25,00	1,86	2,78	7,72	0,45	4,16	0,00	0,00
Dialysis 4	2,00	9,00	10,00	0,64	1,03	1,05	0,39	1,64	0,00	0,00

Table VII.19: Expected shortage per replenishment cycle's (ESPRC) calculations

The first step in order to calculate the shortage costs in Jan de Rijk is to assess the amount of safety stock (SS) by means of the next formula:

$$SS = k * \sigma(weekly.consumption) * n$$

Where,

k= security factor to procure as less shortages as possible. For all the products, in this case, equals 1 unless for the dialysis products that is equal to 2

n= number of weeks between replenishments from the supplier to Jan de Rijk, in this situation equals 4 weeks

For the calculation of the ESPRC see section 2.3 in Annex C.

	Expected shortage per replenishment cycle	Cost perunit short	Number of cycles per year	Expected annual shortage cost
WC paper tissues	0,00	6,51	12,00	0,00
Kleenex	0,00	6,22	12,00	0,01
Tena Bed	0,00	6,58	12,00	0,00
Tena Bed Green	0,00	10,39	12,00	0,00
Kimguard 1step, KC 300, 101x101	0,00	12,61	12,00	0,16
Kimguard 1step, KC 200, 121x121	0,01	6,93	12,00	0,83
Kimguard 1step, KC 300, 76x76	0,00	9,73	12,00	0,39
Concentraat D294	0,05	1,65	12,00	0,90
Bicart 720 gr.	0,03	2,54	12,00	0,98
Concentraat D292	0,00	2,49	12,00	0,05
Concentraat D296	0,00	4,77	12,00	0,03
Total cost				3,35

The cost per unit short equals to the cost per unit short in the Cw in the current situation. For the sterile and dialysis products which do not have any stock in the Cw in the current situation it has been taken the half of the departments' storage cost.

Table VII.20: Shortage costs in Jan de Rijk

We can observe in this table how small are the shortage costs within Jan de Rijk since it is stored a big amount of SS.

A.1.2.4. Transport costs

A.1.2.3.1. WC toilet paper

At the beginning of Chapter VI, we have mentioned that these transport costs could contain a part of subjective information and we see an example in section A.2.1 of this chapter.

However, in this scenario these transports costs are quite precise and it can be add to the total costs. As follows we explain why this phenomenon occurs.

Why are we saying that this section could contain much subjective information?

Because, the transport cost always have a value due to the fuel and the time spent in the shipment but we cannot know the mentioned cost from the supplier's side since it is included in the value of the product and this cost depends on many aspects that we cannot measure:

- The load of the truck: it is not the same price if the truck is full or if it is carrying only one box
- The tour the truck has to do. It is not the same price if it has to do more shipments close to Franciscus Ziekenhuis or it has to go on purpose
- The transport cost is included in the value of the product and we cannot know the proportion because it is a percentage of the price agreed between the purchasing area of the hospital and the supplier

Why are we worried about this information?

Because, it is not fear to add to the total cost the transport costs from Jan de Rijk to Franciscus Ziekenhuis and any cost from the supplier: it should be a difference in the case the supplier delivers once per month (current situation) and the cases studied later where it delivers just twice per year to Jan de Rijk.

Looking for a solution of this situation, in section A.2.1, we consider different possibilities of transport costs and then we chose the most realistic one.

This subjective information is the reason why we have started the analysis with a situation, where, even if the products are stored in Jan de Rijk, the replenishment periods are the same as in the current situation and consequently we do not have to consider the transport costs from the supplier because this scenario do not represent any difference neither for the supplier's effort (delivers once per month to the hospital or once per month to Jan de Rijk) ,

nor to the money spent in transportation (there are only 5km from Franciscus Ziekenhuis to Jan de Rijk).

After, all this explanation we can conclude than in this situation we have only to consider the costs of transportation from Jan de Rijk to Franciscus Ziekenhuis, which are shown in the next table: (See Annex F for the prices within Jan de Rijk)

	Number of pallets	Transport rate per shipment	Frequency per year	Transport cost per year [euros]
Shipments to the hospital	1,00	30,00	48,00	1440,00

Table VII.21: Transport costs per year due to the shipments of Toilet paper from Jan de Rijk to Franciscus hospital

Nevertheless, an important observation has to be done:

This result it is not realistic because this is the price to carry in the truck only 1 pallet of one product. As we see, as follows, this cost does not have that much impact when the truck carries all the products together.

A.1.2.3.2. All the products

The transport cost is determined by the number of pallets transported and the frequency. The transport rate per shipment is specified in Annex F and the number of pallets is the sum of the outbound of all the products in the tables above.

	Number of pallets	Transport rate per shipment	Frequency per year	Transport cost per year [euros]
Shipments to the hospital	20,00	104,00	48,00	4992,00

Table VII.22: Transport costs per year due to the shipments of all the products from Jan de Rijk to Franciscus hospital

A.1.3. COMPARISON OF RESULTS WITH THE CURRENT SITUATION

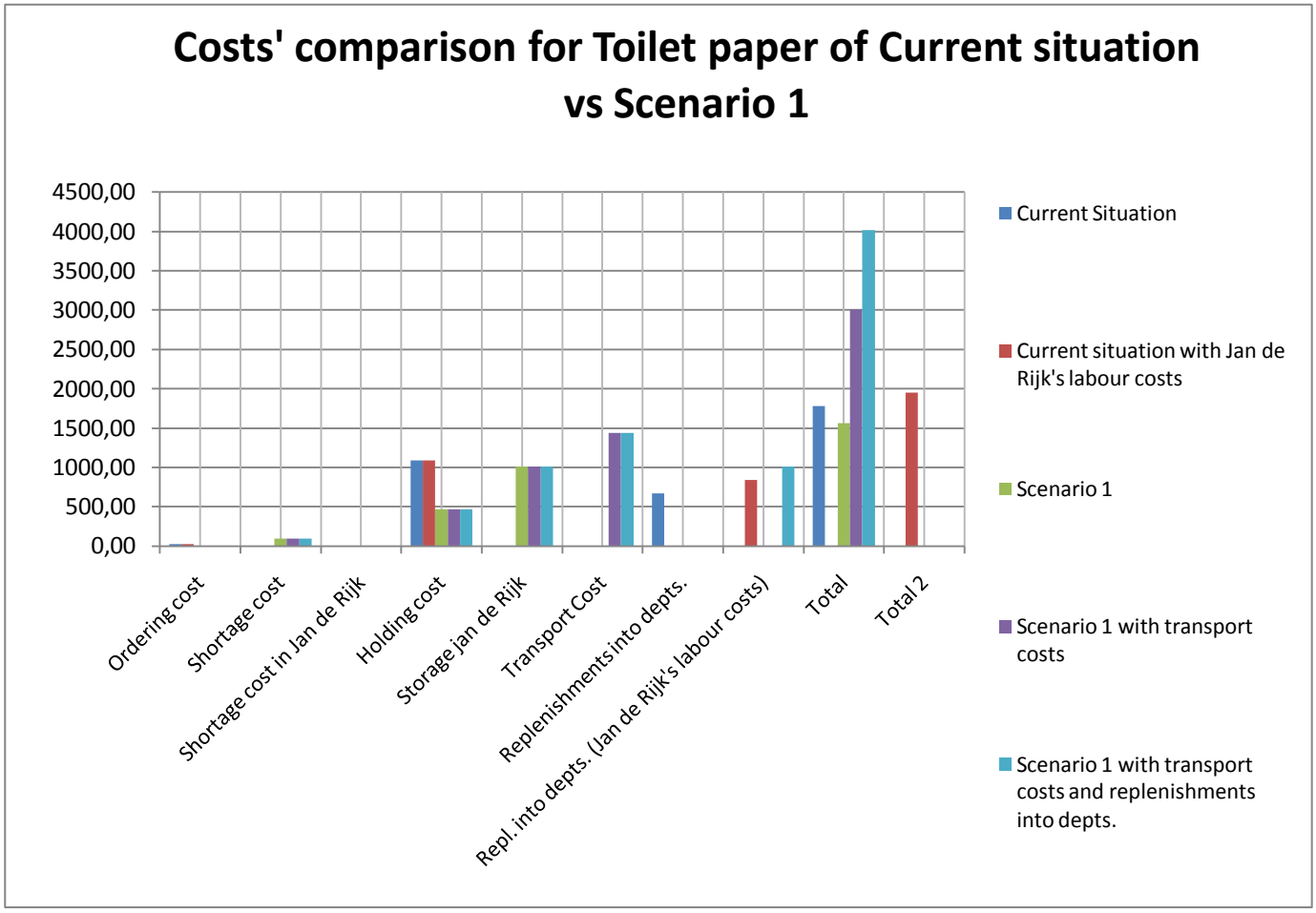
To compare the results obtained in the current situation and in this first scenario we do it by using graphs since we think it is more understandable in a visual way.

A.1.3.1 Independent products

We show first the graphs of the comparison with one of the products: WC toilet paper, since it is interesting to see how the prices decrease when the costs of this scenario 1 are applied for more products being quite obvious the economies of scale.

A.1.3.1.1. WC Toilet paper

In the next figure the total costs are compared. The light blue column represents the total costs in this new scenario adding the cost of replenishing into departments and the transport costs.



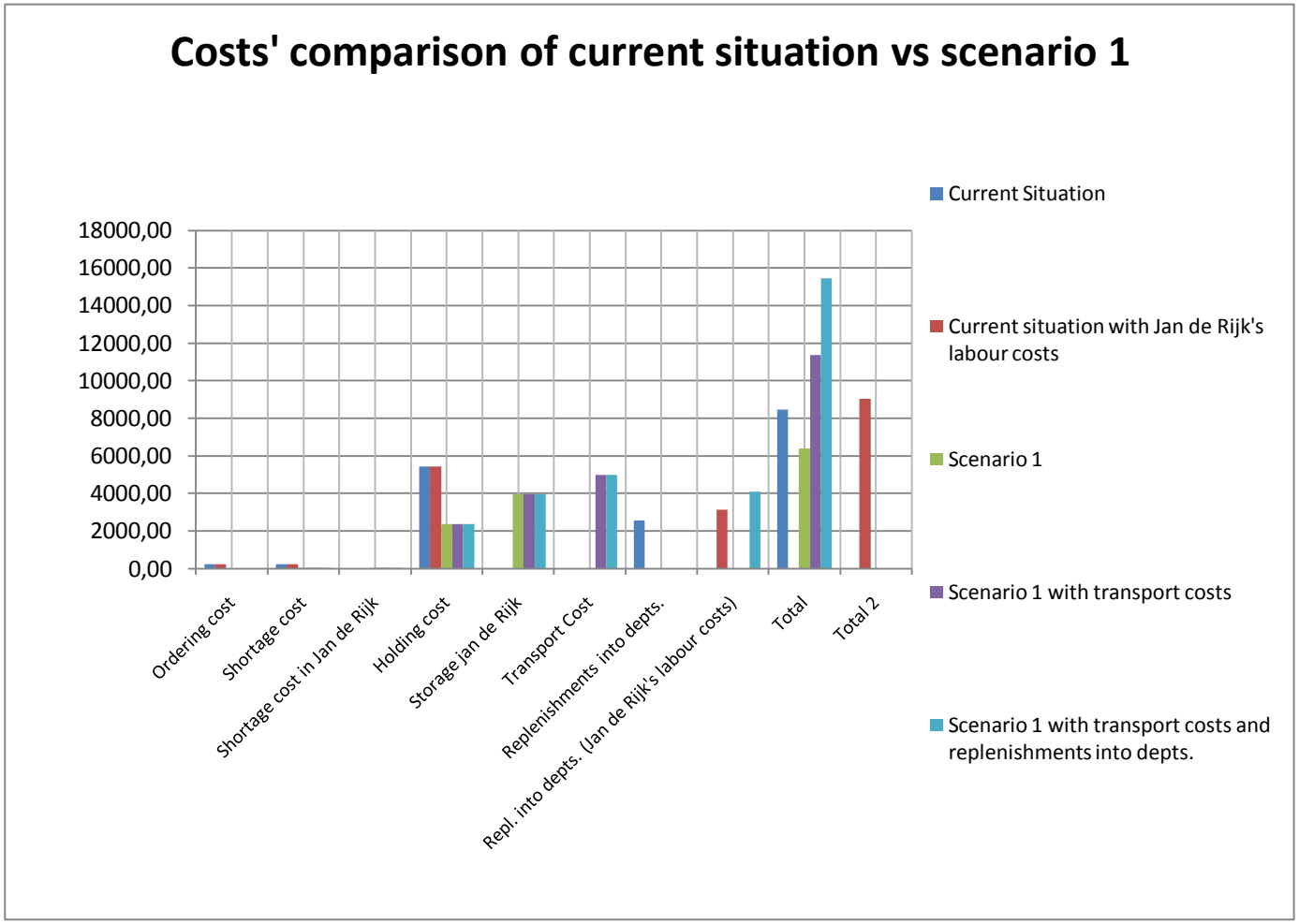
Graph VII.1: Total costs for toilet paper in the current situation and in scenario 1

As, we can observe the total cost in this scenario 1 is quite higher in comparison with the current situation. This is due to:

- In the scenario1 the inventory costs are lower but, although the handling times required are also lower the cost per hour in the case of the carrier from Jan de Rijk is much higher than the hospital employee's cost per hour.
- Furthermore, if we add the transport costs of only carrying this product the total cost increase a lot. By the way, as I mentioned before, it is not realistic to add this transport cost, because in this case, it is considered that the truck of Jan de Rijk is carrying only this product.

A.1.3.2. All the products in global

In this situation we can have a clearer picture of the impact of this scenario 1 with many products involved.



Graph VII.2: Total costs for all the products in the current situation and in scenario 1

In this we can observe how the economies of scale affect to the costs, comparing this graph with graph VII.1. Moreover, we can add the next observations:

- All the costs regarding storage are lower in Scenario 1

- Adding transport costs we can observe that even if the total costs are higher in scenario 1, they have decreased considerably in respect to the case of carrying only one product see Graph VII.1.
- The replenishments into departments by Jan de Rijk represents also a higher total cost than in the current situation

But, we would like also to mention the non economical benefits due to this scenario 1:

- No stock in the central warehouse
- Less safety stock required since the frequencies of replenishments are higher
- Less volume occupied due to this decrease in the stock
- No responsibility for the hospitals' employees for the replenishing of the products. Jan de Rijk is the responsible one. So, the handling times within the hospital drop radically.

A.2. SCENARIO 2: UNKNOWN INVENTORY LEVEL; JAN DE RIJK RECEIVES PRODUCTS FROM SUPPLIER TWICE PER YEAR AND DELIVERS INTO THE DEPARTMENTS ONCE PER WEEK

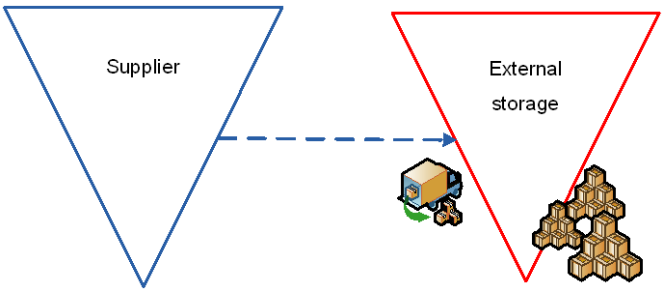


Figure VII.3: Representation of the change in the number of deliveries per year from the supplier to Jan de Rijk

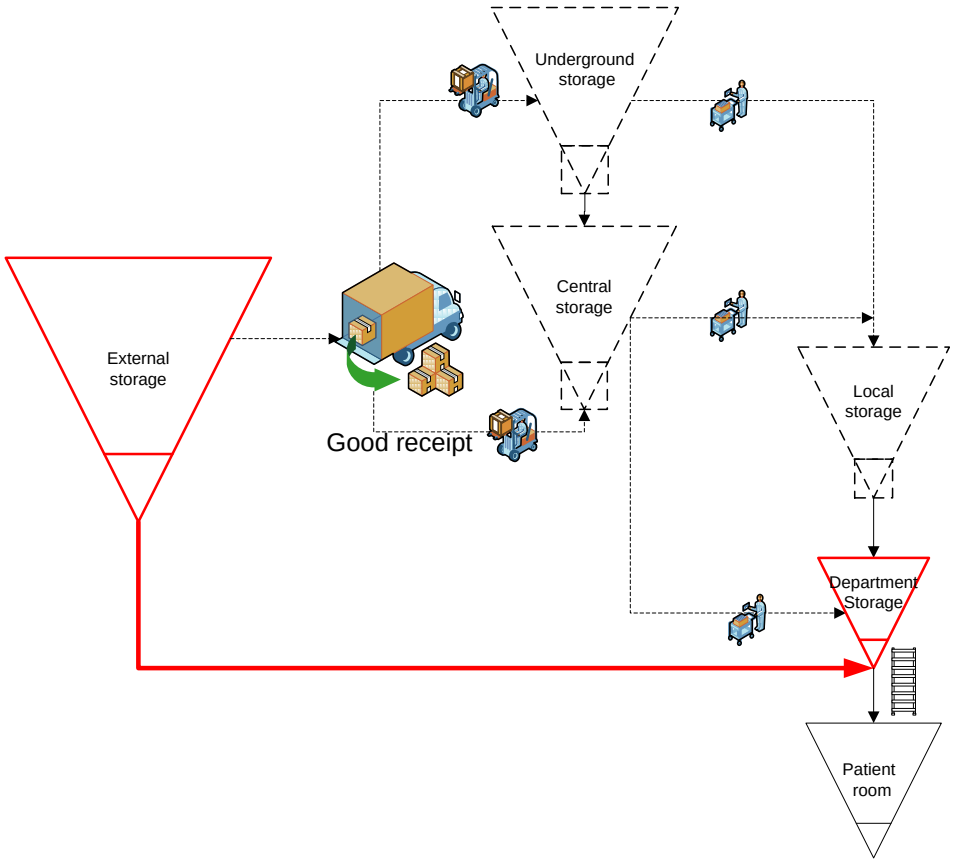


Figure VII.4: Schema of the distribution of material flows within the hospital in scenario 2

The goal of this scenario is to analyze how the total costs changes after modifying the frequency the supplier delivers products to Jan de Rijk.

This idea is based on the fact that the storage in Jan de Rijk is cheaper than in the hospital. So, a bigger amount of products can be stored there reducing the transportation costs from the supplier to Jan the Rijk.

As we mentioned earlier it is hard to assess this costs reduction in transportation from the supplier's side. So, in this chapter we predict the possible wideness of the effect of this scenario.

- ***Assumptions***:

- All the assumptions made for scenario 1 are also valid for this scenario since the methodology of replenishments established within the hospital does not change (see section A.1 of this chapter). Therefore, the quantities of replenishment and safety stocks are also invariable for this scenario in reference with scenario 1
- Within Jan de Rijk, it changes the frequency of inbounds: twice per year
- Since Jan de Rijk is only supplied twice per year the amount of products stored is much bigger
- The safety stock in Jan de Rijk also increases because it has to cover the deviation of the consumption during the period between deliveries in Jan de Rijk from the supplier. That is why; the safety stock in Jan de Rijk is calculated as:
  $k \cdot \sigma$(6 months consumption); where, k is the safety factor that in this situation can be neglected since the SS is big enough in order to do not have shortages

The first consequence of this scenario is that the value of the product change since a percentage of this value is due to transportation costs from the supplier's side and these costs should decrease.

That is why in the next section we try to assess the effect this scenario will have in the price of the product.

A.2.1. THE REPERCUSSION OF THE TRANSPORT COSTS IN THE VALUE OF THE PRODUCT

As we mentioned in some occasions earlier, how are we going to assess the transportation costs if they are a part of the price of the product?

The methodology tries to approach the reality basing the calculations in the differences between the benefits in the transportation costs' in this scenario regarding the current situation.

To be aware of the mentioned differences, we classify them in the next table:

Supplier	*Products*	*Nº of pallets in the current situation*	*Frequency per year*	*Nº of pallets in the scenario 2*	*Frequency per year*	*Distance to the hospital*	*Distance to Jan de Rijk*
Bunzl	*Toilet paper & Kleenex*	*6*	*12*	*53*	*2*	*109*	*115*
SCA	*Tena Bed & Tena Bed Green*	*2*	*12*	*12*	*2*	*109*	*98*
Kimberly & Clark	*Sterile products*	*12*	*12*	*48*	*2*	*77,30*	*69,8*
Gambro	*Dialysis products*	*9*	*12*	*50*	*2*	*33*	*25,8*

Figure VII.5: Suppliers and their deliveries in the current situation and in scenario 2

Since, the prices of carrying the products depend directly on the load of the truck and we have the rate shipments in the case of Jan de Rijk carrying pallets to the hospital (see Annex F) and we also know all the distances between the main parts in this scenario. We can calculate the rate shipment from each supplier to Jan de Rijk by using the next formula:

$$(\text{Rate shipment by Jan de Rijk: from the company to Franciscus Ziekenhuis}) \cdot \frac{(\text{km from supplier to Jan de Rijk})}{(\text{km from Jan de Rijk to the hospital})}$$

This calculation is done for each supplier to obtain all the rates for every number of pallets carried. Doing this, we obtain lists for each supplier which we show in the Annex G to simplify reading this report.

The next tables contain the differences in the transport cost in both scenarios, in the current situation and in scenario 2 after considering the load of the truck and the different distances.

