CHALMERS

Improving transport packaging sustainability – a case study in a production logistics company

Master of Science Thesis in the Master Degree Programme, Supply Chain Management

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Report No. E2013:015

MASTER'S THESIS

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Abstract

This master thesis aims to enhance knowledge on how to contribute to an increased sustainability in transport packaging. Five main categories gathering improvement strategy opportunities are developed and illustrated in an Ishikawa diagram. These categories are Process, People, Environment, Unitisation and Material.

Empirical data has been collected at company X, both at its headquarters in Gothenburg, and during a one-week visit to its International Distribution Centre in Poland, where interviews to shop floor operators, observations at the packing station, and experiments of different transport packaging alternatives have been carried out.

Four initiatives have been undertaken during this study. (1) The layout at the packing area was redesigned to make the material flow more direct and the packing process lean. (2) A guidebook for standardizing operators' packing methods has been created. (3) Knowledge has been gained from experiments to define best load units across the supply chain. (4) The most valuable packaging materials have been figured out to make a return flow of packaging material possible. This would reduce raw material consumption as well as reduce the procurement costs of packaging materials.

Due to the limitation that only one company has been examined deeply in this master thesis, the result of the study is mainly a good support to the case company focused to work towards sustainable transport packaging. However, the categories of improvement strategy opportunities and the method used in this master thesis can still be a reference to other manufacturing companies in industry.

Keywords: transport packaging, sustainability, standardization, process mapping, cyclical packaging.

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1 INTRODUCTION

This chapter gives an introduction to this Master Thesis. It starts with a general background which illustrates the importance of the subject. It is followed by a description of the purpose of this study, a problem analysis with its associated research questions and finally the limitations.

1.1 Background

In today's global business, the greatest change may have been the trend towards outsourcing. According to Porter (1985), organizations should focus on activities in their value chain where they have a distinctive competitive advantage. Otherwise, outsourcing should be considered because a partner could provide a cost or value advantage in non-core activities. This trend towards outsourcing has been particularly clear in logistics where transport operations and warehouse operations are increasingly subcontracted to logistics partners. (Christopher, 2011)

Although there are strong economic reasons explaining decisions of outsourcing activities previously performed in-house many companies are today reliant on external suppliers of goods and services. The latter are as well reliant on their external suppliers called second tier suppliers and so on. This creates a more complex network with many nodes and links which increase the risk of disruption. In fact, outsourcing often came with a loss of understanding, of information, of knowledge as well as a loss of power. With outsourcing decisions, "there are more interfaces to be managed and the need for a much higher level of relationship management increases" (Christopher, 2011).

"The trend towards global organisation of both manufacturing and marketing is highlighting the critical importance of logistics and supply chain management as the keys of profitability" (Christopher, 2011). Sourcing, producing and distributing operations are now carried out on a worldwide basis by global companies. Drivers for firm's internationalization are numerous and diverse. The main logic is to look for business growths by extending its markets while reducing costs at the same time through economies of scale in purchasing and production (Christopher, 2011). Other drivers such as prestige, taxes, access to resources or protection of the home market are also often put forward (Schweizer, 2012). Globalisation of supply chains, i.e. globalisation of the supplier and customer bases, also presents certain challenges. In fact, logistics operations complexity is increased to a high extent which can result in higher costs and extended lead times unless there is a high level of coordination (Christopher, 2011).

Due to outsourcing and globalisation, transport demand has significantly increased in the last decades and especially air transport. Air transportation is the fastest safe way to transport goods across long distances. The time between the ordering stage and the delivery stage has become a crucial factor. A competitive advantage can be reached in markets where availability is the order winner that may distinguish you from your competitors. Although air transportation is often the most expensive transport mode it has always been used to ship expensive goods (high value per unit of weight) over long distances. In fact, the time for the capital to be tied-up is shorter which can make air transportation profitable. (Lumsden, 2007)

In order to transport goods, packaging is necessary and has several functions such as to protect, contain, carry and dispense a product (Hanlon et al., 1998). The global packaging industry turned over US$ 670 billion in 2010 (Smithers Pira, 2012). The packaging industry is linked to the world economy and hence there is a near-zero growth in packaging consumption in the developed world and a rapid growth in emerging countries with fast-growing economies. Therefore, in mature markets such as in Europe, Japan and North America companies have exerted downward pressures on prices at all levels of the supply chains. (World Packaging Organisation, 2008)

In nowadays volatile markets, the competition is so fierce that margins cannot be raised at a too high extent to account for the increased risk. Instead, cost reduction or cost rationalization projects are undertaken to reduce the total cost of a product or service. Packaging is then a factor that can help to reduce a product or service total cost to a great extent. Its efficiency and sustainability become increasingly critical. In industries using air transportation the leverage power of packaging is even greater because of the high cost of shipping heavy and voluminous packaging that are not part of the finished product sold to the end customer.

1.2 Purpose of the thesis

The purpose of this study is to help and support company X, a production logistics company using different transportation modes, in its willingness to make its transport packaging usage more sustainable. The goal is to assess and improve different aspects that relate to transport packaging at company X.

The study also aims to contribute with a general conceptual framework which shows different improvement strategy possibilities when it comes to improve transport packaging sustainability. This framework is based on a literature study and is built in the theory chapter in section 3.4.

1.3 Problem analysis and research questions

A problem was presented by company X to the authors. It started by the realization that the cost for packaging materials and transportation is a significant part of the company cost base. Moreover, company X realised that they are most likely overusing transport packaging materials when packing components before shipping them out from their warehouse. This problem is broken down into two sub-problems below leading to two research questions.

