

Last mile logistics requirements on secondary e-commerce packaging: Application to CDON

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MASTER THESIS



Last mile logistics requirements on secondary e-commerce packaging: Application to CDON

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Abstract

This master's thesis is the final step of the master's degree in Supply chain and Logistics taken in the Lunds Tekniska Högskola.

Buying products on the internet is a trend that has been increasing with the passing years. Even though nowadays this shopping behavior is established in our lives, it is predicted that it will keep growing within the next upcoming years.

These changes in the shopping behavior have come up faster than the necessary changes in some packaging requirements.

The present project focuses on understanding what requirements need to meet the secondary packaging solutions for e-commerce at the very last part of the supply chain, the last mile logistics. To conduct the research, first, an extensive literature review was conducted in order to understand what has been studied in this field and what needs to be studied.

Following, a real e-commerce company was selected, and the research was applied to it, by studying the different packaging solutions employed and discovering the importance given by the company to the different packaging requirements when selecting the packaging solutions. Parameters like volume utilization or dimensional weight were measured and calculated for different products and packaging solutions.

In addition, the different incentives, barriers and trade-offs for improving the employed packaging solutions to more logistically efficient ones are presented

Keywords: e-commerce, packaging requirements, last mile logistics, secondary e-commerce packaging, logistical efficiency.

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Lund, April 2019

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1 Introduction

This chapter will introduce the reader to the project. First, a brief background about the increasing growth of the global sales through e-commerce and the low logistical efficiency of the packaging systems will be presented. Then, in the problem discussion, the reader will find the motivation of this study. After, the research questions are presented, and the purpose of the study is described as well as the objectives to reach. Following, the author describes the delimitations of the project. To finish the chapter, the structure of the report is defined.

1.1 Background

Buying products on the internet (Business to consumer e-commerce), instead than in physical stores, has become more popular in the last years and it's expected to keep growing even faster in the future. The possibility of buying a product at any time, comparing different items and tracking the ordered products, all this from home, make this way of shopping interesting for the customers (Khurana, 2018).

According to the market and statistics research web Statista, by 2021 the global sales through e-commerce will reach 4800 billion USD, a huge increase compared to the 2300 billion USD of 2017. This has changed the shopping behavior and new sales channels have emerged, with new supply chain requirements, but these changes are taking place faster than the improvements in the packaging solutions for e-commerce (Wallin, 2014). According to a survey, sponsored by the company *Jabil*, where more than 200 different packaging-decision makers participated, 96% of brands think about e-commerce packaging problems but only 54% test for them. Both omni-channel and exclusively online seller companies participated in this survey, resulting in only the 44% of the brands creating different packaging for e-commerce and store sales. The packaging solutions are often developed for the store sales even these have different requirements than the e-commerce sales. According to an online article (Pierce, 2017), while some of the packaging requirements for a retail store are to be eye-catching for the customer or to have redundant features to prevent theft, the requirements for products sent directly home are product protection, high volume utilization and easy recycling.

One concern is related to the e-commerce secondary packaging's efficiency, which refers to the package solution chosen by the retailer to pack the product's primary

package and send it to the end consumer. As written in an online article (Benavides, 2018), this situation occurs because a smaller package is sent in a much larger box filled with paper or foam on the inside so that, in the end, a high percentage of what is transported is air and filler products that, furthermore, generate large amounts of waste. For some e-commerce companies it's cheaper to purchase 500 identical boxes, even they are larger than the products, than having 20 references of different measurements, which leads to low volume utilization. This can be explained by the concept of economy of scale, which states that the cost per unit decreases while the scale increases. According to a survey from an online article (Tyndall, 2017), 40% of the online deliveries are coming with packaging too big, which leads to a large amount of air within the package and to occupy unnecessary space at the pick-up points. At the same time, 72% of the people surveyed think that the retailers use too much packaging for online orders, which can lead to a big environmental impact and unnecessary extra handling for the consumers.

Another concern is that nowadays the logistical process sets the limits for the packaging's efficiency and its creative development in e-commerce and at the same time these are conditioned to shipping and handling costs, as said in the article (Benavides, 2018).

As found in a report published by the company *Billerudkorsnäs*, where eleven e-commerce and packaging experts participated, packaging development has a low priority in the rapidly growing world of e-commerce. This report states as well that there is plenty of room for improvement by retailers to meet the needs of consumers. Improving e-commerce packaging can increase the value of the packaging, the product and the brand for online retailers and consumers alike.

1.2 Problem discussion

The present project will focus on understanding what requirements need to meet the secondary packaging solutions for e-commerce at the very last part of the supply chain, the last mile logistics. Then, the author will find out which of these packaging requirements have more importance for a company, with internet as its only sales channel, when selecting the packaging solutions they will employ. The selected company will offer a wide range of different products excepting food and drinks, which are not considered in this project.

One of the concerns to study will be the volume efficiency in secondary packaging used for e-commerce, as some e-commerce companies (Benavides, 2018) tend to purchase boxes of few different measurements even they have a considerable variety of products with different sizes. This leads to pack products in packages that are much bigger and as a result there is a big percentage of air being transported and lot of material being wasted. However, having many different standard packages could have higher inventory, handling or traceability costs for the companies (Anthony,

2018) so finding the trade-offs between being economically efficient and being environmentally friendly is a big challenge.

There are many requirements (Lockamy, 1995) on secondary packaging, such as protection, material handling efficiency in the whole supply chain, stackability, volume and weight efficiency, communication to the consumers or saleability, but the special requirements of the secondary e-commerce packaging in the last mile will need to be studied and analyzed in this project. These requirements are different than the ones from the conventional distribution channel, as, for example, according to an online article (Mohan, 2017), in the e-commerce distribution channel, in average, packaging changes hands 20 times before it reaches the customer versus 5 times in the conventional retail supply chain. Then, the importance of requirements like protection is different in the e-commerce channel than in the conventional sales channel. To find more requirements that have an increased importance in the e-commerce challenge will be part of the study.

1.3 Research questions

The following research questions (RQ) are proposed for the present thesis:

- *RQ1: What packaging requirements have more and less weight for the chosen company when selecting secondary e-commerce packaging solutions for their products?*
- *RQ2: What packaging requirements show more potential to be improved in the employed packaging, and what are the possible solutions that the company could apply in order to achieve it?*

1.4 Purpose and objectives

The purpose of this master thesis is to identify different packaging requirements for secondary e-commerce packaging in the last mile logistics and to understand how an e-commerce company prioritizes among these requirements when selecting the packaging solutions they will employ. In addition, if it is identified that one or more packaging requirements show potential for improvement, possible solutions will be studied.

The overall objectives that this project will cover are:

1. To identify last mile logistics requirements on secondary e-commerce packaging.

2. To understand the criteria applied in the process for selecting secondary packaging in the selected company.
3. Find out the different packaging solutions the selected company employs and their advantages and disadvantages.
4. Evaluate the performance of the packaging solutions for different products and estimate the potential to reduce packaging waste and increase volume efficiency.
5. To identify incentives, barriers and trade-offs for changing to more logistically efficient the current packaging solutions for the selected company.

1.5 Delimitations

The delimitations for the present project are presented below

First, the packages used by the drop-shippers are not taken into account. Each drop-shipper has its own packaging solutions and, due to the large number of different drop-shippers working with CDON, the gathering of this data has been ruled out. Also, the shipping bags made of plastic used as the packaging solution for some products, mainly clothing, have not been studied in the present project. This is due to the high-volume utilization and efficiency of this package. Then, the present project focuses on the different packaging solutions made of cardboard that the chosen company employs.

The own criticism that the author brings up, is that it would have been interesting to interview additional e-commerce companies with similar characteristics to CDON. With more time and contacts to do so, it would have been relevant to do it in order to compare similar companies in the same distribution channel and to have the chance to increase the number of packaging solutions studied. Additionally, a warehouse visit in order to maintain in person conversations instead of phone conversations or to be able to make additional observations could have been interesting, but the company's private policy did not permit it.

Additionally, the study focuses in ten last mile packaging requirements for the e-commerce sales channel, that were identified in the literature. This is a major delimitation, as recent publications suggest some more requirements that were not in the focus of the project.

1.6 Structure of the Report

In this section, a brief abstract about each report chapter is given:

Introduction

This chapter starts giving a background to the reader in order to provide it with knowledge to follow the report. After, the problem discussion presents some studies related to the report's topic and to what extent it has been studied. Then, the proposed research questions for the project are presented. The purpose and objectives chapter enable the reader to anticipate in which direction will the report flow and the delimitations set the limits of the study and what aspect will not be studied or taken into account later in the report.

Methodology

The research strategy followed in the present project starts the methodology chapter. There, the reader can learn what type of strategy is followed by the author and how it is related to the project itself. Later, the explanation about which data gathering methods are employed during the research is given. Both types of literature review methods are described as well as how the planning process of the interviews was developed. To finish, a brief summary presents the main parts of the chapter.

Frame of reference

The purpose of this chapter is to give the reader a frame and a background about different terms that will set the paths of the study. This chapter establishes a foundation for the rest of the thesis. Concepts related to e-commerce, packaging importance among the supply chain, main packaging requirements or its environmental effects are presented through the chapter. After this chapter, the empirical study is presented.

Empirical Study

This chapter gives first an explanation of the studied company as well as the packing process is explained. Later, the different packaging evaluation is presented by the use of scorecards. After, the packaging selection effects applied to certain products are presented.

Analysis

The different sections in this chapter are focused on covering the objectives and answering the research questions. The first section of this chapter is centered on the analysis of the different last mile logistics requirements found for the e-commerce packaging. It is followed by the analysis of the packaging selection criteria that the selected company employs. After, the advantages and disadvantages of the different packaging solutions employed by the selected company are stated. To finish the chapter, a performance analysis about the volume utilizations and dimensional weights of the selected products is carried out.

Concluding discussion

The chapter starts with a review of the objectives, one by one, set at the beginning of the report. After, the research questions are answered. To finish, the next steps to be taken in future research are proposed.

2 Methodology

The aim of this chapter is to describe the methodology followed by the author. It introduces the reader to the selected research purpose, strategy and data collection methods and explains how they are related to the present project. After, the different data gathering methods applied to the project are presented and an explanation of how they are conducted is given. The concluding section summarizes the chapter.

2.1 Research strategy

While conducting a research in a master thesis it is key to have a clear structure. A research strategy is an overall plan for conducting a research study and it helps the researcher in planning, executing and monitoring the study (Johannesson & Perjons, 2014).

The conducted research in the present master thesis is exploratory. Exploratory research allows researchers to explore an area or problem in order to gain understanding (Singh, 2007). In the present project, the author plans to gain an understanding about the packaging requirements in secondary e-commerce packaging, in the last mile logistics, and about their importance when selecting them for a leading e-commerce company. At the same time, exploratory research is adaptable and flexible to change if new data appears. This is crucial for the current project as one of the data gathering methods will be interviews, which often provide additional information for the interviewee due to its dynamic nature (Saunders, et al., 2009).

The research strategy followed in the present project is the case study strategy. The purpose and objectives of the present project (see 1.4 *Purpose and objectives*) have led the author to follow this type of strategy. This strategy is adequate if the researcher pretends to gain a rich understanding of the study's context and processes being enacted (Saunders, et al., 2009). The author has selected diverse data gathering techniques for the project that are used in combination to obtain, at the end, reliable and valid information for the report, which is another characteristic of the case study strategy.

The different data collection methods selected for the present project are a literature review and interviews with workers from the selected leading e-commerce company.

Some of the project's objectives can be accomplished by conducting an extensive literature review and the rest will be confronted by carrying out interviews and gathering data from them. It is important to choose different gathering methods in order to ensure the veracity and reliability of the data. This technique is called triangulation, which refers to the use of at least two different data collection methods in order to support and verify the gathered data within a study (Saunders, et al., 2009).

2.2 Literature review

In the present chapter the methodology followed while conducting the literature review is explained. The author conducted two different types of literature review: An academic literature review and a non-academic literature review. This is, reviewing different academic papers and as well some reports or articles that are non-academic.

In order to conduct a proper literature review, first the objectives and research questions have to be established. After that, the search of articles to determinate what has been studied about these research questions and objectives is done. By conducting this literature review, the author will be able to find out what research has been done in the studied area leading to the fulfillment of the objectives 1 and 2 (See 1.4 *Purpose and objectives*). Once the literature review is conducted, it will lead to a frame of reference.

2.2.1 Academic literature review

The literature review for academic papers was conducted via the database LUBSearch, which is the digital library of Lund University. It is a library where employees and students have access to roughly 320,000 e-books, 200 databases and more than 78,000 e-journals. The author considered that this library is big enough to use it as the main search engine for the project.

The initial keywords used in the search for academic papers were determined at the beginning of the project, at the same time as the research questions. The initial keywords that gave some productive results were: *e-commerce pack**, *online pack**, *pack* in supply chain*, *e-tailing requirements*, *e-commerce requirements* and *online pack* requirements*. The reason of using *pack** is due to cover both the words packaging and package. Once the results of the search were shown, the author filtered the articles by their titles, keywords and abstract. The articles were selected

if, after a first read of their abstracts and keywords, the author considered that they had relevant information for the project. As it can be imagined, some of the articles that appeared on the different searches were discarded as the author considered, after reading the abstract, that the information contained was not relevant for the present project. After selecting the articles that were useful for the project, a review of the problem formulation and findings was carried out. As literature review is an iterative process, more keywords were used in order to find further literature: *Pack* rationalization*, *pack* standardization*, and *cost-reduction in pack**. The same process conducted with the results of the first search was carried out with this search. After the second search, the process was stopped because a point of saturation was reached, as suggested by Randolph (Randolph, 2009).

2.2.2 Non-academic literature review

Apart from LUBSearch, the search engine Google was used in order to find non-academic articles. By doing this, the author had the chance to find a wider variety of documentation that could support and give additional information to the academic texts. Also, non-academic search was useful as more recent articles were found, some of them of just months ago, that had updated and useful information. The methodology conducted in this non-academic literature review was similar to the one from the academic literature review. Different keywords were typed in the search engine Google. The different keywords were determined after carrying out the academic literature review and identifying the questions that required more research. The keywords used were *Packaging selection process*, *Packaging challenges in ecommerce* and *Sustainable packaging for ecommerce*. These searches resulted in different links that were filtered by the titles of the articles and the dates these were written. Once the articles were selected and considered useful for the project, a deep review of them was carried out.

With both, the academic and non-academic texts and articles found, the author gathered enough information to gain insight into the topic, to identify what has been studied in the field of study and to support some of the statements that have been done throughout the report.

2.3 Interviews

Gathering data through interviews can be very interesting and useful while carrying out a master thesis. By making use of them, it is probable to gather reliable and valid data that will make easier the achievement of the project's objectives. At the same time, interviews are dynamic which allows the person carrying out the project to change the way the interview is flowing if necessary.

For the present project, interviews have been chosen as one of the data gathering methods, as interviews are essential sources of case study information (Yin, 2003). While planning the interviews, firstly, the author developed a list of topics and subjects in order to cover the research questions. This is the first step taken in order to end with a proper question list that will be used in the interviews. Some of the topics that the interview guide should cover are:

- Packaging process followed by the company
- Packaging systems used and its evaluation
- Number of different SKU's held in the company's warehouse
- Packaging requirements set by the company
- Importance given to the rest of actors in the supply chain
- Current state of returnable packaging
- Importance given to packaging efficiency vs. other parts of the supply chain

These topics have been selected because the author considers that they cover some of the objectives and research questions (See 1.3 *Research questions and* 1.4 *Purpose and objectives*).

Based on the topics written above, the author developed a list of questions to be asked in the interviews. With these questions, the author considers that the data gathered from the interviews will cover the research questions. The list of questions, which can be found in the appendix, complies with the two main jobs of an interview: to follow the line of inquiry and to ask questions in an unbiased manner (Yin, 2003).

After developing the list of questions, the author set a date for the interviews. This list of questions was employed in the interviews and, within a short time since the interviews ended, the author went through all the gathered data. This was done in order to analyze the data and to figure out if there was lack of information regarding any of the topics. In case this happened, additional interviews would have been scheduled. The interview guide for this project can be found in the appendix, and as mentioned before, it covers the data needs as an exhaustive developing process of the question list, based on topics that cover the research questions, has been done.

2.3.1 Observations from the interviews

In the present project, the observations are related to documents and packaging materials showed to the author during the interviews. The displayed documents, large Excel files, contained information about all the products stored in the warehouse with some of their characteristics. Due to the large amount, and confidentiality, of the information contained in those documents, they were just displayed and not handed in. The author gathered data from them by taking notes. Additionally, one of the interviewees showed some packaging solutions. The author

could interact with them and took notes about different aspects. Two different packaging solutions were handed in to the author of the project.

In addition to the data gathered from the interview questions and the observations made during its development, the author collected data from two additional ways. One of them was to ask the interviewees to rank different requirements regarding their importance and satisfaction applied to different packaging solutions containing a specific product. These are the scorecards, which explanation and result can be found later in the report (See 4.3 *Packaging solutions evaluation*). The other way which from the author could gather data was a document that one of the interviewees handed in. The document handed in was the 2017 annual report of the company, where a lot of data can be found and applied to the present project. Information regarding, among others, the total amount of customers, merchants, how the product waste is handled, trade-offs of some environmentally friendly measures, etc.

Visiting the warehouse could have been very interesting as it is a proper place for observation studies. Nevertheless, the author of the present project was not authorized to conduct a visit to the warehouse as the company's policy did not permit it.

2.4 Chapter summary

The chapter started with the research strategy. The type of research strategy used in the present project, case study, is explained as well as how it is related and adapted to the present project and which data gathering methods are employed. Later, the literature review methodology is explained and both, the academic and the non-academic literature review carried out, are explained. After, the advantages of gathering data from interviews are explained and how they are linked to case study research. It is followed by a brief explanation of how the interviews were planned in the present project and how it is ensured that the gathered data is reliable. To finish, other documents from which data was gathered are presented as well as some observations that were made during the interviews.

3 Frame of reference

The main purpose of this chapter is to give the reader a frame and background regarding e-commerce, packaging and how both are linked. First, the e-commerce concept is explained in detailed as well as its different types, distributions channels and current situation. Then, a section about packaging can be found, where its different types are explained as well as the concept of packaging logistics, finishing with the environmental effects of packaging. After, the role of packaging in e-commerce is presented by explaining the concepts of last mile distribution, reverse logistics, special e-commerce packaging requirements and ending with a section about the current state of e-commerce packaging.

3.1 E-commerce concept

One of the multiple definitions of e-commerce is “To use the internet and other networks to purchase, sell, transport or trade data, goods or services” (Turban et al., 2018). Another common definition is that “E-commerce is the process of trading goods, information, or services via computer networks including the internet” (Fraser et al. 2000). Multiple definitions can be found in a large number of publications, but all of them agree on that e-commerce is the act of trading by using the internet. In this chapter, the different e-commerce types are listed. Then, the different online retailing distribution channels are enumerated. Finally, the reader will find a chapter where the past, present and future of e-commerce is explained.

3.1.1 E-commerce types

An e-commerce can be classified by the nature of the transactions and the relationships among the participants. The main classification is show as it follows:

- Business-to-business (**B2B**)
- Business-to-consumer (**B2C**)
- Consumer-to-business (**C2B**)
- Consumer-to-consumer (**C2C**)

As the main focus in this project will be in the transactions Business-to-consumer, only a literature review about this type of e-commerce has been carried out. A

Business-to-consumer e-commerce, from now on B2C, uses internet as the meeting point between a business or enterprise and the customer (Qin, 2009). It corresponds to the retail section of e-commerce, and retailing conducted on the internet is called e-tailing or online retailing (Turban et al., 2018). This kind of relationship among the participants might be more dynamic than in another type of e-commerce, but they can also be more sporadic as consumer behavior is unpredictable.