Supplier	Current situation						
Bunzl	nº of pallets	rate shipment (€)	frequency	distance (km)	transport cost (€)	items per pallet	cost per item (€)
	6,00	1170,74	12,00	109,00	14048,89	28,00	6,97

Supplier	Scenario 2						
Bunzl	nº of pallets	rate shipment (€)	frequency	distance (km)	transport cost (€)	items per pallet	cost per item (€)
1st truck	27,00	2662,04	2,00	115,00	5324,07	28,00	4,81
2nd truck	26,00	2662,04	2,00		5324,07		
total					10648,15		

Table VII.23: Repercussion of scenario 2 in the cost per item for Bunzl

Looking at the *Figure VII.5*, we can see that Bunzl supplies toilet paper and Kleenex tissues. And after calculations we can realize that the difference in the total cost per unit per year is remarkable: 6,97 vs 4,81euros.

We would like to remind that the rate shipments takes in account the load of the truck and the distance, so multiplying this value by the frequency per year we obtain the total cost per year. To obtain the cost per unit we have just divided the total cost by the total of boxes carried per year, considering that all the pallets are full. This assumption is not important since we have done the same in the both cases are compared.

We do the same procedure with the rest of suppliers and we present the results as follows:

Supplier	Current situation						
SCA	nº of pallets	rate shipment (€)	frequency	distance (km)	transport cost (€)	items per pallet	cost per item (€)
	2,00	666,11	12,00	109,00	7993,33	28,00	11,89

Supplier	Scenario 2						
SCA	nº of pallets	rate shipment (€)	frequency	distance (km)	transport cost (€)	items per pallet	cost per item (€)
	12,00	1415,56	2,00	98,00	2831,11	28,00	4,21

Table VII.24: Repercussion of scenario 2 in the cost per item for SCA

Supplier	Current situation						
Kimberly-Clark	nº of pallets	rate shipment (€)	frequency	distance (km)	transport cost (€)	items per pallet	cost per item (€)
	12,00	1574,44	12,00	77,30	18893,33	16,00	8,20

Supplier	Scenario 2						
Kimberly-Clark	nº of pallets	rate shipment (€)	frequency	distance (km)	transport cost (€)	items per pallet	cost per item (€)
1st truck	25,00	1551,11	2,00	69,80	3102,22	16,00	3,88
2nd truck	25,00	1551,11	2,00		3102,22	16,00	
total					6204,44		

Table VII.25: Repercussion of scenario 2 in the cost per item for Kimberly-Clark

In this case, the sterile products' sizes are not the same. Thus, two of them can fit 15 boxes in a pallet and from the other one can fit 30 in a pallet. In this situation we do a weighted sum and the result is 16 boxes per pallet.

Supplier	Current situation						
Gambro	nº of pallets	rate shipment (€)	frequency	distance (km)	transport cost (€)	items per pallet	cost per item (€)
	9,00	409,44	12,00	33,00	4913,33	60,00	9,10

Supplier	Scenario 2						
Gambro	nº of pallets	rate shipment (€)	frequency	distance (km)	transport cost (€)	items per pallet	cost per item (€)
1st truck	25,00	573,33	2,00	25,80	1146,67	16,00	1,43
2nd truck	25,00	573,33	2,00		1146,67	16,00	
total					2293,33		

Table VII.26: Repercussion of scenario 2 in the cost per item for Gambro

We can observe in this case that the cost per item in the current situation is not that expensive because Gambro is closer to the hospital or to the company than other suppliers.

Once calculated the impact that this scenario would have in the transportation costs of the supplier. The next step is to predict the discount that the suppliers would do per product in this scenario.

But first we have to discover the percentage of the product corresponding to transport costs in the current situation. To do this, we do the next assumption:

- We consider that the percentage of the value of the product corresponding to transport costs has been calculated considering the cost of one shipment with the truck completely full of the product we are considering. Thus, in the case of toilet paper and Kleenex Ultra for example, the percentage would be calculated as follows:

Supplier	Current situation				
Bunzl	nº of pallets	rate shipment (€)	transport cost (€)	items per pallet	cost per item (€)
	26,00	2523,15	2523,15	28,00	3,47

Table VII.27: Calculation of the cost per item in the case the truck carries the max. load

So, the cost of transporting paper toilet and Kleenex tissues is 3,47 euros per box. This represents a 13,4% of toilet paper's cost and a 13,2 % of Kleenex tissues' cost.

Doing the same for all the suppliers and all the products, we find out the percentage corresponding transport costs for each product.

Within this percentage already calculated we have to calculate the discount per box in this new scenario. And it is calculated as follows:

$$c_{cs} \cdot (1 - d) = c_{s2}$$

Where,

c_{cs} : transport cost per item in the current situation

d : Discount

c_{s2} : transport cost per item in scenario 2

With this discount, d, we calculate the new value per box for each product as:

$$new_value = old_value \cdot (1 - tc \cdot d)$$

Where,

tc : Percentage of the product's price corresponding to transport costs

Applying these formulas, the new values of the products in this scenario are shown in the table VII.28.

	Old value per box (€)	tc	d	New value per box (€)
WC toilet paper	25,81	0,134	0,31	24,74
Kleenex Ultra 2LGS	26,17	0,132	0,31	25,10
Tena Bed	16,20	0,214	0,65	13,96
Tena Bed Green	45,78	0,076	0,65	43,54
Kimguard 1step, KC 300, 101x101	83,90	0,051	0,53	81,63
Kimguard 1step, KC 200, 121x121	41,08	0,105	0,53	38,81
Kimguard 1step, KC 300, 76x76	76,91	0,056	0,53	74,64
Concentraat D294	4,13	0,119	0,84	3,72
Bicart 720 gr.	22,79	0,021	0,84	22,38
Concentraat D292	6,68	0,073	0,84	6,27
Concentraat D296	6,68	0,073	0,84	6,27

Table VII.28: New value per box in scenario 2

With these new values per box we can calculate all the costs for this scenario.

A.2.2. COSTS WITHIN THE HOSPITAL

The intermediate tables remain constant.

A.2.2.1. Ordering cost

The ordering costs remain as in scenario 1.

A.2.2.2. Shortage cost

The shortage costs remain as in scenario 1.

A.2.2.3. Handling cost

It remains equal as in scenario 1.

A.2.2.4. Holding costs

	Average inventory on-hand in Cw (boxes)	Average inventory on-hand in all the departments (boxes)	Net price per unit	v (unit variable cost)	Holding cost
WC toilet paper	0,00	12,87	25,81	24,74	465,30
Kleenex Ultra 2LGS	0,00	12,20	26,17	25,10	29,88
Tena Bed	0,00	5,81	16,20	13,96	327,29
Tena Bed Green	0,00	3,06	71,98	43,54	17,55
Kimguard 1step, KC 300, 101x101	0,00	3,85	83,90	81,72	93,62
Kimguard 1step, KC 200, 121x121	0,00	27,51	41,08	38,90	308,23
Kimguard 1step, KC 300, 76x76	0,00	2,43	76,91	74,73	89,90
Concentraat D294	0,00	123,13	4,13	3,72	199,47
Bicart 720 gr.	0,00	37,55	22,79	22,38	146,63
Concentraat D292	0,00	17,61	6,68	6,27	87,25
Concentraat D296	0,00	5,60	6,68	6,27	88,33
					1853,47

Table VII.29: Holding costs for all the products in scenario 2

So, the total inventory costs are:

	Ordering cost	Shortage cost	Holding cost	Total cost
WC paper tissues	0,00	1,82	465,30	467,11
Kleenex	0,00	6,21	29,88	36,09
Tena Bed	0,00	0,75	327,29	328,04
Tena Bed Green	0,00	2,39	17,55	19,95
Kimguard 1step, KC 300, 101x101	0,00	1,10	93,62	94,72
Kimguard 1step, KC 200, 121x121	0,00	10,08	308,23	318,31
Kimguard 1step, KC 300, 76x76	0,00	1,28	89,90	91,19
Concentraat D294	0,00	1,38	199,47	200,86
Bicart 720 gr.	0,00	1,46	146,63	148,09
Concentraat D292	0,00	0,14	87,25	87,39
Concentraat D296	0,00	0,55	88,33	88,88
Total cost	0,00	27,16	1853,47	1880,63

Table VII.30: Total costs for all the products in scenario 2

A.2.2.5. Benefit for the hospital because of the price's difference

To the total costs within the hospital we have to add the benefits due to the acquisition of products after applying the discount because of the reduction in the transportation costs. Therefore, in the next table, it appears the difference in costs from the old price to the new one for the total of consumption per year.

Products	Average consumption per year	old price	Old cost	new price	New costs	Benefit in this scenario (€)
WC toilet paper	**731,00**	**25,81**	**18867,11**	**24,74**	**18083,68**	**783,43**
Kleenex Ultra 2LGS	**495,00**	**26,17**	**12954,15**	**25,10**	**12423,65**	**530,50**
Tena Bed	**373,00**	**16,20**	**6042,60**	**13,96**	**5207,71**	**834,89**
Tena Bed Green	**134,00**	**45,78**	**6134,52**	**43,54**	**5834,59**	**299,93**
Kimguard 1step, KC 300, 101x101	**193,00**	**83,90**	**16192,70**	**81,72**	**15771,47**	**421,23**
Kimguard 1step, KC 200, 121x121	**1016,00**	**41,08**	**41737,28**	**38,90**	**39519,82**	**2217,46**
Kimguard 1step, KC 300, 76x76	**86,00**	**76,91**	**6614,26**	**74,73**	**6426,56**	**187,70**
Concentraat D294	**3580,00**	**4,13**	**14785,40**	**3,72**	**13314,16**	**1471,24**
Bicart 720 gr.	**874,00**	**22,79**	**19918,46**	**22,38**	**19559,28**	**359,18**
Concentraat D292	**628,00**	**6,68**	**4195,04**	**6,27**	**3936,96**	**258,08**
Concentraat D296	**109,00**	**6,68**	**728,12**	**6,27**	**683,33**	**44,79**
TOTAL						**7408,44**

Table VII.31: Benefit due to the different cost acquisition of the products in this scenario 2

A.2.3. COSTS WITHIN JAN DE RIJK

A.2.3.1. Costs within the company

As we did for the scenario one, we calculate the costs within Jan de Rijk using the same procedure, but considering that now the quantities of Inbound, outbound and storage are different since the supplier only delivers to Jan de Rijk twice per year.

Thus, the safety stock has been calculated considering the consumption's standard deviation during 6 months, which is the time between replenishments in Jan de Rijk by the supplier.

The outbound quantities remain as in the scenario 1 since the replenishments into the hospital does not change and the inbound quantities equal to the hospital's consumption for 6 months plus the security stock in the departments in the hospital.

Toilet paper & Kleenex

	items per pallet	Safety stock	Frequency	nº of boxes	nº of pallets	Cost per pallet and year	Cost [euros]
Inbound	28,00	93,00	2,00	696,00	25,00	3,00	150,00
Outbound			48,00	29,00	2,00	5,00	480,00
Storage			2,00	441,00	16,00	55,00	880,00
Total							1510,00

Table VII.32: Costs within Jan de Rijk because of the storage of Toilet paper and Kleenex tissues per year

Tena bed & Tena Bed Green

	items per pallet	Safety stock	Frequency	nº of boxes	nº of pallets	Cost per pallet and year	Cost [euros]
Inbound	**28,00**	**28,00**	**2,00**	**312,00**	**12,00**	**3,00**	**72,00**
Outbound			**48,00**	**13,00**	**1,00**	**5,00**	**240,00**
Storage			**2,00**	**184,00**	**7,00**	**55,00**	**385,00**
Total							**697,00**

Table VII.33: Costs within Jan de Rijk because of the storage of Tena Bed and Tena Bed Green per year

Sterile products

	items per pallet	Safety stock	Frequency	nº of boxes	nº of pallets	Cost per pallet and year	Cost [euros]
Inbound	15,00	160,00	2,00	768,00	48,00	3,00	288,00
Outbound	15,00		48,00	32,00	3,00	5,00	720,00
Storage	30,00		2,00	544,00	34,00	55,00	1870,00
Total							2878,00

Table VII.34: Costs within Jan de Rijk because of the storage of sterile products per year

Dialysis products

	items per pallet	Safety stock	Frequency	nº of boxes	nº of pallets	Cost per pallet and year	Cost [euros]
Inbound	60,00	781,00	2,00	2909,00	49,00	3,00	294,00
Outbound			48,00	120,00	2,00	5,00	480,00
Storage			2,00	2235,50	38,00	55,00	2090,00
Total							2864,00

Table VII.35: Costs within Jan de Rijk because of the storage dialysis products per year

The total costs due to the storage in Jan de Rijk are:

Total cost [euros]	7949,00

A.2.3.2. Replenishments into departments

This cost does not change from scenario 1

A.2.3.3. Shortage costs in Jan de Rijk

	lead time	SS	Reorder point	Lead time demand	σLead time demand	sq(σ)lead time demand	G	B	1-P1	ESPRC
WC toilet paper	6,00	39,00	52,00	12,14	1,62	2,63	56,03	0,22	0,00	0,00
Kleenex tissues	14,00	54,00	71,00	16,39	2,23	4,99	53,81	0,30	0,00	0,00
Onderlegger Tena Bed	4,00	15,00	17,00	1,03	0,60	0,36	2,92	0,35	0,00	0,00
Onderlegger Tena Bed Green	4,00	13,00	18,00	4,71	0,52	0,27	81,82	0,06	0,00	0,00
Sterile 1	9,00	15,00	16,00	0,57	0,62	0,38	0,86	0,66	0,00	0,00
Sterile 2	3,00	133,00	142,00	9,00	5,50	30,30	2,67	3,37	0,00	0,00
Sterile 3	3,00	12,00	13,00	0,25	0,48	0,23	0,26	0,93	0,00	0,00
Dialysis 1	3,00	517,00	528,00	10,57	21,53	463,64	0,24	43,86	0,00	0,00
Dialysis 2	2,00	172,00	175,00	2,57	7,14	50,93	0,13	19,81	0,00	0,00
Dialysis 3	2,00	67,00	69,00	1,86	2,78	7,72	0,45	4,16	0,00	0,00
Dialysis 4	2,00	25,00	26,00	0,64	1,03	1,05	0,39	1,64	0,00	0,00

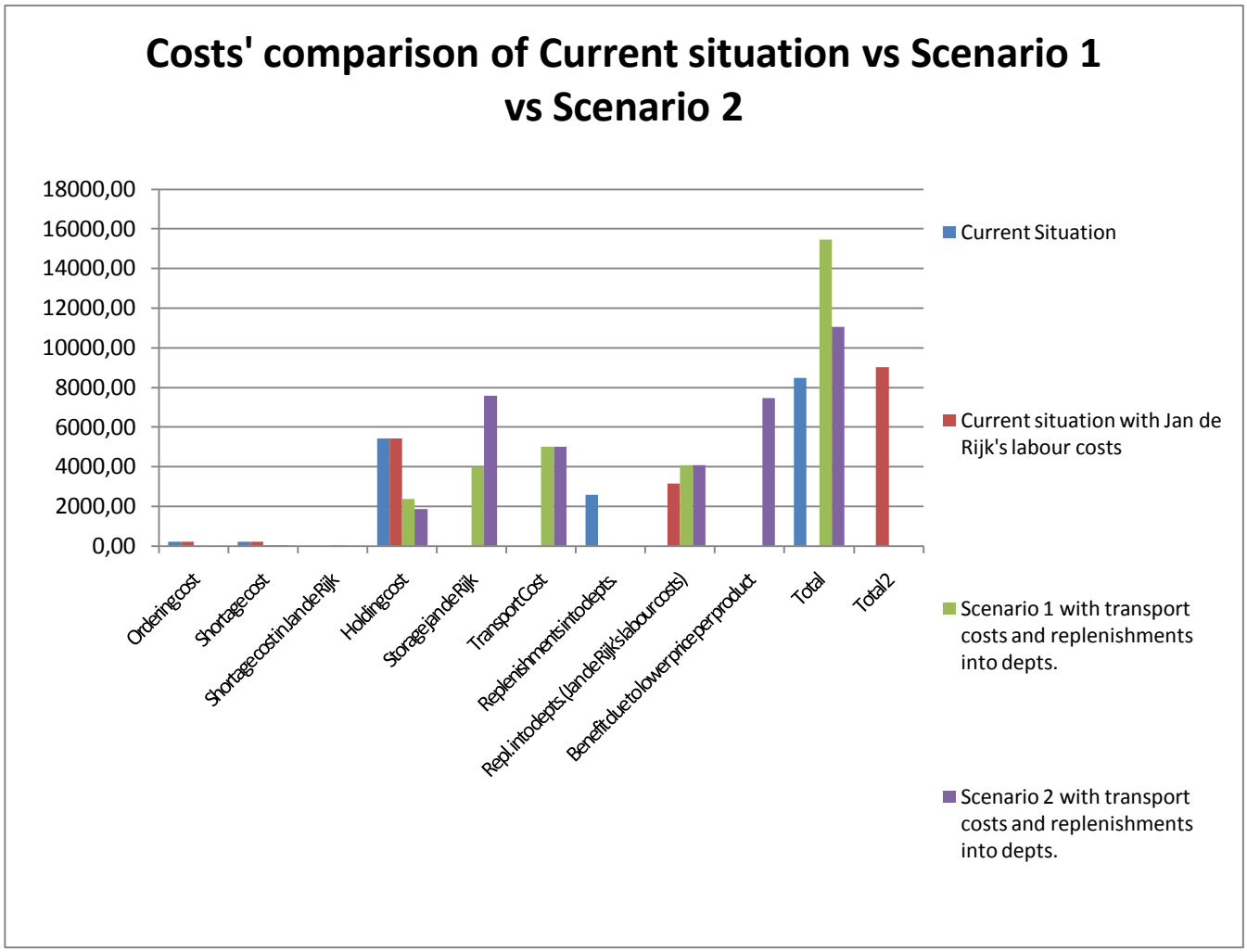
Table VII.36: Expected shortages per replenishment cycle in Jan de Rijk

As we can see in the table VII.36 there is not any shortage within Jan de Rijk because we have calculated the limit SS required to make it possible. So, the shortage costs are zero.

A.2.3.4. Transport costs

This cost does not change from scenario 1, since the delivers into the hospital are also once per week and the quantities are also the same.

A.2.4. COMPARISON OF RESULTS WITH THE CURRENT SITUATION



Graph VII.5: Costs comparison of the current situation, scenario 1 and scenario 2

In this figure we can observe in this scenario 2 a huge reduction in the total costs due to the new price of the product.

We find out that this reduction is enough to compensate the impact of the transport costs but still it is not enough to compensate the replenishments into departments' costs

This scenario, although is cheaper than scenario 1, it is still more expensive than the current situation, since the benefit due to the transport costs' differences cannot compensate all the associated costs of this scenario 2, such as the replenishments into departments.

Nevertheless, I would like to do some observations about the advantages of this scenario 2:

- The fist impact we observed during the analysis is the impact in the price of the products

- As this scenario keeps the assumptions from scenario 1, it also maintains its benefits like:
  - Less volume occupied due to no stock in the central warehouse and less safety stock
  - Less handling time within the hospital due to the responsibility from Jan de Rijk to do all the replenishments from the beginning of the supply chain to the end
- In case, there is urgency in the hospital, Jan de Rijk is located much closer than all the suppliers
- In long term, if more products would be added to this scenario 2, probably the discount from the supplier would increase

B. Known Inventory Level

As we described at the beginning of this chapter the known inventory level represents another node of this arborescence analysis, which brings a big amount of possibilities.

- ***Description***:

All the scenarios within this big group share the idea that Jan de Rijk knows the stock level of the departments before transporting the materials.

The methodology by means of Jan de Rijk knows the stock level is also divided in two categories: the continuous or the periodic review.

In the continuous review, the stock level is always known but it is not needed a permanent surveillance; instead there are tools for its automatic upload to the system. As a matter of fact, nowadays transactions reporting do not need to be computerized; there are many manual stock card systems. Alternatively, there is the point-of-sale data collection system, where we can find the electronic scanners. But, even in this case, the inventory decisions are usually done by computer at closing hours. So, we can consider that the review period is one day.

The benefit of the continuous review is that less safety stock is required, since the system detects automatically when the stock level is under the reorder point. The disadvantage is that it is a quite expensive system and that there are many errors, especially when there are many transactions at the same time (Silver, Pyke, & Peterson, 1998).

If we would implement this system in Franciscus Ziekenhuis, in the current situation, it would imply a big investment since there are many rooms storing the same products and many transactions at the same time. That is why; in this section we analyze the case of a periodic review system.

B.1. SCENARIO 3: KNOWN INVENTORY LEVEL; DELIVERIES FROM THE SUPPLIER INTO JAN DE RIJK TWICE PER YEAR AND DELIVERIES FROM JAN DE RIJK INTO CENTRAL WAREHOUSE ONCE PER WEEK.