Find out improvement strategies

Many companies have worldwide customer orders. They may consist of assortments of various components more or less long, big, heavy, fragile, etc. packed in different load unit standards and shipped with different transportation modes. These load units and other packaging materials, used to protect components during transportation and to allow a high fill rate and a good handling efficiency, represent a significant share of the total logistics cost. However, these materials are not part of the product packaging, i.e. they are not part of the extended product sold to customers. Therefore, an objective of this study is to find out improvement strategies that can contribute to an increased sustainability in transport

packaging regarding the economic, environmental and social perspectives. This leads to the first research question:

RQ1 *"What are the available strategies that can contribute to an increased sustainability in transport packaging?"*

Strategies implementation

These available strategies figured out in RQ1 are linked with potential issues in the current ways of packing and transporting heterogeneous goods. However, a packaging system is usually very complex and it is usually quite long and difficult to accurately calculate or evaluate its efficiency. Therefore, it is often much easier to only point out the inefficiencies or to come up with improvement strategies rather than really implement them. As a result, a second research question is stated:

RQ2 *"How to implement improvement strategies to a complex industrial context?"*

1.4 Limitations

This study is limited to transport packaging, i.e. on what is called tertiary packaging in the section 3.1, and does not deal with product packaging. However, some aspects of this study might be used with adaptations to others kinds of packaging.

The authors only spent one week at the International Distribution Centre in Poland where they got a large part of the knowledge and empirical data. This was due to financial reasons.

Due to time restrictions, the findings are limited and can show the potential of further research. Rather than being a project end with implemented improvements, this study is more a call to action, a call to implement the emphasized strategies.

2 METHODOLOGY

This chapter describes the philosophy behind the study, its design, and how data was collected. Finally, the chapter presents the analysis of the study quality.

2.1 Abductive research philosophy

In this study an abductive research approach has been used, and the case study method is taken as empirical data.

The traditional research approaches in the Western world are deduction and induction. Deductive research follows a conscious direction from a general law to a specific case, while the inductive research approach reasons through moving from a specific case or a collection of observations to a general law. A new method by combining both the inductive and deductive approach was formed in order to get advantages of both approaches, and it is called abductive approach. (Kovács and Spens, 2005)

Abductive approach is also named "systematic combining" and is described below in Figure 1. In the abductive approach, a preliminary analytical framework is formed with 'preconceptions'. The framework directs the search for collecting relevant data, which in turn contributes to the further developed or redirected current framework according to what has been unexpected through the empirical data collection, as well as through analysis and interpretation. It is by the continuous matching between the theories and the empirical world that the theoretical framework and the case is kept involving. (Dubois and Gadde, 2002)

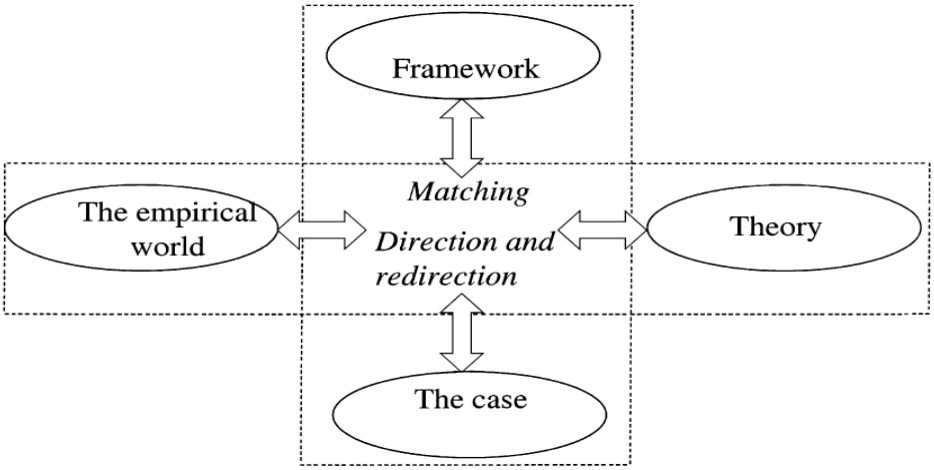

Figure 1 - Systematic combining (Dubois and Gadde, 2002)

The study starts with a pre-built theoretical framework with the sustainable packaging framework, and the fishbone framework defining strategies contributing to an increased sustainability in transport packaging. During the empirical data collection, the theory is reviewed and even revised when there had been new findings. As the research field is not well developed in the case study focal company, it is hardly possible for the authors to get complete empirical data at one time with pre-built theories. The fact that theory and collection

of empirical data mutually and successively redirected during the research, makes the research consistent.

A case study at company X was carried out and used as empirical data. There are mainly two reasons for using a case study to collect empirical data. (1) According to Yin (2003), the research questions can be defined as the terms of the questions who, what, where, how, and why, and the case study method suits well to answer that of "why" and "how", which can be explanatory in nature. This is applicable for the second research question in this study. (2) Case studies can be used to provide description, test theory, or generate theory (Eisenhardt, 1989). Apparently, it adapts to the abductive approach.

As a result, it came natural in this study to use the abductive approach, together with the case study as a support.

2.2 Design of the study

As mentioned previously, the study begun with forming the theoretical framework. During the theoretical framework building, a fishbone diagram was found as the most relevant framework, which became the centre for designing the study. The framework guided further theory searching, and the data collection was conducted under the perspectives for improvement in the fishbone diagram.

2.2.1 Fishbone guideline diagram

The fishbone diagram (see Figure 2), also called the cause-and-effect diagram or Ishikawa diagram was created by Kaoru Ishikawa in 1968. This diagram is known as a fishbone because of its shape which looks like a fish skeleton. It is one of the seven tools of quality control in quality management and is well approved in risk analysis.