At first (Turban et al., 2018), B2C e-commerce used to sell products that were easy to manage and handle, as books, music and software. Since the year 2000, a new wave of products started to be sold as the consumers were looking for more complex products like furniture, expensive clothing, etc.

Some advantages that online retailing has in comparison to traditional retailing are (Xu, 2014):

- Lower product cost, as they need to be more competitive
- Lower supply chain costs
- Possibility of small companies to compete with larger companies
- Sell specialized products worldwide
- More flexibility by being able to change prices and catalogs quickly

3.1.2 Online distribution channels

An online retailing company is driven by a business model, which describes the methods that the company will follow in order to generate income by its business operations. One way to classify online retailing business models is by the distribution channel, the most common ones are described as it follows (De Koster, 2003):

- **Direct marketing by manufacturers:** Companies conducting this business model sell their online products directly, without intermediaries, from their website and sometimes they sell via retailers. These companies also have physical stores thus more than one sales channel.
- **Pure-play online retailers:** These companies only sell their product online, being their only sales channel. Thus, they do not have physical stores.
- **Click-and-mortar retailers:** Brick-and-mortar retailers that have a website to supplement their sales from the physical stores.

The present project is focused on a company with internet as its only sales channel, thus a pure-play online retailer. Pure-play online retailers usually conduct their sells in two different ways, by holding inventory in their warehouse or by conducting drop-shipping. As the present project focuses only in the packaging solutions used by the selected company, the drop-shipping term is mentioned but not explained in detail.

One of the strategies that these kind of online retailers conduct is to hold inventory in their warehouses. This inventory (Khouja, 2001) is previously bulk-bought to different wholesalers for a determined price. After, the company stores the inventory in their own warehouse until a product is ordered. Once an order is placed for a certain product, an operator will pick the product from its location, pack it and then load it on the delivery vehicle to finally arrive to the customer. The different requirements that each company has when selecting the packaging solution for a certain product is of interest for the present project. Some advantages (Turban et al., 2018) about carrying out inventory are a greater control of the stock, greater control over the shipping options, take advantage of bulk savings and reduction of the lead time. Also, in the case of an order with multiple products, all of them can be delivered at the same time as they come from the same place. At the same time there are some disadvantages like the need of an investment, risk of obsolescence and need of personnel.

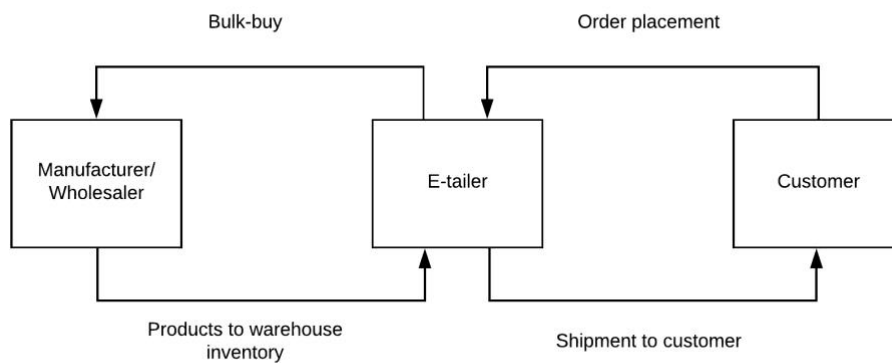


Figure 1. Main activities when holding inventory in the online retailer's warehouse (own design)

3.1.3 Past, present and future of e-commerce

Over the past decade, the evolution of the internet has had a direct correlation with e-commerce. Just as internet (Augment, 2016) has grown in terms of marketing, advertising, and purchasing of products, goods or services, e-commerce has grown to rival traditional shopping in many ways. The most (Augment, 2016) impactful changes that have been taken in e-commerce over the past 10 years include:

- Rise of marketplaces
- Shift to using mobile devices for online shopping
- Enormous growth of digital marketing and advertising

According to the market and statistics research web Statista, the worldwide online retailing sales in 2014 reached 1336 billion U.S. Dollars. At the end of 2018, this figure reached 2842 billion U.S. Dollars. In just 4 years, the worldwide sales have been doubled, which shows the huge growth that e-commerce is experiencing. According to a report published by Postnord, the Swedish freight transport company, where more than 11,000 consumers from Europe were interviewed, a total of 260 million consumers bought online in 2017. The leading country in Europe in money spent annually by consumer, according to the report, is UK (874€), followed by the Nordic countries (656€) and with Germany in third position (647€). E-commerce does not have a big impact just in these countries, countries like Spain, Belgium and Italy had an enormous growth of consumers between 2016 and 2017, increasing a 27%, 34% and 44% respectively. The report states that e-commerce is in a stage of constant development as more people are gaining access to the Internet and the number of potential e-commerce consumers is growing. An important fact about the potential of e-commerce is the percentage of consumers depending on the age. While up to the 78% of the surveyed people between 18 and 29 years old are e-commerce consumers, when talking about people aged between 50 and 64 years old this figure drops down to 52%. With the passing of time, it can be assumed that if no drastic changes in shopping behavior appear this high percentages will move up the age groups.

In the future we will not likely see the same growth in new e-commerce consumers, but instead purchase amounts and frequency will keep rising and more and more sectors will migrate to the Net. As found in the web Statista, the forecast is that by 2021 the worldwide online retailing sales will grow up to 4878 billion U.S. Dollars, increasing this figure a 72% compared to the sales registered by the end of 2018.

3.2 Packaging

A good definition of packaging system is “A coordinated system of preparing goods for transport, distribution, storage, retailing and end use” (Paine, 1981). Packaging can be designed for all kind of products conceived, depending on them the packaging will have different special requirements, but the common role of every packaging system is to transport, distribute and storage a product (Paine, 1981). In this chapter, first an explanation about the different types of packaging and its functions is given. After, the concept of packaging logistics is explained. To end, the environmental effects of packaging are explained.

3.2.1 Types of packaging and functions

Packaging is typically classified into primary, secondary and tertiary packaging. Primary packaging (Johnsson, 1999) is in contact with the product and its main function is protection. Secondary packaging is designed to contain the primary packaging and to provide extra protection, to the product and also to the primary packaging itself. In the case of a manufacturer shipping multiple products to the logistic center, normally the secondary packaging contains multiple primary packaging in order to facilitate the transport. On the other hand, in the case of an online retailer shipping directly a product to the customer, the secondary packaging will contain just the products ordered by the customer, with a big chance that this will be just one product. In the present project the main focus will be in the secondary packaging used in the last mile logistics when a customer places an order to an online retailer, and will be referred as secondary e-commerce packaging. Tertiary packaging is usually a container or a pallet containing multiple secondary packages in order to transport them efficiently (Johnsson, 1999). This kind of packaging is used mainly when the manufacturer ships multiple products to the logistic center. It is not present in the deliveries from an online retailer to a customer, for example.

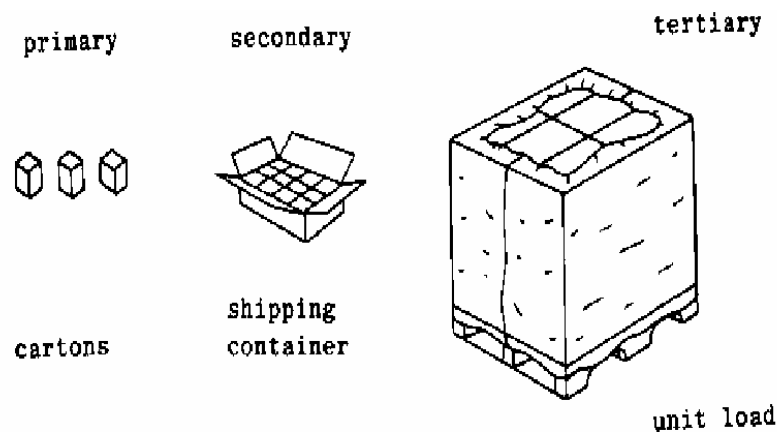


Figure 2. Example of primary, secondary and tertiary packaging (“Packaging levels”, 2008)

When talking about its functions, packaging has to fulfill different requirements. According to Lockamy III (1995), there are six different packaging functions:

- **Containment:** This function is the responsible for restraining the contents in the package.

- **Protection:** Related to the containment function. Its function is to protect the content of the package from outside influences as high/low temperatures, odors or vibrations than can damage the product.
- **Apportionment:** The aim of this function is to reduce the large-scale production to a size that is manageable for the end-user.
- **Unitization:** This function permits primary packages to fit in secondary packages and secondary packages to fit in tertiary packages. It facilitates the movement of packages and the optimization of the material handling activities.
- **Communication:** It allows the customer to easily identify the products contained in the package by its branding and labelling. It also facilitates the identification of the products contained in a tertiary or secondary packaging in the warehouse.
- **Convenience:** It simplifies and helps the customer to use the product. Usually applied to pre-prepared foods, which sometimes its packaging its compatible with the use of a microwave.

The packaging functions described previously are the basis for any kind of package. While designing a package (Lockamy III, 1995), all of them should be taken into account in order to achieve a suitable result.

3.2.2 Packaging standardization & Customization

Standardizing on fewer types of packages is a cost-cutting method used by the vast majority of companies nowadays. It consists on having few different standard packages even the range of products that the company offers is wide (Anthony, 2018).

Packaging standardization has its advantages and its disadvantages. The main advantage, as said before, is its cost-cutting potential. The costs can be reduced due to:

- Taking advantage of economies of scale, discounts are offered by buying large quantities of a specific package.
- Fewer needs for equipment changes, as the packaging line will be handling the same kind of packaging constantly.
- Easier to store in the warehouse, as the need for specific storage decreases.

At the same time, conducting packaging standardization in a wrong way can have many disadvantages. This can happen if the company just focuses on reducing the number of standard packages to the lowest without conducting a proper study and analysis of their current products and requirements. Packaging standardization should be proactive as the company should keep evaluating its packaging and the new requirements that might come within time (Anthony, 2018). An important

disadvantage that packaging standardization can cause is the big chance of shipping some products in larger boxes than needed. This causes the following problems:

- Increasing material waste, as the box is bigger than necessary and additional material has to be placed in the package in order to protect the product.
- Shipping air, which translates into paying for space that is not being used.
- Increasing the CO₂ footprint, by conducting a poor volume efficiency in the delivery vehicles.

Custom packaging is the opposite concept to standard packaging. It refers to packaging systems that are developed for a specific product in order to make the product fit perfectly (Greasley, 2016). The main advantage of this kind of package is that the product fits in it perfectly and additional material is not required, or very few, to ensure protection. By having a high-volume efficiency, the material waste is reduced dramatically, the volume efficiency of the delivery vehicles also increases, and the product protection will be higher. The main disadvantage of this solution is located on its cost. Purchasing customized packaging is very expensive for the companies as a packaging structural engineer is required to design it as well as a minimum volume of packages have to be ordered (Greasley, 2016).

Both standard and custom packaging have its advantages and disadvantages. While companies that are starting or that are small in size might opt for standard packaging, bigger companies with a higher budget have custom packaging for certain products with high sales rates. Therefore, small companies usually have few standard packaging and bigger companies have a mix of standard packaging and custom packaging for their top sold products (Greasley, 2016).

3.2.3 Packaging logistics

Packaging plays multiple roles in the supply chain as it tries to fulfil requirements for logistics, production, marketing and environment (Jahre & Hatteland, 2004). This is because packaging interacts with vehicles, handling equipment, products, information systems, warehouses or customers at the different stages of the supply chain.

The concept of packaging logistics (Saghir, 2002) focuses on the synergies achieved by integrating the systems of packaging and logistics with the potential of increased supply chain efficiency and effectiveness, through the improvement of both packaging and logistics related activities.

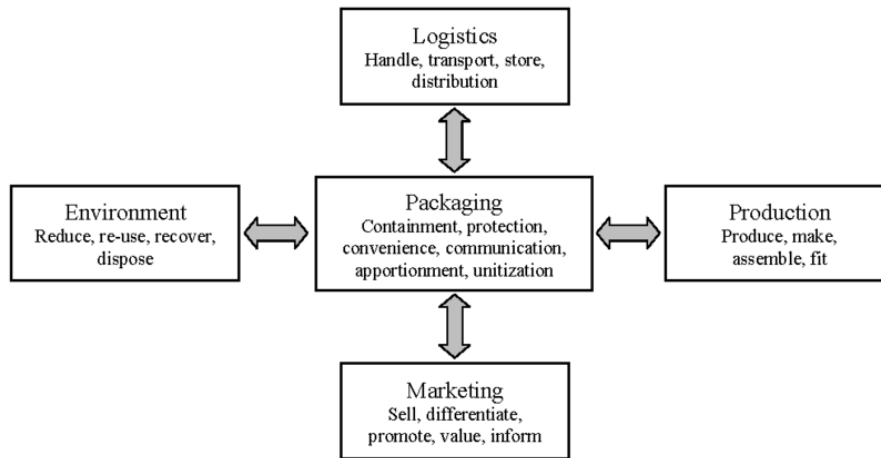


Figure 3. Main interactions of the packaging system (Jahre & Hatteland, 2004)

The packaging specifications (Lockamy III, 1995) have a direct influence on the time required for completing packaging operations which basically affect lead time and delivery dates to the customer. Below, the relationship between some packaging and logistical activities can be found.

Table 1. Packaging cost trade-offs compared with other logistical activities (Lambert et. Al., 1998)

LOGISTICS ACTIVITY	TRADE-OFFS
TRANSPORTATION	
Increased package information	Decreases shipment delays; increased package information decreases tracking of lost shipments
Increased package protection	Decreases damage and theft in transit but increases package weight and transport costs.
Increased standardization	Decreases handling costs, vehicle waiting time for loading and unloading; increased standardization; increases modal choices for shipper and decreases need for specialized transport equipment
INVENTORY	
Increased product protection	Decreased theft, damage, insurance; increases product availability (sales); increases product value and carrying costs
WAREHOUSING	
Increased package information	Decreases order filling time, labor cost.
Increased product protection	Increases cube utilization (stacking), but decreases cube utilization by increasing the size of the product dimensions
Increased standardization	Decreases material handling equipment costs
COMMUNICATIONS	
Increased package information	Decreases other communications about the product such as telephone calls to track down lost shipments

At the same time (Saghir, 2002), packaging also affects the supply chain effectiveness, as it connects the supply chain and the end user (its main customer), and enables the chain's first task to be accomplished, to serve consumers. Therefore, packaging is of relevant importance and has a significant influence on the supply chain, as it has an important economic and environmental effect. Even though, few research has been carried out in this area and there is still a lot to improve. Among other attributes, packaging has much potential to reduce costs and environmental impact (Pålsson & Hellström, 2016).

The role of packaging in the supply chain has become more important within the last years as it is a resource that is present from the point of fulfillment to the point of consumption. A better understanding of the complexity of packaging logistics and providing new packaging concepts and solutions that facilitate smoother handling throughout the whole supply chain are demanded (Saghir, 2002).

3.2.4 Environmental effects of packaging

Packaging has positive and negative impacts on the environment. On the one hand (Pongrácz, 2007), the positive impact is related to the facilitation of the distribution of consumer goods while protecting them at the same time. This permits the products to reach the customer at the same stage, or very similar, they departure from the manufacturing center. In other words, packaging has a positive impact on the environment by helping to avoid product waste. On the other hand (Pongrácz, 2007), the negative impact includes the use of resources and specially the effects of packaging-related wastes and emissions.

A figure where the packaging usages by type of goods in developed countries is displayed below.

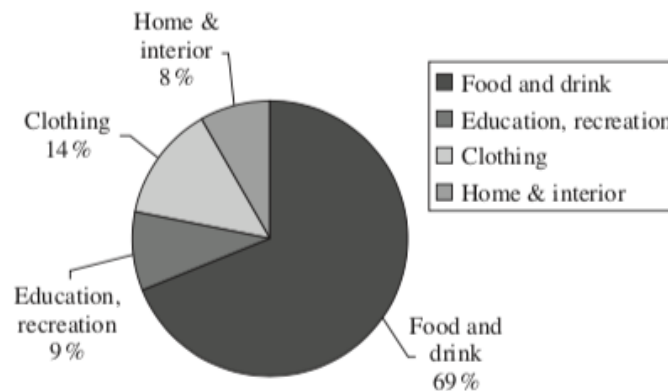


Figure 4. Packaging use divided by good types in developing countries (Kooijman, 2000)

For the present project, the types of goods that the selected company works with include all the good types displayed above excepting food and drinks, this is a 31% of the total packaging usage. In particular, the packaging solutions studied in the present project are made of carton. Carton boxes are easy to print on, collect into secondary packages, and pile over each other. After its use, carton is 100% recyclable (Pongrácz, 2007) and it is the most broadly used material in secondary packaging. However, in a study (Fan et. al, 2017) comparing the main emissions of 6 types of packaging, carton boxes show the largest CO₂ emissions, which are directly related to the processes of their production and consumption. A proper management of forests can facilitate a continued supply of wood for paper and other purposes while contributing to the environment. Trees are large carbon dioxide consumers and by managing properly the forests, the lack of trees and its corresponding increase of carbon dioxide in the atmosphere can be avoided.

There is an existing, and growing, trend nowadays regarding the environmental concern with packaging. Consumers (Regattieri, et al., 2014) are increasingly demanding more environmentally-friendly packaging; reduced packaging, recyclable packaging or re-usable packaging. At the same time, customers do not want to give up features that they currently have (Keating, 2018).

3.3 The role of packaging in e-commerce

With the ongoing rise in e-commerce comes a concurrent increase in demand for secondary and transit packaging (Keating, 2018). Every year, e-commerce companies ship millions of packages throughout the world (De Felice et. al. 2016) and the more people shop online, the more the role and the function of packaging change since the shelf presentation of the product becomes less important. In this chapter, first an explanation about the principle of last mile distribution is given. After, the reverse logistics concept will be brought up followed by the special supply chain requirements that packaging has in the e-commerce channel. To end, the current situation of e-commerce packaging is presented.

3.3.1 Last mile distribution

The last mile is mentioned as the last segment of movement from the last upstream distribution center, local warehouse or consolidation point to the final destination (Xiao, 2017). It is the point at which the package finally arrives to the customer's door. It is the part of the supply chain that the present project focuses on. Last mile distribution (Dolan, 2018) is a key to consumer satisfaction, but at the same time is the most expensive and time-consuming part of the shipping process. The last mile problem is related to its cost and inefficiencies, often due to how it is developed.

The final part of the shipment, typically involves multiple stops with low drop sizes, with only one or two packages being dropped off at each time.

According to Dolan (2018), taking into account the whole cost of shipping products in the e-commerce channel, an estimation of the last mile delivery costs involve around the 53% of it. And, with the growing trend of the free shipping customers are less willing to pay for a delivery fee.

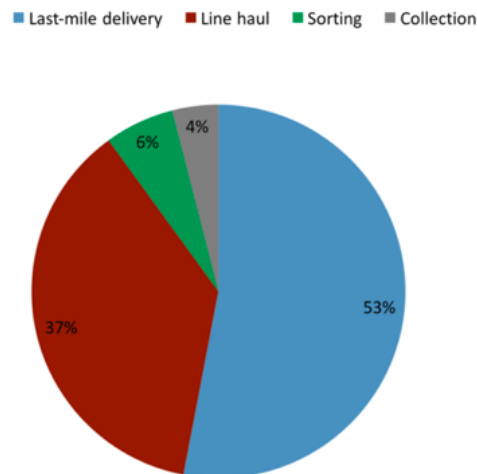


Figure 5. Share of delivery costs (Dolan, 2018)

Last mile distribution challenges include (Dolan, 2018):

- Deliver goods faster to meet consumer expectations
- Reduce costs as it is the most expensive part of the shipping costs
- Develop reception systems that can congregate the reception of goods in one area
- Develop solutions to avoid a reception failure due to customer's absence in the receiving address

Therefore, developing solutions in order to reduce the last mile problem will be of significant importance in the future as e-commerce is predestined to keep growing in the upcoming years.