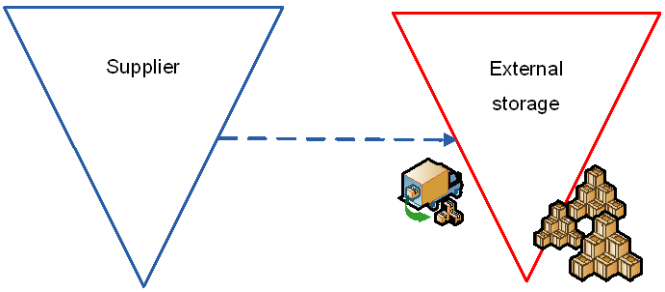


Figure VII.5: Deliveries from the suppler to Jan de Rijk twice per year

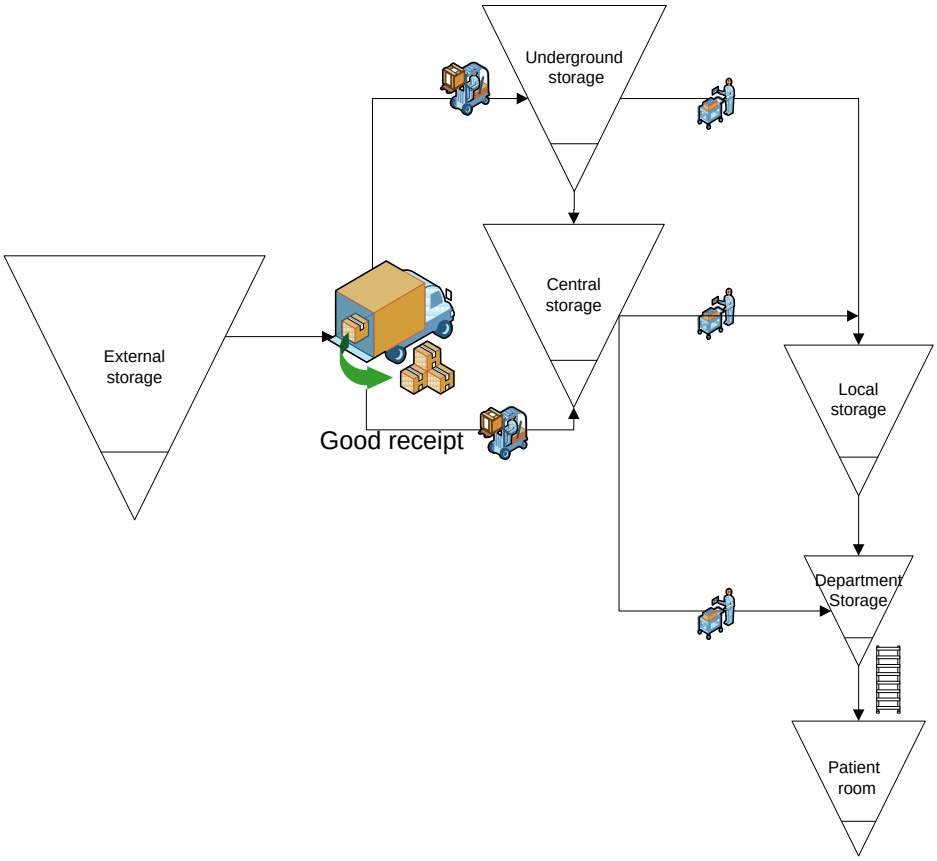


Figure VII.6: Distribution of material flows within the hospital in scenario 3

- ***Assumptions***:

- Since the consumption is quite stable, the review period (R) established is one week
- The model that approaches the reality in the departments is a (R,s,S) system. Each R units of time the stock level is controlled, if it is under the reorder point s, the replenishment has to be enough to replenish until the stock-up-to-level S
- Jan the Rijk makes use of the Vendor Management System (VMS) by means of when the stock level drops the reorder point s, Jan the Rijk delivers the corresponding products to the hospital. Since the reviews in the hospital are once per week. The stock up-to-level established is one week's consumption. In this situation the ordering cost per year is zero, since no orders are needed
- In this scenario, Jan de Rijk delivers into the Central Warehouse and then employees from Franciscus Ziekenhuis deliver the products into departments by use of rolcontainers. Therefore, the handling times have to be recalculated for this new situation.
- The safety stock in the departments is enough to cover the expected shortages per cycle
- Since, the supplier delivers into Jan de Rijk twice per year and it saves a lot of money in transport costs, the discounts due to this situation and calculated in section A.2.1, are also used in this scenario
- The lead time considered is zero: Franciscus Ziekenhuis and Jan de Rijk agree one day of the week for the stock reviewing. A employee from the hospital scan the products in the departments, the mentioned day in the morning, and Jan de Rijk check from their computer the quantities needed doing the replenishment that same day.

B.1.1. COSTS WITHIN THE HOSPITAL

In this scenario, we have to recalculate the handling times within the hospital: the person responsible has to scan the products and distributing them into the departments when Jan de Rijk arrives, using a rolcontainer.

Moreover, we also have to recalculate the safety stock required since the lead time in this situation has changed. The protector interval in this scenario is R+L= 7 + 0 days= 7 days.

On the opposite, we can use the same amounts to carry per replenishment than in scenario 1 and 2 since this analysis is made using average quantities and the consumption is quite regular.

As we did in other occasions, first we show the intermediate table we use later for the different calculations.

B.1.1.1. Intermediate table

	Weekly demand	SS in depts.	Order up-to-level	Volume occupied	Protection interval demand	σprotection interval	sq(σ)protection interval demand	Reorder point s	α	β	1-P1	ESPRC	Qweek
WC toilet paper	**15,17**	**1,78**	**16,96**	**5,87**	**15,17**	**1,62**	**2,63**	**16,96**	**87,55**	**0,17**	**0,137**	**0,12**	**16,00**
Kleenex Ultra 2LGS	**10,06**	**2,46**	**12,52**	**3,17**	**10,06**	**2,23**	**4,99**	**12,52**	**20,26**	**0,50**	**0,137**	**0,19**	**11,00**
Tena Bed	**7,74**	**0,66**	**8,40**	**4,79**	**7,74**	**0,60**	**0,36**	**8,40**	**164,20**	**0,05**	**0,137**	**0,05**	**8,00**
Tena Bed Green	**2,77**	**0,57**	**3,34**	**1,62**	**2,77**	**0,52**	**0,27**	**3,34**	**28,30**	**0,10**	**0,137**	**0,04**	**3,00**
Kimguard 1step, KC 300, 101x101	4,00	1,85	5,85	0,96	4,00	0,62	0,38	5,85	42,24	0,09	0,004	0,00	4,00
Kimguard 1step, KC 200, 121x121	21,00	16,51	37,51	2,88	21,00	5,50	30,30	37,51	14,55	1,44	0,006	0,02	22,00
Kimguard 1step, KC 300, 76x76	1,77	1,43	3,20	0,96	1,77	0,48	0,23	3,20	13,63	0,13	0,006	0,00	2,00
Concentraat D294	74,00	86,13	160,13	2,88	74,00	21,53	463,64	160,13	11,81	6,27	0,001	0,01	74,00
Bicart 720 gr.	18,00	28,55	46,55	0,96	18,00	7,14	50,93	46,55	6,36	2,83	0,002	0,01	18,00
Concentraat D292	13,00	11,11	24,11	0,96	13,00	2,78	7,72	24,11	21,89	0,59	0,001	0,00	13,00
Concentraat D296	2,24	4,10	6,34	0,96	2,24	1,03	1,05	6,34	4,77	0,47	0,002	0,00	3,00

Table VII.37: Intermediate calculations for all the products in scenario 3

To fill the table in we have taken some decisions that we explain as follows:

- The safety stock in the departments is calculated, as in the scenario 1, as k· standard deviation of the protection interval. In this case, the protection interval is one week because of the review period and k is estimated as 3 for all the products except for dialysis products which k equals 4

- The quantity Jan de Rijk carries every week is the order quantity. In this situation it does not carry a safety stock because the employee from Jan de Rijk delivers the quantities in the central warehouse, so, if in each replenishment the quantity supplied would be higher than the amount required the stock in the departments would grow in each period

- With the new safety stocks we recalculate all the volumes, following the same method we used for the first scenario (see section A.1.1): In each department we calculate the quantity stored as the sum of the order quantity plus the safety stock. In the VII.36, above, we calculate the total safety stock, so in auxiliary tables we calculate the weight of the safety stock in each department regarding the consumptions. In this scenario, we do not show the mentioned tables because are exactly the same procedure than in scenario 1

B.1.2. COSTS WITHIN THE HOSPITAL

B.1.2.1. Ordering costs

As we explained in the assumptions of this scenario the ordering costs are zero.

B.1.2.2. Handling costs

Product	Percentage of the total handling	Time for unloading the truck per week	Time for handling: scanning & replenishing (per week)	Handling cost per week (€)	handling cost per year and unit	Average Consumption per year (boxes)
Total 4 products	**1,00**	**0,000**	**0,360**			
WC paper tissues	**0,35**	**0,000**	**0,126**	**2,62**	**0,18**	**768,00**
Kleenex	**0,20**	**0,000**	**0,072**	**1,50**	**0,15**	**528,00**
Tena Bed	**0,30**	**0,000**	**0,108**	**2,24**	**0,30**	**384,00**
Tena Bed Green	**0,15**	**0,000**	**0,054**	**1,12**	**0,41**	**144,00**
Kimguard 1step, KC 300, 101x101	0,14	0,000	0,029	0,61	0,16	192,00
Kimguard 1step, KC 200, 121x121	0,82	0,000	0,179	3,71	0,18	1056,00
Kimguard 1step, KC 300, 76x76	0,04	0,000	0,000	0,00	0,00	96,00
Concentraat D294	0,69	0,00	0,598	12,42	0,18	3552,00
Bicart 720 gr.	0,16	0,00	0,139	2,90	0,17	864,00
Concentraat D292	0,11	0,00	0,100	2,07	0,17	624,00
Concentraat D296	0,03	0,00	0,030	0,62	0,22	144,00

Table VII.38: Handling costs for all the products in scenario 3

All the handling costs are recalculated for this scenario doing the same assumptions as the mentioned ones in section 2.2.4 and 2.2.5 of chapter V. But, we added some more:

- These handling times are based on the handling times for the current situation, see tables in sections 2.2.4 and 2.2.5
- In the current situation the products are unloaded from the trucks once per month and scanned, picked, replenished and ordered once per week. In this scenario, every week the products are only scanned and replenished in each department. So the method used has consisted in taking the part corresponding to the tasks in this scenario from the current situation and divide them by 4 because we assess firstly the costs per week
- We also have to add another discount of time since in the current situation the same product is replenished different days of the week in different departments, so the total time for picking and replenishing is bigger than in this scenario where, the quantities supplied are delivered directly to all the departments. That is why the household and incontinent materials, which are the ones affected by this assumption, are divided by 4

(to convert the time in weeks), then we take the 60% which corresponds to the tasks of scanning and replenishing and then we multiply the result again by a 60% to consider the time saved delivering the products directly to all the departments

- In the case of the sterile and dialysis products we take the time assessed in the current situation, we divide it by 4 and we multiply it by a safety factor of 1,3. We do it like this because these products in the current situation are already delivered in the departments once per month. We multiply by 1,3 to compensate the extra time walking since now the replenishments are once per week

Once we have these handling times we can continue calculating the rest of the costs within the hospital.

B.1.2.3. Shortage cost

	ESPRC	Cost per unit short	Number of cycles per year	Expected annual shortage cost
WC paper tissues	0,00	22,21	48,00	1,82
Kleenex	0,00	25,89	48,00	6,21
Tena Bed	0,00	31,02	48,00	0,75
Tena Bed Green	0,00	52,21	48,00	2,39
Kimguard 1step, KC 300, 101x101	0,00	25,22	48,00	1,10
Kimguard 1step, KC 200, 121x121	0,02	13,85	48,00	10,08
Kimguard 1step, KC 300, 76x76	0,00	19,47	48,00	1,28
Concentraat D294	0,01	3,30	48,00	1,38
Bicart 720 gr.	0,01	5,09	48,00	1,46
Concentraat D292	0,00	4,97	48,00	0,14
Concentraat D296	0,00	9,53	48,00	0,55
				27,16

Table VII.39: Shortage costs for all the products in scenario 3

B.1.2.4. Holding cost

	Average inventory on-hand in Cw (boxes)	Average inventory on-hand in all the departments (boxes)	Net price per unit	v (unit variable cost)	Holding cost
WC toilet paper	0,00	12,87	25,81	24,92	465,46
Kleenex Ultra 2LGS	0,00	12,20	26,17	25,25	331,12
Tena Bed	0,00	5,81	16,20	14,27	327,42
Tena Bed Green	0,00	3,06	71,98	43,95	132,73
Kimguard 1step, KC 300, 101x101	0,00	3,85	83,90	81,88	93,67
Kimguard 1step, KC 200, 121x121	0,00	27,51	41,08	39,08	308,59
Kimguard 1step, KC 300, 76x76	0,00	2,43	76,91	74,73	89,90
Concentraat D294	0,00	123,13	4,13	3,90	284,75
Bicart 720 gr.	0,00	37,55	22,79	22,55	147,09
Concentraat D292	0,00	17,61	6,68	6,44	87,46
Concentraat D296	0,00	5,60	6,68	6,49	88,41
					2356,60

Table VII.40: Holding costs for all the products in scenario3

B.1.2.5. Total inventory costs

	Ordering cost (€)	Shortage Cost (€)	Holding cost (€)	Total costs (€)
WC paper tissues	0,00	1,82	465,46	467,27
Kleenex	0,00	6,21	331,12	337,32
Tena Bed	0,00	0,75	327,42	328,16
Tena Bed Green	0,00	2,39	132,73	135,13
Kimguard 1step, KC 300, 101x101	0,00	1,10	93,67	94,77
Kimguard 1step, KC 200, 121x121	0,00	10,08	308,59	318,67
Kimguard 1step, KC 300, 76x76	0,00	1,28	89,90	91,19
Concentraat D294	0,00	1,38	284,75	286,13
Bicart 720 gr.	0,00	1,46	147,09	148,55
Concentraat D292	0,00	0,14	87,46	87,60
Concentraat D296	0,00	0,55	88,41	88,97
Total costs	0,00	27,16	2356,60	2383,76

Table VII.41: Total costs for all the products in scenario 3

To all these costs we have to add the benefit calculated in scenario 2 due to the transport costs' discount explained in section A.2.1 and which result is shown in Table VII.31.

B.1.3. COSTS WITHIN JAN DE RIJK

B.1.3.1. Costs within the company

What differs in this case from other scenario is that Jan de Rijk only carries per replenishment the order quantity without any safety factor to recover the level of the safety stock from the departments.

The safety stock within the company is kept as in scenario 2 just in case there is urgency in the hospital.

Toilet paper & Kleenex

	items per pallet	Safety stock	Frequency	nº of boxes	nº of pallets	Cost per pallet and year	Cost [euros]
Inbound	28,00	93,00	2,00	648,00	24,00	3,00	144,00
Outbound			48,00	27,00	1,00	5,00	240,00
Storage			2,00	417,00	15,00	55,00	825,00
Total							1209,00

Table VII.42: Costs for the storage of Toilet paper and Kleenex tissues in Jan de Rijk per year in scenario 3

Tena bed & Tena Bed Green

	items per pallet	Safety stock	Frequency	nº of boxes	nº of pallets	Cost per pallet and year	Cost [euros]
Inbound	**28,00**	**28,00**	**2,00**	**264,00**	**10,00**	**3,00**	**60,00**
Outbound			**48,00**	**11,00**	**1,00**	**5,00**	**240,00**
Storage			**2,00**	**160,00**	**6,00**	**55,00**	**330,00**
Total							**630,00**

Table VII.43: Costs for the storage of Tena Bed and Tena Bed Green in Jan de Rijk per year in scenario 3

Sterile products

	items per pallet	Safety stock	Frequency	nº of boxes	nº of pallets	Cost per pallet and year	Cost [euros]
Inbound	15,00	160,00	2,00	672,00	42,00	3,00	252,00
Outbound	15,00		48,00	28,00	3,00	5,00	720,00
Storage	30,00		2,00	496,00	31,00	55,00	1705,00
Total							2677,00

Table VII.44: Costs for the storage of sterile products in Jan de Rijk per year in scenario 3

Dialysis products

	items per pallet	Safety stock	Frequency	nº of boxes	nº of pallets	Cost per pallet and year	Cost [euros]
Inbound	60,00	781,00	2,00	2592,00	44,00	3,00	264,00
Outbound			48,00	108,00	2,00	5,00	480,00
Storage			2,00	2077,00	35,00	55,00	1925,00
Total							2669,00

Table VII.45: Costs for the storage of dialysis products in Jan de Rijk per year in scenario 3

Total cost within the company:

Total cost [euros]	7185,00

B.1.3.2. Replenishment into departments' costs

This cost does not exist in this scenario since Jan de Rijk delivers the products into the Central Warehouse

B.1.3.3. Shortage costs in Jan de Rijk

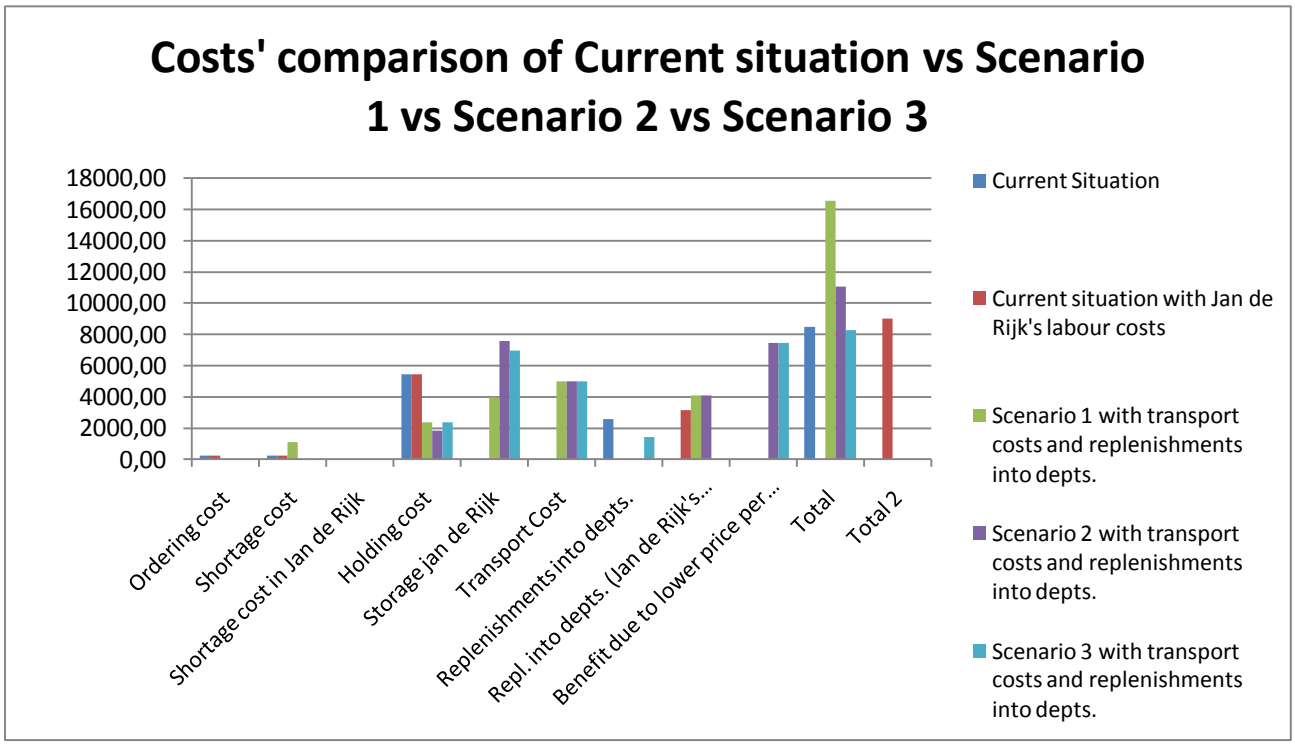
The shortage costs are zero as in the scenario 1 because the safety stocks in Jan de Rijk, replenishments, and lead times are the same.

B.1.3.4. Transport costs

The transport costs are equal than in scenario 2, since the quantities carried and the frequency do not change.

B.1.4. RESULTS AND COSTS' COMPARISON

We analyze in the next graph the costs' differences between the scenarios studied.



Graph VII.6: Total costs in current situation and in the three scenarios studied

This scenario 3 is the cheapest option for Franciscus Ziekenhuis and we would like to mention some of the reasons in the next observations:

- Within the three scenarios this last one is the one which has a higher holding cost since more handling time is needed within the hospital to replenish the products to the departments. Still, is much lower than in the current situation. And in fact, it is one of the benefits of this scenario since the volume occupied decrease and the handling time, taking as reference the current situation, also decrease
- Furthermore, it is not needed that much safety stock since the inventory level is known and the lead time is zero.
- Another benefit of this scenario is that there is a discount per box since the supplier only has to transport the products twice per year instead of every month. Even if the discount is small, at the end of the year the amount of money saved is significant.

More benefits regarding this scenario, although non economical ones, are:

- Possibility of reduction of rooms for storage, being possible to designated the mentioned rooms for other purposes
- There is already, with this scenario, no stock in the central warehouse. So, this volume available can be also occupied for another purposes of the hospital

- The handling time in the hospital is reduced, so, the employees can also designate that time for other tasks required
- The effort and costs for the supplier are also reduced. So, in long term it could also imply bigger discounts

Chapter VIII. Conclusions

This investigation within the healthcare sector and particularly within Franciscus Ziekenhuis has given many outcomes and answers to our initial questions. That is why; we would like to structure these conclusions doing a parallelism between the proposed Goals at the beginning of the thesis and the results as an outcome of the study.

To do a market research in order to know how the different supply chain in some hospitals in Netherlands is working....

During the literature researched we have found out many important concepts for the development of this investigation.

Thus, we have learnt the importance of a good management of the inventory, since there are many associated costs that sometimes are hard to assess and many organizations do not even know the weight these carrying inventory costs have within their supply chain.