It is a causal diagram that is commonly used to identify common causes of an overall effect. The causes are usually grouped into major categories. Usual categories are the 6 Ms (Ishikawa, 1990):

- Manpower (People). The people involved in a process.
- Machines. The equipment required to carry out the job.
- Materials. The materials that are used from raw materials to the end products as well as information.
- Measurements. Any data generated from a process that are used to assess its quality.
- Milieu (Environment). The different conditions where the job is performed (e.g. the location, the time, the temperature, the humidity, etc.).
- Methods. How the process is performed (policies, procedures, regulations, etc.).

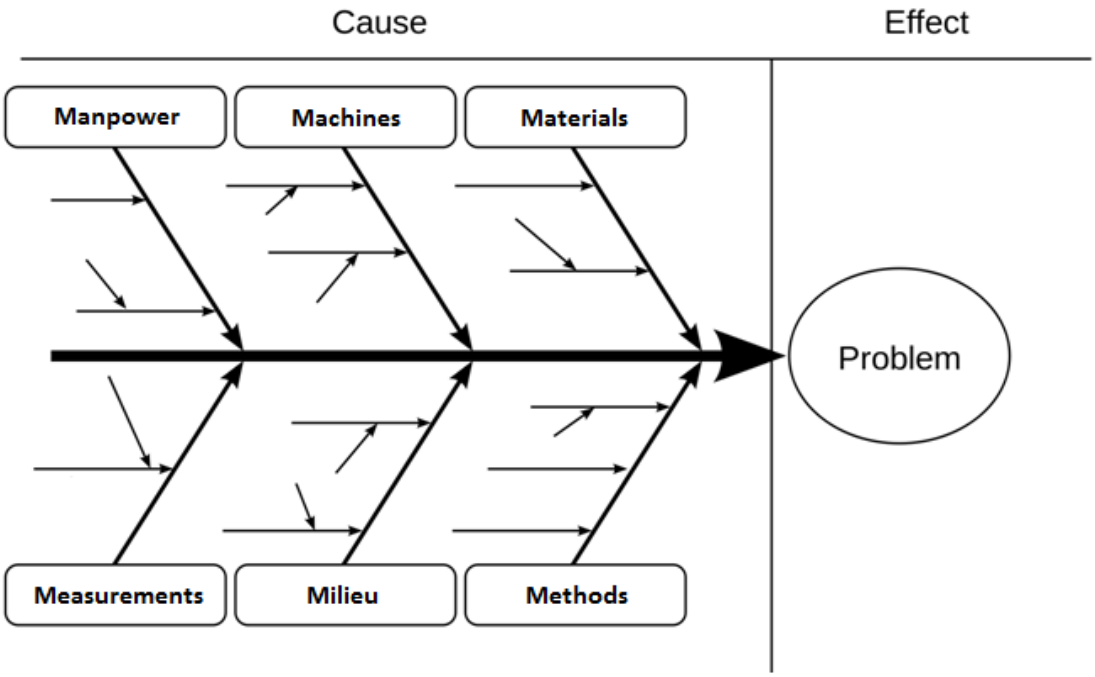

Figure 2 - Common fishbone diagram

The six classical categories have been seen as the main causes of any problems of business process, and the analysis of these six variables reveals the reasons of a problem irrespective of its type or severity. (Bose, 2012)

In this study, starting with the six classical categories, the authors adapted the framework according to the literature review related to packaging and to the case study. The adapted categories are Process, People, Environment, Unitisation, and Material.

2.2.2 Data collection

The data collection stems from two fields: (1) an extended literature study for describing the five categories in the theoretical framework chapter; (2) an empirical data collection at company X, which includes interviews at its headquarters in Gothenburg and a one-week visit to its International Distribution Centre in Poland for interviews, observations, and experiments. As you may have noticed, the case study company has been called "company X" in this report due to confidentiality issues.

Literature study

The theoretical study, developed in chapter 3, is based on articles from scientific journals and periodicals as well as academic books. Firstly, comprehensive understanding of the packaging concept, its importance, and the environmental aspect of it are presented. Secondly, five fields namely Process, People, Environment, Unitisation, and Material are developed individually. Finally, the adapted conceptual fishbone framework is built. It helps to answer the research questions and is the foundation of the analysis.

Interviews

There are three groups of interviewees in this study.

The first interviewee group is management people at company X in Gothenburg. The objective is to (1) gain overall information (out of the International Distribution Centre) about products, packaging, transportation, and distribution channels; (2) prepare for the visit to the International Distribution Centre. The different persons interviewed are:

- Product Managers to get familiar with company X's product catalogue;
- Senior Purchaser of Transport Services to understand the transportation cost current status and calculation methods at company X;
- Director of Supply Chain to understand the distribution network of company X in the world which includes where the sales units in the world lie, the transportation frequency and mode to different destinations;
- Warehouse Manager in Poland, which was carried out by video conference.

These interviews have been carried out to pre-study the operations in the warehouse and the packing process there. All the interviews in this first group are set with a list of topics or issues, so called "general interview guides". The questionings are informal. According to Bryman and Bell (2011), this kind of interview is called unstructured interview.

The second interviewee group is shop floor packaging operators. The interview took place during the one-week visit at the International Distribution Centre. The aim was to get knowledge about the social aspect of the working environment at the packing area, to know how the operators work, and their motivation about their work. Altogether seven people at the packing area have been interviewed, and their job responsibilities were both picking materials from the warehouse, packing, and printing pack notes. There have been eleven questions in the interview, which is a mix of open and close questions (see Appendix A). The interview questions were sequenced differently, and in some cases, the questions had been slightly modified according to the interviewee's roles and answers. The authors had the chance to ask further questions in response to what was regarded as significant replies, which featured it as "semi-structured interview" (Bryman and Bell, 2011). Since the English proficiency of the operators was not high, explanation had been needed.