3.3.2 Reverse logistics

Reverse logistics (Xiong, 2005) of e-commerce refers to the return, counter-flow or reverse-flow of products which are ordered on the internet from customers to suppliers. These products are generally returned for reasons of poor quality or other factors of customer dissatisfaction. In the reverse logistics process (Robinson, 2014)

two main groups need to be satisfied: the customer and the company. Below, a figure where the key components for an effective e-commerce reverse logistics is displayed.

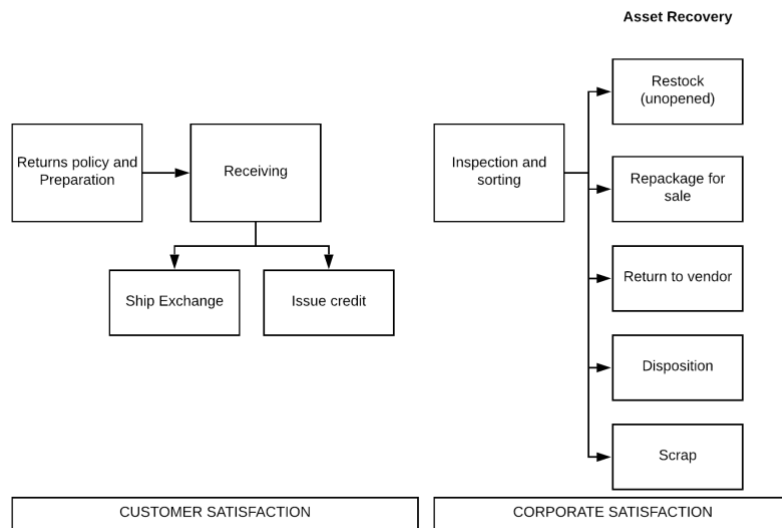


Figure 6. Key components of e-commerce reverse logistics (Robinson, 2014)

As seen in the figure, the key components are:

- Returns policy and preparation
- Receiving and decide if ship an exchange or issue a credit
- Inspection and sorting
- Asset recovery, which can lead to restock the product, repack for sale, return to vendor, dispose or scrap

When talking about costs (iThink logistics, 2018), product returns add an estimated 8 to 10% of the cost price of the product. The true cost of a product return is not related just to the logistics costs, the damage to the customer experience due to the inconvenience has to be taken into account as well. Each time (iThink logistics, 2018) the customer returns a product, chances are high that they will not buy again and most probably they will start buying from the competitors.

Considering the potential significance of reverse logistics for e-business, this issue persists as an important one, and requires urgent attention, if businesses want to survive in competitive market environments (XiaoYan et. al, 2012). With reverse logistics, packaging has an additional requirement: re-use capability, which aim is to re-use the same package the customer received in a potential return.

3.3.3 Particular e-commerce packaging requirements

Packaging (Hellström et. al, 2007) affects supply chain effectiveness because it represents an interface between the supply chain and its main customer, the end user. In a publication where a packaging performance evaluation method is presented (Olsmats et. al, 2003), a theoretical framework for a packaging scorecard was developed. There, the most significant functional packaging criteria for different actors along the supply chain are presented. The different packaging requirements presented as the most significant ones are presented in a table below.

Table 2. Most significant functional packaging criteria along the supply chain (Olsmats et. al, 2003)

<i>Nbr</i>	<i>Packaging criteria</i>
1	Machinability
2	Product protection
3	Flow information
4	Volume & weight efficiency
5	Right amount and size
6	Handleability
7	Other value-adding properties
8	Product information
9	Selling capability
10	Safety
11	Reduced use of resources
12	Minimal use of hazardous substances
13	Minimal amount of waste
14	Packaging costs

In a more recent study (Pålsson & Hellström, 2016), where the packaging scorecard mentioned above is employed to evaluate different packaging solutions, six additional packaging criteria are suggested and used in the study. The mentioned additional packaging criteria are presented as it follows:

- Stackability
- Unwrapping
- Traceability
- Recyclability
- Reverse handling
- Packaging design

Nevertheless, packaging has different requirements depending on its distribution channel. In particular (Visser, 2002), in the e-commerce channel, packaging has specific requirements that are key to fulfill. It is hard to transform the traditional

retail channel packaging into online retailing; thus, e-commerce requires a new paradigm for the product packaging.

The e-commerce packaging is meant to fulfill requirements related to three main areas: Design, Logistics and Environment (Regattieri, et al., 2014). The main aspects that have to be taken into account in the packaging design are mainly physical and mechanical. Aspects like dimensions, volume & weight efficiency, handleability or protection are fundamental while designing a package. The logistical part of a package includes aspects like protection against theft, traceability or reverse logistics. Returns (Regattieri, et al., 2014) are a big deal in the e-commerce supply chain, thus a package that facilitates returns will improve the logistical efficiency in the supply chain. The environmental part of a package is also very important, and its concern is increasing within the last years. To use recyclable and bio-degradable materials, reduce the amount of material used and the additional materials are aspects that can help to improve the environmental efficiency of a package. Customer requirements are present in these three areas. Related to the design area for example (Regattieri, et al., 2012), customers expect packages to guarantee a good handleability (e.g., easy to handle, easy to open or being user-friendly). From the logistics area, customers buying online request quick product delivery, thus lead time should be reduced. As the environmental concern is increasing within the last years, consumers (Regattieri, et al., 2014) are increasingly demanding more environmentally-friendly packaging, which translates into a customer requirement within the environmental area.

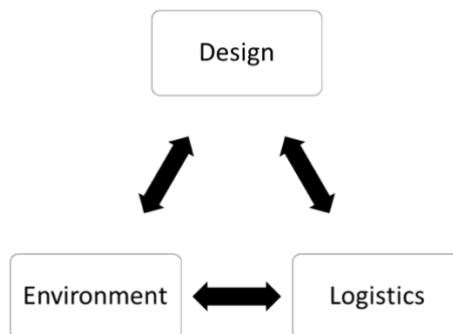


Figure 7. Three main pillars of packaging in e-commerce

The main packaging requirements stated by Regattieri et al. (2014) that have to be fulfilled in the e-commerce distribution channel are presented as it follows:

- Protection
- Handleability
- Security
- Environmentally friendly
- Re-use capability
- Volume & weight efficiency

Based on the packaging criteria found in the previously mentioned literature in the section and focusing in the e-commerce last mile logistics part of the supply chain, the author of the present project has identified the most important packaging criteria for e-commerce secondary packaging. These criteria are presented below together with a short description of each of them.

Protection

In the e-commerce supply chain, packages change hands up to 20 times versus 5 times in the traditional retail supply chain (Mohan, 2017). That is why packaging in the e-commerce last mile logistics requires high protection levels. It can be accomplished by a proper material selection and packaging design. Packaging should also have tight and durable closures that can be easily opened and closed (Korzeniowski, et al., 2005).

Handleability

The ergonomics need to be considered while designing packaging for the e-commerce last mile logistics. Logistical efficiency is linked to handleability as it facilitates the movements within the warehouse and transport. The customer appreciates if packages are easy to handle, easy to carry or easy to open (Regattieri, et al., 2014).

Safety

In the e-commerce last mile distribution, the distances that packages have to travel might be long and be conducted in different vehicles. That is why safety is such an important requirement. Some options to ensure package safety are to use identification barcodes or RFID tags to reduce theft and minimize the time spent on traceability (Regattieri, et al., 2014)

Minimal amount of waste

This requirement refers to the total waste derived from the packaging. As in e-commerce there are more frequent orders of smaller quantities than in traditional commerce, the waste produced can increase. Packaging solutions that are bigger than the contained product leading to low volume utilizations and additional filling material employed lead to large amounts of packaging waste. Minimal amount of waste refers to have a packaging solution that will produce as minimum material disposition as possible. It is directly related with the packaging's environmental load.

Re-use capability

One of the biggest issues related to e-commerce is the returns. As the product is not seen in person until it arrives to the customer it can change its opinion and decide to return the product. Then, developing packaging that is re-usable is very important as it facilitates the customer to return an item. At the same time, even if the customer

decides to keep the product, if the package is re-usable the customer can give it a second use and thus reduce waste.

Volume & weight efficiency

It is the ability to make use of all the available volume within the packaging solution. It is important to reach a proper volume and weight efficiency, as it can lead to reduce costs of transport and storage. It can also lead to a waste reduction as less materials are used for both the package and the additional material.

Packaging cost

The total cost associated to the packaging solution. The cost for the company packing the products for each packaging solution. Taking advantage of the economies of scale or not using additional filling material are some ways to reduce the cost of a package.

Stackability

Stackability (Pålsson, 2017) refers to the ability to stack many shipment units as possible in warehouse and during shipping. By achieving this, the efficiency of the warehouse storing and transport deliveries increases as more packages can be stored and shipped with the same floor positions.

Machinability

It refers to the ability of packaging to be processed effectively in the production line (Pålsson & Hellström, 2016). In the present project, machinability refers to the ability of packing products in a machine (automated) or not (manual). Packaging solutions that are compatible with fully or partially automated processes will favor the packaging rates. This criterion focuses on the filling operation.

Reduced used of resources

This requirement is directly linked with the environmental load of the packaging, as well as the requirement minimal amount of waste. To employ as minimum packaging materials as possible and to buy packaging solutions that are manufactured under sustainable processes that help reduce the carbon footprint are examples of actions to reduce the use of resources.

Out of these criteria, six of them are present in the different studies mentioned throughout the present section. Other requirements like *packaging cost*, *stackability* or *machinability* have been included as the author considers that these requirements are important for the focus of the present project regardless the sales channel. The requirement *re-use capability*, only mentioned as important in one of the studies (Regattieri, et al., 2014), has been included as well as one of the last mile logistics requirements for the secondary ecommerce packaging due to the large number of returns present in this sales channel. Other requirements present in the studies (Olsnats et. al, 2003; Pålsson & Hellström, 2016) like *product information*, *selling capability* or *packaging design* have not been taken into account as its importance

in the ecommerce sales channel is secondary due to the fact of the customer not seeing the package when purchasing the product.

Nevertheless, these criteria identified and selected for the study by the author are not the only packaging criteria existent in the ecommerce channel, thus the most important according to the author thoughts and focus of the present project. Some other packaging requirements like unitization, apportionment, communication or identification are as well considerable in the ecommerce sales channel, but they have been left aside for the present study. This is a project's delimitation and future research could include these above-mentioned packaging requirements.

3.3.4 Current situation of e-commerce packaging

According to (De Felice et. al., 2016) it is difficult to translate the existing packaging design used for the traditional way of buying in a real shop and marketing tactics into online retailing. E-commerce requires a new paradigm for the entire product packaging system. For example, in real shop the traditional primary package is a good agent for any products, not only because of the text descriptions, but also for its visual communication. It can effectively deliver product information and brand identity and is a good cognitive agent for recognition. In an online shop, users cannot directly see the package nor touch the product, but other characteristics such as protection and re-usability for efficient take-back of products take on great importance.

The Internet does not determine the design of packages. However, if online shopping is becoming more common, packaging design must be reconsidered (Visser, 2002). The changing role of packaging in the purchase of a product makes it desirable and possible to give more attention to the consumer's perception of a brand while the user is using it, and less attention to its shelf presentation. Retailers that sell online have to consider packages as a means of marketing and disseminating information instead of a mere covering for a product (Visser, 2002)

3.4 Chapter summary

The chapter started with a section about the e-commerce concept. Here, the different types of e-commerce were listed and the B2C was explained in detail as this project is focused in a company with this type of relation among the participants. After, the different online retailing distribution channels were enumerated, where a more detailed explanation about pure-play online retailers was given. To end the section, the past, present and future of e-commerce was presented. The second section in this chapter was related to packaging. The different types of packaging were explained as well as the difference between standard and customized packaging.

After, the packaging logistics concept was introduced including some trade-offs regarding packaging cost compared to logistical activities. The environmental effects of packaging were presented and some data about the emission of carton boxes was given. To end the chapter, a section about the role of packaging was presented. There, the concepts of last mile distribution and reverse logistics were introduced and the special requirements for packaging in the e-commerce last mile logistics were introduced. To finish the section and the chapter, a brief explanation about the current state of packaging in e-commerce was given as well as some challenges that the industry will face in the future.

4 Empirical study

In the present chapter, first a description of the selected company for the study is given. It is followed by an extensive description of the packing process followed in the company, including how the products and packaging are managed in the warehouse, the different packaging solutions employed, packaging requirements, management of product returns and challenges to analyze. After, a packaging evaluation by using packaging scorecards is presented. After, the packaging selection effects applied to selected products are studied. To finish, a chapter summary ends the chapter.

4.1 Description of the company: CDON

When looking for a company which characteristics were suitable and appropriate for the present project's purpose and objectives, different options were analyzed. At the end, and due to its characteristics and some other aspects, the selected company for this project was CDON, a Swedish marketplace. Below, an explanation about the company is given, with information retrieved from the annual report (Qliro, 2017).

CDON marketplace is the leading Nordic online store, with over 1.8 million customers, with a broad offering of consumer electronics, mobile phones, books, games, films, sport and leisure goods, clothing, shoes, furnishings and toys. CDON.com was launched in 1999 and is pioneer in Nordic e-commerce. From initially selling media products, the offering has been broadened and today includes everything from consumer electronics to sport and leisure articles, clothing, shoes and toys. This is driven by external merchants who have sold goods at CDON since 2013. CDON.com sells products from its own warehouse, but also welcomes external traders to sell their products through the site, with over 1,500 affiliates. Together with Qliro and Nelly they form the Qliro group.

As described, CDON is a big company that offers a very wide range of different products. Therefore, there is also a wide range of different packaging solutions used by this company, as products with very different dimensions and characteristics are handled. Also, CDON, is a company that works only in the e-commerce channel, they do not have physical stores. They have a big office in Malmö which facilitates the communication with the author of the project due to its short distance to Lund,

the place where the thesis is developed. All the listed characteristics, summed up, convinced the author of the thesis to choose this company.

The data gathered from this company comes from different data gathering methods. The main data gathering method employed was the interviews. The author maintained conversations and interviews with different people from the company, highlighting the senior logistics controller and the warehouse manager. Scheduled interviews took place as well as additional conversations via email were maintained in order to collect additional data. In addition, some documents were filled in by two different members of the company and some materials were handed in, like some packaging solutions, which allowed the author to make some observations. Also, the company's annual report was handed in, where different information about the quantity of products sold, the trends that the company will follow, or the measures employed to optimize use of packaging materials or reduce environmental impact are presented.

4.2 Packing process

The aim of this section is to present information and data gathered from the studied company, regarding its packing process. First, a detailed description about the management of the products within the warehouse is given: reception of goods, storage, picking, packing and shipment. Following, the different packaging solutions used by the company are listed and explained in detail, with their characteristics. After, the packaging requirements of CDON and its relationship with its packaging suppliers is presented. Later, the company's product returns management is explained. To end the section, the challenges encountered after gathering data about the company's packing process are presented.

4.2.1 Warehouse product management

CDON moved most of its operations to a new warehouse in Ljungby in 2015. It is one of Sweden's largest and most modern facilities, designed specifically for e-commerce. CDON has nearly 60,000 products stored in the warehouse, where almost 40,000 are media, this is Cd's & Dvd's, videogames, movies, etc. This can be explained as CDON used to be a media company that has grown and adapted to new market requirements. Even the large number of different products, the most sellers for this company are still DVD's and videogames which have similar sizes. The procedure of how the products are stored is as it follows.

After different market studies, CDON contacts its different product suppliers and negotiates the quantities and prices of different products, reaching an agreement. Then, the products are received at the warehouse, where the operators unpack them

from their tertiary and secondary packaging systems. After, depending on the product type, they are stored in their primary packaging system at different places within the warehouse. The warehouse has two main parts, one where all the different media is stored and another part for the rest of the products. As media products result in around the 65% of the warehouse and its order rate is high, it is an intelligent method to store the products.

The warehouse receives a batch of new orders every 2 hours. Depending on the order's content the picking method may vary. CDON uses two different picking trolleys. The most used one, for media (see *Figure 8*), has 80 small slots with barcodes containing the information of the product to pick. This picking trolley is used for media items, and normally for single orders. These slots can fit all media products as they have very similar sizes.



Figure 8. A worker picking media products at CDON's warehouse (Retrieved from "Ergobjörn at CDON video)

The other picking trolley that CDON uses has 20 slots. These slots also have barcodes, but they are bigger than the ones from the previous trolley, and they are used for orders containing bigger items or for orders with multiple items as they should be stored in the same slot. Once the products are picked, they are transported to the packing stations (see *Figure 9*), where the packaging solution used will depend on the type of product and its size. This will be explained in the next subchapter.



Figure 9. A worker from CDON's warehouse grabs a product from the picking trolley to place it on the packing station (Retrieved from "Ergobjörn at CDON video)

When the products are packed they are ready to be shipped. CDON sends products to four different countries: Sweden, Denmark, Norway and Finland. For most of the products, Postnord is the shipment company chosen by CDON. There are two different ways of shipping regarding the customer. While sending products to a single customer (B2C) the packages of different customers will coexist in the same delivery truck. If the orders are placed by companies, thus an order with a lot of products (B2B), the delivery transport method will contain only products from one customer. As a clarification, the type of customer does not affect the selection of the package, just the shipping procedure varies.

Since 2013, CDON also uses drop-shipping as a selling method for some of the products that are displayed on their marketplace. Specifically, the 21% of the marketplace's total sales in 2017 was accounted to drop-shipping. All the merchants that CDON has an agreement with are for electronics instead of one, that works with phone, tablet and laptop cases. The different merchants do not have specific packaging solutions required from CDON. They have their own packages and criteria when they have to pack the ordered products. The requirements that CDON has for its drop-shippers are to proportionate good product protection, to put effort on sending an order in one package and to use a specific tape that contains the CDON logo, to enhance the brand-loyalty with the customer. When buying a product in their website, the customer can see in the product description if it will come from the CDON warehouse or if instead it is being drop-shipped (see *Figure 10*).

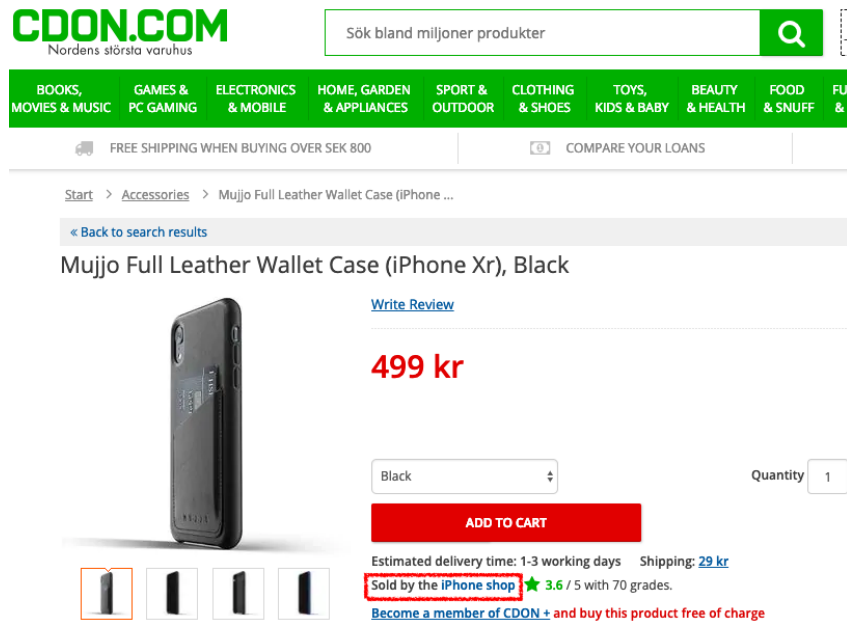


Figure 10. Example of a product in CDON's website coming from a merchant (Retrieved from CDON's marketplace)

One big issue about drop-shipping some products is the fact of having a mixed order with products that are actually in the CDON's warehouse, thus the order will not arrive all together at the same time, but this will be explained later at the end of the chapter.