We have also understood that the managing of the inventory has to deal with many challenges, since many parties are linked within the supply chain and also because some functional areas desire high stocks, as a result of economies of scale.

Many other concepts are involved along this report, but we would also like to mention the importance of the trend the healthcare is taking by using outsourcing and alliances between hospitals.

Choose the most proper products for this investigation...

The products chosen follow the theory of ABC items, explained in chapter II, by means of, we took few products represents a big impact for the supply chain.

With the products in scope we have been able to observe the changes´ repercussion within the total inventory costs within the supply chain.

Also it is important to mention that the long expiry date was essential in order to consider the possibility of using an external storage being replenished just twice per year from the supplier.

For further analysis, it would be interesting to add more categories, as we will see later in these conclusions.

Explore the information sources to realize the data possible to obtain and develop assumptions for the data that is not available...

At this point we warn one of the bottlenecks in the supply chain of Franciscus Ziekenhuis and it is: a bad forecasting of the consumption demand.

Looking at the Data obtained in Annex A and the Assumptions we have done in chapter V, it is easy to realize that the hospital does not have many historical data from the products.

So the consumption patterns are calculated based on averages from very few data and this represents a bad forecasting which has to be compensated with higher stocks in the hospital. What means higher probabilities of stocking out and higher carrying costs.

Regarding the assumptions done, we have tried to be as much realistic and precise as possible. By the way, for some assumptions it is almost impossible to be precise with the data available, such as the depreciation ratio per square meter or the value holding cost, since for their determination it is required to know the opportunity cost, bank loans, the reparations have been done in the building or future investments, between others.

But, in fact, this lack of precision in these parameters does not influence the goal of our study, since the same criteria is applied in all the scenarios. Thus, the relative result, which is the most interesting, is correct.

To know and understand the current situation in Franciscus Ziekenhuis....

In the analysis of the costs in the current situation we have assess the costs by product and we have also split these costs in order to have a detailed analysis. Thus, from the outcome of the analysis we could observe the following aspects, which were important in order to find out the scenarios analyzed, but also as starting point for future studies:

- The group formed by WC toilet paper, Kleenex tissues 2LGS, Onderlegger Tena Bed and Onderlegger Tena Bed Green are the ones which represent a higher costs per year in proportion with the total consumption. This is because these products are stored in the central warehouse and in the departments; They have a big amount of safety stock due to a bad forecasting of the demand and big standard deviation of the lead time; Moreover the volume occupied is quite high since the stock level is also high, but also because of the storage in the departments – the products are stored in shelves, out of the boxes. Furthermore, in the case of the Toilet paper and Kleenex tissues even having a huge safety stock their units short per cycle are quite high due to the suppliers variance's lead time

- Alternatively, the group formed by the sterile and dialysis products represents lower costs regarding the total costs because these products are only stored in the department where are used, sterile and dialysis respectively. This means a lower volume occupied and less effort from the employees of Franciscus Ziekenhuis for their handling. Moreover, the lead time is more precise since only one department has to be controlled. For the same reason, the safety stock is smaller and covers the lead time demand which does not have much deviation and the combination of all this, also implies no shortage costs

Look for ways of improvement within the supply chain of Franciscus Ziekenhuis by using a third Party Logistics service...

In chapter VII we work out different possibilities of improvement by using Jan de Rijk's services.

The possibilities posed were based in the literature review and in the results from the study of the current situation. We modified different parameters in order to observe their effect in the total costs.

In all the scenarios posed, the products' volume occupied is lower since the storage is only in department level and the safety stock required is also lower due to a higher frequency of replenishments (Jan de Rijk instead of the respective supplier). The lead time variance is much smaller because of the few distance between Jan de Rijk and the hospital.

The handling time within the hospital has also decreased in all the scenarios analyzed since in the current situation every week the employees had to scan, pick, replenish and order from the central warehouse to the departments. Alternatively in the three scenarios posed: in the first two scenarios, the handling time within the hospital is zero, since Jan de Rijk is the responsible of the entire process of replenishments into departments, in the third one, although Jan de Rijk delivers into the central warehouse, the handling cost is still smaller due to savings in the different way of replenishments (by product instead of by department), and no time required for ordering.

Due to this lower volume occupied and less handling time required, in all the scenarios the carrying costs of inventory are much lower than in the current situation.

But, as a matter of fact, this decrease in the inventory costs within the hospital cannot compensate other costs associated with each scenario:

- The storage within Jan de Rijk
- The transport costs from Jan de Rijk to Franciscus Ziekenhuis, every week
- The replenishments into departments is quite expensive

Except in the third scenario, where even considering all these costs, is the cheapest option for Franciscus Ziekenhuis and that is why; we summarize here the benefits:

- Within the three scenarios this last one is the one which has a higher holding cost since more handling time is needed within the hospital to replenish the products to the departments. Still, is much lower than in the current situation. And in fact, it is one of the benefits of this scenario since the volume occupied and the handling time decrease

- Furthermore, it is not needed that much safety stock since the inventory level is known and the lead time from Jan de Rijk is zero.

- Another benefit of this scenario is that there is a discount per box since the supplier only has to transport the products twice per year instead of every month. Even if the discount is small, at the end of the year the amount of money saved is really significant (see section A.2.1). We would like to add here that the supplier part has also benefits with this scenario, since they can produce long runs that are cheaper without storing the products later, since it is Jan de Rijk who does that task. Thus, in long term it could be easy to achieve bigger discounts per item. Also, considering the economies of scale, if the products would increase in type and number, the discounts would also be bigger.

***Be able to find out possible benefits**...*

We have already mentioned a lot of benefits that Jan de Rijk's services could offer to the supply chain in Franciscus Ziekenhuis in the paragraphs above. But we would like to add, a final observation.

Along this report we have been discussing the importance of dealing with the amount of stock to avoid the stock outs per cycle but occupying the less possible volume at the same time. We have also deal with the uncertainty of the consumption patterns and with the lower price for larger quantities- what means much stock stored. And we have found a solution for reconciling all these aspects:

- We can take the profit of buying in larger quantities taking advantage of the discounts, but the carrying costs do not increase that much because they are stored in a place (Jan de Rijk) where the storage is cheaper
- In fact, traditionally, companies rationalized long production runs to lower unit costs without really evaluating their inventory carrying costs, which can be high for finished goods. So, for the supplier is also beneficial to produce in long runs, lower costs, and transport it to Jan de Rijk, to be stored there.
- Eliminate uncertainty, reduces costs. Collaboration in the sharing of information in the supply chain between Jan de Rijk and Franciscus Ziekenhuis has results in reducing inventory cost and actually improving service at the same time.

To conclude we would like to add, that all these benefits represent an improvement for the supply chain within Franciscus Ziekenhuis, but also a possibility of increase the service' portfolio for Jan de Rijk taking part of its supply chain.

This investigation is only the starting point for many opportunities. Further studies should observe the results doing the same analysis but in a big scale: adding more products' categories and considering the alliance of different hospitals. The outcome would be a huge increase in the saving costs' due to economies of scale.

Chapter IX. Recommendations

Which should be the next steps for improving the supply chain of Franciscus Ziekenhuis? Is it proper to start storing products in Jan de Rijk logistics based on the outcome of this analysis? Which should be the trend of improvement in short and long term? Which decisions should be taken within the hospital?

In this chapter we answer these questions as matter of recommendations for the parties involved: Franciscus Ziekenhuis and Jan de Rijk logistics.

From the outcome of this thesis we could observed that the storage in Jan de Rijk in the third scenario, receiving the products twice per year and delivering into the hospital every week, has multiple benefits such as less volume occupied, less handling time within the hospital, the union of internal distributions, the centralization of information, and all these is summarized in less costs for the hospital.

Nevertheless, we do not consider that this outcome is enough in order to be applied yet in the supply chain of Franciscus Ziekenhuis. It should be required, at least, an intermediate step to involve more products. We should remind that this thesis has studied 4 categories of products, which means 11 products in total, so the benefit of storing just these products in an external storage will not compensate the effort of making the change.

By the way, this intermediate step could be quite simple, since we have found out a remarkable benefit reducing the frequency the supplier delivers into Jan de Rijk. Thus, we could add more products from the same supplier in the external storage even though they are not A items in order to increase the discount from the supplier and increase the products that Jan de Rijk would be responsible of. Moreover, in this way, we would take profit of economies of scale.

Also it is very important in order to improve the supply chain within Franciscus Ziekenhuis to be more precise collecting data and to have more historical information. As we saw, along the report, it is basic in order to do a good forecast of the consumption and it allows to decrease the stock within the hospital and to be precise with the order quantities and the frequencies to do not have shortages.

Indeed, it would be really beneficial for an improvement in the management of the materials' flows to invest in mechanisms for a continuous review, such scanners, so making use of the Vendor Management system (VMI) which Jan de Rijk has available, the hole process would be much more precise with all the good consequences it implies.

Regarding possible steps to be taken within the hospital we should add the reduction and redistribution of the rooms for storage. Nowadays, the same products are stored in many rooms around the hospital, what implies an increase in the handling time of those products, a loss of precision in the stock required and many rooms occupied that could be used with another purposes within the hospital. Therefore, a further study could contemplate the possibility of redistribution of the rooms for storage and the change of the way of replenishment: by products instead of by departments.

Also, related with the concept above, we should add that if the rooms for storage would be reduced also it could be considered the possibility of the replenishment into departments by Jan de Rijk.

And, last but not least, it should be analysed for a long term improvement, the possibility of alliance with other hospitals. This union of the supply chains would increase the efficiency, reducing costs by concentration of activities and collaboration. Also, the economies of scale would also have a big beneficial impact in the centralization in an external storage.

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ANNEXES

Annex A. Data obtained

In order to understand better the information set in this appendix, the different classifications of data are shown in different tables and different colours. Thus, each colour has a meaning explained as follows:

Information about the Central Warehouse of the hospital

General costs of the hospital

Information about the departments where the product is consumed

Data based on assumptions

Household materials

WC toilet paper

PRODUCT	ORDER DATE	RECEPTION DATE	LEAD TIME	LEAD TIME (AVERAGE)	SUPPLIER	DISTANCE FROM/TO THE SUPPLIER	ORDER QUANTITY (every box= 36x2 rols)	ORDER QUANTITY (average)	Items per box	Items per pallet	ORDER QUANTITY [rols]	DISCOUNT	GROSS PRICE	NET PRICE	Safety stock	Replenishments per month
WC PAPER TISSUES	20-4-2010	27-4-2010	7,00	6,00	BUNZL	109,00	62,00	62,00	36,00	28,00	2232,00	0,00	21,69	25,81	?	1,00
	23-3-2010	25-3-2010	2,00				60,00									
	23-2-2010	2-3-2010	9,00				64,00									
							59,00									
							59,00									
							64,00									

Table A.1: Hospital's general Data for WC toilet paper

ratio square meter	euros/m2 at the nursery departments per year	euros/m2 at the central warehouse per year	euros/m2 at the underground storage per year	explotation cost [euros]	handling cost per hour, laboral days [euros]	handling cost per hour on Saturdays [euros]	handling cost per hour on Sundays [euros]	handling cost per hour (on average)
0,08	129,60	92,00	92,00	??	25,00	38,00	51,00	25,98
					20,00	30,40	40,80	20,78

Table A.2: Hospital's general costs for WC toilet paper

Consumption different departments:

Department	Consumption last year[rols]	Consumption two years ago[rols]	Consumption average per month, last year (boxes)	Consumption average per month, two years ago (boxes)	Consumption average per month [boxes]	standard deviation	Lead time demand (boxes)	Inventory level desired in each replenishment (boxes) (once per week)	Safety stock (boxes)	Replenishments per month to the departments	stock max.in the departments [boxes]	stock max. In the dept. Integer part	stock max. In the dept. decimal part	Volume occupied in each department
1. 6A	982,00	1061,00	2,27	2,46	2,36	0,06	0,47	1,18	0,59	4,00	1,18	1,00	0,18	0,29
2. 6B	320,00	390,00	0,74	0,90	0,82	0,06	0,16	0,41	0,21		0,41	0,00	0,41	0,11
3. 5A	605,00	790,00	1,40	1,83	1,61	0,15	0,32	0,81	0,40		0,81	0,00	0,81	0,22
4. 5B	670,00	704,00	1,55	1,63	1,59	0,03	0,32	0,80	0,40		0,80	0,00	0,80	0,22
5. 4A	1078,00	1082,00	2,50	2,50	2,50	0,00	0,50	1,25	0,63		1,25	1,00	0,25	0,29

6. 4C	1220,00	1220,00	2,82	2,82	2,82	0,00	0,56	1,41	0,71		1,41	1,00	0,41	0,29
7. 1E	28,00	222,00	0,06	0,51	0,29	0,16	0,06	0,14	0,07		0,14	0,00	0,14	0,11
8. 3A	1874,00	1060,00	4,34	2,45	3,40	0,67	0,68	1,70	0,85		1,70	1,00	0,70	0,40
9. 3B	0,00	820,00	0,00	1,90	0,95	0,67	0,19	0,47	0,24		0,47	0,00	0,47	0,11
10. 3C	854,00	744,00	1,98	1,72	1,85	0,09	0,37	0,92	0,46		0,92	0,00	0,92	0,22
11. 2A	0,00	314,00	0,00	0,73	0,36	0,26	0,07	0,18	0,09		0,18	0,00	0,18	0,11
12. 2B	1548,00	1630,00	3,58	3,77	3,68	0,07	0,74	1,84	0,92		1,84	1,00	0,84	0,40
13. KINDERAFDELING	824,00	836,00	1,91	1,94	1,92	0,01	0,38	0,96	0,48		0,96	0,00	0,96	0,22
14. ZIEKENHUIS ALGEMEEN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00		0,00	0,00	0,00	0,00
15. RUIMTENBEHEER ALGEMEEN	504,00	108,00	1,17	0,25	0,71	0,32	0,14	0,35	0,18		0,35	0,00	0,35	0,11
16. KOSTEN SCHOONMAAK	12660,00	10866,00	29,31	25,15	27,23	1,47	5,45	13,61	6,81		13,61	13,00	0,61	2,56
17. KEUKEN	64,00	60,00	0,15	0,14	0,14	0,00	0,03	0,07	0,04		0,07	0,00	0,07	0,11
18. BLOKKADE FLAT	0,00	432,00	0,00	1,00	0,50	0,35	0,10	0,25	0,13		0,25	0,00	0,25	0,11
19. AFDELING 2A	78,00	10,00	0,18	0,02	0,10	0,06	0,02	0,05	0,03		0,05	0,00	0,05	0,11
20. OPERATIE	777,00	826,00	1,80	1,91	1,86	0,04	0,37	0,93	0,46		0,93	0,00	0,93	0,22
21. FUNKTIE	8,00	30,00	0,02	0,07	0,04	0,02	0,01	0,02	0,01		0,02	0,00	0,02	0,11
22. FYSIOTHERAPIE	12,00	26,00	0,03	0,06	0,04	0,01	0,01	0,02	0,01		0,02	0,00	0,02	0,11
23. APOTHEEK	154,00	128,00	0,36	0,30	0,33	0,02	0,07	0,16	0,08		0,16	0,00	0,16	0,11
24. KLINISCH	386,00	398,00	0,89	0,92	0,91	0,01	0,18	0,45	0,23		0,45	0,00	0,45	0,11
25. MICROBIOLOGISCH	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00		0,00	0,00	0,00	0,11
26. NUCLEAIRE	14,00	42,00	0,03	0,10	0,06	0,02	0,01	0,03	0,02		0,03	0,00	0,03	0,11
27. ST. HUISARTSENPOST	108,00	0,00	0,25	0,00	0,13	0,09	0,03	0,06	0,03		0,06	0,00	0,06	0,11
28. POLI ETTEN LEUR	155,00	0,00	0,36	0,00	0,18	0,13	0,04	0,09	0,04		0,09	0,00	0,09	0,11
29. MED.CENTR. OUDENBOSCH	452,00	474,00	1,05	1,10	1,07	0,02	0,21	0,54	0,27		0,54	0,00	0,54	0,22
30. BEHANDELCENTRUM	412,00	282,00	0,95	0,65	0,80	0,11	0,16	0,40	0,20		0,40	0,00	0,40	0,11
31. SPODEISENDE HULP	504,00	446,00	1,17	1,03	1,10	0,05	0,22	0,55	0,27		0,55	0,00	0,55	0,22
32. HEMODIALYSE	254,00	300,00	0,59	0,69	0,64	0,04	0,13	0,32	0,16		0,32	0,00	0,32	0,11
33. 1B	31,00	142,00	0,07	0,33	0,20	0,09	0,04	0,10	0,05		0,10	0,00	0,10	0,11
34. 4B	150,00	272,00	0,35	0,63	0,49	0,10	0,10	0,24	0,12		0,24	0,00	0,24	0,11
SUM	26727,00	25715,00	61,87	59,53	60,70			30,35	15,17		30,35	30,00	0,35	7,88
AVERAGE						0,15	0,36							

Table A.3: Consumptions and volumes occupied in each department

Consumption last year per month for all the departments:

Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Apr	May	Average (rols)	Average (boxes)
2350,00	1980,00	2053,00	2280,00	2104,00	2314,00	2687,00	1998,00	2382,00	2623,00	2047,00	2250,00	2255,67	63,00

Table A.4: Consumption last year per month for all the depts. for WC toilet paper

Kleenex Ultra 2LGS

PRODUCT	ORDER DATE	RECEPTION DATE	LEAD TIME	LEAD TIME (AVERAGE)	SUPPLIER	DISTANCE FROM/TO THE SUPPLIER [km]	ORDER QUANTITY [boxes]	ORDER QUANTITY (average)	Number of items per box	Items per pallet	ORDER QUANTITY [rols]	DISCOUNT	GROSS PRICE	NET PRICE	Safety stock	Replenishments per month
KLEENEX 2LGS	13-4-2010	20-4-2010	7,00	14,00	Bunzl	109,00	62,00	55,00	20,00	28,00	1100,00	0,00	21,99	26,17	?	1,00
	16-3-2010	6-4-2010	20,00				60,00									
	16-2-2010	2-3-2010	16,00				50,00									
							60,00									
							50,00									
							50,00									

Table A.5: General data of the hospital for Kleenex tissues

ratio square meter	euros/m2 at the nursery departments per year	euros/m2 at the central warehouse per year	euros/m2 at the underground storage per year	explotation cost [euros]	handling cost per hour, laboral days [euros]	handling cost per hour on Saturdays [euros]	handling cost per hour on Sundays [euros]	handling cost per hour (on average)
0,08	129,60	92,00	92,00	??	25,00	38,00	51,00	26,82
					20,00	30,40	40,80	20,78

Table A.6: General costs of the hospital for Kleenex tissues

Consumption different departments:

Department	Consumption last year [boxes]	Consumption two years ago[boxes]	Consumption per month last year [boxes]	Consumption per month two years ago [boxes]	Consumption average per month [boxes]	Safety stock [boxes]	Replenishments per month	stock max.in the departments [boxes]	stock max. In the dept. Integer part	stock max. In the dept. decimal part	Volume occupied in each department
6A	3,00	3,00	0,25	0,25	0,25	0,06	1,00	0,13	0,00	0,13	0,11
4C	109,00	114,00	9,08	9,50	9,29	2,32		4,65	4,00	0,65	1,14
3C	72,00	71,00	6,00	5,92	5,96	1,49		2,98	2,00	0,98	0,70
RUIMTENBEHEER ALGEMEEN	20,00	5,00	1,67	0,42	1,04	0,26		0,52	0,00	0,52	0,26
KOSTEN SCHOONMAAK	130,00	62,00	10,83	5,17	8,00	2,00		4,00	4,00	0,00	0,99
BLOKKADE FLAT	0,00	16,00	0,00	1,33	0,67	0,17		0,33	0,00	0,33	0,11
OPERATIE	10,00	8,00	0,83	0,67	0,75	0,19		0,38	0,00	0,38	0,11

FYSIOTHERAPIE	26,00	17,00	2,17	1,42	1,79	0,45		0,90	0,00	0,90	0,26
KLINISCH	20,00	15,00	1,67	1,25	1,46	0,36		0,73	0,00	0,73	0,26
ST. HUISARTSENPOST	6,00	8,00	0,50	0,67	0,58	0,15		0,29	0,00	0,29	0,11
POLI ETTEN LEUR	7,00	0,00	0,58	0,00	0,29	0,07		0,15	0,00	0,15	0,11
POLI ALGEMEEN ROOSENDAAL	15,00	0,00	1,25	0,00	0,63	0,16		0,31	0,00	0,31	0,11
MED.CENTR. OUDENBOSCH	3,00	0,00	0,25	0,00	0,13	0,03		0,06	0,00	0,06	0,11
HEMODIALYSE	25,00	0,00	2,08	0,00	1,04	0,26		0,52	0,00	0,52	0,26
1B	37,00	36,00	3,08	3,00	3,04	0,76		1,52	1,00	0,52	0,48
4B	3,00	2,00	0,25	0,17	0,21	0,05		0,10	0,00	0,10	0,11
SUM	486,00	357,00	40,50	29,75	35,13	8,78		17,56	17,00	0,56	5,24

Table A.7: Consumptions and volumes occupied in each department

Consumption last year per month for all the departments:

Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	Apr	May	Average [boxes]	Total Average [boxes]
44,00	37,00	33,00	39,00	39,00	40,00	56,00	45,00	53,00	62,00	57,00	39,00	45,33	40,23

Table A.8: Consumption last year per month for all the depts.