The third interviewee group is eight company X's sales units around the world. Eight sales units had been selected because of the volumes shipped and diverse geographic locations: United Kingdom, Germany, USA, Indonesia, Spain, Australia, Brazil and China. The objective was to understand what happens to the packaging materials after shipment from the International Distribution Centre. The interview was a closed questionnaire sent by email to the sales units (see Appendix C). Personalized emails were afterwards sent to the different sales units to follow up the answers and avoid misunderstandings. The result of the interviews contributed to a better knowledge of the packaging material lifecycle and has been a base for the analysis about cyclical possibilities of packaging materials.

Observation

An obvious solution to the problems identified had been to observe operators' behaviours directly rather than to rely on research instruments, and the method is called systematic observation (Bryman and Bell, 2011).

The authors went to Gemba to understand the operations in the International Distribution Centre. Pictures and notes were taken on site, and the movement of one of the packing operators had been recorded, which resulted in the drawing of a "Spaghetti diagram" (see Figure 12).

The objective of the site observation, on the one hand, is to serve as a complementary method besides the interview to shop floor operators for understanding the packing environment, and operators' packing behaviours. On the other hand, it was useful to understand the whole packing process including the operators' movement, and the warehouse layout.

Experiments

During the International Distribution Centre visit, three sets of experiments on different packing methods were conducted. The experiments were carried out to gain knowledge about how the different packing methods, i.e. the different load units here, affect the total cost of a consignment.

The three packing experiments chosen were common customer orders at the International Distribution Centre. In each set of experiment, two ways of packing were compared. The recorded data for each experiment was: the time spent, number of operators, packaging material consumed with volumes, gross weight of the load unit(s) and its cubic volume.

The data collected for the experiments was gathered in an Excel sheet. With data about packaging materials costs provided by the warehouse manager, the transport cost calculated together with the transportation department, and the labour cost calculated thanks to the operator's recovery rate data provided by the financial department at the headquarters in Gothenburg; the total cost (sum of labour, packaging, and transportation costs) for each way of packing was calculated. In order to be broad and to facilitate the comparisons, two different destinations have been selected. They are the USA with air transportation and Germany with road transportation.

The experiments results showed the importance of the packing method choice on the total cost. It was also interesting for the company to build standards to guide the packing operators when selecting the appropriate transport packaging.

2.3 Quality of the study

To make a formal assessment of the quality of the study, validity and reliability are evaluated. Validity and reliability are in scientific contexts, a way to critically examine the collected information (Eriksson & Wiedersheim-Paul, 2008).

Reliability

Reliability is concerned with the issue of whether the results of a study are replicable (Bryman & Bell, 2011). The abductive approach, since the foundation is going back and forth between theory and empirical data (Dubois and Gadde, 2002), which make the theory suit well with the case study that had been chosen. Also, in this case study, various data collection has been conducted including three types of interviews, site observation, and experiments, which cover several information sources. As Yin (2003) suggested, in a case study, the findings and

conclusions are more convincing and accurate when it is based on several different sources of information working collaboratively. The well adapted theory together with the abundant empirical data from the case in this study makes the result trustworthy and reliable.

Validity

According to Bryman and Bell (2011) "Validity is concerned with the integrity of the conclusions that are generated from a piece of research". Using a fishbone diagram as a start, a holistic view has been obtained about strategies for future improvement, which helps to improve the validity.

However, there are also some points lowering the validity. Firstly, the redirection of the theoretical framework in the abductive approach allowed equivocal evidence on biased views to influence the direction of the findings and conclusions (Yin, 1994). In this case, the findings and redirection of the theory building are exposed to the authors' subjectivity. Secondly, critics have argued that case-based researches usually have a low validity, which is their most significant weakness since in a single case design there is little scope for generalization (Schell, 1992). This is also aligned with Yin's opinion (1994) saying that critics on case study method typically state that single cases offer a poor basis for generalizing. It means that it is likely that the result of the study can only be a reference for the case study focal company, and hence has a low validity.

3 THEORETICAL FRAMEWORKS

To be able to answer the research questions in a scientific way a literature review of packaging and sustainability is presented below. Sustainable packaging is defined and this leads to an opportunities framework which is the base of the upcoming analysis.

3.1 Packaging system

There are a lot of definitions about packaging, but a broad and well-established one is as follows. Packaging is "a coordinated system of preparing goods for transport, distribution, storage, retailing and end-use; the means of ensuring safe delivery to the ultimate consumer in sound condition at minimum cost; a techno-economic function aimed at minimizing costs of delivery while maximizing sales (and hence profits)." (Hellström and Nilsson, 2011)

According to Hanlon et al. (1998), the functions of a packaging system are basically to protect, contain, carry, and dispense a product. Twelve years later, The Consumer Goods Forum (2010) has a broader definition of a packaging system functions which are to:

- **Protect** the product;
- **Promote** the product;
- Provide **information** on product, usage, health and safety, disposal, etc.;
- Enable the **convenient** transportation and usage of the product;
- Allow **unitisation** of the product through the supply chain;
- Support efficient **handling** of the product, again throughout the supply chain.

These different functions are fulfilled by the packaging system as a whole which consists of a few components or in other words different layers. These layers are described in Table 1 and illustrated in Figure 3 below.