4.2.2 Packaging types

CDON's packaging solutions can be divided in two main groups: plastic bags and carton packaging solutions. Plastic bags are mainly used for clothing. This packaging solution reaches a full volume efficiency when packing clothing and due to this, it will not be further taken into account when describing the packaging solutions or in the analysis in the next chapter.

The other main group of packaging solutions employed by CDON are the ones made of carton. Four different types of packaging solutions made of carton are used by CDON:

- Standard carton boxes
- Size customized carton boxes
- Carton packages made with a Cold seal machine
- Carton boxes made to fit the product with a CMC machine

The process of selecting packaging for these solutions depends on the type of product, its characteristics and dimensions. At the same time, some of these packaging solutions are assembled manually (standard and customized carton boxes) and the rest (cold seal machine and CMC machine) are assembled in an automated process. In the following sections, these four types of packaging solutions will be further explained as well as which products each of them contains.

4.2.2.1 Standard carton boxes

Standard carton boxes refer to the regular cardboard boxes of different sizes that are used for a wide range of different products. Due to its cost-cutting potential, as carton boxes are some of the least expensive cartons available (Packaging innovation, 2014), it is a common packaging solution employed by companies. Depending on the range of product number and sizes, each company has a determined number of different boxes to cover all the products. Another advantage of this packaging solution is that provides protection, as (Packaging innovation, 2014) carton boxes provide a stable cushion for any product.

If the volume efficiency achieved while packing products in these packages is low (less than 90%), filling material is required to ensure a proper protection of the product. The quantity of filling material needed is directly proportional to the volume efficiency, it will increase when the obtained volume efficiency is lower. CDON makes use of two different types of additional materials; small airbags and small foam parts called "*foam peanuts*", made of polystyrene. These additional materials absorb the vibrations and potential hits that the packages may suffer while being transported. The cost of the filling material varies between different packaging solutions and products because the fill rates are variable as well as the dimensions of the boxes. Comparing them and making some assumptions, the cost of the filling material can be up to the 8-10% of the total packaging cost. Furthermore, filling materials like the "*foam peanuts*" have recycling issues due to its polystyrene component.

CDON has currently 8 different sizes for standard carton boxes. The dimensions and volumes of these boxes cover a wide range, showed as it follows:

Table 3. Standard carton boxes sizes

<i>Standard carton box</i>	<i>Dimensions (LxWxH mm)</i>	<i>Volume (liters)</i>
1	135x130x80	1.4
2	205x140x115	3.3
3	260x200x135	7
4	320x225x155	11.2
5	400x350x170	23.8
6	570x380x140	30.3
7	570x380x285	61.7
8	1185x785x800	744.2

As it can be seen, most of the sizes are within little variations except of the largest box that is considerably bigger. It is assumable that most of the products packed in these boxes fit in volumes between 1.4 and 61.7 liters while there are few products between 61.7 and 744.2 liters. Some of the products packed in these boxes fit well and have high volume efficiencies, but the majority of them leave considerable free space and filling material is required. According to warehouse workers, an estimated average of 60-70% of volume efficiency is achieved with this type of boxes.

The procedure that CDON follows while packing with this type of boxes is as it follows. The operator grabs the product to pack and selects the standard box that thinks that will fit better. After, the operator puts the product inside the box and leaves it open on a conveyor belt that will take it to the next station, where another operator will close and tape the box. If the operator is unable to close and tape the box properly, due mainly to a wrong package selection from the previous operator, the box will be taken to another station called “trouble station”. There, another operator will fix the problem by selecting a proper package for the product and will take care of its taping and closing.

As it can be seen, these standard packages require a fully manual process and the products do not have a previously selected box, which can lead to delays in the warehouse. Some of the products that CDON packs in these kinds of boxes are for example:

- Smartphones
- Headphones
- Speakers
- Laptops
- Batteries

A picture of two different standard carton boxes is shown as it follows.



Figure 11. 7 and 11.2-liter standard carton boxes (own picture)

4.2.2.2 Size customized carton boxes

This type of packaging is very similar to the standard carton boxes, with the difference that they are designed for specific products in order to fit them perfectly. They are regular cardboard boxes as well that, a part of having a specific size, they may have a specific opening method if the product requires it. This kind of packaging is more expensive than the standard carton boxes as they are designed specifically for one product. The box size and characteristics are designed to demand and are not chosen from a catalogue, which increases the price. Usually, companies pick these packaging systems for products that are top sellers or that need a special protection. By fitting the product perfectly, the risk of suffering damage during the transport decreases dramatically. This type of box does not require additional material usually, as the percentage of air within the box barely exists.

The packing procedure followed for these boxes is also fully manual, like the one followed for the standard carton boxes. The biggest difference is that in this case, the operators know exactly which box to use as they are linked to the product. Then, the risk of selecting a wrong package decreases.

CDON has five size customized carton boxes that are used for just six products, as two of them use the same packaging. These products are top sellers and/or products that require a special protection as they are fragile.

Table 4. Products with size customized carton boxes

<i>Size customized carton box</i>	<i>Product/s</i>	<i>Requirement</i>
1	Vynils	Protection
2	Hard drives	Top Seller
3	Nintendo Switch	Top Seller & Protection
4	PS4 Slim	Top Seller & Protection
5	PS4 Pro & Xbox One X	Top Seller & Protection

Below, a picture of the size customized packaging for the PS4 Pro & Xbox One X is displayed. It is the last acquisition by CDON, the size is 28.8 liters and it has differentiated marks in order to facilitate the unboxing once it reaches the customer.



Figure 12. Both sides of the 28.8-liter size customized box for PS4 Pro & Xbox One X (own picture)

4.2.2.3 Carton packages made with a Cold seal machine

A cold seal machine (IPS Packaging, 2018) is designed to instantly seal by the use of pressure, without the use of heat. It creates strong and lightweight packages with flat edges, similar to the shape of an envelope. The resulting package protects the product from dust, dirt and abrasion and it absorbs the potential hits produced while being transported.

The packing process that it follows is described as it continues:

The machine makes use of two cardboard reels. One of the reels provides the bottom layer and the other reel provides the top layer. These cardboard reels have an

adhesive material that will glue against each other both layers after they are pressed by the machine. Some reels may include a tear strip to facilitate the opening of the package by the customer, however the re-use capability will result harder as part of the package is pulled out. CDON uses cardboard reels with tear strips. The products are placed on trays that are moving on a conveyor belt. Once it enters the machine, the product is placed between two layers of cardboard. Then, the machine presses the top layer against the bottom one in order to seal the edges. After it is sealed, the machine makes a cut in order to separate the package from the layers. Finally, the machine adds a sticker with a barcode and the shipping information. The packing process in this machine is fully automated. Additional filling material is not required for this packing method as the product is fitted perfectly in the package.



Figure 13. Example of a Cold Seal machine, 9000-18 by Angloscand (“The 9000-18 Cold Seal machine”, 2018)

It is an appropriate machine for e-commerce companies because of its fast packing rate, up to 30 products per minute, and its flexibility as it adapts to the dimensions of the product. The range of products that CDON packs with this machine are:

- CD’S
- DVD’S
- Videogames

These products are always packed in this way if they do not exceed the maximum permitted thickness by the machine, which is 30 millimeters. Normally, up to two products can be packed in a single package with this procedure. If the order consists in more than two of these products, then they will be packed in a standard carton box.

It is an efficient packaging method as it is automated and the failure rate decreases. Material waste is also reduced because no filling material is used, and the cardboard used to make the package is minimized. These machines imply an investment and are worthwhile if the forecasted usage rate is high. An example of the packaging produced is displayed below. In CDON's case, as the media products mean approximately the 66% of the warehouse, this machine has a lot of advantages.



Figure 14. Example of a package produced by a cold seal machine and a cardboard reel (“Corro Seal™ Cohesive Singleface”, 2018)

4.2.2.4 Carton boxes made to fit the product with a CMC machine

This type of machine is a fully automated carton packaging system that is able of creating size customized carton boxes. This integrated solution (CMC, 2018) is designed to help companies that use large amounts of boxes of different sizes, such as e-commerce and fulfillment companies that need to send out several boxes of different sizes according to the orders received. It produces unique boxes from a corrugated fanfold according to the size of the product being packed.

The machine has two different entries. One of them is in charge of providing the corrugated fanfold to the system. The other entry receives the products to pack. This entry has a scanner that measures the product and calculates the amount of corrugated fanfold necessary to pack it. The scanner also reads the shipment information, in order to print and add a tag to the final box. After scanning the product, the machine sends the product through a conveyor belt to the line where the packing material is. There, the system will automatically pack the product into a unique box that fits perfectly its measurements. Finally, the machine adds the tag with the shipment information. This type of machine also allows labeling, by printing a logo or picture on the box once the product is packed. It is a way to

enhance brand loyalty by improving the customer's opening experience. It is a fully automated packing process and additional filling material is not required as the products are perfectly fitted within the package.

Together with Postnord, CDON recently acquired one of these machines. Currently, the type of products being packed in it are not specified as they are testing which products fit better. The machine has minimum and maximum size requirements, so not all the products are able to be packed in it. The minimum box size that the machine can produce is 150x240x30 mm (LxWxH) and the maximum 350x600x200. These machines imply a big investment and are appropriate for companies with high budgets and high usage rates. A research about the investment was made but no result was obtained as CMC just reveals the price when there is an acquiring interest. In an online article (Stuart-Turner, 2015), where the owner of a British company who acquired this machine was interviewed, revealed that this machine costs hundreds of thousands of pounds. This solution can lead to a decrease in material waste as no additional material is used and the packaging material is minimized. The maximum mechanical speed of this machine is 1000 boxes per hour. A picture of this type of machine is displayed below.



Figure 15. Example of a CMC machine, CMC Cartonwrap by CMC (“CMC Cartonwrap”, 2018)

4.2.3 Packaging suppliers and requirements

CDON has five different suppliers for its packaging solutions. One of the suppliers is for the cardboard reels used in the cold seal machine. Another supplier is for the corrugated fanfold used in the CMC machine. The other three suppliers are for the standard and size customized carton boxes. As mentioned in the frame of reference, there are ten main packaging requirements that are important to fulfill in the e-commerce channel:

- Protection
- Handleability
- Safety
- Minimal amount of waste
- Re-use capability
- Volume and weight efficiency
- Packaging cost
- Stackability
- Machinability
- Reduced use of resources

CDON trusts the criteria from its packaging suppliers and lets them decide the different characteristics regarding the composition of the material used, its thickness and the opening types. With this, CDON expects its suppliers to fulfill the requirements mentioned above, with a special emphasis on protection and cost. This are the requirements that CDON focus most on. From time to time, CDON tests the protection from the different packaging materials. The different tests carried out include drop, vibration and temperature tests. If the results obtained do not reach the minimum required, those packaging systems will not be used and will ask for another batch to the supplier.

Regarding the standard and size customized carton boxes, the suppliers offer two different types regarding the assembling method. The first one is the most common box style. All flaps have the same length and shape. Is the cheapest type of box and additional material such as glue and/or tape are necessary to assemble it. They are commonly known as “Regular slotted containers”. The second type of box is similar to the first one but in this case the flaps on the base have different shapes and lock themselves mechanically without the use of additional material. This type of boxes is commonly called “Self-locking base boxes” or “Automatic locking boxes”, and help to improve the machinability of the packaging solutions.

From a requirements point of view, both of these boxes are the same, just the way to assemble them changes. From a productivity point of view there is a difference. The operators who assemble the boxes prefer to work with the self-locking boxes as they become more efficient because it takes them less time. Even that the self-locking boxes are slightly more expensive that the regular ones, CDON opts to acquire them in order to improve productivity. At the same time, no additional

material is needed to assemble the boxes which is another incentive. If productivity is improved, lead-times are reduced which translates into a faster packing and thus the packages will be received by the customers sooner. Therefore, to increase productivity is a factor that CDON takes into account when selecting the package systems from its suppliers.

The company's position towards the eco-efficiency is clear, as written in the annual report, Qliro group works to minimize resource consumption and environmental impact related to manufacturing, warehousing and transportation. In the means of packaging, CDON aims to improve the re-use capability, to buy packages that are totally recyclable and to reduce the filling material used by improving the volume efficiency. As said in the annual report, optimized use of packaging materials is important for cost-effectiveness, profitability and environmental impact which means that packages are tailored to the size of the product to minimize packaging material use and air. Nevertheless, up to the 30% of products stored in their warehouse are packed in standard carton boxes where there is an average of 60-70% volume efficiency. This point will be studied and analyzed further in the report.

4.2.4 Product returns

CDON allows its customers to return the ordered products. When the customer receives the package at home, the product comes together with a return form that has to be filled. All the carton boxes, standard and size customized, from CDON are returnable, so the customer who wants to return a product will be able to do it in the same package that was delivered home. On the other hand, the carton packages made with the cold seal machine for media are not returnable, as a tear strip is included on the package and some packaging material is ripped off when opening it. In the carton boxes, besides the product and the return form, the package includes a peel tape that can be used to close the package when a product is going to be returned. Once the product is back at the warehouse the package is thrown away thus the re-use capability is only for one use. The management of the returned products is divided into three different categories:

- Products that are received by the customer but are returned instantly without even opening the primary package. Usually this event occurs because the customer regrets the purchase. Some reasons can be a delay in the delivery, a need to get the money back or just not wanting the product anymore. In these cases, the products are stored back in the warehouse and can be sold for the original price.
- Products that have their primary package opened. Some examples can be that the customer does not like the product in person or in the case of clothing that the size does not fit properly. These products can be sold again but they will have a discount. For this type of event CDON has technicians in their warehouse to evaluate the state of the returned products. After

evaluating the state of the product, they can be divided into three classes: Perfect condition, small defect or some parts missing. Depending on the class, the discount offered will be higher or lower.

- Products that are returned because they have imperfections, or they are broken. These products cannot be sold again and the procedure that CDON follows is to contact the supplier in order to try to find the origin of the problem.

The management of all the returns is laborious and hard to control. Decreasing the percentage of returns is important for any company, especially e-commerce companies as traceability is harder to manage. Currently CDON has approximately a 2 ± 0.5 % of returns for media, which comprises the 66% of the products from the warehouse.

4.2.5 Encountered challenges

In this section, the different challenges encountered are presented. Some of these challenges have been retrieved from the interviews, by directly evidence stated from the interviewees or by observations made by the author of the project while they were being conducted. Other challenges are proposed by the author after reading the annual report and observing the handed material

4.2.5.1 Product size information

CDON used to be a media company. For this reason, this company did not put effort on having a database with the sizes of the products, as almost all of them had the same or similar size. As it has been mentioned before, nowadays CDON has products of all kinds and with a wide range of different sizes. This rise in the number of different products has not come together with a development of a proper database with the product sizes. CDON has not found yet, and has not put enough effort, a proper way to transfer the size information of their products to a database. This event is causing some difficulties when the package selection for a product has to be made, regarding the standard carton boxes. As the operators choose the packages on their own judgement, the risk of choosing a box that is not the optimal is higher. The lack of a proper database also causes difficulties when the picking of the products is done. The picking trolleys have fixed dimension spots and sometimes the products do not fit and have to be put on top of the trolley, which is dangerous. Having the size information of the products to pick in advance would help to avoid this situation.

4.2.5.2 Standard carton boxes process of selection

The packing process with standard carton boxes is fully manual. Also, the box that is going to be used is chosen by the operator and it is not predetermined. These events limit the number of standard packages that CDON has, 8 currently. As the process is manual and slower than if it was automated, and the operators need to spend time deciding the package to use, the company does not plan to include more sizes for the standard carton boxes.

4.2.5.3 Orders with multiple products

Orders with more than one product affect the packing process. On the one hand, a customer can order one item that is stocked in the CDON's warehouse and another item that comes directly from a drop shipper. In those cases, inevitably, the orders will arrive in different packages and most probably at different times which can annoy the customer. As CDON has around 1,500 merchants, the chance of this happening is high. On the other hand, there are some products that are commonly ordered together with other products. This happens commonly with videogames. When a customer orders a console often orders also another remote controller or another videogame. The consoles sold by CDON have their customized packaging with no additional space for another product. This event forces CDON to send the order in different packages although one of their priorities is to send the whole order in a single package. This particular event related to videogames occurs nearly the 40% of times that a customer buys a console.

4.2.5.4 Low importance given to packaging efficiency

Even that it is important for the company, as stated in the annual report, to optimize the use of packaging materials for cost-effectiveness, profitability and environmental impact, the truth is that the 30% of the products in the warehouse are packed in boxes that have an average of 60-70% volume efficiency. The Senior logistics controller of CDON, who was interviewed, admitted that nowadays the performance of the company towards the efficiency of its packaging is not the ideal. Anyway, he expects to see a change in this trend as e-commerce is forecasted to keep growing in the upcoming years and the population's perception about being environmentally friendly is becoming stronger. As mentioned before, the fact of having a manual based packing process for the standard carton boxes limits the number of standard packaging that the company has, which leads to low volume utilization in some packages.

4.2.5.5 Drop in music sales expectative

CDON expects physical music sales to keep dropping. With the emergence of digital music, the sales of music CD's have been dropping constantly. For CDON, this can cause a big problem as still nowadays the sales of music are a high percentage of the total sales of the company. Regarding the packaging, if the sales of CD's and DVD's keep falling the way of packing them could change. A viability study would have to be done in order to decide if is profitable to keep using the cold seal machine, as it has a maintenance cost.

4.3 Packaging solutions evaluation

In the present section some products and their corresponding packaging have been selected. These have been evaluated by the packaging scorecard, which concept is described below. The tables containing the evaluation data are displayed as well as scattered diagrams in order to facilitate the visualization for the reader. After each evaluation is presented, a brief explanation of the results can be found.

The packaging evaluation method carried out in the present project is the satisfaction-importance analysis or packaging scorecard. It is a systematic evaluation method (Olsnats et. al, 2003) based on research of functional criteria of packaging and the theories of 'balanced scorecard', a general management approach to evaluating organizational performance using different perspectives. It consists on the evaluation given by an actor/s present in the supply chain. The evaluation involves the importance given to the different packaging requirements and the satisfaction level regarding their accomplishment. The requirements are scored from 0% to 100% regarding the importance level, being 0% not important at all and 100% very important. Regarding the satisfaction level, the requirements are scored from 0 to 4. Below, a table where the meaning of the scores for the satisfaction level is displayed.

Table 5. Scores explanation for the satisfaction level

<i>Score</i>	<i>Satisfaction level</i>
0	Not applicable
1	Not approved
2	Approved
3	Well approved
4	Met excellently

After, the results are plotted in a graph. The satisfaction level is plotted on the horizontal axis and the importance level is plotted on the vertical axis. The resulting positions on the graph determine if a packaging requirement needs improvements or if meets the objectives. Different people from the company including the senior logistics controller, warehouse manager and workers evaluated different products with its corresponding packaging solutions. The different requirements that have been evaluated are:

1. Product protection
2. Handleability
3. Safety
4. Minimal amount of waste
5. Re-use capability
6. Volume & weight efficiency
7. Packaging cost
8. Stackability
9. Machinability
10. Reduced use of resources

These requirements are the most important packaging criteria for ecommerce secondary packaging identified in the frame of reference (See 3. *Frame of reference*).

These requirements are very similar to the ones proposed in original scorecard literature (Ols mats et. al, 2003) but some of them have not been taken into account for different reasons and some have been added. Requirements like “*product information*”, “*packaging design*” and “*selling capability*” have been discarded as these are requirements meant to packaging sold in different sales channels rather than the e-commerce sales channel. Other requirements like “*re-use capability*” have been added due to its importance in the e-commerce sales channel. Then, the ten requirements chosen for the evaluation are an adaptation from the original literature (Ols mats et. al, 2003) to the e-commerce sales channel.