Incontinent material

Onderlegger Tena Bed

PRODUCT	ORDER DATE	RECEPTION DATE	LEAD TIME	LEAD TIME (AVERAGE)	SUPPLIER	DISTANCE FROM/TO THE SUPPLIER [km]	ORDER QUANTITY [boxes]	ORDER QUANTITY (average)	Number of items per box	Items per pallet	ORDER QUANTITY [rols]	DISCOUNT	GROSS PRICE	NET PRICE	Safety stock	Replenishments per month
Tena Bed	7-4-2010	12-4-2010	5,00	4,00	Zeist	109,00	32,00	32,00	180,00	28,00	5760,00	0,40	25,47	16,20	?	1,00
	9-3-2010	12-3-2010	3,00				35,00									
	9-2-2010	12-2-2010	3,00				30,00									

Table A.9: General Data of the hospital for Onderlegger Tena Bed

ratio square meter	euros/m2 at the nursery departments per year	euros/m2 at the central warehouse per year	euros/m2 at the underground storage per year	explotation cost [euros]	handling cost per hour, laboral days [euros]	handling cost per hour on Saturdays [euros]	handling cost per hour on Sundays [euros]	handling cost per hour (on average)
0,08	129,60	92,00	92,00	??	25,00	38,00	51,00	26,82
					20,00	30,40	40,80	20,78

Table A.10: General costs of the hospital for Kleenex tissues

Consumption different departments:

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average[boxes]	Safety stock [boxes]	Replenishments per month	stock max.in the departments [boxes]	stock max. In the dept. Integer part	stock max. In the dept. Decimal part	Volume occupied in each department
6A	14,00	13,00	13,50	0,29	1,00	0,56	0,00	0,56	0,29
5A	20,00	19,00	19,50	0,42		0,81	0,00	0,81	0,29
5B	20,00	21,00	20,50	0,42		0,85	0,00	0,85	0,29
4A	24,00	19,00	21,50	0,50		0,90	0,00	0,90	0,29
4C	44,00	37,00	40,50	0,92		1,69	1,00	0,69	0,53
3A	80,00	39,00	59,50	1,67		2,48	2,00	0,48	0,62
3B	1,00	36,00	18,50	0,02		0,77	0,00	0,77	0,29
3C	31,00	37,00	34,00	0,65		1,42	1,00	0,42	0,38
2B	11,00	10,00	10,50	0,23		0,44	0,00	0,44	0,14
KINDERAFDELING	15,00	11,00	13,00	0,31		0,54	0,00	0,54	0,29
VERLOSBLOK 2 LI	14,00	12,00	13,00	0,29		0,54	0,00	0,54	0,29
POLI- UROLOGIE PK B RSD	9,00	9,00	9,00	0,19		0,38	0,00	0,38	0,14
POLI INTERNISTEN PK A RSD	2,00	0,00	1,00	0,04		0,04	0,00	0,04	0,14
POLI GYNAECOLOGIE PK B RSD	2,00	0,00	1,00	0,04		0,04	0,00	0,04	0,14
POLI CHIRURGIE PK B RSD	1,00	0,00	0,50	0,02		0,02	0,00	0,02	0,14
KLINISCH	0,00	1,00	0,50	0,00		0,02	0,00	0,02	0,14
ST. HUISARTSENPOST	2,00	1,00	1,50	0,04		0,06	0,00	0,06	0,14
POLI ETTEN LEUR PK A RSD	2,00	2,00	2,00	0,04		0,08	0,00	0,08	0,14
POLI ALGEMEEN ROOSENDAAL	23,00	20,00	21,50	0,48		0,90	0,00	0,90	0,29
HEMODIALYSE	36,00	33,00	34,50	0,75		1,44	1,00	0,44	0,38
1B	9,00	8,00	8,50	0,19		0,35	0,00	0,35	0,14
4B	30,00	25,00	27,50	0,63		1,15	1,00	0,15	0,38
SUM	390,00	353,00	371,50	8,13		15,48			5,90

Table A.11: Consumption different depts. of Onderlegger Tena Bed

Tena Bed Green

PRODUCT	ORDER DATE	RECEPTION DATE	LEAD TIME	LEAD TIME (AVERAGE)	SUPPLIER	DISTANCE FROM/TO THE SUPPLIER [km]	ORDER QUANTITY [boxes]	ORDER QUANTITY (average)	Number of items per box	Items per pallet	ORDER QUANTITY [rols]	DISCOUNT	GROSS PRICE	NET PRICE	Safety stock	Replenishments per month
TENA BED GREEN	7-4-2010	12-4-2010	5,00	4,00	Zeist	109,00	12,00	10,00	3,00	28,00	30,00	0,40	71,98	45,78	?	1,00
	9-3-2010	12-3-2010	3,00				6,00									
	9-2-2010	12-2-2010	3,00				9,00									
							10,00									
							8,00									
							12,00									

Table A.12: General data of the hospital for Onderlegger Tena Bed Green

Ratio square meter	euros/m2 at the nursery departments per year	euros/m2 at the central warehouse per year	euros/m2 at the underground storage per year	explotation cost [euros]	handling cost per hour, laboral days [euros]	handling cost per hour on Saturdays [euros]	handling cost per hour on Sundays [euros]	handling cost per hour (on average)
0,08	129,60	92,00	92,00	??	25,00	38,00	51,00	30,57
					20,00	30,40	40,80	20,78

Table A.13: General costs of the hospital for Onderlegger Tena Bed Green

Consumption different departments:

Department	Consumption last year[paks]	Consumption two years ago[paks]	Consumption average[paks]	Consumption average (boxes)	Standard deviation consumption	Safety stock [boxes]	Replenishments per month	stock max.in the departments [boxes]	stock max. In the dept. Integer part	stock max. In the dept. Decimal part	Volume occupied in each department
6A	26,00	28,00	27,00	9,00	1,41	0,54	1,00	0,38	0,00	0,38	0,14
5A	27,00	26,00	26,50	8,83	0,71	0,56		0,37	0,00	0,37	0,14
5B	85,00	102,00	93,50	31,17	12,02	1,77		1,30	1,00	0,30	0,38
4A	42,00	40,00	41,00	13,67	1,41	0,88		0,57	0,00	0,57	0,29
4C	94,00	91,00	92,50	30,83	2,12	1,96		1,28	1,00	0,28	0,38

3A	74,00	52,00	63,00	21,00	15,56	1,54		0,88	0,00	0,88	0,29
3B	1,00	67,00	34,00	11,33	46,67	0,02		0,47	0,00	0,47	0,14
3C	40,00	43,00	41,50	13,83	2,12	0,83		0,58	0,00	0,58	0,29
2B	0,00	1,00	0,50	0,17	0,71	0,00		0,01	0,00	0,01	0,14
KINDERAFDELING	2,00	2,00	2,00	0,67	0,00	0,04		0,03	0,00	0,03	0,14
RONTGENDIAGNOSTIEK	1,00	1,00	1,00	0,33	0,00	0,02		0,01	0,00	0,01	0,14
SPOEDEISENDE HULP	0,00	3,00	1,50	0,50	2,12	0,00		0,02	0,00	0,02	0,14
	392,00	456,00	424,00	141,33		8,17		17,67			2,64

Table A.14: Consumption and volumes occupied in each department

Consumption last year per month for all the departments:

Jun	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*March*	*Apr*	*May*	*Average (paks)*	*Average (boxes)*	*Average*
44,00	32,00	36,00	24,00	37,00	29,00	31,00	21,00	25,00	34,00	31,00	30,00	31,17	10,39	11,08

Table A.15: Consumption last year per month for all the departments for Onderlegger Tena Bed green

Sterile products

Kimguard one-step KC 300, 101x101cm

PRODUCT	LEAD TIME (AVERAGE)	SUPPLIER	DISTANCE FROM/TO THE SUPPLIER [km]	ORDER QUANTITY [boxes]	ORDER QUANTITY (average)	Number of items per box	Items per pallet	ORDER QUANTITY [rols]	DISCOUNT	GROSS PRICE	NET PRICE	Safety stock	Replenishments per month
STERILE 1	3,00	Kimberly-Clark	77,30	13,51	14,00	96,00	15,00	1344,00	1,00	1,00	83,90	1,00	1,00

Table A.16: General data of the hospital for Kimguard one-step KC 300, 101x101cm

ratio square meter	euros/m2 at the nursery departments per year	euros/m2 at the central warehouse per year	euros/m2 at the underground storage per year	explotation cost [euros]	handling cost per hour, laboral days [euros]	handling cost per hour on Saturdays [euros]	handling cost per hour on Sundays [euros]	handling cost per hour (on average)
0,08	129,60	92,00	92,00	??	25,00	38,00	51,00	30,57
					20,00	30,40	40,80	20,78

Table A.17: General costs of the hospital for sterile products

Consumption:

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per month (boxes)	Safety stock [boxes]	Replenishments per month	stock max.in the departments	Volume occupied in the department
Center sterilisatie	148,00	173,00	160,50	13,00	3,25	1,00	18,00	1,92

Table A.18: Consumption and volume occupied in sterile centre

Consumption last year per month:

Months	Consumption per month (boxes)
June	17,00
July	10,00
August	9,00
Sep.	14,00
Okt.	12,00
Nov.	12,00
Dec.	13,00
Jan.	10,00
Feb.	12,00
Mrt.	16,00
Apr.	13,00
Mei	10,00

Table A.19: Consumption last year per month in sterile centre

Kimguard one-step KC 200 121x121 cm

PRODUCT	LEAD TIME (AVERAGE)	SUPPLIER	DISTANCE FROM/TO THE SUPPLIER [km]	ORDER QUANTITY [boxes]	ORDER QUANTITY (average)	Number of items per box	Items per pallet	ORDER QUANTITY [rols]	DISCOUNT	GROSS PRICE	NET PRICE	Safety stock	Replenishments per month
STERILE 2	3,00	Kimberly-Clark	77,30	82,43	82,43	24,00	15,00	1978,38	1,00	1,00	41,08	?	1,00

Table A.20: General data of the hospital for Kimguard one-step KC 200 121x121 cm

Ratio square meter	euros/m2 at the nursery departments per year	euros/m2 at the central warehouse per year	euros/m2 at the underground storage per year	explotation cost [euros]	handling cost per hour, laboral days [euros]	handling cost per hour on Saturdays [euros]	handling cost per hour on Sundays [euros]	handling cost per hour (on average)
0,08	129,60	92,00	92,00	??	25,00	38,00	51,00	30,57
					20,00	30,40	40,80	20,78

Table A.21: General costs of the hospital for Kimguard one-step KC 200 121x121 cm

Consumption:

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per month(boxes)	Safety stock [boxes]	Replenishments per month	stock max.in the departments [boxes]	Volume occupied in each department
Center sterilisatie	916,00	668,00	792,00	83,00	20,75	1,00	104,00	6,72

Table A.22: Consumption and volume occupied in sterile centre for Kimguard one-step KC 200 121x121 cm

Consumption last year per month:

Months	Consumption per month (boxes)
June	128,00
July	60,00
August	39,00
Sep.	90,00
Okt.	101,00
Nov.	80,00
Dec.	86,00
Jan.	92,00
Feb.	72,00
Mrt.	94,00
Apr.	72,00
Mei	80,00

Table A.23: Consumption last year per month for sterile centre for Kimguard one-step KC 200 121x121 cm

Kimguard one-step KC 76x76 cm

PRODUCT	LEAD TIME (AVERAGE)	SUPPLIER	DISTANCE FROM/TO THE SUPPLIER [km]	ORDER QUANTITY [boxes]	ORDER QUANTITY (average)	Number of items per box	Items per pallet	ORDER QUANTITY [rols]	DISCOUNT	GROSS PRICE	NET PRICE	Safety stock	Replenishments per month
STERILE 3	3,00	Kimberly-Clark	77,30	10,00	10,00	144,00	30,00	1440,00	1,00	1,00	76,91	?	1,00

Table A.24: General data of the hospital for Kimguard one-step KC 76x76 cm

ratio square meter	euros/m2 at the nursery departments per year	euros/m2 at the central warehouse per year	euros/m2 at the undergrounds storage per year	explotation cost [euros]	handling cost per hour, laboral days [euros]	handling cost per hour on Saturdays [euros]	handling cost per hour on Sundays [euros]	handling cost per hour (on average)
0,08	129,60	92,00	92,00	??	25,00	38,00	51,00	30,57
					20,00	30,40	40,80	20,78

Table A.25: General costs of the hospital for Kimguard one-step KC 76x76 cm

Consumption:

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per month(boxes)	Safety stock [boxes]	Replenishments per month	2weeks consumption [boxes]	Volume occupied in each department
Center sterilisatie	84,00	81,00	82,50	8,00	2,00	1,00	4,00	1,00

Table A.26: Consumption and volume occupied for Kimguard one-step KC 76x76 cm

Consumption last year per month:

Months	Consumption per month (boxes)
June	11,00
July	6,00
August	5,00
Sep.	9,00
Okt.	7,00
Nov.	6,00
Dec.	8,00
Jan.	6,00
Feb.	7,00
Mrt.	10,00
Apr.	7,00
Mei	5,00

Table A.27: Consumption last year per month for Kimguard one-step KC 76x76 cm

Dialyze products

Concentraat D 294

PRODUCT	LEAD TIME (AVERAGE)	SUPPLIER	DISTANCE FROM/TO THE SUPPLIER [km]	ORDER QUANTITY [boxes]	ORDER QUANTITY (average)	Number of items per box	Items per pallet	ORDER QUANTITY [rols]	DISCOUNT	GROSS PRICE	NET PRICE	Safety stock	Replenishments per month
Concentraat D 294	2,00	Gambro	33,20	345,00	345,00	6,00	60,00	2070,00	1,00	1,00	4,13	?	1,00

Table A.28: General data of the hospital for Concentraat D294

ratio square meter	euros/m2 at the nursery departments per year	euros/m2 at the central warehouse per year	euros/m2 at the underground storage per year	explotation cost [euros]	handling cost per hour, laboral days [euros]	handling cost per hour on Saturdays [euros]	handling cost per hour on Sundays [euros]	handling cost per hour (on average)
0,08	129,60	92,00	92,00	??	25,00	38,00	51,00	30,57
					20,00	30,40	40,80	20,78

Table A.29: General costs of the hospital for dialysis products

Consumption:

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per month(boxes)	Safety stock [boxes]	Replenishments per month	2weeks consumption [boxes]	Volume occupied in each department
Center sterilisatie	3540,00	3520,00	3530,00	295,00	73,75	1,00	147,50	4,80

Table A.30: Consumption and volume occupied for Concentraat D 294

Consumption last year per month:

Months	Consumption per month (boxes)
June	360,00
July	300,00
August	360,00
Sep.	300,00
Okt.	180,00
Nov.	180,00
Dec.	180,00
Jan.	120,00
Feb.	180,00
Mrt.	180,00
Apr.	120,00
Mei	180,00

Table A.31: Consumption last year per month for Concentraat D 294

Bicart 720gr.

PRODUCT	LEAD TIME (AVERAGE)	SUPPLIER	DISTANCE FROM/TO THE SUPPLIER [km]	ORDER QUANTITY [boxes]	ORDER QUANTITY (average)	Number of items per box	Items per pallet	ORDER QUANTITY [rols]	DISCOUNT	GROSS PRICE	NET PRICE	Safety stock	Replenishments per month
Bicart 720 gr	2,00	Gambro	33,20	80,00	80,00	10,00	60,00	800,00	1,00	1,00	22,79	?	1,00

Table A.32: General data of the hospital for Bicart 720gr.

ratio square meter	euros/m2 at the nursery departments per year	euros/m2 at the central warehouse per year	euros/m2 at the underground storage per year	explotation cost [euros]	handling cost per hour, laboral days [euros]	handling cost per hour on Saturdays [euros]	handling cost per hour on Sundays [euros]	handling cost per hour (on average)
0,08	129,60	92,00	92,00	??	25,00	38,00	51,00	30,57
					20,00	30,40	40,80	20,78

Table A.33: General costs of the hospital for Bicart 720gr.

Consumption:

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per month(boxes)	Safety stock [boxes]	Replenishments per month	stock max. at the departments [boxes]	Volume occupied in each department
Center sterilisatie	828,00	864,00	846,00	71,00	17,75	1,00	88,75	1,92

Table A.34: Consumption and volume occupied for Bicart 720gr.

Consumption last year per month:

Months	Consumption per month (boxes)
June	72,00
July	72,00
August	108,00
Sep.	72,00
Okt.	36,00
Nov.	36,00
Dec.	72,00
Jan.	0,00
Feb.	36,00
Mrt.	36,00
Apr.	36,00
Mei	36,00

Table A.35: Consumption last year per month for Bicart 720gr.

Concentraat D 292

PRODUCT	LEAD TIME (AVERAGE)	SUPPLIER	DISTANCE FROM/TO THE SUPPLIER [km]	ORDER QUANTITY [boxes]	ORDER QUANTITY (average)	Number of items per box	Items per pallet	ORDER QUANTITY [rols]	DISCOUNT	GROSS PRICE	NET PRICE	Safety stock	Replenishments per month
Concentraat D 292	2,00	Gambro	33,20	57,00	57,00	6,00	60,00	342,00	1,00	1,00	6,68	?	1,00

Table A.36: General data of the hospital for Concentraat D 292

ratio square meter	euros/m2 at the nursery departments per year	euros/m2 at the central warehouse per year	euros/m2 at the underground storage per year	explotation cost [euros]	handling cost per hour, laboral days [euros]	handling cost per hour on Saturdays [euros]	handling cost per hour on Sundays [euros]	handling cost per hour (on average)
0,08	129,60	92,00	92,00	??	25,00	38,00	51,00	30,57
					20,00	30,40	40,80	20,78

Table A.37: General costs of the hospital for Concentraat D292.

Consumption:

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per month(boxes)	Safety stock [boxes]	Replenishments per month	stock max.at the departments [boxes]	Volume occupied in each department
Center sterilisatie	537,00	694,00	615,50	52,00	13,00	1,00	70,00	1,92

Table A.38: Consumption and volume occupied for Concentraat D292

Consumption last year per month:

Months	Consumption per month (boxes)
June	66,00
July	39,00
August	42,00
Sep.	45,00
Okt.	47,00
Nov.	29,00
Dec.	31,00
Jan.	23,00
Feb.	31,00
Mrt.	39,00
Apr.	35,00
Mei	34,00

Table A.39: Consumption last year per month for Concentraat D292

Concentraat D 296

PRODUCT	LEAD TIME (AVERAGE)	SUPPLIER	DISTANCE FROM/TO THE SUPPLIER [km]	ORDER QUANTITY [boxes]	ORDER QUANTITY (average)	Number of items per box	Items per pallet	ORDER QUANTITY [rols]	DISCOUNT	GROSS PRICE	NET PRICE	Safety stock	Replenishments per month
Concentraat D 296	2,00	Gambro	33,20	14,00	14,00	10,00	60,00	140,00	1,00	1,00	6,68	?	1,00

Table A.40: General data of the hospital for Concentraat D 296

ratio square meter	euros/m2 at the nursery departments per year	euros/m2 at the central warehouse per year	euros/m2 at the underground storage per year	explotation cost [euros]	handling cost per hour, laboral days [euros]	handling cost per hour on Saturdays [euros]	handling cost per hour on Sundays [euros]	handling cost per hour (on average)
0,08	129,60	92,00	92,00	??	25,00	38,00	51,00	30,57
					20,00	30,40	40,80	20,78

Table A.41: General costs of the hospital for Concentraat D296

Consumption:

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per month(boxes)	Safety stock [boxes]	Replenishments per month	stock max.at the departments [boxes]	Volume occupied in each department
Center sterilisatie	178,00	252,00	215,00	14,21	3,55	1,00	17,76	0,96

Table A.43: Consumption and volume occupied for Concentraat D296

Consumption last year per month:

Months	Consumption per month (boxes)
June	11,00
July	10,00
August	17,00
Sep.	15,00
Okt.	16,00
Nov.	10,00
Dec.	11,00
Jan.	9,00
Feb.	3,00
Mrt.	10,00
Apr.	5,00
Mei	9,00

Table A.44: Consumption last year per month for Concentraat D296

Annex B. Current distribution of products from the Central warehouse to the departments

Monday

6A- Cardiology

6B- CC/MC

5A- Nephrology department

5B- Neurology

Satellite apoth.5

Kitchen

Outpatient

Outpatient (general)

Outpatient (pharmacy)

Outpatient (brochures)

Function unit

Children wardrobe

Gynecology wardrobe

Barrack wardrobe

S.E.H wardrobe

2C – Dialyze

Other outpatients':

Cardiology, Rheumatology, Psychiatry, Dermatology, Orthopedic, Neurology, Gynecology, Pediatrics, surgery, plastic surgery, PPO, KNO, ophthalmology, room 4, diabetes, pulmonologists.

Tuesday

3A- General surgery, urology (kitchen, dish washer, secretary, printed matter, brochures)

3B- surgery (kitchen, dish washer, secretary, printed matter, brochures)

3C- Orthopedic

Ostomy

Mum care

Satellite apoth.3

Patient transport

Nuclear

Pharmacy

O.K

IC/MC

Container press

F.I.A

C.M.A

Reception

Restaurant

Snack bar

Refrigerator

Wednesday

Chemical Laboratories

Micro biology laboratories

Sterile center

Flat

Flat (restaurant)

Drinks (flat)

Thrombosis

Radiology

Physiotherapy

S.E.H

Plaster room

Treatment center

1B-nursing behavior

Automation

Thursday

2A- Short stay

2B- Gynecology

2C- Dialyze

Satellite apoth.2

Kitchen

4A- Pulmonary department

4B- Day care

4C- Intern

Satellite apoth.4

Friday

O.K.