Table 1 - Packaging system (Fitzpatrick et al., 2012; Commission of the European communities, 1994)

Packaging layer	Common name	Definition	Functions
Primary	Sales Consumer Retail	The sales unit at the point of purchase	Protection, promotion, convenience, information, handling, safety
Secondary	Display Merchandising	Packaging used at the point of purchase to contain or present a number of sales units; it can be removed from the product without affecting its characteristics	Protection, promotion, convenience, information, utilisation, handling, safety
Tertiary	Transport Distribution Traded	Used to facilitate handling and transport of a number of sales units or grouped packages in order to prevent physical handling and transport damage; does not include road, rail, ship and airfreight containers	Protection, information, handling, safety

Industrial	Business-to-business	Used for transport and distribution of products for industrial use	Protection, information, handling, safety

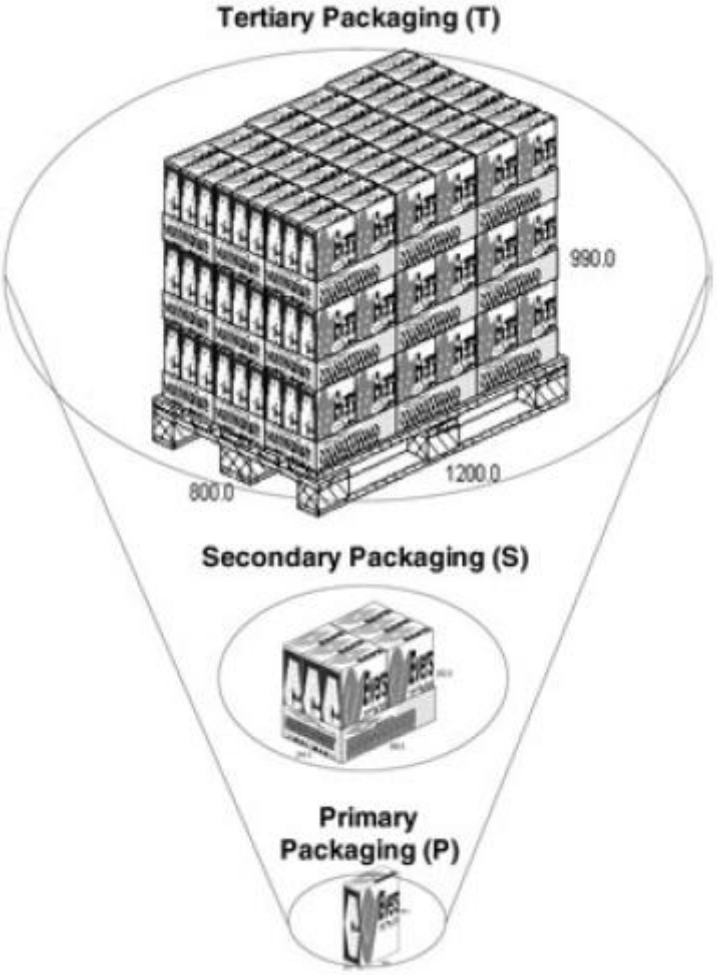

Figure 3 - Packaging levels (Hellström and Saghir, 2006)

3.2 Role of packaging in the sustainable business development

In today's business, sustainability goals are increasingly important and pre-requisites for the business to be sustainable in addition to well-known goals such as profitability, market shares, revenue growth, occupational health and safety and so on. These sustainability goals consist of providing sustainable products and services from cradle-to-grave. This deals with reducing the consumption and/or improving the usage efficiency of limited resources such as energy, water, land, raw materials etc. At the same time, renewable and/or recyclable resources consumption is increased to reduce waste at all stages of the supply chain. (Fitzpatrick et al., 2012)

In the past decade, environmental concerns of unsustainable consumerism have risen dramatically up through political and consumer campaigns especially on packaging which is sometimes seen as unnecessary and bad for the environment. As products, packaging

generates environmental impacts and costs throughout its life cycle by consuming materials, energy and water, and by generating wastes and emissions. In popular belief, as the product environmental impact is often higher than the packaging one, it is not worth the trouble to focus on packaging. But products and the relative packaging cannot be separated in order to avoid sub-optimisation and thereby act as a system. Then, initiatives on packaging sustainability aim to reduce the environmental impact of the product-packaging system as a whole. (Fitzpatrick et al., 2012)

In order to reach sustainability via packaging, the economic, environmental and social values added to the product by the packaging system have to be monitored. To do so and to identify opportunities the following principles have to be considered during the design process (Sustainable Packaging Alliance, 2002):

- The entire packaging system life cycle has to be taken into account from raw materials through to disposal and recycling;
- The interactions between the packaging system and the product system have to be understood as well as how this interacts in the ambient (moisture, oxygen …) and macro (marketing, legislation …) environments.

Four sustainable principles for designing packaging are described in the following Sustainable Packaging Framework

3.3 Sustainable Packaging Framework

There are four pre-requisites that a packaging needs to fulfil to be sustainable in alignment with the triple bottom line approach (Lewis, 2012):

- **Effectiveness** in delivering the functional requirements;
- **Efficiency** in its use of materials, energy and water throughout its life cycle;
- **Cyclicality** in its use of renewable materials and recoverability at end-of-life;
- **Safety** for people and the natural environment.

These four principles are illustrated in Figure 4.