The selected packages, with their corresponding products, that have been selected for the evaluation are:

- Standard carton box for iPhone X
- Standard carton box for Bosch PSR 18
- Standard carton box for Blue Microphones Yeti Blackout
- Size customized carton box for PS4 Pro
- Carton package made with cold seal machine for a CD

As the CMC machine has been recently acquired and it is in its testing state, there is no packaging of any products associated to it on a regular basis. Due to this, no

packaging from the CMC machine has been evaluated. In the following subchapters, the results of the different scorecard evaluations are presented.

4.3.1 Standard carton box: iPhone X

The results of the scorecard evaluation for the standard carton box packing an iPhone X are displayed in the table below.

Table 6. Packaging scorecard results for the standard carton box containing an iPhone X

<i>Standard carton box: iPhone X</i>		
Requirement	Scores	
	Importance (0-100)	Satisfaction (0-4)
Product Protection	50	4
Handleability	75	3
Safety	60	3
Minimal amount of waste	10	2
Re-Use Capability	25	3
Volume & Weight Efficiency	25	2
Packaging Cost	100	2
Stackability	50	2
Machinability	0	0
Reduced use of resources	10	0

In order to give a better understanding of the data to the reader and to differentiate easier the performance of the different packaging requirements, the results from the table are plotted in a scattering graph.

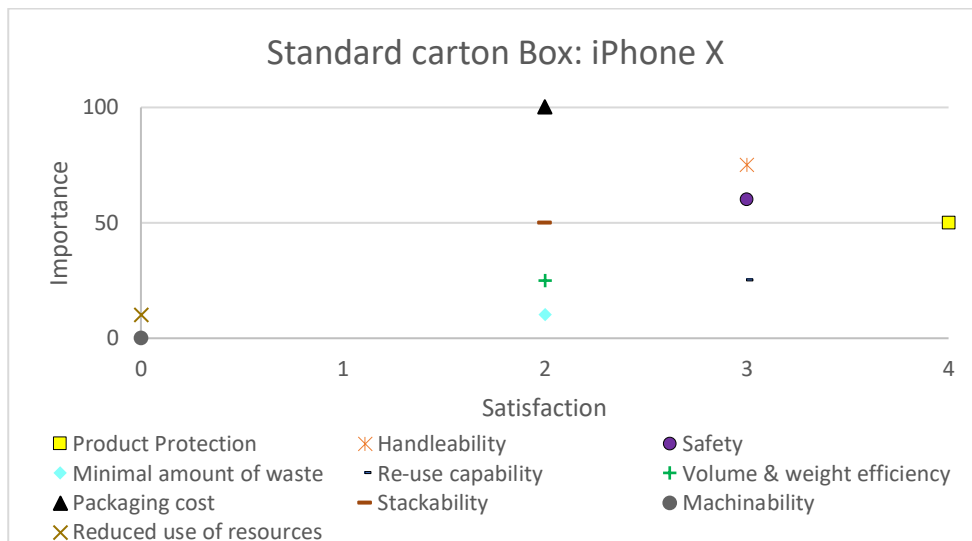


Figure 16. Packaging scorecard scattering diagram for the standard carton box containing an iPhone X

It is remarkable to mention that as this packing process is manual, the machinability is not a concern for the company. The satisfaction level of the product protection in this particular case is met excellently and other requirements like re-use capability, safety and handleability are well approved. Packaging cost has a 100% of importance but it is not translated into the satisfaction level as it is evaluated with just an approved. Volume and weight efficiency's satisfaction is rated just with an approved. Reduced use of resources has not a big importance neither satisfaction.

4.3.2 Standard carton box: Bosch PSR 18

The results of the scorecard evaluation for the standard carton box packing a drill model Bosch PSR 18 are displayed in the table below.

Table 7. Packaging scorecard results for the standard carton box containing a Bosch PSR 18

<i>Standard carton box: Bosch PSR 18</i>		
Requirement	Scores	
	Importance (0-100)	Satisfaction (0-4)
Product Protection	50	3
Handleability	75	3
Safety	45	3
Minimal amount of waste	15	1
Re-Use Capability	10	2
Volume & Weight Efficiency	50	2
Packaging Cost	100	3
Stackability	50	2
Machinability	0	0
Reduced use of resources	10	0

In order to give a better understanding of the data to the reader and to differentiate easier the performance of the different packaging requirements, the results from the table are plotted in a scattering graph.

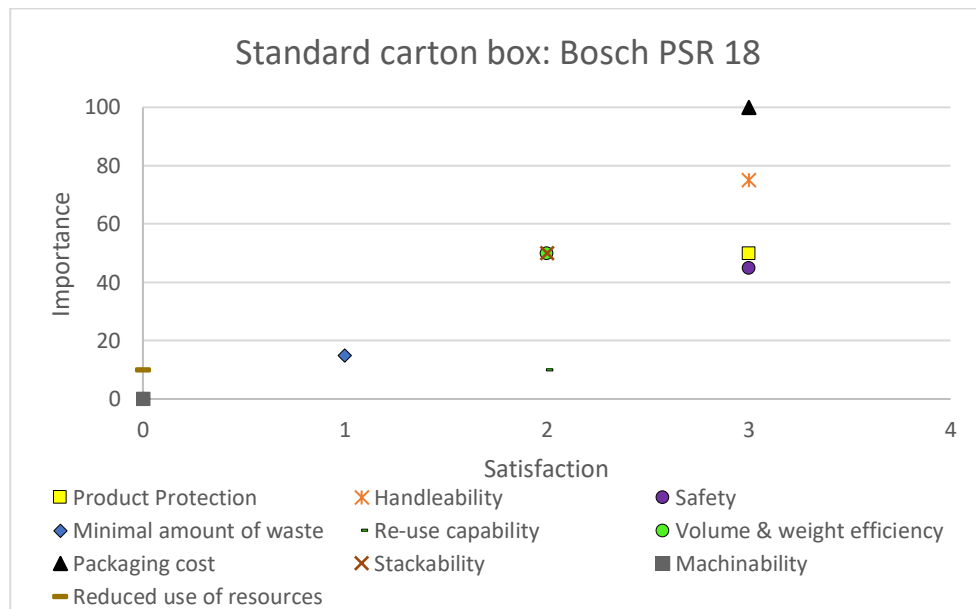


Figure 17. Packaging scorecard scattering diagram for the standard carton box containing a Bosch PSR 18

As well as happened with the previous standard carton box, the one containing the iPhone X, the packing process is fully manual, so the machinability is not taken into account by the company. Handleability and packaging cost represent a high importance and satisfaction and again the reduced use of resources is not considered of importance and the satisfaction is not applicable.

4.3.3 Standard carton box: Blue microphones Yeti Blackout

The results of the scorecard evaluation for the standard carton box packing the Blue microphones Yeti Blackout are displayed in the table as it follows.

Table 8. Packaging scorecard results for the standard carton box containing the Blue microphones Yeti Blackout

<i>Standard carton box: Blue microphones Yeti Blackout</i>		
Requirement	Scores	
	Importance (0-100)	Satisfaction (0-4)
Product Protection	50	3
Handleability	75	3
Safety	40	2
Minimal amount of waste	25	2
Re-Use Capability	33	3
Volume & Weight Efficiency	50	2
Packaging Cost	100	2
Stackability	50	3
Machinability	0	0
Reduced use of resources	10	0

In order to give a better understanding of the data to the reader and to differentiate easier the performance of the different packaging requirements, the results from the table are plotted in a scattering graph.

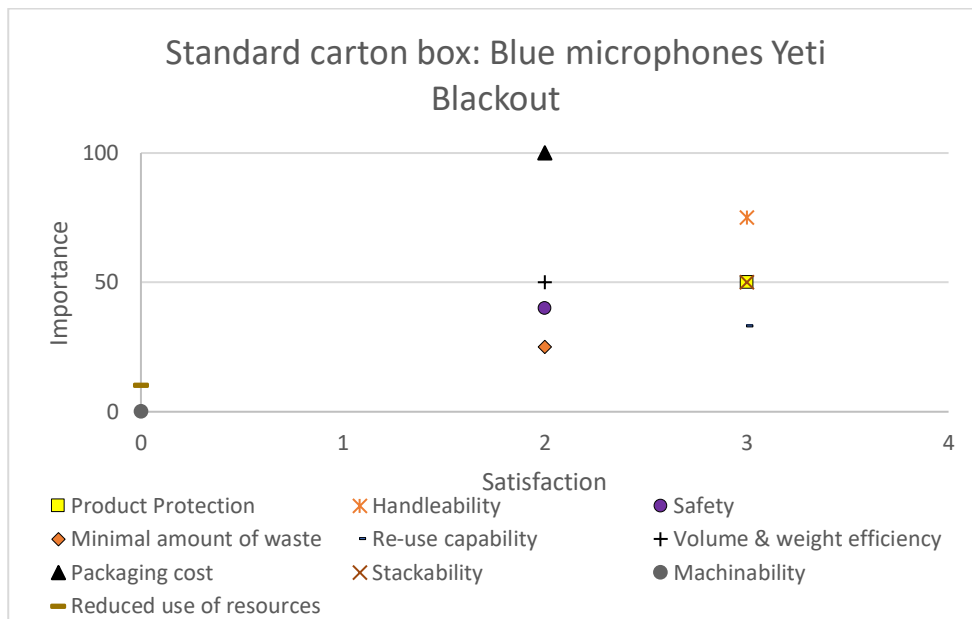


Figure 18. Packaging scorecard scattering diagram for the standard carton box containing the Blue microphones Yeti Blackout

As it happened with the two previous cases, the ones employing standard carton boxes, the process is fully manual therefore the company does not put importance on the machinability and its satisfaction is not applicable. The satisfaction of requirements like re-use capability, handleability and stackability are well approved. Packaging cost, even it has a 100% of importance is rated with just an approved satisfaction. As it happened with the previous cases, the reduced use of resources is not a concern. One of the persons who filled the scorecards mentioned in this aspect that it is not a concern even it should be.

4.3.4 Size customized carton box: PS4 Pro

The results of the scorecard evaluation for the customized size carton box packing a PS4 Pro are displayed in the table as it follows.

Table 9. Packaging scorecard results for the customized size carton box containing a PS4 Pro

<i>Size customized carton box: PS4 Pro</i>		
Requirement	Scores	
	Importance (0-100)	Satisfaction (0-4)
Product Protection	75	4
Handleability	75	3
Safety	65	3
Minimal amount of waste	10	2
Re-Use Capability	25	3
Volume & Weight Efficiency	50	3
Packaging Cost	100	3
Stackability	50	3
Machinability	0	0
Reduced use of resources	40	2

In order to give a better understanding of the data to the reader and to differentiate easier the performance of the different packaging requirements, the results from the table are plotted in a scattering graph.

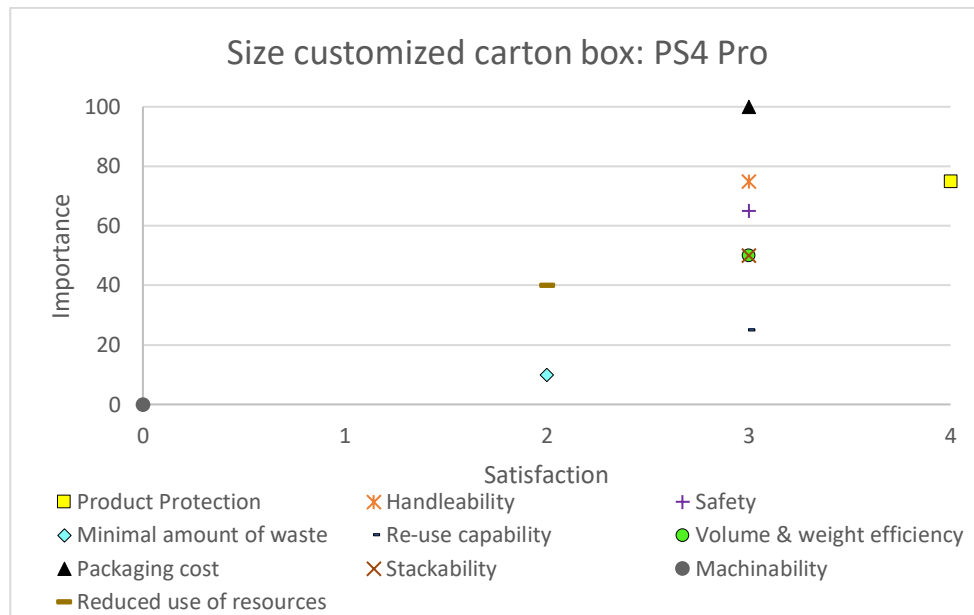


Figure 19. Packaging scorecard scattering diagram for the customized size carton box containing a PS4 Pro

Even this packaging solution is different from the three previous one, which were standard carton boxes, the machinability is not a requirement taken into account by

the company as the process is fully manual as well. Product protection represents a high importance as well as a satisfaction level of met excellently. Safety and packaging cost have as well a high importance and their satisfaction levels are high, with a score of well approved. Reduced use of resources gains importance in comparison to the previous cases, which could be due to the higher cost of this packaging solution.

4.3.5 Carton package made with cold seal machine for a CD

The results of the scorecard evaluation for the carton packaging made with a cold seal machine containing a CD are displayed in the table as it follows.

Table 10. Packaging scorecard results for the carton package made with cold seal machine containing a CD

<i>Carton packaging made with cold seal machine: CD</i>		
Requirement	Scores	
	Importance (0-100)	Satisfaction (0-4)
Product Protection	75	2
Handleability	100	4
Safety	25	2
Minimal amount of waste	50	3
Re-Use Capability	0	0
Volume & Weight Efficiency	100	4
Packaging Cost	100	4
Stackability	25	3
Machinability	100	4
Reduced use of resources	75	4

In order to give a better understanding of the data to the reader and to differentiate easier the performance of the different packaging requirements, the results from the table are plotted in a scattering graph.

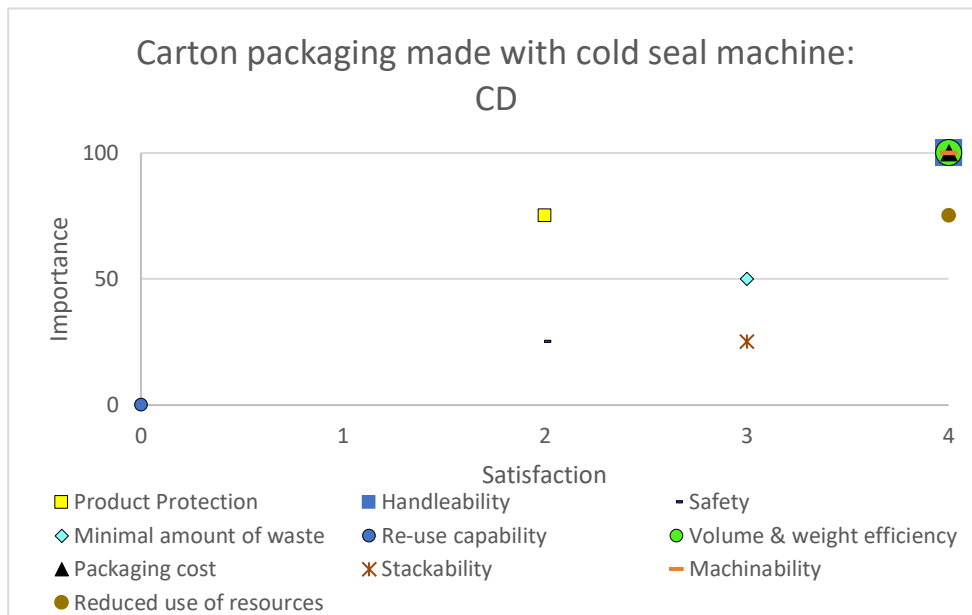


Figure 20. Packaging scorecard scattering diagram for the carton packaging made with cold seal machine containing a CD.

This packaging solution presents results significantly different than the previous four cases. As its packing process is fully automated, machinability has a lot of importance and its satisfaction is met excellently. Other requirements that share position with machinability (100% of importance and satisfaction level 4) are packaging cost, handleability and volume & weight efficiency. For this packaging solution, re-use capability is not taken into account as, due to its tear strip opening system which rips off packaging material and omits the opportunity to re-use the package. Product protection and safety show a lower satisfaction level compared to the previous packaging solutions evaluated.

4.4 Packaging selection effects applied to certain products

In the previous section, packaging scorecards were applied to evaluate the satisfaction and importance that the company gives to different packaging requirements for the different packaging solutions employed. The present section's purpose is to gather data in order to cover one of the project's objectives ('*Evaluate the performance of the packaging solutions the selected company employs and estimate the potential to reduce packaging waste and increase volume efficiency*').

As the packaging solutions for the size customized carton boxes and the carton packaging made with the cold seal machine reach high volume & weight efficiencies and the packaging waste is low, and the aim is to evaluate the effects that the packaging selection has on volume efficiency and material waste, the different products selected for this section are packed in standard carton boxes. Top seller products packed in standard carton boxes have been selected for the calculations.

In the first subchapter, the dimensions and weights of the selected products and their corresponding primary packages are presented. Later, an explanation of how the standard carton boxes used for each product are estimated, is given. The second subchapter, presents the calculations of the volume utilizations of each product's primary packaging within its corresponding standard carton box, as well as the calculations of the dimensional weights for each product.

The top-seller products information was handed in a document by the company. The information included the name and description of the product as well as the dimensions and weight of its primary package. With these dimensions, and the sizes of the standard carton boxes employed, is possible to estimate the box that suits better each product. After, a calculation of the volume utilization is done.

Dimensional weight is a pricing technique used by freight transport companies. The calculation method varies depending on the transport company, but the differences are small between them. The calculations obtain a result of a theoretical weight of a package. This weight is then compared to the actual weight of the package to ship. If the weight of the actual package is lower than the calculated dimensional weight, the transport company will charge the price of the dimensional weight. By using this method, freight transport companies try to have a minimum density in the packages that are being shipped. It is a way to increase the efficiency of the shipments as packages with low densities are often linked to low volume utilizations. Consequently, companies are encouraged to reach higher densities and volume utilizations in their packages.

The total weight of the selected products and boxes will be calculated and compared to the dimensional weight. The calculation for the dimensional weight will be done following Postnord's technique, as most of the packages sent by CDON are via this transport company. Postnord calculates its dimensional weight by equating 1 cubic meter to 280kg (Weight by volume, 2018).

4.4.1 Selected products and packaging information

The selected products for this analysis and their corresponding primary packaging sizes and weights are presented as it continues.

Table 11. Information about the products to analyze

<i>Product name</i>	<i>Product type</i>	<i>Length (mm)</i>	<i>Width (mm)</i>	<i>Height (mm)</i>	<i>Weight (kg)</i>	<i>Volume (liters)</i>
Blue microphones Yeti Blackout	Microphone	160	130	250	0.55	5.2
Chromecast Audio	Electronic device	125	40	125	0.15	0.625
Melitta Look 4.0	Coffee machine	270	240	385	2.9	24.95
Emerio Äggkokare Clatronic	Egg boiler	165	165	170	0.48	4.63
Bosch Skruvdragare PSR 18	Electric screwdriver	295	100	380	1.3	11.21

As it can be seen, there is diversity regarding the types of products and the sizes of their primary packaging. These products figure among the top seller products of CDON in the last year. In order to estimate the standard carton box that fits better each product it is necessary to know their sizes as well. The measurements have been retrieved from a document handed in by the company. The sizes and corresponding volumes for the 8 different standard carton boxes are presented as it follows.