Children's block

Treatment center

IC/ MC+

Copy room

GP post

Restaurant

Snack bar

Refrigerator

Annex C: Parameters definitions and Cost formulas

1. Intermediate calculations

- ***Lead time***

It is the time from the point at which you determine the need to order to the point at which the inventory is on hand and available for use. It includes supplier lead time, time to initiate the purchase order or work order including approval steps, time to notify the supplier, and the time to process through receiving and any inspection operations.

In this study I have two consider two different lead times. In the central warehouse it coincides with the time between the orders are made and the shipment arrives from the supplier. In the case of the departments the lead time is more complex. Each department is reviewed in different days of the week. In fact, the most probable is that the lead time is zero because the central warehouse has much stock to supply the departments but if the central warehouse run out of some products, then the lead time depends accordingly the day of the week is made the scanning in each department.

I explain as follows an example based on the current situation to make it understandable:

The review day in the central warehouse is on Tuesdays and the shipment arrives, on average, 3 days later from the supplier. Although in the departments the review day is also once per week, depends on each department. So, if one department is reviewed on Monday and there are not enough products in the central warehouse for its replenishment, the lead time, in this case, is 4 days, because on Tuesday the central warehouse makes the order and the supplier spends 3 days to arrive. In the case, the department is reviewed on Tuesday the lead time is 3 days. In the same way, if the review in the department is made on Wednesday the lead time is 9 days, because the order cannot be made until the next Tuesday and still it has to wait 3 days more. And, in the same way we could calculate the lead times for every day of the week.

Moreover, to calculate these probabilities for the lead time I have to know the probability of stock outs in the central warehouse since while there are products stored in the central warehouse the lead time in the departments is zero.

It is important to add that in the current situation the transhipments between departments are not used in general circumstances, only if there is an urgent situation. Therefore, I assume no transhipments in any situation since I have to do a basis for my study.

- ***Lead time demand***

It is the forecasted demand during the lead-time period. For example, if the forecasted demand is 3 units per day and the lead time is 12 days; the lead time demand would be 36 units.

- ***Order cycle***

It is also called replenishment cycle. The order cycle refers to the time between orders of a specific item. It is most easily calculated by dividing the order quantity by the annual demand and multiplying by the number of days in the year.

- ***Reorder point***

It is the inventory level which initiates an order:

Reorder Point = Lead Time Demand + Safety Stock

- **Shortages per cycle and p*robabilities of a stock out***

The shortages per cycle are directly related with the lead time demand and its variance. Thus, i use the next parameters and formulas to determine the probability of a stock out:

α and β are the parameters of the Gamma distribution. $\alpha \cdot \beta$ is the mean lead time demand and $\alpha \cdot \beta^2$ is the variance of the lead time demand, then given a reorder point s and an order quantity Q, I can calculate next variables by using Excel:

Probability of a stock out= 1 – P1= 1- GAMMADIST(s,α,β,true),

Where,

True= It is desired the cumulative distribution function

Expected shortages per replenishment cycle (ESPRC):

α·β·(1-GAMMADIST(s,α+1,β,true))-s·(1-GAMMADIST(s,α,β,true))

Given a probability of not stocking out, P1:

Reorder point s= GAMMAINV(P1,α,β)

2. Costs formulas

For each product and scenario studied I calculate the total inventory annual cost, following the next formula:

Total inventory annual costs*= *Ordering cost + Holding cost + Shortage cost

2.1. ORDERING COST

First, I have to determine how many orders are placed each year:

$$\text{Orders per year} = D_a/Q$$

Where,

D_a: annual demand

Q: order size

Secondly I have to determine the cost per order, which it is calculate by using the handling cost per hour and the time spent per order, both already explained in the assumptions at the beginning of this chapter.

Finally the ordering cost is:

$$\text{Ordering cost} = \text{orders per year} \cdot \text{cost per order}$$

*Obs.: In the current situation the number of orders per year is established

2.2. HOLDING COST

The holding cost is defined as the money spent to keep and maintain a stock of goods in storage.

The most obvious holding costs include rent for the required space: equipment, materials, and labor to operate the space, insurance, interest on money invested in the inventory and space and other direct expenses. Also it has to be considered the opportunity cost of reduces responsiveness to customers' changing requirements, slowed introduction of improved items, and the inventory's value, since that money could be used with other purposes.

For the products studied I have approach the holding cost by the next formula:

$$Q_{h,cw}\cdot(v\cdot C_{h,u}+V_{cw}\cdot SQM_{cw}/(Q+SS_{cw})) + Q_{h,d}\cdot(v\cdot C_{d,u}+V_{d}\cdot SQM_{d}/(Q+SS_{d}))$$

Where,

$Q_{h,i}$: average inventory on-hand in the room i; with i= central warehouse (cw) or depts. (d)

v: unit variable cost

$C_{h,u}$: value holding cost per year and unit

V_i: volume occupied in room i; with i=cw or d

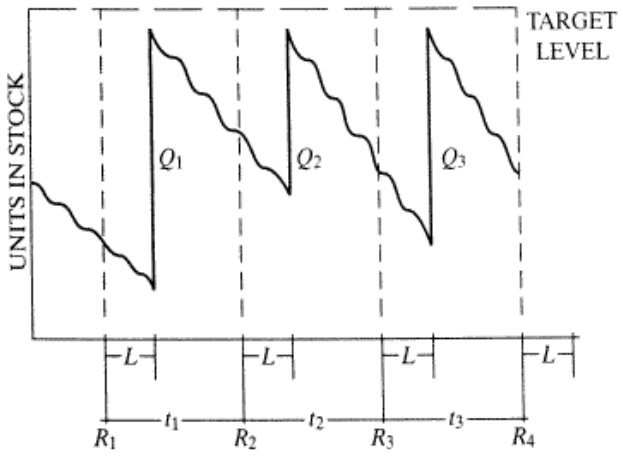
SQM_i: price per square meter in i; with i= cw or d

Q: order quantity

SS_i: safety stock in i; with i=cw or d

- ***Average inventory on-hand*** **($Q_{h,i}$)**:

It is the level of inventory that is available on average. In the figure 4.2 it is represented the saw tooth that represents the units in stock per unit of time.



t: represents the time between replenishments

Q: is the order quantity

L: lead time

R: represents the instant when the stock is reviewed and the quantity required is ordered

Figure 4.2

As we can observe in the figure, when the order quantity is ordered during the lead time the level of inventory continues decreasing until the shipment arrives (Q) and the stock level rises until the stock-up-to level. We have to imagine this saw tooth floating on a "buffer" which we call safety stock.

According to figure and the explanation done, the average inventory on-hand is calculated by:

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

Where,

Q: order quantity

SS: safety stock

- ***Unit variable cost (v)**:*

The unit variable cost refers to the total price of the product compounded of two parts: its value and a variable part referred with the cost of its manipulation. In this case, this handling variable cost is the handling cost per year and unit by the employees from the hospital.

$$v = p_u + C_{ha,u}$$

Where,

p_u : Net price per unit $C_{ha,u}$: Handling cost per year and unit

Observation:

The handling cost per year and unit is the result of divide the handling cost per year (see assumptions, section 4.2.4 and 4.3.5) by the average consumption per year, in boxes.

- ***Value holding cost per year and unit,* $C_{h,u}$**:

It is also called carrying charge and it is made up of the opportunity costs of the capital tied up that otherwise could be used elsewhere in an organization and opportunity costs of warehouse space claimed by inventories.

The value of this variable it is very hard to assess because I do not have information about the investments the hospital would do instead of investing in these products or information about the purpose which could replace the area, nowadays occupied by theses products.

So, the criteria chosen in order to predict this value are based on literature and in other examples within the Dutch healthcare market (Vinesh, 1995).

The outcome of this research gives a value of 7 percent of the value unit cost.

- ***Volume occupied (V_i)**:*

The volume occupied is already explained in the assumptions in the sections 4.2.4 and 4.3.5 of this chapter.

- ***Price per square meter (SQM_i)**:*

This price it is also explained in the section 4.1.1 of this chapter.

- ***Order quantity (Q)**:*

It is the size of the order in each shipment.

- ***Safety stock (SS)**:*

In the current situation the safety stock is data obtained from the hospital.

In the scenarios posed in next chapters, the safety stock will be calculated in different ways accordingly with the mathematical models used and it will be described in each respective analysis.

2.3. SHORTAGE COST

The shortage cost is the money spent due to the stock outs during a year. For calculating this cost, firstly it has to be determined how many units we expect to be short per replenishment cycle. Thus, the shortage cost is:

$$U_{s,R} \cdot R \cdot C_{u,s}$$

Where,

$U_{s,R}$: Expected units short per replenishment cycle

R : Number of cycles per year

$C_{u,s}$: Cost per unit short

- **Expected units short per replenishment cycle**:

$$\alpha \cdot \beta \cdot (1 - gammadist(s, \alpha + 1, \beta, true)) - s \cdot (1 - gammadist(s, \alpha, \beta, true))$$

Where,

$\alpha = \frac{x_l}{\beta}$; x_l = lead time demand on average

$\beta = \frac{v_l}{x_l}$; v_l = variance of lead time demand

As we can observe in the definition of α and β, these units short depend directly on the lead time demand which is explained in the section 4.4.2 and it is more understandable looking at the practical case of the current situation in the chapter 5.

Once, the lead time demands and the safety stocks in the central warehouse and in the departments are determined respectively, it is determined the reorder point in order to have the less expected shortages per replenishment cycles as possible.

- **Number of cycles per year**

In the current situation, this is a data from the hospital and it is equal to twelve cycles per year, what it means: the replenishments are once per month in the central warehouse.

The cycles at the departments are one week.

In the scenarios where I fix the order quantity instead of the order cycle, I use the next formula:

$$\frac{Da}{Q}$$

Where,

Da: annual demand; Q: order size

- **Cost per unit short per year**

The cost per unit short per year is the money that represents the stock out of one unit of product per year and it is calculated as twenty times the cost of the holding cost per unit and year.

I do this cost separately in the central warehouse and in the departments and later I sum the results.

The calculation for the each i location (where i= central warehouse or departments) is:

$$20 \cdot h_i / TUY_i$$

Where,

h_i : holding cost in i

TUY_i : Total units that pass through i per year

$$h_i = Q_{h,i} \cdot (v \cdot C_{h,u} + V_i \cdot SQM_i / (Q + SS_i))$$

Where,

$Q_{h,I}$: average inventory on-hand in the room i; with i= central warehouse (cw) or depts. (d)

v: unit variable cost

$C_{h,u}$: value holding cost per year and unit

V_i: volume occupied in room i; with i=cw or d

SQM_i: price per square meter in i; with i= cw or d

Q: order quantity

SS_i: safety stock in i; with i=cw or d

Annex D: Costs' development for the products in current situation

1. Kleenex tissues 2LGS

1.1. Ordering cost

Orders per year (hospital info.)	Orders per year (calculated)	Cost per order	Ordering cost per year
12,00	1,00	1,73	20,78

Table D.1: Ordering cost of Kleenex tissues in the current situation

1.2. Shortage cost

- ***Central warehouse**:*

Expected shortage per replenishment cycle	Cost per unit short	Number of cycles per year	Expected annual shortage cost
3,84	6,22	12,00	287,17

Table D.2: shortage costs in the current situation in the Cw of Kleenex tissues

- ***Departments**:*

Expected shortage per replenishment cycle	Cost per unit short	Number of cycles per year	Expected annual shortage cost
0,70	25,89	48,00	872,24

Table D.3: Shortage costs in the current situation in depts. of Kleenex tissues

The high value of the expected annual shortage in the departments is due to two reasons:

Firstly, the high lead time demand and secondly, that the holding cost in the departments is always higher than in the central warehouse and one of the reasons is that the central warehouse is in the lowest floors where the square meters' price is cheaper.

1.3. Handling cost

See section 4 of chapter VI.

1.4. Holding cost

Average inventory on-hand in the central warehouse (boxes)	Average inventory on-hand in the departments (boxes)	v (unit variable cost)	value holding cost per unit and year	Holding cost
41,50	20,88	26,33	0,07	1082,14

Table D.4: Holding cost in the current situation of Kleenex tissues

1.5. Total cost per year

Cost per year [€]	2396,50
Cost per year with labour cost as Jan de Rijk [€]	2430,05

2. Onderlegger Tena Bed

2.1. Ordering cost

Orders per year (hospital info.)	Orders per year (calculated)	Cost per order	Ordering cost per year
12,00	11,61	1,73	20,78

Table D.5: Ordering cost in the current situation of Onderlegger Tena Bed

2.2. Shortage cost

- ***Central warehouse:***

Expected shortage per replenishment cycle	Cost per unit short	Number of cycles per year	Expected annual shortage cost
0,00	6,58	12,00	0,00

Table D.6: Shortage costs in the Cw in the current situation of Onderlegger Tena Bed

- ***Departments:***

Expected shortage per replenishment cycle	Cost per unit short	Number of cycles per year	Expected annual shortage cost
0,00	31,02	48,00	0,00

Table D.7: Shortage costs in the depts. in the current situation of Onderlegger Tena Bed

2.3. Handling cost

See section 4 of chapter VI.

2.4. Holding cost

Average inventory on-hand in the central warehouse (boxes)	Average inventory on-hand in the departments (boxes)	v (unit variable cost)	value holding cost per unit and year	Holding cost
24,00	12,00	17,65	0,07	737,02

Table D.8: Holding cost in the current situation of Onderlegger Tena Bed

3.3.2.5. Total cost per year

Cost per year	1332,89
Cost per year with labour cost as Jan de Rijk	1476,66

3. Onderlegger Tena Bed Green

3.1. Ordering cost

Orders per year (hospital info.)	Orders per year (calculated)	Cost per order	Ordering cost per year
12,00	15,00	1,73	20,78

Table D.9: Ordering cost in the current situation of Onderlegger Tena Bed Green

3.2. Shortage cost

- **Central warehouse:**

Expected shortage per replenishment cycle	Cost per unit short	Number of cycles per year	Expected annual shortage cost
0,00	10,39	12,00	0,00

Table D.10: Shortage cost in the Cw in the current situation of Onderlegger Tena Bed Green

- ***Departments:***

Expected shortage per replenishment cycle	Cost per unit short	Number of cycles per year	Expected annual shortage cost
0,00	52,21	48,00	0,00

Table D.11: Shortage cost in the depts. in the current situation of Onderlegger Tena Bed Green

3.3. Handling cost

See section 4 of chapter VI.

3.4. Holding cost

Average inventory on-hand in the central warehouse (boxes)	Average inventory on-hand in the departments (boxes)	v (unit variable cost)	value holding cost per unit and year	Holding cost
8,00	14,00	51,01	0,07	385,01

Table D.12: Holding cost in the depts. in the current situation of Onderlegger Tena Bed Green

3.5. Total cost per year

Cost per year	693,34
Cost per year with Jan de Rijk's labour costs	765,22

4. Sterile products

4.1. Ordering cost

	Orders per year (hospital info.)	Orders per year (calculated)	Cost per order	Ordering cost per year
Kimguard 1step, KC 300, 101x101	12,00	11,46	1,67	20,00
Kimguard 1step, KC 200, 121x121	12,00	12,00	1,67	20,00
Kimguard 1step, KC 300, 76x76	12,00	9,60	1,67	20,00

Table D.13: Ordering cost in the depts. in the current situation of sterile products

The ordering cost per year differs from other products' ordering cost because the cost per order is lower n this case. The main reason is that the replenishments for sterile products are always done in labour days and the handling cost per hour is lower during those days in comparison with the weekends.

4.2. Shortage cost

	Expected shortage per replenishment cycle	Cost perunit short	Number of cycles per year	Expected annual shortage cost
Kimguard 1step, KC 300, 101x101	0,00	25,22	12,00	0,00
Kimguard 1step, KC 200, 121x121	0,00	13,85	12,00	0,00
Kimguard 1step, KC 300, 76x76	0,00	19,47	12,00	0,00

Table D.14: Shortage cost in the depts. in the current situation of sterile products

4.3. Handling cost

Product	Percentage of the total handling	Time for unloading the truck per month	Time for handling: scanning, replenishing (per month)	Total time for handling per month	Total time for handling per year	Handling cost per month	handling cost per year and unit	Average Consumption per year (boxes)	Labour cost per year for replenishing into depts.	Labour cost per year for replenishing into depts. with same cost per hour than Jan de Rijk
Total 3 products	1,00	0,38	1,00	1,38	16,50	27,50			330,00	412,50
Kimguard one-step KC 300 (101x101)	0,14	0,05	0,14	0,19	2,23	3,72	0,29	156,00	44,59	55,74
Kimguard one-step KC 200	0,82	0,31	0,82	1,13	13,60	22,67	0,27	996,00	272,03	340,03
Kimguard one-step KC 300 (76x76)	0,04	0,02	0,04	0,06	0,67	1,11	0,14	96,00	13,38	16,72

Table D.15: Handling cost per year for replenishing into departments

4.4. Holding cost

	Average inventory on-hand in the central warehouse (boxes)	Average inventory on-hand in the departments (boxes)	v (unit variable cost)	Holding cost
Kimguard 1step, KC 300, 101x101	0,00	11,00	84,19	216,89
Kimguard 1step, KC 200, 121x121	0,00	62,50	41,35	704,30
Kimguard 1step, KC 300, 76x76	0,00	8,00	77,05	119,71

Table D.16: Holding cost in the depts. in the current situation of sterile products

4.5. Total cost

	Total cost per year	Total cost per year with Jan de Rijk's labour costs
Kimguard 1step, KC 300, 101x101	236,89	292,63
Kimguard 1step, KC 200, 121x121	724,30	1064,34
Kimguard 1step, KC 300, 76x76	139,71	156,43

5. Dialysis products

5.1. Ordering cost

In the dialysis department, the employees do not work replenishing products the weekend, what it decreases the cost of the handling cost per hour and consequently the ordering cost per year.

	Orders per year (hospital info.)	Orders per year (calculated)	Cost per order	Ordering cost per year
Concentraat D294	12,00	12,00	1,67	20,00
Bicart 720 gr.	12,00	13,52	1,67	20,00
Concentraat D292	12,00	13,15	1,67	20,00
Concentraat D296	12,00	12,92	1,67	20,00

Table D.17: Ordering cost in the depts. in the current situation of dialysis products

5.2. Shortage cost

	Expected shortage per replenishment cycle	Cost per unit short	Number of cycles per year	Expected annual shortage cost
Concentraat D294	0,00	3,30	12,00	0,00
Bicart 720 gr.	0,00	5,09	12,00	0,00
Concentraat D292	0,00	4,97	12,00	0,00
Concentraat D296	0,00	9,53	12,00	0,00

Table D.17: Shortage cost in the depts. in the current situation of dialysis products

5.3. Handling cost

Product	Percentage of the total handling	Time for unloading the truck per month	Time for handling: scanning, picking, replenishing per month	Total time for handling per month	Total time for handling per year	Handling cost per month	handling cost per year and unit	Average Consumption per month (boxes)	Labour cost per year for replenishing into depts.	Labour cost per year for replenishing into depts. With the same labour cost per hour as Jan de Rijk's
Total 4 products	0,97	0,38	1,00	1,38	16,50	27,50			330,00	412,50
Concentraat D 294	0,69	0,26	0,69	0,95	11,38	18,97	0,66	345,00	227,59	284,48
Bicart 720 gr.	0,16	0,06	0,16	0,22	2,66	4,43	1,04	51,00	53,10	66,38
Concentraat D 292	0,11	0,04	0,11	0,16	1,90	3,16	1,00	38,00	37,93	47,41
Concentraat D 296	0,03	0,01	0,03	0,05	0,57	0,95	1,03	11,00	11,38	14,22

Table D.18: Handling cost per year for replenishing into depts. for dialysis products

5.4. Holding cost

	Average inventory on-hand in the central warehouse (boxes)	Average inventory on-hand in the departments (boxes)	v (unit variable cost)	Holding cost
Concentraat D294	0,00	221,50	4,79	597,05
Bicart 720 gr.	0,00	60,00	23,83	249,39
Concentraat D292	0,00	43,50	7,68	173,72
Concentraat D296	0,00	11,00	7,71	81,97

Table D.19: Holding cost in the depts. in the current situation of dialysis products

The highest holding cost is the one related to the first dialysis product (Concentraat D294). Its consumption is much higher than the rest of products: 60 pallets per year versus 14, 10 and 3 pallets respectively. And I would like to make notice that the volume occupied is the factor which represents a highest impact for the holding cost due to the expensive price per square meter in a hospital.