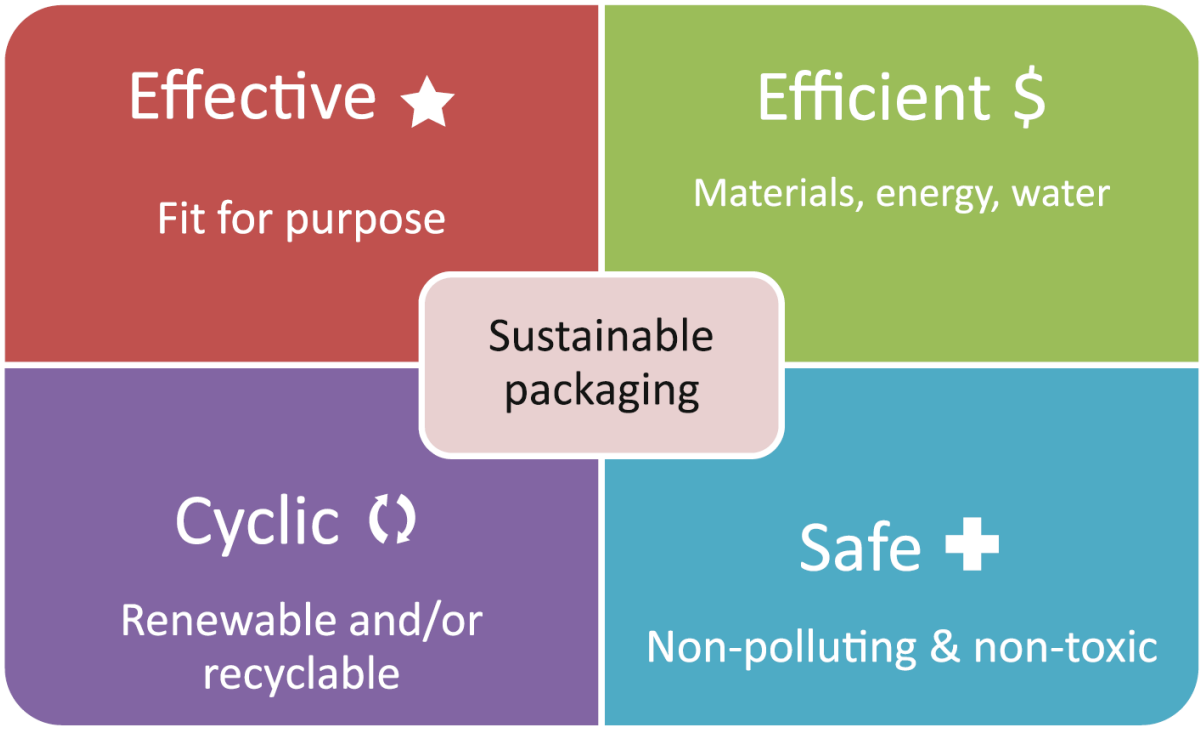

Figure 4 - Four principles for a sustainable packaging (Lewis, 2012)

The four pre-requisites are described more in detail below with their potential benefits in a triple bottom line approach.

3.3.1 Effectiveness

"A well-designed packaging will meet the requirements of the product while minimising the economic, social and environmental impacts of both the product and its package" (The Consumer Goods Forum, 2010). This statement describes an effective packaging. An effective packaging is a packaging which does the right things i.e. fulfil its functions previously enumerated in the section 3.1. Potential benefits of an effective packaging with a triple bottom line approach are outlined in Table 2.

Table 2 - Potential triple bottom line benefits of an effective packaging (Lewis, 2012)

Economic benefits	Reduced product damage Increased product sales Compliance (labelling)
Social benefits	Consumer convenience Accessible packaging (e.g. easy to open, handle …)
Environmental benefits	Reduced production waste Reduced product damage in the supply chain

In the past, the packaging design has been focused on its functional aspects but not really on sustainability and this switch in the focus can open up new opportunities. "If we are to improve what we make, reduce our impacts and create a better world, we will need to rethink the way we design at every scale" (Sustainable Packaging Coalition, 2006). The effectiveness

principle helps to boost up innovation on the product-packaging system. For instance, the packaging can be adapted to avoid injuries due to the need of opening with scissors.

3.3.2 Efficiency

"Efficient packaging is designed to minimise resource consumption (materials, energy and water), wastes and emissions throughout its life cycle" (Lewis, 2012). An efficient packaging is a packaging which does the things right in comparison with the effective one. It must have the lowest environmental impact. Potential benefits of an efficient packaging with a triple bottom line approach are outlined in Table 3.

Table 3 - Potential triple bottom line benefits of an efficient packaging (Lewis, 2012)

Economic benefits	Reduced resource costs – material, energy, water Increased supply chain efficiency Cost savings passed on to consumers
Social benefits	More affordable products Reduced weight or volume
Environmental benefits	Reduced consumption of resources – material, energy, water Reduced waste and emissions from production of virgin materials Reduced energy consumption and emissions from transport Reduced product waste

In order to get an efficient packaging, a Life Cycle Assessment (LCA) is useful. It helps to have a holistic view of the packaging from cradle-to-grave, i.e. from raw material extraction to disposal or recycling. Then, the inefficient aspects from an economic, social or environmental perspective can be highlighted and improved. Many companies regularly follow various KPIs to assess their packaging efficiency (e.g. packaging weight, percentage of recycled packaging material …). Hence they can set up sustainability goals for packaging. (Lewis, 2012)

3.3.3 Cyclicality

"Cyclic packaging is designed to maximise the recovery of materials, energy and water throughout its life cycle" (Lewis, 2012). An efficient packaging objective was to reduce the use of materials, energy and water as much as possible. However, there will still be materials, energy and water consumed. The cyclic packaging objective is to avoid creating waste by reusing and/or recycling materials and water and by recovering energy. Potential benefits of a cyclic packaging with a triple bottom line approach are outlined in Table 4.