Table 12. Sizes for the different standard carton boxes

<i>Measurements</i>			<i>Volume (liters)</i>
<i>Length (mm)</i>	<i>Width (mm)</i>	<i>Height (mm)</i>	
135	130	80	1.4
205	140	115	3.3
260	200	135	7
320	225	155	11.2
400	350	170	23.8
570	380	140	30.3
570	380	285	61.7
1185	785	800	744.2

With this information, the boxes that fit better each of the selected products can be estimated. The procedure to estimate the proper boxes is simple. First, the volume of the primary packaging of each product is compared to the volumes of the standard carton boxes. The smallest box that fits the product is selected temporarily. Then, in order to ensure that the product fits in the box, the measurements of the products are compared to the ones from the boxes. If the product's measurements are smaller or

equal to the ones from the temporarily selected box, then it is the box that fits better that product. If not, the next box in size has to be compared.

The next table shows the estimation of the boxes that fit better each product.

Table 13. Estimated boxes for the different selected products

<i>Product name</i>	<i>Estimated standard carton box (liters)</i>
Blue microphones Yeti Blackout	7
Chromecast Audio	1.4
Melitta Look 4.0	30.3
Emerio Äggkokare Clatronic	7
Bosch Skruvdragare PSR 18	23.8

4.4.2 Volume utilization and dimensional weight

In this subchapter the volume utilization and dimensional weight of the set of products and boxes will be calculated. First of all, the volume utilization will be calculated dividing the volume of the product's primary packaging by the volume of the box where it will be packed.

Table 14. Volume utilization of the different selected products

<i>Product name</i>	<i>Product's primary packaging volume (liters)</i>	<i>Standard carton boxes volume (liters)</i>	<i>Volume utilization (%)</i>
Blue microphones Yeti Blackout	5.2	7	74.3
Chromecast Audio	0.625	1.4	44.6
Melitta Look 4.0	24.95	30.3	82.3
Emerio Äggkokare Clatronic	4.63	7	66.1
Bosch Skruvdragare PSR 18	11.21	23.8	47.1

In order to obtain a better visualization, a graph reflecting the different percentages for the different products is presented as it continues.

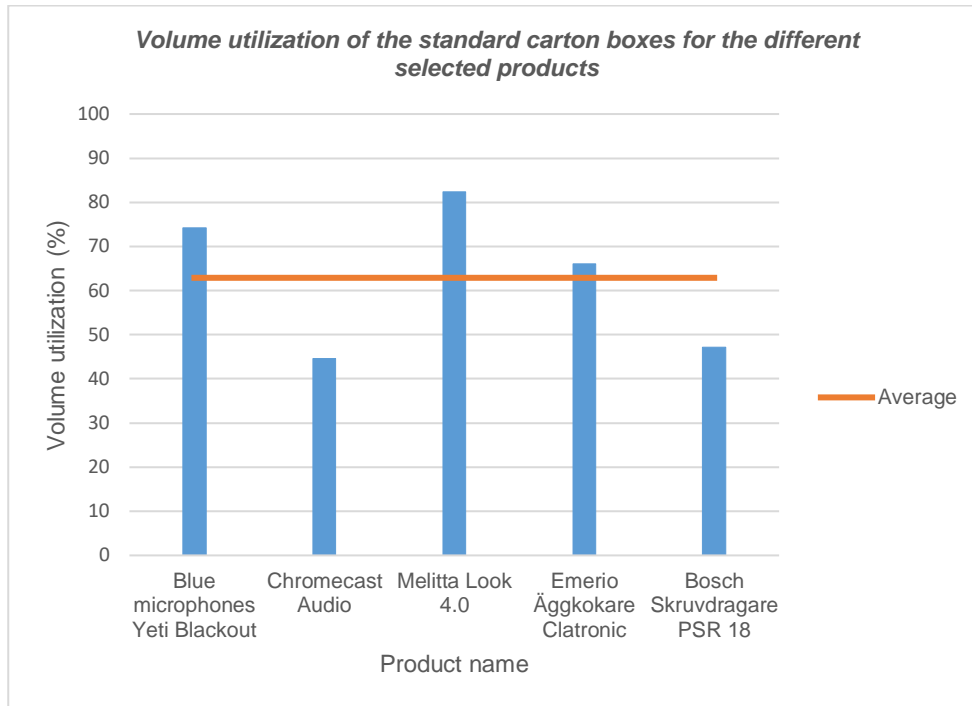


Figure 21. Volume utilization of the selected products and the average

As it can be seen from the graph the different volume utilizations are not optimal. The product “*Melitta Look 4.0*” reaches an utilization of the 82.3%, which is acceptable but on the other hand the product “*Chromecast Audio*” does not even reach the 50%. The average of all the percentages is presented by the orange line and represents a 63% of volume utilization. With these poor volume utilizations filling material is required in order to protect the products properly. Low volume utilizations involve a poor logistical efficiency of the packages. The volume occupied in the delivery vehicles and in the pick-up points, if applicable, is higher than necessary. The material waste is higher as there is a percentage of the box that is not necessary and additional material has to be used. At the same time, larger packages are harder to handle and can lead to delays or customer dissatisfaction.

Once the volume utilization is calculated, the dimensional weight will be analyzed. In order to calculate the dimensional weight, from now on DIM, it is necessary to have the volume of the packages, the weight of the primary boxes and the weight of the packages. CDON has not provided the data of the weight of the different standard carton boxes, but it can be estimated by their volumes. According to the Recycling council of British Columbia in Canada, corrugated cardboard boxes have a density that varies from 30 to 90 kg/m³ (Corrugated cardboard, 2004). With this, is possible to estimate the weight of each of the standard packages. Since the ratio goes from 30 kg/m³ to 90 kg/m³ the estimated density used in the present analysis is

the average, 60 kg/m³. As a reminder, the DIM is calculated according to Postnord's method, which equates one cubic meter to 280 kg.

On the following table, the data of the weight of both the product's primary boxes and the packages as well as the calculated DIM is presented.

Table 15. Total weights and DIMs of the packages (Density of 60 kg/m³)

<i>Product name</i>	<i>Standard carton box volume (liters)</i>	<i>Product weight (kg)</i>	<i>Standard carton box weight (kg)</i>	<i>Total weight (kg)</i>	<i>DIM (kg)</i>
Blue microphones Yeti Blackout	7	0.55	0.42	0.97	1.97
Chromecast Audio	1.4	0.15	0.08	0.23	0.39
Melitta Look 4.0	30.3	2.9	1.82	4.72	8.49
Emerio Äggkokare Clatronic	7	0.48	0.42	0.9	1.97
Bosch Skruvdragare PSR 18	23.8	1.3	1.43	2.73	6.66

According to the calculations, none of the five top-seller products reach the DIM set by Postnord. This means that CDON has to pay for more weight than the actual weight that is shipping, mainly due to the low volume utilizations achieved. Even carrying out the calculations with the density of 90kg/m³, the resulting total weight of all the products is still lower than the DIM. It can be seen in the table presented below.

Table 16. Total weights and DIMs of the packages (Density of 90 kg/m³)

<i>Product name</i>	<i>Standard carton box volume (liters)</i>	<i>Product weight (kg)</i>	<i>Standard box weight (kg)</i>	<i>Total weight (kg)</i>	<i>DIM (kg)</i>
Blue microphones Yeti Blackout	7	0.55	0.63	1.18	1.97
Chromecast Audio	1.4	0.15	0.13	0.28	0.39
Melitta Look 4.0	30.3	2.9	2.73	5.63	8.49
Emerio Äggkokare Clatronic	7	0.48	0.63	1.11	1.97
Bosch Skruvdragare PSR 18	23.8	1.3	2.14	3.44	6.66

In the previous calculations the weight of the additional material has not been considered. In any case, it is considered that the amount of weight required to reach the DIM is too high to cover it with additional material, as this type of material is light (around 3 grams/liter in the case of the polystyrene '*foam peanuts*')

4.5 Chapter summary

The chapter started with the description of the selected company: CDON, and the main reasons of why this particular company has been selected were presented. Following, a section about the packing process of the company is presented. This section includes parts like the warehouse product management, the different packaging solutions employed, the packaging requirements set to the packaging suppliers, how the product returns are managed, and the different challenges encountered. After, a section where some packaging solutions are evaluated by the use of a packaging scorecard is presented. Later, the packaging selection effects on volume & weight efficiency applied to certain products are evaluated. The following chapter analyzes the findings made throughout the thesis.

5 Analysis

This chapter presents the analysis and discussion on the findings and results of the thesis. It is divided in different sections, that focus on making an analysis about the results and data that will lead to cover the different objectives and answer the research questions. First, the last mile logistics requirements for e-commerce packaging found in the literature are discussed and compared to the results from the scorecards. After, an analysis about the selection criteria for the different packaging solutions is carried out, with data from the packaging scorecards. Following, the different packaging solutions are analyzed with data from the interviews, in order to present their different advantages and disadvantages. Finally, the results from the evaluation of the selected packaging solutions in chapter 4.4 are analyzed, which will lead to estimate the potential to reduce waste and increase volume efficiency.

5.1 Last mile logistics requirements for e-commerce packaging analysis

In this section, the last mile logistics requirements for e-commerce packaging found in the literature are discussed and the correlations between them are analyzed. In addition, the scorecards' results from the empirical data chapter are brought up in order to compare the supply chain requirements identified in the theory with results from a real case. This will lead to cover the objectives (“*To identify supply chain requirements on secondary e-commerce packaging*” and “*To identify incentives, barriers and trade-offs for changing to more logistically efficient the current packaging solutions for the selected company*”)

As presented in the frame of reference (see 3.3.3 *Particular e-commerce packaging requirements*), the packaging requirements are different depending on its distribution channel. For the e-commerce distribution channel, the main packaging requirements that need to be fulfilled are:

- Protection
- Handleability
- Safety
- Minimal amount of waste

- Re-use capability
- Volume & weight efficiency
- Packaging cost
- Stackability
- Machinability
- Reduced use of resources

Below, these requirements are discussed and an analysis about the correlations between them is carried out. Then, data gathered from the scorecards from the empirical data chapter is brought up. At the end of the section, a table summarizing the different trade-offs to improve the different requirements is presented.

Protection

Protection in the e-commerce distribution channel can be determining. The wide range of products that can be sold in this channel include fragile products or items with specific protection specifications. This, together with the long distances from the sending point (the warehouse) to the point of reception (residences or delivery points), gives this requirement a key importance. The main and principal purpose of this requirement is to guarantee that the product will reach the reception point at the same state as it departed from the sending point.

There are different ways to enhance the packaging's protection but, how can packaging ensure a good protection? Is it better to spend more money in filling material to ensure protection or to develop a proper design that will fit the product perfectly and will absorb better the vibrations from the transportation? There is not an explicit answer to these questions as it all depends on the specific situation. Changing the packaging's specifications in order to improve protection can have a negative effect on other requirements as well. Protection can be improved by adding extra filling material, but this will also increase costs and environmental impact. Other way to enhance protection is to develop packaging that fits perfectly the product, no additional filling material is required here but the costs will increase significantly as a specific package has to be developed. In CDON, approximately the 30% of the products from the warehouse are packed in standard carton boxes. In the majority of those cases, additional filling material is needed to ensure product protection as the volume utilizations reached are low.

From the scorecards presented in the empirical data chapter, data regarding the importance given by the selected company to the protection requirement for different packaging solutions can be brought up. The importance given to protection in the different packaging solutions is one of the highest compared to the rest of requirements. In all the packaging solutions it is ranked top 3 in importance, except for the standard carton box for the iPhone X that is ranked as the fourth most important. Also, different interviewees from the company stated that product protection is very important for them, which is reflected in the levels of satisfaction

achieved in the scorecards. Definitely, product protection is a requirement that the company takes into consideration in their packaging solutions.

Handleability

This packaging requirement is directly linked with logistical efficiency. It is the ability of the packaging to facilitate handling. In the e-commerce distribution channel this translates into facilitating the handling and transportation within the warehouse, the freight transport company and the customer, i.e. if the package is collected from a reception point and has to be taken home.

Handleability has to do with the size of the package, its weight, the shape or the ergonomics. How can then a package reach a good handleability? From an operator point of view for example, a package's handleability is higher if it has a pre-cut bottom which allows them to assemble the packages faster. A package performs a good handleability if it is easy to grab, transport and/or place. Packages with openings or handles that help the user to grab and transport them will enhance this requirement, but at the same time this special design can lead to an increase of the cost of the package. It can be related with the volume & weight efficiency requirement, as packages with high volume utilizations will not have unnecessary packaging material and thus the size of the package will be in accordance with the product.

In the scorecards presented in chapter 4.3, the importance given to handleability is remarkable. Without taking cost into account, handleability is the packaging requirement with highest importance in all the scorecards. The importance given to the packaging solution used for media, the carton packaging made with the cold seal machine, is the highest, 100. The large amount of media products managed in the warehouse, up to 65%, make handleability a very important requirement to fulfil in their packaging solutions, as the logistical efficiency in the warehouse is improved. Handleability is, for CDON, an important packaging requirement to take into account.

Safety

Safety has to do with the protection against theft or manipulation of the product since it is packed until it reaches the final customer. Also, safety must ensure that the product is not lost during transportation. The customer expects to receive the same product as it was ordered without any manipulation signs. Also, the customer trusts the authenticity of the product, especially in products from well-known and fancy brands.

The customer expects this requirement to be fulfilled, and an awareness of a problem with safety in a package can lead to quality incidents and/or customers lost. How can packages ensure a high safety? In order to ensure traceability, identification numbers that can be followed in the tracking systems of the transport companies have to be printed on the package. Additionally, by employing materials that are hard to penetrate or to open. Also, employing additional materials in order to ensure a secure closure of the packages can be done. These options definitely increase the

cost of the package, and in the case of employing additional material, more waste will be produced thus will have an environmental impact.

The data from the scorecards reflects that the importance given to this requirement compared to other requirements is average. This is, not as high as requirements like protection or handleability but not as low as other requirements that will be analyzed later on. The packaging solutions that show a greater importance in this requirement are the ones containing the iPhone X and the PS4 Pro, due mainly to the high cost of these products thus the greater necessity of having a good traceability of the product or to ensure product authenticity to the customer. Summing up, the company focuses on fulfilling this requirement but to lower extent compared to other requirements.

Minimal amount of waste

This requirement refers to the total waste derived from the packaging. As in e-commerce there are more frequent orders of smaller quantities than in traditional commerce, the waste produced can be high. Minimal amount of waste refers to have a packaging solution that will produce as minimum material disposition as possible. It is directly related with the packaging's environmental load.

The amount of waste produced by a packaging solution has direct correlations to packaging requirements like cost, protection or volume & weight efficiency. For example, trying to reduce the amount of waste of a package can be done by reducing the filling material used in a package, but if this package is way bigger than the containing product then its protection will decrease drastically. Another example could be the improvement of the volume efficiency of a package, which has a positive effect on the amount of waste produced, among others, but the packaging costs will increase.

As reflected from the results of the scorecards, the importance given by CDON to this requirement is low, especially in the standard and size customized boxes. Even that in the interviews, the interviewees recognized that they should put more effort in this requirement, the actual state is that they are focusing more in other requirements like protection, handleability or even safety.

Re-use capability

The re-use capability has a stretch link with product returns. Even that a re-usable package can be employed by the customer for a different function after the product is received, the main interest of having re-usable packages is to make use of them in case that a product is returned after reception.

In order to consider that a package is capable to be used for a return, its main characteristics should remain equivalent to how they were when it departed the warehouse. As it is crucial for a package to fulfill the packaging requirements when is sent to the customer, the same should occur if a product will be returned. In order to achieve this, packages might need special protection or materials that ensure that

the package characteristics remain invariable along the transportation process. To achieve it, packaging cost might increase as special focus on this matter has to be taken into account in the developing process. On the other hand, enabling the use of the same package for the returns has a positive environmental impact as less new packages, thus less packaging material waste, are employed. Other point that is remarkable to mention is that, if a customer is doubtful about returning a product and it is found that there are a lot of facilities to do so, e.g. a re-usable package, it is probable that the product will end up returned. Returns and reverse logistics costs can add up to an 8-10% of the product cost.

According to the data retrieved from the scorecards, the re-use capability is not in the major importance focus for the company. In the packaging solution used for media, the importance given to this requirement is nonexistent as this solution has a tear strip used for its opening that, once opened, rips off some packaging material and disables the opportunity to re-use it. A potential trade-off for this packaging solution would be to improve it by developing another opening system, without losing the current characteristics. As said by one of the interviewees, the re-use capability is kind of important for smaller boxes that have a higher ratio of returns, but it is not something they focus enough.

Volume & weight efficiency

This requirement has to do with the total volume usage of the packaging solution. As the volume not used is occupied by air, the logistical efficiency is directly affected as more space than the necessary is used. Different actors are influenced by low volume efficiencies, as it affects warehousing storage, transport or final customer handling. It has a stretch relationship with other packaging requirements like environmental impact, handleability or protection.

It is one of the requirements with more room for improvement, but the trade-offs linked to it are numerous. A package with a high-volume efficiency can reduce the environmental impact and increase the package protection, but can be translated into an increase of packaging costs. Nowadays e-commerce companies work with a wide range of different products and sizes, and it is not attainable to have packages that fit them all perfectly with high-volume utilizations. On the other hand, if a package has a low-volume efficiency, filling material will be needed, causing an environmental impact, and the protection can be involved towards a lower performance. In the case of CDON, up to the 30% of the products approximately, are packed in standard carton boxes. In the majority of the cases, this leads to low volume utilizations and additional filling material is needed, increasing protection but as well increasing the environmental impact and packaging waste. In the empirical data chapter (See 4.4. *Packaging selection effects applied to certain products*) different top-seller products were studied and their average volume utilizations is just the 63%, requiring large amounts of filling material to ensure protection.

Taking a look into the results from the scorecards from chapter 4.3, the importance given by the company to the volume & weight efficiency varies depending on the packaging solution, but in general it is not as high as protection and handleability but there are requirements with lower importances like reduced use of resources and re-use capability. As gathered from the interviews, the company has a wide range of different products. Volume efficiency's focus for CDON is mainly in media products (they comprise the 65% of the products). On the other hand, the importance given to this requirement for the packaging solutions committed for a wide range of products is much lower. To sum up, CDON gives importance to the volume & weight efficiency requirement but not equally to all the packaging solutions.

Packaging cost

Packaging cost is basically the cost of the packaging solution. As large number of packaging solutions are bought by companies like CDON, savings in this area can lead to important general savings. Material type, quantities purchased per order or design complexity are some of the characteristics that have an impact on the cost of a packaging solution.

Packaging cost is directly related with most of the packaging requirements as mostly every change in a package's characteristic will have an impact on the cost. For example, designing size customized packages for a specific product will improve the package's volume utilization and will reduce the packaging waste, but the cost will be higher as lower quantities will be purchased, not taking advantage of the economies of scale. On the other hand, purchasing cheap and low-quality packaging solutions can lead to low product protection leading to product damage and its corresponding increase of total costs due to the returns and product replacement. Also, packaging cost can be reduced by purchasing large amounts of standard packages, but having a wide array of products with different sizes can lead to low volume utilizations and extra filling material will be needed to ensure protection, increasing the environmental impact and as well the packaging cost.

By taking a look to the scorecards, it is clear that CDON gives a great importance to the packaging cost. Furthermore, it is the criterion that CDON focuses most on, more than any other criteria evaluated. Regardless the packaging solution, packaging cost is the biggest focus of the company. As confirmed by the Senior logistical manager, packaging cost is pretty much the most important and defining factor for all of their packaging material.

Stackability

The stackability of a package refers to the ability to stack as many shipment units as possible, in the present project's case secondary ecommerce packaging, in the warehouse and during shipping. High performance in this requirement lead to a high space utilization rate, as more packages can be stored or transported within the same floor positions.

Stackability is directly related to the packaging's design, as its size and shape have a great impact on a package's stackability. Product protection is related as well with stackability, as packages with low product protection will not be able to support the weight of other packages stacked on top of them. At the same time, increasing a packages stackability can lead to increase its size, having a negative impact on the package's volume & weight efficiency and packaging cost.