5.5. Total cost

	Total cost per year	Total cost per year with Jan de Rijk's labour costs
Concentraat D294	844,63	901,53
Bicart 720 gr.	322,49	335,77
Concentraat D292	231,65	241,13
Concentraat D296	113,35	116,20

Annex E: Intermediate tables for all the products in Scenario 1

Kleenex Ultra 2LGS

Department	Consumption last year [boxes]	Consumption two years ago[boxes]	Consumption average [boxes]	Consumption average per week (boxes)	Standard deviation	Inventory level desired in each replenishment (boxes) (once per week)	Safety stock [boxes]	Replenishments per month	stock max. Integer part	stock max. decimal part	Volume occupied in each department
6A	3,00	3,00	3,00	0,06	0,00	0,11	0,05	4,00	0,00	0,11	0,11
4C	109,00	114,00	111,50	2,32	3,54	4,10	1,77		4,00	0,10	0,83
3C	72,00	71,00	71,50	1,49	0,71	2,63	1,14		2,00	0,63	0,58
RUIMTENBEHEER ALGEMEEN	20,00	5,00	12,50	0,26	10,61	0,46	0,20		0,00	0,46	0,11
KOSTEN SCHOONMAAK	130,00	62,00	96,00	2,00	48,08	3,53	1,53		3,00	0,53	0,76
BLOKKADE FLAT	0,00	16,00	8,00	0,17	11,31	0,29	0,13		0,00	0,29	0,11
OPERATIE	10,00	8,00	9,00	0,19	1,41	0,33	0,14		0,00	0,33	0,11
FYSIOTHERAPIE	26,00	17,00	21,50	0,45	6,36	0,79	0,34		0,00	0,79	0,22
KLINISCH	20,00	15,00	17,50	0,36	3,54	0,64	0,28		0,00	0,64	0,22
ST. HUISARTSENPOST	6,00	8,00	7,00	0,15	1,41	0,26	0,11		0,00	0,26	0,11
POLI ETTEN LEUR	7,00	0,00	3,50	0,07	4,95	0,13	0,06		0,00	0,13	0,11
POLI ALGEMEEN ROOSENDAAL	15,00	0,00	7,50	0,16	10,61	0,28	0,12		0,00	0,28	0,11
MED.CENTR. OUDENBOSCH	3,00	0,00	1,50	0,03	2,12	0,06	0,02		0,00	0,06	0,11
HEMODIALYSE	25,00	0,00	12,50	0,26	17,68	0,46	0,20		0,00	0,46	0,11
1B	37,00	36,00	36,50	0,76	0,71	1,34	0,58		1,00	0,34	0,29
4B	3,00	2,00	2,50	0,05	0,71	0,09	0,04		0,00	0,09	0,11
	486,00	357,00	421,50	8,78		15,48	6,70		10,00	5,48	3,96

Table E.1: Kleenex Ultra intermediate calculations in scenario 1

- Consumption per month last year:

	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	Apr	May	Average	total Average
Monthly demand (boxes)	44	37,00	33,00	39,00	39,00	40,00	56,00	45,00	53,00	62,00	57,00	39,00	45,33	40,23
Weekly demand (boxes)	11,00	9,25	8,25	9,75	9,75	10,00	14,00	11,25	13,25	15,50	14,25	9,75	11,33	10,06

Table E.2: Kleenex tissues consumption last year per month

Tena Bed

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average[boxes]	Consumption per week (boxes)	standard deviation per week (boxes)	Inventory level desired in each replenishment (boxes) (once per week)	Safety stock [boxes]	Replenishments per month	stock max. Integer part	stock max. decimal part	Volume occupied in each department
6A	14,00	13,00	13,50	0,28	0,01	0,58	0,30	4,00	0,00	0,58	0,22
5A	20,00	19,00	19,50	0,41	0,01	0,83	0,42		0,00	0,83	0,22
5B	20,00	21,00	20,50	0,43	0,01	0,87	0,44		0,00	0,87	0,22
4A	24,00	19,00	21,50	0,45	0,07	0,97	0,52		0,00	0,97	0,22
4C	44,00	37,00	40,50	0,84	0,10	1,79	0,95		1,00	0,79	0,40
3A	80,00	39,00	59,50	1,24	0,60	3,08	1,84		3,00	0,08	0,65
3B	1,00	36,00	18,50	0,39	0,52	1,29	0,90		1,00	0,29	0,29
3C	31,00	37,00	34,00	0,71	0,09	1,51	0,80		1,00	0,51	0,40
2B	11,00	10,00	10,50	0,22	0,01	0,45	0,23		0,00	0,45	0,11
KINDERAFDELING	15,00	11,00	13,00	0,27	0,06	0,60	0,33		0,00	0,60	0,22
VERLOSBLOK 2 LI	14,00	12,00	13,00	0,27	0,03	0,57	0,30		0,00	0,57	0,22

POLI- UROLOGIE PK B RSD	9,00	9,00	9,00	0,19	0,00	0,38	0,19		0,00	0,38	0,11
POLI INTERNISTEN PK A RSD	2,00	0,00	1,00	0,02	0,03	0,07	0,05		0,00	0,07	0,11
POLI GYNAECOLOGIE PK B RSD	2,00	0,00	1,00	0,02	0,03	0,07	0,05		0,00	0,07	0,11
POLI CHIRURGIE PK B RSD	1,00	0,00	0,50	0,01	0,01	0,04	0,03		0,00	0,04	0,11
KLINISCH	0,00	1,00	0,50	0,01	0,01	0,04	0,03		0,00	0,04	0,11
ST. HUISARTSENPOST	2,00	1,00	1,50	0,03	0,01	0,08	0,05		0,00	0,08	0,11
POLI ETTEN LEUR PK A RSD	2,00	2,00	2,00	0,04	0,00	0,08	0,04		0,00	0,08	0,11
POLI ALGEMEEN ROOSENDAAL	23,00	20,00	21,50	0,45	0,04	0,94	0,49		0,00	0,94	0,22
HEMODIALYSE	36,00	33,00	34,50	0,72	0,04	1,48	0,76		1,00	0,48	0,29
1B	9,00	8,00	8,50	0,18	0,01	0,37	0,19		0,00	0,37	0,11
4B	30,00	25,00	27,50	0,57	0,07	1,22	0,65		1,00	0,22	0,29
	390,00	353,00	371,50	7,74	0,60	17,29	10,00		8,00	9,29	4,79

Table E.3: Tena Bed intermediate calculations in scenario 1

Tena Bed Green

Department	Consumption last year[paks]	Consumption two years ago[paks]	Consumption average[paks]	Consumption average (boxes)	Weekly consumption (boxes)	Standard deviation consumption	Inventory level desired in each replenishment (boxes) (once per week)	Safety stock [boxes]	Replenishments per month	stoc max. integer part	stock max. decimal part	Volume occupied in each department
6A	26,00	28,00	27,00	9,00	0,19	1,41	0,23	0,04	1,00	0,00	0,23	0,11
5A	27,00	26,00	26,50	8,83	0,18	0,71	0,23	0,04		0,00	0,23	0,11

5B	85,00	102,00	93,50	31,17	0,65	12,02	0,80	0,15		0,00	0,80	0,22
4A	42,00	40,00	41,00	13,67	0,28	1,41	0,35	0,07		0,00	0,35	0,11
4C	94,00	91,00	92,50	30,83	0,64	2,12	0,79	0,15		0,00	0,79	0,22
3A	74,00	52,00	63,00	21,00	0,44	15,56	0,54	0,10		0,00	0,54	0,22
3B	1,00	67,00	34,00	11,33	0,24	46,67	0,29	0,05		0,00	0,29	0,11
3C	40,00	43,00	41,50	13,83	0,29	2,12	0,35	0,07		0,00	0,35	0,11
2B	0,00	1,00	0,50	0,17	0,00	0,71	0,00	0,00		0,00	0,00	0,11
KINDERAFDELING	2,00	2,00	2,00	0,67	0,01	0,00	0,02	0,00		0,00	0,02	0,11
RONTGENDIAGNOSTIEK	1,00	1,00	1,00	0,33	0,01	0,00	0,01	0,00		0,00	0,01	0,11
SPOEDEISENDE HULP	0,00	3,00	1,50	0,50	0,01	2,12	0,01	0,00		0,00	0,01	0,11
	392,00	456,00	424,00	141,33	2,94		3,62	0,68		0,00	3,62	1,62

Table E.4: Tena Bed Green intermediate calculations in scenario 1

- Consumption per month last year:

	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	Apr	May	Average (paks)	Average (boxes)	Total Average (boxes)
Monthly demand (paks)	44,00	32,00	36,00	24,00	37,00	29,00	31,00	21,00	25,00	34,00	31,00	30,00	31,17	10,39	21,47
Weekly demand (boxes)	3,67	2,67	3,00	2,00	3,08	2,42	2,58	1,75	2,08	2,83	2,58	2,50		2,60	2,77

Table E.5: Tena Bed Green consumption last year per month

Kimguard 1step, KC 300, 101x101 (sterile 1)

Months	Consumption per month (boxes)
June	17,00
July	10,00
August	9,00
Sep.	14,00
Okt.	12,00
Nov.	12,00
Dec.	13,00
Jan.	10,00
Feb.	12,00
Mrt.	16,00
Apr.	13,00
Mei	10,00

Table E.6: Last year sterile 1 products' monthly consumption

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per week (boxes)	Inventory level desired in each replenishment (boxes) (once per week)	Safety stock [boxes]	Replenishments per month	Pallet size (m2)	Volume occupied in each department
Kimguard 1step, KC 300, 101x101	148,00	173,00	160,50	4,00	4,80	0,80	4,00	0,96	0,96

Table E.7: Intermediate calculations for sterile 1 products

Kimguard 1step, KC 200, 121x121 (sterile 2)

Months	Consumption per month (boxes)
June	128,00
July	60,00
August	39,00
Sep.	90,00
Okt.	101,00
Nov.	80,00
Dec.	86,00
Jan.	92,00
Feb.	72,00
Mrt.	94,00
Apr.	72,00
Mei	80,00

Table E.8: Last year sterile 2 products' monthly consumption

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per week boxes)	Inventory level desired in each replenishment (boxes) (once per week)	Safety stock [boxes]	Replenishments per month	Pallet size	Volume occupied in each department
Kimguard 1step, KC 200, 121x121	916,00	668,00	792,00	21,00	42,00	21,00	1,00	0,96	2,88

Table E.9: Intermediate calculations for sterile 2 products

Kimguard 1step, KC 300, 76x76 (sterile 3)

Months	Consumption per month (boxes)
June	11,00
July	6,00
August	5,00
Sep.	9,00
Okt.	7,00
Nov.	6,00
Dec.	8,00
Jan.	6,00
Feb.	7,00
Mrt.	10,00
Apr.	7,00
Mei	5,00
	7,25

Table E.10: Last year sterile 2 products' monthly consumption

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per week (boxes)	Inventory level desired in each replenishment (boxes) (once per week)	Safety stock [boxes]	Replenishments per month	pallets' size	Volume occupied in each department
Kimguard 1step, KC 300, 76x76	84,00	81,00	82,50	1,72	2,34	0,62	1,00	0,96	0,96

Table E.11: Intermediate calculations for sterile 3 products

Concentraat D294 (dialysis 1)

Months	Consumption per month (boxes)
June	360,00
July	300,00
August	360,00
Sep.	300,00
Okt.	180,00
Nov.	180,00
Dec.	180,00
Jan.	120,00
Feb.	180,00
Mrt.	180,00
Apr.	120,00
Mei	180,00
	220,00

Table E.12: Last year dialysis 1 products' monthly consumption

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per week(boxes)	Inventory level desired in each replenishment (boxes) (once per week)	Safety stock [boxes]	Replenishments per month	pallets' size	Volume occupied in each department
Concentraat D294	3540,00	3520,00	3530,00	74,00	101,99	27,99	4,00	0,96	1,92

Table E.13: Intermediate calculations for dialysis 1 products

Bicart 720 gr. (dialysis 2)

Months	Consumption per month (boxes)
June	72,00
July	72,00
August	108,00
Sep.	72,00
Okt.	36,00
Nov.	36,00
Dec.	72,00
Jan.	0,00
Feb.	36,00
Mrt.	36,00
Apr.	36,00
Mei	36,00
	51,00

Table E.14: Last year dialysis 2 products' monthly consumption

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per week(boxes)	Inventory level desired in each replenishment (boxes) (once per week)	Safety stock [boxes]	Replenishments per month	pallets' size	Volume occupied in each department
Bicart 720 gr.	828,00	864,00	846,00	18,00	27,28	9,28	4,00	0,96	0,96

Table E.15: Intermediate calculations for dialysis 2 products

Concentraat D292 (dialysis 3)

Months	Consumption per month (boxes)
June	66,00
July	39,00
August	42,00
Sep.	45,00
Okt.	47,00
Nov.	29,00
Dec.	31,00
Jan.	23,00
Feb.	31,00
Mrt.	39,00
Apr.	35,00
Mei	34,00

Table E.16: Last year dialysis 3 products' monthly consumption

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per week (boxes)	Inventory level desired in each replenishment (boxes) (once per week)	Safety stock [boxes]	Replenishments per month	pallets' size	Volume occupied in each department
Concentraat D292	537,00	694,00	615,50	13,00	16,61	3,61	4,00	0,96	0,96

Table E.17: Intermediate calculations for dialysis 3 products

Concentraat D296 (dialysis 4)

Months	Consumption per month (boxes)
June	11,00
July	10,00
August	17,00
Sep.	15,00
Okt.	16,00
Nov.	10,00
Dec.	11,00
Jan.	9,00
Feb.	3,00
Mrt.	10,00
Apr.	5,00
Mei	9,00

Table E.18: Last year dialysis 4 products' monthly consumption

Department	Consumption last year[boxes]	Consumption two years ago[boxes]	Consumption average per year (boxes)	Consumption average per week(boxes)	Inventory level desired in each replenishment (boxes) (once per week)	Safety stock [boxes]	Replenishments per month	pallets' size	Volume occupied in each department
Concentraat D296	178,00	252,00	215,00	2,24	3,36	1,12	4,00	0,96	0,96

Table E.19: Intermediate calculations for dialysis 4 products

Annex F: Prices Jan de Rijk Logistics

INBOUND	
	Price per year and pallet (euros)
Unload the truck check quantities visual verification of the pallet transport from the truck to the expedition floor labelling pallet transport from the expedition floor to the pallet location	
TOTAL	3

STORAGE	
	Price per year and pallet (euros)
TOTAL	55

OUTBOUND	
	Price per year and pallet (euros)
Order picking	2
Pallet outbound	3
TOTAL	63

TRANSPORT COSTS	100

***In case Jan de Rijk, deliver to the department: add 1euro/min·pallet to the transport costs

Table F.1: Prices for storage in Jan de Rijk Logistics

In the next table it appears the prices of transportation, depending on the number of pallets the truck carries.

# pallets	Transport rate per shipment
1	€ 30,00
2	€ 33,00
3	€ 36,00
4	€ 43,00
5	€ 51,00
6	€ 58,00
7	€ 61,00
8	€ 63,00
9	€ 67,00
10	€ 71,00
11	€ 75,00
12	€ 78,00
13	€ 81,00
14	€ 85,00
15	€ 88,00
16	€ 91,00
17	€ 94,00
18	€ 98,00
19	€ 101,00
20	€ 104,00
21	€ 107,00
22	€ 111,00
23	€ 114,00
24	€ 118,00
25	€ 120,00
26	€ 125,00

Table F.2: Transport rate per shipment by Jan de RIjk

Annex G: Rate shipments for each supplier

Bunzl

To the hospital/ To Jan de Rijk

# pallets	Transport rate per shipment
1	€ 605,56
2	€ 666,11
3	€ 726,67
4	€ 867,96
5	€ 1.029,44
6	€ 1.170,74
7	€ 1.231,30
8	€ 1.271,67
9	€ 1.352,41
10	€ 1.433,15
11	€ 1.513,89
12	€ 1.574,44
13	€ 1.635,00
14	€ 1.715,74
15	€ 1.776,30
16	€ 1.836,85
17	€ 1.897,41
18	€ 1.978,15
19	€ 2.038,70
20	€ 2.099,26
21	€ 2.159,81
22	€ 2.240,56
23	€ 2.301,11
24	€ 2.381,85
25	€ 2.422,22
26	€ 2.523,15

# pallets	Transport rate per shipment
1	638,89
2	702,78
3	766,67
4	915,74
5	1086,11
6	1235,19
7	1299,07
8	1341,67
9	1426,85
10	1512,04
11	1597,22
12	1661,11
13	1725,00
14	1810,19
15	1874,07
16	1937,96
17	2001,85
18	2087,04
19	2150,93
20	2214,81
21	2278,70
22	2363,89
23	2427,78
24	2512,96
25	2555,56
26	2662,04

Table G.1: Transport rate per shipment from Bunzl to the hospital or to Jan de RIjk

SCA

To the hospital/ To Jan de Rijk

# pallets	Transport rate per shipment
1	€ 605,56
2	€ 666,11
3	€ 726,67
4	€ 867,96
5	€ 1.029,44
6	€ 1.170,74
7	€ 1.231,30
8	€ 1.271,67
9	€ 1.352,41
10	€ 1.433,15
11	€ 1.513,89
12	€ 1.574,44
13	€ 1.635,00
14	€ 1.715,74
15	€ 1.776,30
16	€ 1.836,85
17	€ 1.897,41
18	€ 1.978,15
19	€ 2.038,70
20	€ 2.099,26
21	€ 2.159,81
22	€ 2.240,56
23	€ 2.301,11
24	€ 2.381,85
25	€ 2.422,22
26	€ 2.523,15

# pallets	Transport rate per shipment
1	544,44
2	598,89
3	653,33
4	780,37
5	925,56
6	1052,59
7	1107,04
8	1143,33
9	1215,93
10	1288,52
11	1361,11
12	1415,56
13	1470,00
14	1542,59
15	1597,04
16	1651,48
17	1705,93
18	1778,52
19	1832,96
20	1887,41
21	1941,85
22	2014,44
23	2068,89
24	2141,48
25	2177,78
26	2268,52

Table G.2: Transport rate per shipment from SCA to the hospital or to Jan de RIjk

Kimberly-Clark

To the hospital/ To Jan de Rijk

# pallets	Transport rate per shipment
1	€ 429,44
2	€ 472,39
3	€ 515,33
4	€ 615,54
5	€ 730,06
6	€ 830,26
7	€ 873,20
8	€ 901,83
9	€ 959,09
10	€ 1.016,35
11	€ 1.073,61
12	€ 1.116,56
13	€ 1.159,50
14	€ 1.216,76
15	€ 1.259,70
16	€ 1.302,65
17	€ 1.345,59
18	€ 1.402,85
19	€ 1.445,80
20	€ 1.488,74
21	€ 1.531,69
22	€ 1.588,94
23	€ 1.631,89
24	€ 1.689,15
25	€ 1.717,78
26	€ 1.789,35

# pallets	Transport rate per shipment
1	387,78
2	426,56
3	465,33
4	555,81
5	659,22
6	749,70
7	788,48
8	814,33
9	866,04
10	917,74
11	969,44
12	1008,22
13	1047,00
14	1098,70
15	1137,48
16	1176,26
17	1215,04
18	1266,74
19	1305,52
20	1344,30
21	1383,07
22	1434,78
23	1473,56
24	1525,26
25	1551,11
26	1615,74

Table G.3: Transport rate per shipment from Kimberly-Clark to the hospital or to Jan de RIjk

Gambro

To the hospital/ To Jan de Rijk

# pallets	Transport rate per shipment
1	€ 183,33
2	€ 201,67
3	€ 220,00
4	€ 262,78
5	€ 311,67
6	€ 354,44
7	€ 372,78
8	€ 385,00
9	€ 409,44
10	€ 433,89
11	€ 458,33
12	€ 476,67
13	€ 495,00
14	€ 519,44
15	€ 537,78
16	€ 556,11
17	€ 574,44
18	€ 598,89
19	€ 617,22
20	€ 635,56
21	€ 653,89
22	€ 678,33
23	€ 696,67
24	€ 721,11
25	€ 733,33
26	€ 763,89

# pallets	Transport rate per shipment
1	143,33
2	157,67
3	172,00
4	205,44
5	243,67
6	277,11
7	291,44
8	301,00
9	320,11
10	339,22
11	358,33
12	372,67
13	387,00
14	406,11
15	420,44
16	434,78
17	449,11
18	468,22
19	482,56
20	496,89
21	511,22
22	530,33
23	544,67
24	563,78
25	573,33
26	597,22

Table G.4: Transport rate per shipment from Gambro to the hospital or to Jan de RIjk

Annex H. Procedures for handling and storage of goods in Franciscus Ziekenhuis

This procedure shows the criteria for establishment of a warehouse stock item in a decentralized department store and how a customer can ask for

Scope

Warehouse employees and its customers.

Method

Not all items in stock at the central warehouse also put stock in any local department stores. This is because a number of departmental items are. The criteria for a magazine article in the range of a decentralized department store to take are:

> The article must by multiple departments within the hospital used, or
> The article should be an article where one may never get caught without, or
> The article has been boxed in on the department store cannot in decentralized locations.

An article in the set is included, provides a more limited administrative processing for both the customer and the central warehouse than any time by purchasing the item to be ordered.

When a customer finds an article that is increasingly used, it may consider this item in the department decentralized warehouse to stock. It should, however, thought that it affects the department budget and available space in the local department store. If ultimately the decision is made to the article actually decentralized stock interest may contact the team leader warehouse or the warehouse employee who has contact with the relevant department. This should only by or with the consent of the head of the department, in order to avoid misunderstandings.

This procedure describes how the stock level of items is determined and monitored; this applies both to the central warehouse and for the local warehouses.

Target

Clarity with respect to the establishment and monitoring of stock levels of items.

Definitions and concepts

Job inventory in the computer, this information can be obtained for example, consumption, purchase, etc.

Scope

This procedure applies to the warehouse and all its employees (internal) customers.

Method

Below is a breakdown between the central and local warehouses.

Central Warehouse

Once four weeks makes a computer system advice for a particular product. The 'Vover' states on the basis of consumption to order the numbers. The stock level should be determined by the past consumption, and work with an average stock to be added. Prolonged consumption will therefore provide higher inventory levels over time.