Table 4 - Potential triple bottom line benefits of a cyclic packaging (Lewis, 2012)

Economic benefits	Reduced material costs (recycled materials) Cost savings passed on to customers
Social benefits	Reduced aesthetic impacts of litter Extension of life for existing landfills

Environmental benefits	Reduced consumption of resources – materials, energy, water Reduced waste and emissions from production of virgin materials Reduced packaging waste requiring disposal/recovery

The more sustainable recycling method is the closed loop recycling. Materials are reprocessed back into the same application, e.g. packaging to packaging. But some materials are more difficult to reprocess back into the same application. Then, if they need to be used, down-cycling is another recycling method. It consists in reprocessing a material into an alternative with a lower value application, e.g. packaging into garden mulch. Different reasons or barriers may explain why a material cannot be closed loop recycled such as feasibility, regulations, quality of the recycled material, cost of recycling etc. (Lewis, 2012)

3.3.4 Safety

"Safe packaging is designed to minimise health and safety risks to humans and ecosystems throughout its life cycle" (Lewis, 2012). Potential benefits of a safe packaging with a triple bottom line approach are outlined in Table 5.

Table 5 - Potential triple bottom line benefits of a safe packaging (Lewis, 2012)

Economic benefits	Reduced cost of disposal (hazardous or toxic waste) Reduced risk of product recalls Carbon credits or reduced cost of carbon emissions
Social benefits	Reduced health and safety risks for consumers and neighbours
Environmental benefits	Reduced eco-toxicity impacts Reduced contribution to global warming

Reducing packaging litter is an aspect of a safe packaging because packaging litter has unsustainable impacts such as death of wildlife, aesthetic impacts in public places and waterways, damage to equipment or injuries to people etc. (Lewis, 2012). These impacts may give a bad company image and result in financial losses.

3.4 Opportunities Framework

The opportunities framework (see Figure 5 below) is a summary of five different perspectives described afterwards to improve transport packaging sustainability from an academic point of view. These perspectives are not completely distinct but sometimes overlap to be holistic on possible improvements opportunities. This framework helps to give an understanding of the current issues of a packaging system as well as to provide project strategy ideas to improve packaging efficiency. The upcoming case study and its different areas of focus are based on this opportunities framework.

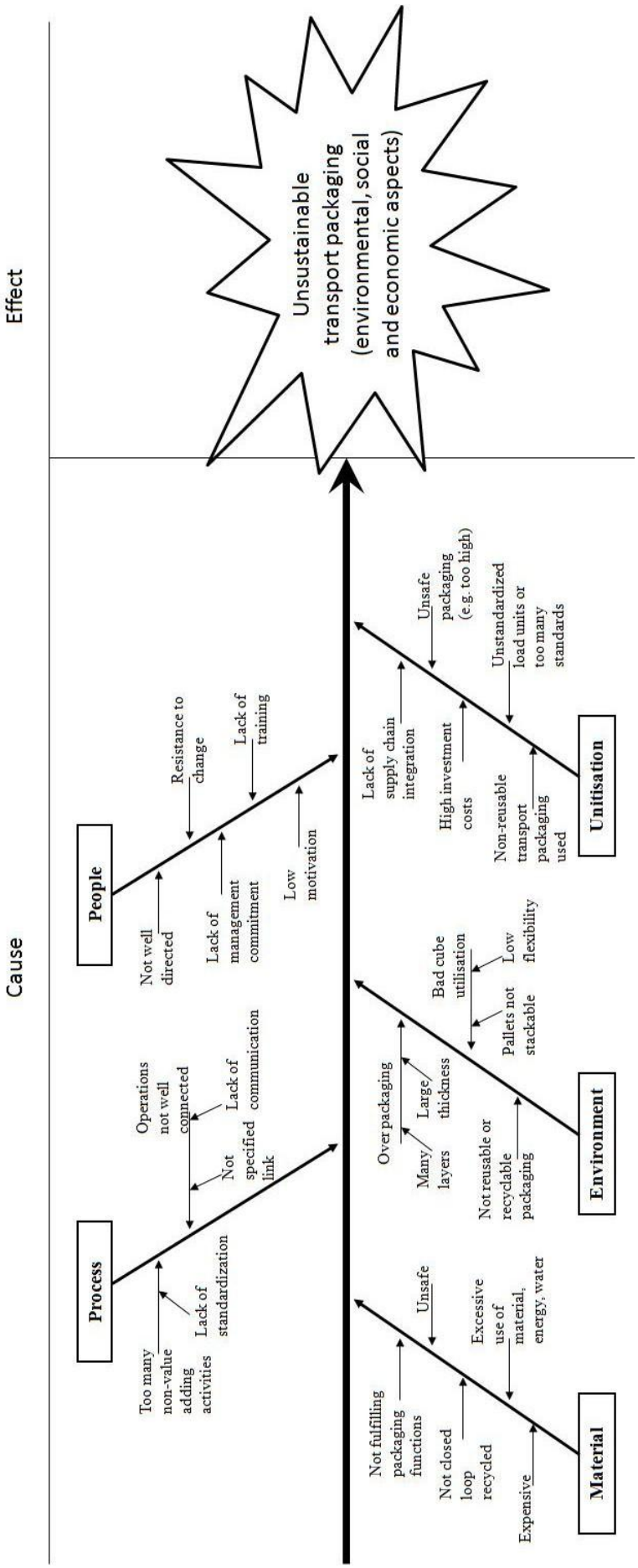

Figure 5 - Opportunities framework

3.4.1 Process

Manufacturers nowadays put a lot of attention on Toyota Production System, also known as "lean production", to both increase productivity and product quality while reducing cost (Liker and Meier, 2006). Sawhney et al. (2007) emphasized the connection between lean production and the environmental perspective, showing that "the lean concept, its inherent value stream view and its focus on systematic elimination of waste fit well with the overall strategy of protecting the environment" (Sawhney, et al, 2007). Lean process, furthermore, is regarded as the most important for being lean.