From the scorecard's results, the importance given to this packaging requirement varies depending on the packaging solution. For the media products, as their size is small compared to the majority of packages handled in the warehouse, they are not designed to support the weight of other packages on top. Due mainly to this fact, the importance given to this criterion for the media products is just of the 25%. For the rest of packaging solutions, standard carton boxes and size customized carton boxes, the importance given to this requirement is 50%. Its importance in these packaging solutions is below the importance given to criteria like packaging cost, handleability or product protection, but it is at the same level as other important requirements like volume & weight efficiency or safety. To sum up, the company focuses on this requirement to lower extent than to cost, protection or handleability but it is still on their focus.

Machinability

This packaging requirement refers to the ability of the packaging solution to be processed effectively in the production line. If a packaging solution is compatible with fully or partially automated processes, the packing rate will be higher as machinability focuses on the filling operation of the packages.

Fully or partially automated packing processes can lead to improve a packages machinability, as their design can be developed towards enhancing this requirement. Packaging solutions that are packed in manual processes will not have a good performance in this packaging requirement as the packages are not handled or processed by machines at any time. Thus, machinability of a packaging solution is related with the automatization of the packing process which requires an investment in order to establish the process. In CDON's case, the media products are packed in automated processes, leading to a high performance in machinability. This packing process leads to obtain a package with a good performance on average in the studied packaging requirements, except for re-use capability, but as mentioned previously an initial investment was required to buy the packing machines.

From the scorecard results, it can be identified that just in the media products the importance given to this requirement is high. Due to the high volume of media products managed in the warehouse, around the 65% of the total, the packing process for these products is automated, leading to high packing rates. In the case of the standard carton and size customized boxes, the packing processes are fully manual and thus the importance given to machinability in these cases is 0%. To sum up, the company focuses on this requirement only for the media packaging solutions, which are the only ones packed in automated processes.

Reduced use of resources

This packaging requirement is directly related with the environmental load of the packaging solution. To employ as minimum packaging materials as possible and to buy packaging solutions that are manufactured under sustainable processes that help reduce the carbon footprint are examples of actions to reduce the use of resources.

By minimizing the packaging materials employed to develop a packaging solution, the packaging cost and environmental impact can be reduced, but there will be a potential impact on product protection, reducing its performance and leading to the necessity of using additional filling material.

For the standard carton and size customized boxes, the importance given by CDON to this requirement is low, aiming their focus to the majority of the rest of the requirements. In the case of the packaging solutions for the media products, CDON focus on this requirement and has a well-approved satisfaction level. This can be explained due to the packing process of these products. The packaging solutions developed for these products consist on two layers of cardboard that form a package that is completely adapted to the product's shape, reducing to the minimum the amount of packaging material employed. To sum up, this requirement is not on CDON's focus for the carton boxes, but it has some importance, to less extent compared to other requirements, for the media products packaging solutions.

After analyzing the different correlations between the last mile logistics requirements for e-commerce packaging solutions found in the literature, a table summarizing the different trade-offs to fulfill them is presented.

Table 17. Main effects of poor requirement performance and trade-offs to improve them

<i>Packaging requirement</i>	<i>Main effects of poor requirement performance</i>	<i>Trade-offs to improve the requirement's performance</i>
Protection	Low protection → Higher risk of product damage, increasing customer dissatisfaction and returns	Add extra filling material → Increase of cost and environmental impact Increase of volume efficiency → Increase of packaging cost
Handleability	Poor handleability → Lower logistical efficiency: warehouse and transport handling are affected	Add openings and/or handles → Increase of packaging cost Having a precut bottom → Tape not required for the bottom thus less packaging material employed
Safety	Low safety → Higher risk of product loss and consumer dissatisfaction, lower chance to ensure authenticity	Improving material characteristics → Increase of packaging cost Additional materials to ensure secure closure → Increase of environmental impact and packaging cost
Minimal amount of waste	High packaging waste → Increase of carbon footprint, consumer dissatisfaction and risk of fees	Reduce use of filling material → Reduction of protection Increase of volume efficiency → Increase of packaging cost
Re-use capability	Poor re-use capability → Increase on product waste and consumer dissatisfaction	Improving material characteristics → Increase of packaging cost Increased number of returns due to facilities → Increase of transportation costs
Volume & Weight efficiency	Low volume & weight efficiency → Reduced protection and logistical efficiency, increase of environmental impact	Having size customized packages → Increase of packaging cost
Packaging cost	High packaging cost → Company's interests are affected. Product cost for the customer can be affected	Purchase large amounts of standard carton boxes → Reduction of weight & volume efficiency and increase of packaging material waste Reduce packaging material → Product protection reduction
Stackability	Poor stackability → Lower logistical efficiency due to higher usage of floor positions for storing and shipping	Increase packaging size → Better stackability, but lower volume & weight efficiencies and higher packaging costs Increase protection → More packages can be stacked on top, but increase of packaging cost and use of packaging materials
Machinability	Low machinability → Reduction of packing/filling rates	Automated packing processes → Packaging solutions' machinability increases, but initial investment cost is required
Reduced use of resources	High use of resources → Environmental impact increases and packaging costs can be impacted negatively	Reduce packaging material → Less environmental impact and reduction of packaging costs, but reduction of product protection leading to need of filling material

5.2 Analysis of the packaging solutions selection criteria

In the present section, an analysis about the packaging solutions selection criteria followed by the company is carried out. The mentioned analysis will cover the objective (“*To understand the criteria applied in the process for selecting secondary packaging in the selected company*”) and will address the first research question (*RQ1: What packaging requirements have more and less weight for the chosen company when selecting secondary packaging solutions for their products?*).

In overall, the most important and deciding factor while selecting the packaging solutions in CDON, as expressed by the department in charge of this function, is the packaging cost. When selecting the different types of packaging solutions, this is the factor that they most focus on. Anyway, there are other factors that also have a special focus on, which are protection and, in a smaller scale, handleability. In general, other factors like volume & weight efficiency, stackability, environmental impact or re-use capability are as well taken into account, but the conditional factors are the above-mentioned packaging cost and, secondly, protection.

As the range of different products that CDON works with is large, the effort and focus of the company when developing packaging solutions needs to be segmented. The company tends to focus more on products that involve a high volume of sales or that have special packaging requirements than to products that do not have restricting characteristics. For example, it would not make any sense to focus on developing a special package to meet a large number of requirements for a phone charger that is barely sold, and employ a standard carton box on a product that involves a high volume of the total sales. That is why CDON segments its products in two main groups: media and non-media products. Media products have very similar sizes and they comprise the 66% of the total product volume of their warehouse. The non-media products are as well divided in two sub-groups. A group with the vast majority of products and a small group of products that have a special requirement or that are top seller products.

Media products

As mentioned above, media products comprise approximately the 66% of CDON’s warehouse. Within media products are included CD’s, DVD’s and videogames. Vynils are also considered in the media products group, but their requirements are slightly different that CD’s, DVD’s and videogames as they are extremely fragile. Due to the large amount of sales and stock that media products embrace, the main efforts of the company when developing packaging solutions are focused on them.

As mentioned before, the main limiting factor that CDON has when selecting packaging solutions is the packaging cost. As the development of packaging solutions for these products is on the company’s focus, other factors are taken into account as well. The packaging solution that CDON developed for this type of products is the carton package made with a cold seal machine (see 4.2.2.3 *Carton*

packages made with a Cold seal machine). The scorecard presented in the previous chapter for these products (see. 4.3.5 *Carton package made with cold seal machine for a CD*) show the importance weight of the company to each packaging requirement and their satisfaction level with them. The information of the company's importance given to each requirement has been retrieved from the scorecards and sorted in order from more to less importance. The resulting table is presented below.

Table 18. Importance given to packaging requirements in cold seal machine packages

<i>Carton packaging made with cold seal machine: CD</i>	
Requirement	Scores
	Importance (0-100)
Packaging Cost	100
Volume & Weight Efficiency	100
Handleability	100
Machinability	100
Reduced use of resources	75
Product Protection	75
Minimal amount of waste	50
Stackability	25
Safety	25
Re-Use Capability	0

It is remarkable to mention that the results from the table are applicable to CD's, DVD'S and videogames due to its nearly identical characteristics, weights and dimensions. Vynils are not included in this analysis. As retrieved from the table, packaging cost is the factor with the biggest importance for the company, as well as volume & weight efficiency, handleability and machinability. Reduced use of resources and product protection also represent a high importance. Other factors like stackability, safety or re-use capability, are not of much importance for the company in this packaging solution. Re-use capability for example, is not possible in this packaging solution as its opening method is by using a tear strip that rips off part of the packaging material.

Non-media products

Approximately, the 34% of products stored in CDON's warehouse belong to non-media products. In this category multiple types of products are included, from consoles, mobile phones or diverse electronic gadgets to appliances or toys. As mentioned before, these products are also segmented into two different groups by CDON. One group, the smallest one, embraces the non-media products that are top-sellers and that deserve a special focus by CDON when developing their packaging solutions. In this group, the products found are the consoles from different companies and hard drives. The other group, which comprises the vast majority of

the non-media products, is composed of the rest of products that are not consoles or hard drives.

To less extent, compared with the media products, CDON also puts its efforts on developing packaging solutions for the top seller products that fulfill various requirements a part of the packaging cost. The packaging solution employed by CDON for these top seller products are size customized carton boxes that fit perfectly to the size of the product. The importance given to the different requirements of this packaging solution has been retrieved from the packaging scorecard presented in the previous chapter (see 4.3.4 Size customized carton box: PS4 Pro). A resulting table with the requirement's importance sorted in order from higher to lower is presented below.

Table 19. Importance given to packaging requirements in size customized carton boxes.

<i>Size customized carton box: PS4 Pro</i>	
Requirement	Scores
	Importance (0-100)
Packaging Cost	100
Product Protection	75
Handleability	75
Safety	65
Stackability	50
Volume & Weight Efficiency	50
Reduced use of resources	40
Re-Use Capability	25
Minimal amount of waste	10
Machinability	0

It is important to mention that, even that the packaging scorecard has been developed for a PS4, a type of console, it has almost identical characteristics than the rest of products packed in this packaging solutions, which are consoles as well and hard drives. Packaging cost is the requirement with most importance in this packaging solution. It is followed by product protection and handleability. The elevated price that this type of products has lead the company to focus in requirements like product protection or safety. Re-use capability, minimal amount of waste or machinability, as the packing process is manual, do not have much importance for the company.

The rest of products that are not media nor are top sellers are packed in standard carton boxes. These are the products that the company focuses less on and the effort putted on the developing of these packages is low. In the previous chapter, three different products packed in standard carton boxes were evaluated by the use of

scorecards. The importances given to the requirements in these three scorecards have been aggregated and as a result a table where the average importance sorted from high to low is presented below.

Table 20. Importance given to packaging requirements in standard carton boxes

<i>Standard carton box</i>	
Requirement	Scores
	Importance (0-100)
Packaging Cost	100
Handleability	75
Product Protection	50
Stackability	50
Safety	48,3
Volume & Weight Efficiency	41,7
Re-Use Capability	22,7
Minimal amount of waste	16,7
Reduced use of resources	10
Machinability	0

As different types of products have been evaluated in the packaging scorecards the average of its importances is valid to make this analysis. As happens in the rest of packaging solutions, packaging cost is the most important requirement factor that CDON takes into account while developing its packaging solutions. Handleability and product protection are as well taken into account but to less extent compared to packaging cost. Stackability is also rated with a significant importance, due mainly to the different sizes and shapes that conform the packaging solutions employed to pack these products and the importance to ease its stacking. Volume & weight efficiency is rated with just a 41.7 % and requirements like reduced use of resources and machinability, again because its packing process is manual, is not taken into account. An alternative that CDON is starting to put in practice for this type of products is to use plastic bags for the products that have a very good primary package in terms of protection and handleability. As this trend is very recent and it is in its trial status, the information about which products are shipped in plastic boxes is not owned, but it will be interesting to follow.

5.3 Advantages and disadvantages of the studied packaging solutions

In this section the different packaging solutions employed by CDON are analyzed. This analysis will lead to identify the different advantages and disadvantages of each of the studied packaging solutions, covering the objective (*Find out the different*

packaging solutions the selected company employs and their advantages and disadvantages). A table summarizing the different advantages and disadvantages of the different packaging solutions is presented at the end of the section.

Standard carton boxes

Almost the 34% percent of the non-media products stored in the warehouse are packed in this packaging solution. CDON currently has 8 different sizes of standard carton boxes, that go from the smallest 1.4 liters to the biggest of 744.2 liters. These packaging system is the one that the company puts less effort on developing. The main criteria that is followed in order to select them is the packaging price, followed, with less importance, by handleability and product protection.

The main advantage of this packaging solution is on the one hand its cost, as it is the packaging solution with the cheapest packaging cost, and its versatility, as the eight different sizes can pack a wide variety of different products of different sizes. It provides an acceptable protection for the vast majority of the products and it is easy to handle. On the other hand, it has disadvantages as well. Its average volume efficiency is between 60-70% which makes necessary the use of filling material in most of the cases, with its corresponding increase of the packaging cost and environmental impact. The packing process is manual which can lead to low productivities and specially to mistakes in the packing process. As the workers need to choose the standard carton box to use under their own judgement, there is a risk of choosing a box that is not the optimal for that product. A proper database, which is missing currently, with the dimensions and weights of all the products in the warehouse would be interesting. With this database, the products could be automatically linked to its optimal standard carton box and the risk of human error by choosing a wrong package would decrease enormously.

Size customized carton boxes

The products packed in this packaging solutions are the non-media top seller products, as mentioned in the previous section. They represent a small percentage within the total number of different products in the warehouse, but their high-volume sales award them with size customized carton boxes. Four different consoles and hard drives are packed in this packaging solutions. The main requirements that CDON focuses on these packages are the packaging price, product protection and handleability. Volume & weight efficiency is not one of the most important criteria for CDON in this type of packaging, but it is very well reached as it is linked directly with product protection.

The main advantage of this packaging solution is the volume & weight efficiency achieved, almost 100% as they are made to fit the product perfectly, and its protection is high, related to the high-volume efficiency. As the volume efficiency is high, no filling material is used in this packaging solution, contributing to reduce the environmental impact and packaging costs. As disadvantages, it has to be taken into account that these are packages made specifically for a certain product, so its

versatility is inexistent. Additionally, this type of packaging solution is expensive as, in comparison to the standard carton boxes, the number of packages bought to the suppliers are much lower and the prices per unit are higher, as it does not take advantage of the economy of scale. Similarly, it is not feasible to have size customized carton boxes for all the products, especially if there is a wide range of products, because it would add difficulties when forecasting the packages to buy and its storing in the warehouse would be difficult as a wide range of different sizes would appear.

Carton packages made with cold seal machine

The 66% of products from the warehouse, media products, are packed in this type of packaging solution. All the CD's, DVD's and videogames are packed by making use of the cold seal machine. As the company's main effort on packaging development is putted on these products, there are various requirements that have a lot of importance. Among these are of course the packaging cost, but also there is a high importance given to requirements like volume & weight efficiency, machinability and handleability. Also, product protection or reduced use of resources represent a high importance in the requirements of this packaging solution.

This packaging solution has a lot of advantages. First of all, the volume & weight efficiency achieved is 100% as the product is packed between two carton layers that leave no free air. The packaging cost is low as no packaging material is wasted and the machine is fed by cardboard reels. There is no need of filling material and the product protection achieved is high. Also, the packing productivity of this machine is high, up to 30 products per minute. The handleability achieved with these packages is high as they are light, small and have a regular shape (the shape of the product packed). But, it also has some disadvantages. To produce these packages, it is necessary to invest in a cold seal machine which cost around 50,000 € (500,000 SEK). Another disadvantage is that the type of products that can be packed in this machine are very limited, as a maximum thickness of 30mm is permitted.

Carton boxes made to fit the product with a CMC machine

The CMC packaging machine, the last acquisition by CDON, is a revolutionary machine that is called to have a bright future in the packaging industry. Currently there is no information about which products of CDON's warehouse are packed with this machine as it is in its trial state. What is well known is that a wide range of products are able to be packed in this machine as the smallest box dimension are (LxWxH in mm) 150x240x30 and the maximum are 350x600x200.

The advantages of the carton boxes made with this machine are multiple. The packaging material used is optimized due to its high-technology scanners. The reached volume & weight efficiencies are near 100% so no filling material is required, and the package protection is high as the box is made to fit perfectly the product. Its productivity is high, up to 1000 packages per hour, and the machine is

also able to attach on the box the note with the shipping information. The main and most important disadvantage is its cost. This machine costs thousands of hundred euros, so only big companies with high budgets are able to invest in one of them. Additionally, as it is a very recent technology, there is not information about the results of the packages produced and its operation process has to be followed up.

To end the section, a table summarizing the main advantages and disadvantages of the studied packaging solutions is displayed below.

Table 21. Advantages and disadvantages of the studied packaging solutions

<i>Packaging solution</i>	<i>Advantages</i>	<i>Disadvantages</i>
Standard carton box	-Packaging cost -High versatility -Acceptable protection	-Low volume efficiencies (average 60-70%) -Risk of choosing not optimal box
Size customized carton box	-High volume efficiencies -Good protection	-Low versatility -Packaging cost -Total amount of different sizes is limited
Carton package made with Cold seal machine	-High volume efficiencies -Good protection -Packaging cost	-Need of investment -Limited to thickness (30mm)
Carton box made with CMC machine	-High volume efficiencies -Good protection -Packaging cost	-Need of investment -New technology, results unknown

5.4 Performance analysis of the selected packaging solutions

In the following section, the analysis about the results obtained in chapter 4.4 will be carried out. This analysis will help to cover the objective (*‘Evaluate the performance of the packaging solutions for different products and estimate the potential to reduce packaging waste and increase volume efficiency’*) and to answer the second research question (*RQ2: What packaging requirements show more potential to be improved in the employed packaging, and what are the possible solutions that the company could apply in order to achieve it?*)

The products selected in chapter 4.4 are packed in standard carton boxes, as the rest of packaging solutions employed by the company reach high volume efficiencies and low material waste. The studied products correspond to five products with high sales rates for the company. In chapter 4.4, first, the process followed to estimate

their corresponding optimal packages was explained. After, with data provided by the company, the volume utilizations and dimensional weights were calculated.

This section is divided in three subchapters. First, the volume utilization's results will be analyzed and discussed. After the analysis of the dimensional weight results will be carried out. To finish, the findings from the analyses are discussed.

5.4.1 Volume utilization

The results of the volume utilization from chapter 4.4 have been summarized in a table, which is presented below. The table shows the names of the products studied, the percentage of volume the product's primary packages take up in the estimated optimal standard carton box and the average of all of them.

Table 22. Summary of volume utilizations of the studied products, retrieved from chapter 4.4 data

<i>Product name</i>	<i>Volume utilization (%)</i>
Blue microphones Yeti Blackout	74.3
Chromecast Audio	44.6
Melitta Look 4.0	82.3
Emerio Äggkokare Clatronic	66.1
Bosch Skruvdragare PSR 18	47.1
AVERAGE	62.9

As mentioned before, these five products have been selected because they represent a considerable volume of sales over the past year. Due to this, and before conducting any analysis, it is assumable that a requirement like volume utilization will have a good performance. By taking a look at the figures above presented, it is clear that the possible assumptions taken before conducting any analysis are completely wrong.

There are just two products, Melitta Look 4.0 and the blue microphone Yeti Blackout, which volume utilization performance is acceptable. Even in these two products, the ones with the higher volume utilizations, filling material is needed. Going in deep, the Melitta Look 4.0 is packed in a 30.3 liters box, and even its volume utilization is the highest among the studied products, filling material will be needed until the total volume utilization reaches a percentage close to the 100%.