Despite the automatic inventory, it can sometimes happen that the stock early deflates, for example problems with supply or a sudden increase in consumption. In this case, the warehousemen themselves intervened by contacting the purchasing department. There can be decided for an alternative use for the item or an early delivery to take place. In this way, the stock levels in the central warehouse guarded.

Decentralized warehouses

Determining the inventory level of the articles applies when a new decentralized warehouse of a whole new department should be organized. It is as following procedure: the head of the department receives a product list of the warehouse. Then the team leader in consultation with the department store assortment with additional inventory level determined. This is used as the starting level. Over time it appears that this level should be adjusted.

Monitoring the stock level is not only applicable for new local stores when they start up, but also at existing warehouses. This monitoring and changes to the stock level are two different ways. One possibility is that the head of a department itself indicates that the stock level of a particular item to be adjusted. The other possibility is that from the warehouse stock levels are advised to adapt. This will be discussed during the annual talks between the head of a department, the responsible warehouse worker and possibly the warehouse team leader. The advice is a list of the average annual range of the department.

Points

From the Department only by the main decision taken at the stock level of an item to adjust. It's common for employees of a department store to ask employees whether they want to adjust the level, but can only by or the consent of the head of the department. The warehouse workers to the staff of the department to this point when demand emerges.

In this procedure describes how to control on physical and administrative inventory data and during the storage of goods.

Target

Clarity with regard to physical and administrative control of inventory data and during storage.

Powers

All warehouse employees are empowered to carry out controls during storage of goods, but also to verify the physical and administrative stock data in line. They were also responsible for changes which are hereby discovered to be processed.

Method

Storage (of stock goods / D-goods)

Upon receipt of the goods are checked against those of the packing list to include quality, quantity, expiry date and date of sterilization. When the order does not comply, for example when the goods already on the date is contacted by an employee of the magazine with the purchasing department. They provide further processing of the issue by contacting the vendor. When the transaction has approved, the goods shall be entered into the inventory program and disposed of in the propositions. This cleaning is done by a number of warehouse lines such as the FIFO system, laws and regulations regarding food, from left to right tackle system and ABC analysis. Where it is found that the shelf life has expired, the goods are disposed of and charged against the cost centre Scrapping (6980/01). Checking for expiration date is especially important for food and sterile products. For storage in local warehouses, we try to maintain stock of two weeks. These two weekly stocks 1 time per year with the department discussed and possibly amended. The establishment of decentralized warehouses of the wards, we try to maintain a uniform format.

Physical and administrative stock data

The administrative records are kept in stock inventory program. This program can be booked in goods and retired and all the other actions that are required to be performed. Ex: notes accompanying printouts, and orders authorizing consulting inventory. For administrative stock tune with the physical inventory is 2 times a year. Here, the current inventory counted and compared to a printout of the inventory program. The program through a list of inventory items turned in a certain position. After checking their differences credited or debited to the cost centre Inventory Differences (6980/00). Articles have 1 or 2 years have not diminished (shop girls) is entered and removed from the central warehouse.

Reporting

To the passage of goods and ex-stock additions or differences are written off, a survey tracked. This is a directory present in the warehouse, which stored 5 years.

In this procedure are the objectives and tasks of the warehouse.

 # Doel* Target

The objective of the warehouse is:

Voor klanten de juiste goederen op het juiste tijdstip en in de gewenste kwaliteit en kwantiteit leveren. For customers the right goods at the right time and deliver the desired quality and quantity. Om dit te kunnen realiseren ontvangt en controleert het magazijn alle goederen die worden aangeleverd en beheren zij zowel het centraal magazijn als decentrale magazijnen (wanneer de klant dit wenst). To realize the warehouse receives and verifies all goods being delivered and they manage both the central warehouse and local stores (if the customer so wishes).

 # Definities en begrippen Definitions and concepts

Fifo: First-in-first-out: De goederen met de kortste houdbaarheidsdatum worden het eerst gepakt. FIFO: First-in-first out: The goods with the shortest expiry date first caught.

Scope

Deze procedure heeft betrekking op alle betrokkenen bij het magazijn. This procedure applies to all those involved in the warehouse. Dit zijn het unithoofd logistiek, teamleider magazijn/csa, medewerkers magazijn, medewerkers inkoop en alle afdelingen en ondersteunende diensten die goederen krijgen aangeleverd via het magazijn. These are the main unit logistics, warehouse team leader / csa, warehouse staff, purchasing staff and all departments and support services that get goods delivered from the warehouse.

Taken Tasks

De volgende taken worden door de medewerkers van het magazijn uitgevoerd: The following tasks by the staff of the magazine carried out:

1. Goods Receipt, storage and processing returned goods.

Het in ontvangst nemen van goederen en het tekenen van ontvangstbewijzen en verzenddocumeThe receipt of goods and the signing of receipts and shipping documents.

Unpacking goods and check on quantity, quality, durability, sterility and state where the product finds.

The daily delivery of non-stock items.

Saving in the appropriate location in the warehouse using the FIFO system. For distribution and storage of sterile items, separate guidelines are followed.

Sending return items to suppliers.

2. Recording and goods issue

The handheld terminal with a record of the order of several departments.

With the purchase orders turned out orders to prepare and clean up the various departments under the FIFO system. While recording and clearing checks the employee keeping the goods and quantity.

The issuance of goods to the warehouse office.

3. Administration and Information

Entering inventory items into the computerized inventory system after the goods have been received and stored.

 Het invoeren van de uitgifte van goederen in het systeem; de medewerker verzorgt dus de gehele administratie van de goederenstroPutting the issue of goods in the system, so the employee handles the entire administration of the commodity. Voor niet-voorraadgoederen bestaat een handmatige en een geautomatiseerde administratie. For non-stock goods is a manual and automated records.

Providing information about items to departments through the stock system.

4. Establishment, maintenance and inventory control

The logical setting of local magazines, including the creation of barcode labels and a site survey of the property.

Moving local warehouses and re-decorating.

Neatly into the central warehouse (cleaning, cleaning) and frequent surveys of the stocks (exact number, location, durability).

Points

Het magazijn ontvangt en controleert alle goederen die worden aangeleverd, behalve de goederen die op basis van wet- en regelgeving door derden dienen te worden ontvangen The warehouse receives and checks all the goods were delivered, but the goods on the basis of laws and regulations by third parties must be received

Reference # / reference / literature

"The Compass", internal publication of the magazine.

In this procedure, all processing times are shown.

Target

Inzicht geven in de verschillende doorlooptijden. Insight into the different times.

Definitions and concepts

Scope

Deze procedure is van toepassing op het magazijn en al haar klanten. This procedure applies to the warehouse and its clients.

Method

Voor het weergeven van de verschillende doorlooptijden is onderscheid gemaakt tussen voorraadartikelen en niet-voorraadartikelen. To display the different lead times is a distinction between inventory items and non-stock items.

Niet-voorraadartikelen Non-stock items

- Na binnenkomst van de order worden de artikelen altijd dezelfde dag nog afgeleverd bij de kAfter entry of the order, the items always same day delivery to the customer. Mocht de klant niet aanwezig zijn op dat moment, worden de artikelen mee terug genomen en later op de dag of de volgende dag opnieuw aan de klant aangeboden. If the customer is not present at that time, the articles brought back and later in the day or the next day to the customer.

  If the order includes refrigerated or frozen products are directly delivered to the customer.

  Also urgently needed items are directly delivered to the customer. The magazine is accordingly informed by the purchasing department or by the customer.

Voorraadartikelen Stock Items

Stock Items urgently needed, can be picked up at the counter. For more information about warehouse and office opening times see the process customer information warehouse facility .

- In all departments in one or more fixed day (s) of the week included the need for stock items. Na het opnemen van de behoefte worden de benodigde artikelen klaargezet en dezelfde dag nog afgeleverd bij de betreffende afdeling. After recording of the necessary items need to be prepared and put on the same day delivered to the appropriate department.

  For items that are in deficit, the following applies: after receipt of the order with the goods receipt of the warehouse, the items the same day delivered to the customer.

Points

Reference # / reference / literature

M. de Bruijn, unit head logistics.

Einde document

These instructions describe how the receipt and storage of goods takes place.

 # Doel* Target

Duidelijkheid verschaffen met betrekking tot de wijze waarop ontvangst en opslag van goederen door het magazijn plaatsvindt. Clarity concerning how receipt and storage of goods carried by the warehouse.

Powers

Alle magazijnmedewerkers zijn bevoegd om een vrachtbrief van een vervoerder te tekenen voor ontvangst. All warehouse employees are entitled to a consignment of one carrier to sign for receipt.

Method

Voor het beschrijven van de werkwijze van ontvangst en opslag van goederen door het magazijn wordt onderscheid gemaakt tussen voorraadartikelen (D-orders) en niet-voorraadartikelen (A-orders en TEAL-orders). To describe the process of receiving and storage of goods through the warehouse is a distinction between inventory items (D-orders) and non-inventory items (A-Teal-orders and orders). Voorraadartikelen worden in het magazijn opgeslagen, niet-voorraadartikelen worden na ontvangst en controle vrijwel direct naar de klant gebracht. Inventory items are stored in the warehouse, non-stock items upon receipt and inspection almost directly to the customer.

Voor elke eigendomsoverdracht moet er zowel getekend - als een leesbare naam op het document geplaatst worden. For any transfer of ownership must be signed both - as a readable name placed on the document.

Voorraadartikelen: ontvangst en opslag Stock Items: receipt and storage

D-orders

Nadat de afdeling inkoop een bestelling bij een leverancier geplaatst heeft, staat deze order in het systeemonderdeel 'Verpli' als een order vermeld met een eigen ordernummer. After purchasing department placed an order with a supplier has is that order in the system component "Verpli 'as an order given by an individual order number. De leverancier stuurt vervolgens de goederen inclusief de vrachtbrief en de pakbon naar het magazijn. De vrachtbrief wordt door een magazijnmedewerker afgetekend en vervolgens met de chauffeur geretourneerd naar de leverancier. The supplier sends the goods including the bill of lading and packing list to the warehouse. The bill of lading is a warehouse worker and then signed off with the driver returned to the supplier. Wanneer de vrachtbrief getekend wordt, vindt ook de eigendomsoverdracht plaats. If the consignment is signed, the transfer of ownership takes place. Vanaf dat moment zijn de magazijnmedewerkers verantwoordelijk voor de order. From that moment on, the warehouse workers responsible for the order. Met behulp van de pakbon worden de goederen gecontroleerd. Using the packing slip the goods inspected. Vervolgens worden de goederen opgeruimd in het magazijn via het fifo-systeem. Subsequently, the goods are cleared through the FIFO in the warehouse system. Daarnaast wordt aan de hand van de pakbon de gegevens in het systeem goederenontvangst “Verpli' ingevoerd. In addition, based on the packing slip data in the goods receipt system "Verpli 'was introduced. Nadat de pakbon is gecontroleerd met de geleidebon, op bijvoorbeeld de omzetting van doos naar aantal stuks per doos, wordt de order geautoriseerd. Once the packing is controlled by the consignment note, eg on the transposition of pieces per box to box, the order authorized. Op dat moment wordt de voorraad pas daadwerkelijk bijgeboekt in het magazijn en kan de administratie de inmiddels ontvangen factuur afhandelen. At that time, the stock not actually booked in the warehouse and the administration can now receive the invoice handling.

Het kan ook voorkomen dat er goederen met spoed nodig zijn, deze worden dan uit de stad gehaald. It can also prevent the goods urgently needed, they are then removed from the city. Dit kunnen zowel voorraad als niet-voorraadartikelen zijn. This can be both stock and non-stock items are.

Sterile products

Voor steriele artikelen gelden specifieke voorschriften waar medewerkers magazijn rekening mee dienen te houden. For sterile products subject to specific rules that employees should take into account stock. Zie hiervoor de procedure wettelijke voorschriften vervoer en opslag magazijn . See the procedure regulations transportation and storage warehouse .

City

Het komt soms voor dat goederen met spoed nodig zijn, deze worden dan uit de stad gehaald. Occasionally, the goods urgently needed, they are then removed from the city. Voorraadgoederen uit de stad moeten worden bijgeboekt via een voorraad mutatieformulier. Stock Goods from the city must be booked through a stock movement form. Deze formulieren bestaan uit drie exemplaren waarbij de witte voor de administratie van het magazijn is, de roze en het gele exemplaar zijn voor de FIA. These forms consist of three units where the white of the administration of the warehouse, the pink and yellow copy to the FIA. Daarnaast worden ook de factuur en de prijsaanpassing in Voink naar de administratie gestuurd. In addition the invoice and the price adjustment Voink sent to the administration.

Niet-voorraadartikelen: ontvangst Non-stock items: receipt

A-orders

Ook hierbij geldt dat wanneer de afdeling inkoop een bestelling geplaatst heeft dat de order met bijbehorend ordernummer in het computersysteem staat vermeld. Again, is that when the purchasing department has placed an order with the order corresponding order number in the computer below. Na het aftekenen van de vrachtbrief, worden ook nu de goederen gecontroleerd aan de hand van de pakbon. Daarna worden de goederen ingevoerd in het verpli-systeem en wordt een geleidebon uitgedraaid. After outlining the consignment, the goods are also now monitored using the packing list. Then the goods imported verpli system and is turned a consignment note. De geleidebon en de goederen gaan vervolgens naar de interne klant. The consignment note and the goods are then shipped to the internal customer. De geleidebon is in tweevoud, na ondertekening van het origineel mag de klant de kopie houden. The consignment note in duplicate, after signing the original copy of the customer may keep. De pakbon blijft in het magazijn totdat de ondertekende geleidebon terugkomt, vervolgens wordt de order goedgekeurd in het computersysteem. The packing list remains in the warehouse until the signed consignment note comes back, then the order is approved in the computer system. Na goedkeuring worden de pakbon en de geleidebon in de A-kast bij de desbetreffende leverancier opgeruimd. Once approved, the delivery note and the consignment note in the A case cleared by the relevant supplier.

Teal-orders

Omdat deze goederenstroom niet geautomatiseerd is, krijgt het magazijn van de afdeling inkoop een blauwe en witte doorslag van de order. Because these goods are not automated, the warehouse receives the purchasing department of a blue and white carbon copy of the order. Ter bevestiging van ontvangst worden deze orders eerst ingeschreven op nummer in een apart boek waarna ze op alfabetische volgorde worden opgeruimd in een dossierkast. To confirm receipt of these orders are entered on first number in a separate book in alphabetical order before they are disposed of in a file cabinet. Bij binnenkomst van de goederen wordt eerst de bestelorder uit deze kast gehaald. Upon entering the property is the first purchase orders from the closet. Aan de hand van deze order wordt de pakbon gecontroleerd. On the basis of this order, the packing list checked. Op de pakbon wordt vervolgens een ontvangststempel gezet. On the packing list is then put a receipt stamp. Hierop wordt de ontvangstdatum, de paraaf van de ontvanger en de klant vermeld. This is the receipt date, the initials of the recipient and the client specified. Vervolgens worden de goederen aan de (interne) klant aangeboden, waarbij de pakbon getekend dient te worden. Then the goods to the (internal) customer offered, the delivery note should be signed. Als het om een deellevering gaat, wordt bij iedere levering een opvolgende letter gebruikt (a=, b=, c=, enzovoorts). If it is a partial delivery, any transfer is a subsequent letter used (a = b =, = c, etc.). Als de bestelorder niet in zijn geheel is uitgeleverd worden er twee kopieën gemaakt, waarvan 1 exemplaar voor de inkoop is en 1 voor de FIA. If the purchase orders is not completely delivered, two copies made, including 1 copy of the purchase and 1 for the FIA. Als de order wel in zijn geheel geleverd is, gaat de pakbon en het blauwe exemplaar van de order naar de FIA, het witte exemplaar gaat terug naar de afdeling inkoop. If the order or in whole is delivered, the delivery note and the blue copy of the order to the FIA, the white copy goes back to the purchasing department.

City

Soms worden ook niet-voorraadartikelen uit de stad gehaald, het magazijn krijgt dan een haalbon. Sometimes even non-inventory items removed from the city, the magazine will get a haalbon. De medewerker van het magazijn zet een ontvangststempel op deze bon en levert de goederen af bij de betreffende klant. The employee of the warehouse receipt puts a stamp on the voucher and deliver the goods on to the customer. Na ondertekening van de klant gaat de haalbon naar de FIA. After signing the client, the haalbon to the FIA.

 # Complicaties Complications

Er zijn diverse soorten afwijkingen mogelijk, hieronder worden enkele afwijkingen weergegeven met bijbehorende handelswijze. There are several types of defects possible, here are some deviations appear related to behavior. Bij twijfel wordt door de magazijnmedewerker contact opgenomen met de teamleider en / of de afdeling inkoop. In doubt by the warehouse employee contacted the team leader and / or the purchasing department.

Handelswijze bij afwijkingen tijdens ontvangst Dealing with deviations during reception

 Beschadigde verpakkingen (geconstateerd vóór tekenen van de vrachtbrief) Damaged containers (noted before signing the bill of lading)

Wanneer een medewerker constateert dat een straatverpakking én de artikelen beschadigd zijn, wordt de levering niet geaccepteerd door het niet tekenen van de vrachtbrief en het direct retour geven van de levering met de vervoerder. Indien alleen de straatverpakking beschadigd is, wordt hiervan een aantekening gemaakt op de vrachtbrief en wordt de vrachtbrief wel getekend. When an employee finds a street packaging and items are damaged, the delivery is not accepted by not signing the consignment note and promptly return all of the delivery to the carrier. If only the street package is damaged, you receive a note made the consignment and the consignment will be drawn. Als later blijkt dat toch de artikelen beschadigd zijn, kan alsnog actie worden ondernomen. If it later appears that the items are damaged, can still be action taken.

Beschadigde verpakkingen (geconstateerd na het tekenen van de vrachtbrief) Damaged packaging (detected after signing the bill of lading)
Na het tekenen voor ontvangst van de levering kan alsnog geconstateerd worden dat een verpakking en / of artikelen beschadigd zijn. After signing for receipt of delivery can still be noted that packaging and / or damaged items. In dit geval wordt contact opgenomen door de medewerker van het magazijn met de afdeling inkoop om de betreffende verpakking alsnog retour te sturen. In this case, contacted by the staff of the magazine with the purchasing department for the return on packaging yet to send.

Handelswijze bij afwijkingen tijdens opslag Dealing with deviations during storage

Alternative supplies
Wanneer een bepaald artikel tijdelijk niet leverbaar is, wordt er soms voor gekozen om een alternatief te bestellen. If an item is temporarily not available, is sometimes chosen to be an alternative to order. Bij ontvangst van deze goederen wordt het vervangende artikel ingeboekt als het 'normale' artikel. Upon receipt of such goods, the replacement article be booked as 'normal' article.

Change of brand and / or supplier
An article can make or change suppliers by purchasing procurement documentation will be updated. The behavior of the magazine remains the same, the article remains the same article number to.

Points

Bij een aantal afdelingen kan de geleidebon, de pakbon of de haalbon niet direct getekend worden vanwege de afdelingsorganisatie. In some departments, the consignment note, delivery note or haalbon not immediately be drawn because of the organization department. Hierover zijn met de betreffende afdelingen afspraken gemaakt. Matter with the relevant departments agreed. Dit geldt voor: Klinisch Chemisch Laboratorium, röntgenafdeling en soms de polikliniek. This applies to: Clinical Chemistry Laboratory, X-ray department and sometimes the clinic.

References / links / literature

"The Compass", internal publication of the magazine.

Diverse magazijnmedewerkers. Several store employees.

In deze procedure wordt de plaats van het magazijn in de organisatie weergegeven. In this procedure, the location of the warehouse organization listed.

 # Doel* Target

Duidelijkheid verschaffen over de plaats van het magazijn binnen de organisatie. Clarify the location of the warehouse within the organization.

Definities en begrippen

Scope

Deze procedure heeft betrekking op alle betrokkenen bij het magazijn. This procedure applies to all those involved in the warehouse. Dit zijn het unithoofd logistiek, medewerkers magazijn, medewerkers inkoop en alle afdelingen en ondersteunende diensten die goederen krijgen aangeleverd via het magazijn. These are the main unit logistics, warehouse staff, purchasing staff and all departments and support services that get goods delivered from the warehouse.

Method

Om de plaats van het magazijn binnen de organisatie duidelijk te maken, staat hieronder het organigram. To replace the warehouse within the organization to make clear, is below the plan.

De teamleider magazijn wordt functioneel en operationeel aangestuurd door het unithoofd logistiek. The team leader warehouse is functionally and operationally driven by the logistics unit head. De medewerkers magazijn worden functioneel en operationeel aangestuurd door de teamleider. The warehouse employees are functionally and operationally controlled by the team leader. Bij afwezigheid van de teamleider neemt een van de medewerkers de taak op zich om de dagelijkse werkzaamheden te coördineren. In the absence of team leader, one of the employees on the task to coordinate the daily activities. De bevoegdheden en verantwoordelijkheden zijn voor alle medewerkers vastgelegd in hun taakfunctieomschrijving. The powers and responsibilities are established for all employees in their job duties. De taakfunctieomschrijvingen zijn opgesteld door het unithoofd en worden onderhouden door PO&O. The task job descriptions prepared by the Unit Head and maintained by RD & D.

 # Referentie / verwijzing / literatuur Reference / literature

"The Compass", internal publication of the magazine.