This is translated on around a 15% of filling material, that out of the 30.3 liters mean a total amount of 4.5 liters of filling material. Putting attention into the rest of products, it is surprising to see that two products, the Bosch drill and the Chromecast Audio, are below the 50% of volume utilization. This means that more than half of the package is air, the material waste in these examples is very high. The average volume utilization of these five products using standard carton boxes that are top sellers is 63%, which is definitely a very low and worrying volume utilization. As mentioned before, these products have a big volume of sales, but not special attention has been putted into their packaging solutions.

5.4.2 Dimensional weight

The results of the dimensional weight calculations from chapter 4.4 are presented below. In the displayed table, the results have been summarized and an additional column is added with the amount of non-existent weight that is being payed to the freight transport carrier.

Table 23. Summary of the dimensional weights of the studied products, retrieved from chapter 4.4 data

<i>Product name</i>	<i>Total weight of product and packaging (kg)</i>	<i>DIM (kg)</i>	<i>Nonexistent weight being paid (kg)</i>
Blue microphones Yeti Blackout	0.97	1.97	1
Chromecast Audio	0.23	0.39	0.16
Melitta Look 4.0	4.72	8.49	3.77
Emerio Äggkokare Clatronic	0.9	1.97	1.07
Bosch Skruvdragare PSR 18	2.73	6.66	3.93

As mentioned in the previous section (see 5.4.1 *Volume utilization*), the studied products are top sellers and thus it can be assumable that the requirements of the packaging solutions selected for them will have a good performance. Volume utilization of course did not show a good performance in these cases, but the dimensional weight does not either. The column with the dimensional weights, show the weights that the freight transport companies will charge for the packaging solutions associated to each product, depending on the size and volume. The column on the right, displays the total non-existent weight that is being extra-paid.

The only product which weight is very close to the dimensional weight is the Chromecast audio. In this case, the total weight is pretty adjusted to the dimensional weight. It is not the case for the rest of the products. In some of them, the Yeti Blackout microphones or the Emerio egg-cooker, the extra weight that is being paid is equivalent to the total weight of the product and the package. This means, that the price that is being paid for their transport is equivalent to the price of transporting two units instead of one. In the case of the Bosch drill, the extra weight being paid is even greater than the actual weight of the product and its packaging. Putting the Chromecast audio aside, the rest of products' weights are far from the dimensional weight calculated for its corresponding volumes. One more sign that even these products are top sellers, CDON does not put much effort in the products packed in standard carton boxes.

5.4.3 Findings discussion

This subchapter aims to discuss the findings encountered in the previous analysis in subchapters 5.4.1 and 5.4.2.

The studied products are all packed in standard carton boxes of different sizes. As these products are top-sellers, their packaging solutions should be on the focus of the company in terms of achieving good performance in requirements like volume & weight efficiency. After conducting the analysis, it is clear that, at least for these products, the company has not put too much effort on improving the volume & weight efficiency of their packaging solutions. It is directly correlated with the results from the dimensional weight calculations. Low volume utilizations lead to have total weights lower than the dimensional weights established for each packaging solution, which is translated into paying for shipping weight that is nonexistent. Low volume utilizations lead as well to high packaging waste, as a high percentage of the material used to make the box is needless and the amount of extra filling material required to ensure protection increases.

After conducting the analyses, it is clear that the potential to increase the volume efficiency and decrease packaging waste for these products is high. The room for improvement in them is high and could be achieved by employing packaging solutions that fit better these products. This statement is regarding the five studied products. In order to have a more general statement, more products should be studied and analyzed. Due to the fact that the studied products were top-sellers, most probably other products with low sales rates will have as well low volume utilizations, but as mentioned before a wider variety of products should be studied. CDON should conduct a study in order to determine if in matters of cost, process-change and feasibility would it be interesting for them to change the packaging solutions for these products and additional ones that have similar low volume efficiencies and high packaging waste.

6 Conclusion

This final chapter presents the conclusions of this master thesis, by reviewing the objectives stated at the beginning of the report followed by a section answering the research questions. To end, a section of future research is presented.

6.1 Objectives review

The purpose of this section is to review the different objectives that were settled at the beginning of the report and to comprehend what has been learnt. Below, the review of the different objectives is presented.

- 1. To identify last mile logistics requirements on secondary e-commerce packaging.*

The chapter 3.3.3 of the frame of reference presented the result of an extensive literature review. There, the different packaging requirements identified for the e-commerce last mile logistics encountered in the literature were presented. These are:

- Protection
- Handleability
- Safety
- Minimal amount of waste
- Re-use capability
- Volume & Weight efficiency
- Packaging cost
- Stackability
- Machinability
- Reduced use of resources

In chapter 5.1, these requirements are discussed and compared with data from the empirical data chapter. By conducting this comparison, it can be stated if these

requirements are important for CDON and if they focus on them when selecting the packaging solutions. In the case of packaging cost, protection, handleability and safety, the importance given by the company to these requirements is high and their packaging solutions accomplish these requirements. In the case of the minimal amount of waste or reduced use of resources, CDON does not focus specially on them but not because the company thinks it is not important. This is because the company's priority is to focus before on fulfilling other packaging requirements, as the interviewees recognize. Then, it would be interesting to further study these requirements in different cases in different companies. Re-use capability's importance in general is low for CDON. The company does not focus on it with the same importance for all the packaging solutions. In the case of the packaging for the media products, they do not focus at all as these packages can't be re-used as some material is ripped off when opening them. Their focus in this requirement is centered in the carton boxes, especially in smaller packages with higher return rates. The volume & weight efficiency requirement has different importance for the company depending on the packaging solution but in general their focus on this requirement is high. For the media products, that comprise the 66% of the warehouse's products, the company employs packaging solutions that have close to a 100% volume utilization. In the standard carton boxes employed for a wide variety of products, the volume utilization has big potential to be improved, as can be identified from the results of the evaluation of different top-seller products in the empirical data chapter (see 4.4 *Packaging selection effects applied to certain products*). Stackability is as well on the company's focus when selecting a packaging solution. The importance given to this requirement is lower than to other criteria like packaging cost, protection or handleability but it is definitely taken into account as its fulfilment leads to a high number of shipment units stacked in the warehouse and during shipping. Machinability is only in the focus for the media products' packaging solutions, as these are packaging solutions that are linked to automated packing processes. In the case of the standard and size customized carton boxes, the packing processes are fully manual and thus this requirement is not taken into account.

To sum up, the literature review helped to identify different last mile logistics requirements on secondary ecommerce packaging, and their importance evaluation applied to a real case from an ecommerce company like CDON was carried out in order to prove its veracity. Some of the requirements have a great importance in all the packaging solutions, others just in determined packaging solutions and some are not in the main focus of the company. As this study is based in only one company and three different packaging solutions, future research should analyze the

importance given to these requirements in different companies and for different packaging solutions to corroborate the findings of this study. Furthermore, additional last mile logistics requirements could be included in further studies, like the suggested by Pålsson (2018): unitization, apportionment, communication or identification.

2. To understand the criteria applied in the process for selecting secondary packaging in the selected company.

By making use of the packaging scorecards, the union of different products and their packaging solutions were evaluated. Different packaging requirements identified in the literature for the e-commerce distribution channel were included in the evaluation. The different importances that the company gives to different packaging requirements in these scorecards are the starting point to understand the selection criteria applied by the company.

Even that in overall, according to the senior logistical manager of the company, the most important and deciding factor when selecting packaging solutions in CDON is packaging cost, the analysis in chapter 5.2 was focused on the product segmentation of the company.

For media products, that consist on the 66% of the total volume of the warehouse, the requirements with biggest importance to the company are packaging cost, volume & weight efficiency, handleability and machinability. These products are packed with a cold seal machine.

For non-media products that are top-sellers, like different brand consoles and hard drives, the requirements with biggest importance to the company are packaging cost, product protection and handleability. These products are packed in size customized carton boxes, that fit the products perfectly.

For the rest of non-media products that are not top-sellers, the company's effort on the packaging selection process is not as big as the previous mentioned products. Packaging cost is the requirement that has more importance for these products, followed by, to less extent, handleability, protection and stackability. These products are packed in standard carton boxes. There are eight different sizes of these boxes and the products are packed in the one that fits them better.

In summary, the criteria that the company focuses most on when selecting secondary packaging for their products are on first place packaging cost, followed by product protection and handleability. Volume and weight efficiency is as well on the main focus of the company but its importance for the non-media products is slightly lower due to the difficulty to achieve a good performance in this requirement.

3. *Find out the different packaging solutions the selected company employs and their advantages and disadvantages.*

The different packaging solutions employed by CDON are presented and described in chapter 4.2.2. These packaging solutions include:

- Standard carton boxes
- Size customized carton boxes
- Carton packages made with a cold seal machine
- Carton boxes made to fit the product with a CMC machine

On the analysis part of the report, in chapter 5.3, these packaging solutions are further analyzed, and the author comes up with different advantages and disadvantages for each of them. The different advantages and disadvantages can be found in a summarized table at the end of the chapter (see *Table 21*).

4. *Evaluate the performance of the packaging solutions for different products and estimate the potential to reduce packaging waste and increase volume efficiency.*

In chapter 4.4, different products were selected in order to do a study about the packaging selection effects on requirements like volume & weight efficiency. Those selected products, with high-volume of sales, are packed into standard carton boxes. In the study, the estimation of their optimal standard carton boxes was made, followed by a calculation of their volume utilizations and dimensional weights. In chapter 5.4, the performance analysis of the selected products was carried out. This analysis determined that in the studied products, the potential to reduce packaging waste and to increase volume efficiency is high, as the average volume utilizations of these products is just a 63%. This is directly related with the material waste, as low volume utilizations require large amounts of extra filling material. This analysis was conducted with five top-seller products and the results about their volume utilizations were not good at all, so most likely other products with low sales rates will have the same bad performance.

The company should employ packaging solutions that fit better the products if the packaging waste wants to be decreased and the volume utilization maximized. In addition, an evaluation about the volume utilization and dimensional weight of additional products should be conducted in order to obtain a more general picture about the volume & weight efficiency performance in their standard carton boxes.

5. To identify incentives, barriers and trade-offs for changing to more logistically efficient the current packaging solutions for the selected company.

In chapter 5.1, an analysis about the different packaging requirements identified for e-commerce packaging was conducted, ending with the effects that the poor performance of these requirement can lead to. Additionally, the different trade-offs entailed in the improvement of these requirements were suggested. At the end of the chapter, a table summarizing these data was presented (See *Table 17*).

The different incentives, barriers and trade-offs identified are presented below:

INCENTIVE: To increase the volume & weight efficiency of the standard carton boxes. With this, apart from volume & weight efficiency, additional filling material would be decreased with its corresponding reduction of the environmental impact, and handleability would be impacted positively.

BARRIERS: To have more standard carton boxes to pick from would translate into an increase of the packaging cost. In addition, adding different types of boxes would be a barrier for the operators that pick the packaging solutions when packing the products, as the quantity of boxes to pick from would increase and would lead to lower packing rates as more time is consumed to develop this task.

TRADE-OFFS: As mentioned previously in the report, a proper database with the sizes of the primary packages of the different products is lacking. Mainly due to this, the operators have to choose on their own judgement between the packaging solutions available for each product instead of having a database that could link each product to a specific packaging solution. With this database, an analysis about the similarities about the sizes of the different products packed in standard carton boxes could be carried out, obtaining groups of products with similar sizes. The company could then focus on these groups when selecting packaging solutions, instead of doing it generally, and purchase standard carton boxes that fit better these groups.

INCENTIVE: To reduce packaging costs by increasing packaging standardization and taking advantage of economies of scale.

BARRIERS: By increasing standardization, this is decreasing the different types of packaging solutions available, the volume & weight efficiency of some products would be negatively impacted and that would lead to a increased necessity of employing extra filling material to ensure protection with its corresponding material waste and environmental impact. Furthermore, handleability could be negatively affected as well.

TRADE-OFFS: To analyze which product's primary packages present good enough characteristics to be capable of being shipped without putting into risk the performance of different packaging requirements, for example product protection, safety, handleability or re-use capability. When identifying these products, they could start being packed in plastic bags, with all the shipping information. This option would decrease the packaging cost, at the same time as volume utilization would be close to the 100% and the packaging solution would be re-usable in case of a product return.

INCENTIVE: To have automated packing processes for the standard and size customized carton boxes, in order to enhance packing rate and lead times.

BARRIERS: The initial costs of implementing automated processes are high. Additionally, there is a transition time required to go from manual processes to automated processes in order to ensure that the packing rates are not affected drastically. The change from a manual process to an automated one cannot be done from one day to other, it has to be done gradually.

TRADE-OFFS: To start using the CMC machine recently acquired by the company with the products that present lower volume utilizations. First, an analysis about the products with the lowest volume utilizations would have to be done. In the present project, five top-seller products packed in standard carton boxes were analyzed, but for the proposed analysis more products with high sales rates would have to be analyzed and the resulting ones with lower volume utilizations could start being packed with the CMC machine. If the packaging solutions obtained with this machine present a good performance regarding the packaging requirements, this machine could start being used for additional products.

6.2 Answer to research questions

After reviewing the different objectives that were settled for the present project, this section presents the answers to the two proposed research questions.

RQ1: What packaging requirements have more and less weight for the chosen company when selecting secondary e-commerce packaging solutions for their products?

The scorecards helped to understand the different importances that the company gives to the different packaging requirements for each of the studied packaging solutions and products. In section 5.2 (*See 5.2 Analysis of the packaging solutions selection criteria*) the results from the scorecards are further analyzed and segmented in different groups, media and non-media products.

From the analysis, and taking into account all of the studied packaging solutions, it can be stated that the packaging requirements that have more weight for CDON are on first place **packaging cost** followed by **handleability** and **product protection**. On the other hand, the requirements that have less weight for the company when selecting secondary packaging solutions for their products are **re-use capability** and **minimal amount of waste**.

It could be interesting to study additional companies with internet as its only sales channel in order to find out if the packaging requirements with more weight when selecting packaging solutions are the same or if they vary.

RQ2: What packaging requirements show more potential to be improved in the employed packaging, and what are the possible solutions that the company could apply in order to achieve it?

The packaging scorecards results showed that the standard carton boxes are the packaging solutions that show a lower average satisfaction in the studied packaging requirements. The mentioned results reinforce that, as it can be guessed in advance, the standard carton boxes are the packaging solutions with lower performance as they are selected for a wide range of different products and not focused for specific products like the size customized carton boxes or the carton packaging made with the Cold seal machine.

It is remarkable that the requirement volume & weight efficiency, which shows one of the higher average importance levels, presents a low performance of just the 63% of volume utilization in top seller products packed in standard carton boxes. In addition, the weights of these top seller products are far from the weights charged by the freight transport carriers for their shipping. Therefore, volume & weight efficiency presents a high potential to be improved in the standard carton boxes as its performance even for top seller products is far from reasonable.

From the incentives, barriers and trade-offs presented in the previous section 6.1, there are different solutions that the company could apply in order to reach higher

volume & weight efficiencies in the products packed in this packaging solutions. First, developing a proper database with the dimensions of the products' primary packaging could help to analyze the similarities in the products' sizes. This analysis would help to identify groups of products with very similar sizes that could be packed in the same standard carton box reaching acceptable volume utilizations. With this analysis, the company could adjust the sizes of the standard carton boxes employed currently, and not necessarily having to increase the number of different boxes. At the same time, with this database, the products could be linked to a specific standard carton box which would make easier the current packing process, where the operator selects under its own judgement the standard carton box to employ.

Secondly, there might be some cases where the product's primary packaging has good enough characteristics to ship it inside a plastic bag, reaching very high volume utilizations. The company should consider reviewing the products' primary packaging as shipping them in plastic bags would solve the low performance in volume & weight efficiency in some of them as well as making easier and faster the packing process.

Finally, it could be interesting to start testing the recently acquired CMC machine for the products that present lower volume & weight efficiencies. After testing these products for a specific time, if the packing rates, costs and the resulting packages are positive it could be applied to additional products with low volume utilizations.

6.3 Future research

As commented in the delimitations chapter, interviewing and studying additional e-commerce companies with such a wide variety of products like CDON will be important to keep learning about their processes and importances given to the different packaging requirements when selecting the packaging solutions. With just one company interviewed it is not possible to state general conclusions, just the ones applied to the particular studied case.

Additionally, as the CMC packing machine is a very recent and new technology, future research should center its attention on it. Its characteristics and the amount of problems that can be solved with these types of machines are promising, that is why future research on them will be very important and fruitful for this field of study.

Future research should also take into account additional packaging requirements in the last mile logistics for the e-commerce sales channel, like the ones proposed in (Pålsson, 2018), and to study them in real cases with companies with e-commerce as their only sales channel.

It could be interesting to have research about the possibility of brands starting to develop primary packages specifically for the e-commerce sales channel that are

good enough in order to be shipped without the need of a secondary packaging, which would reduce material waste and the pain in the neck that can be choosing a secondary package for a product.

To finish, e-commerce will keep its growing trend and companies need to be conscious and prepared. As found in multiple sources while conducting the literature review and specially in the selected company for this study, nowadays, even the high volume of e-commerce transactions, companies do not show a true interest on improving some important packaging requirements while they still focus mainly on the packaging cost. The author own thoughts are that the focus on the packaging cost will remain, but future research should cover if other requirements like volume efficiency and environmental impact will keep gaining importance due to the market trends and needs.

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Appendix A – Interview guide

This appendix shows the interview question list that the author employed in the different interviews. Also a description of how the interviews were carried out is given.

A.1 Interview question list

The developed question list for the interviews is presented as it follows. It is remarkable to mention that these are the questions planned in advance, before the interviews took place. While the interviews were being carried out additional questions could come up and are not presented in this list.

- How are products stored, in their primary, secondary or tertiary packaging?
- Which is the highest priority or the biggest importance when selecting a packaging solution?
- How many standard carton boxes do you employ?
- What other packaging solutions do you employ?
- How many different products do you have in the warehouse? What type are them?
- What type of filling material do you employ? In which cases do you need to employ it?
- Do you make use of drop-shipping? How many merchants do you work with?
- Do you have special packaging requirements for your merchants?
- Is the packaging selection criteria the same when shipping to consumers or to companies?
- Which countries do you ship to?
- Is packaging returnable? How many uses?
- How is the return of products managed?
- How do the fares for shipping work? Are they volume or weight based?
- What importance do you give to packaging efficiency compared to other parts of the supply chain? Is there anything you would like to improve?
- Could you tell me incentives and barriers of improving your current packaging's efficiency?

- What is the position of the company towards reducing the environmental impact of packaging?

A.2 Interview process

Different interviews were carried out with different members of the company. There was a first interview with the senior logistical manager, and it took place at their office in Malmö, where they have most of their packaging materials. As the interview was being carried out, the interviewee brought new concepts and topics into the conversation that were interesting for the project, so the author asked additional questions. During the interview, the interviewee displayed some documents to support his answers. The interview was audio-recorded, previously accepted, some pictures of the different packages were taken and the interviewee handed-over one of the boxes so the author could take it home as well as a printed copy of the company's annual report. Once the interview was finished, the author went through all the gathered data and prepared additional questions that came up. A second interview with the same person was carried out via Skype and additional questions regarding the packaging requirements and the supply chain actors were made. The interviewee provided some data regarding the top seller products in the company. In particular, he handed in data with the dimensions and weights of the primary packaging of those products. Additionally, the interviewee sent via email the measures of some of CDON's packaging systems, including all of the standard carton boxes. After, additional interviews were settled up and carried out via Skype and phone calls with members from the warehouse in Ljungby. The same type of questions were asked in order to validate the data from the previous interviews. In addition, after all the interviews, the author sent a document with different scorecards for different products to the senior logistical manager and to the warehouse. These scorecards were ready to fill, and specific and clear instructions were given in the document, so the participants could fill them properly.