Process visualisation

Lean process management starts with process mapping which helps to detect the seven major non-value-added activities as identified by Toyota, namely overproduction, waiting, transportation or conveyance, over processing or incorrect processing, excess inventory, unnecessary movement, and defects (Liker and Meier, 2006).

One typical tool for process mapping is the "Spaghetti diagram", which is a 3-flow map namely material, people and information flows to reveal these flows through a physical layout. The starting document needed is a 2D scale layout of the work area. Regarding the people flow for example, a line is traced beyond the layout to represent the movement of a working operator within the area. The worker in a typical process flow moves back and forth and the resulting picture usually looks like a bowl of Spaghetti, hence its name. (Flinchbaugh, 2009)

The Spaghetti diagram is a well-approved method to reduce process waste by eliminating unnecessary materials transportation. By observing the resulting diagram, the replacement of materials or activities to make them close to the operators, which involves redesigning the physical plant layout, will come naturally (Theodore, 2010). Weber (2012) also put out that plant floor design is key to an efficient production environment. In a lean layout, for example, space between machines is set minimal to prevent inventory from building up, as well as to reduce motion and conveyance. People, workstations and equipment should be arranged to optimize the flows, minimize waste and boost productivity. (Weber, 2012)

Toyota has some rules to see whether the process is lean or not. Learning from the Toyota lean production system, Bowen and Spear (1999) pointed out a rule which makes a process successful: "The pathway for every product and service must be simple and direct". The production line at Toyota is set so that every product and service flows along a simple path. That path should not change unless the production line is redesigned. With this rule, goods and services do not flow to the next available person or machine, but to a specific person or machine. However, it does not mean each path is dedicated to only one particular product, and it should accommodate many types of products. According to Bowen and Spear (1999), the rule also works for service, a worker, especially new workers when wondering what to do or how to do their task, should turn to a specified 'service supplier', a supervisor, instead of asking people available around.

Ergonomic and safety perspectives

During the research of lean process, one of the most controversial aspects is the requirement of being chair-free i.e. the assemblers standing up rather than sitting (Baudin, 2002). Depending on the task requirement, people have different preferences. Ergonomics requires the work height to be between hip and shoulder. As Baudin highlighted (2002), the fact that people have different heights should be taken into consideration when determining the suitable work station height.

The workplace is a place with many risks; forklifts driving around is one of them. Having clear floor marking to distinguish different zones is a good way to reduce this risk. These different zones might be available to different vehicles and require different carefulness from operators. Miller (2010) proved that in an optimized layout, employee's safety and health are better. Exposure to dangerous material is also reduced by eliminating unneeded material transfers.

3.4.2 People

People are the lifeblood of every organization. If they are not well-motivated and well-directed, it is very difficult for that organization to gain success (Bose, 2012). Thus, the packaging system performance is to a high extent affected by how people work as well as how the people work is guided and standardized.

How people should work

The importance of improvements from a people perspective is widely accepted in industries, which features the fad for learning from 'The Toyota Way' on how people work. Bowen and Spear (1999) explained Toyota's success and they found out that a rigid specification is the very thing to success. Two rules from Bowen and Spear (1999) concerning the operators are presented below:

(1) How people work: all work shall be highly specified as to content, sequence, timing and outcome.
(2) How people are connected: every customer-supplier connection must be direct, and there must be an unambiguous yes-or-no way to send requests and receive response.

In rule (1), Bowen and Spear (1999) concluded from the individual workers' perspective that if the operators in the factory follow a well-defined sequence of steps for a particular job, it is instantly clear when they deviate from the specifications. These specifications may be defined by the operators but managers have to encourage them to do so and are the final decision makers who settle the rules. In rule (2), how the individuals should be connected with each other is described: "every connection must be standardized and direct, unambiguously specifying the people involved, the form and quantity of the goods and services to be provided, the way requests are made by each customer, and the expected time in which the requests will be met" (Bowen and Spear, 1999)

Guiding people by standardizing work

Standardized work should be carried out in order to guide operators through specified processes. Ohno (1988) defined the standardized work as part of a management system, which

aims to align the efforts of the organisation to eliminate waste, unevenness, and unreasonableness. Twenty years after Ohno, Whitmore (2008) detailed the description of standardized work as "a detailed, documented, and visual system by which workers develop and follow a series of predefined process steps", in which Whitmore emphasized its convenience for operators.

The standardized work document should describe the types of parts required to complete a job, the types of tools used in the job, and the way the job is organised (Marksberry et al., 2011), which is the foundation for future improvements (Liker and Meier, 2006). Besides the process documentation for future changes, the standardized work benefits include reduction in variability, fewer errors, and simplified training of new personnel (Marksberry, 2011).

Liker and Meier (2006) commend that the employees should be involved in the standardized work creation, which means they should have the right to participate in making standards and providing feedback. Group and team leaders should not only have the responsibility of training operators with the standardized work, but also soliciting and encouraging their input. Employees should be motivated to develop better methods (Liker and Meier, 2006). The fatigue and ergonomic aspects should also be taken into consideration when standardizing the work (Marksberry et al, 2011).

3.4.3 Environment

By designing the packaging system ingeniously, the environmental impact would be reduced together with the economic cost. Some companies are willing to pay more for a better environmental performance because they can use it as a marketing argument but only win-win measures on the environment and the economic aspects are investigated here.

In order to improve the environmental impact of packaging, a recent trend is to reduce its thickness without affecting its strength. The benefit is to use much less material but also less energy and water in the manufacturing stage.

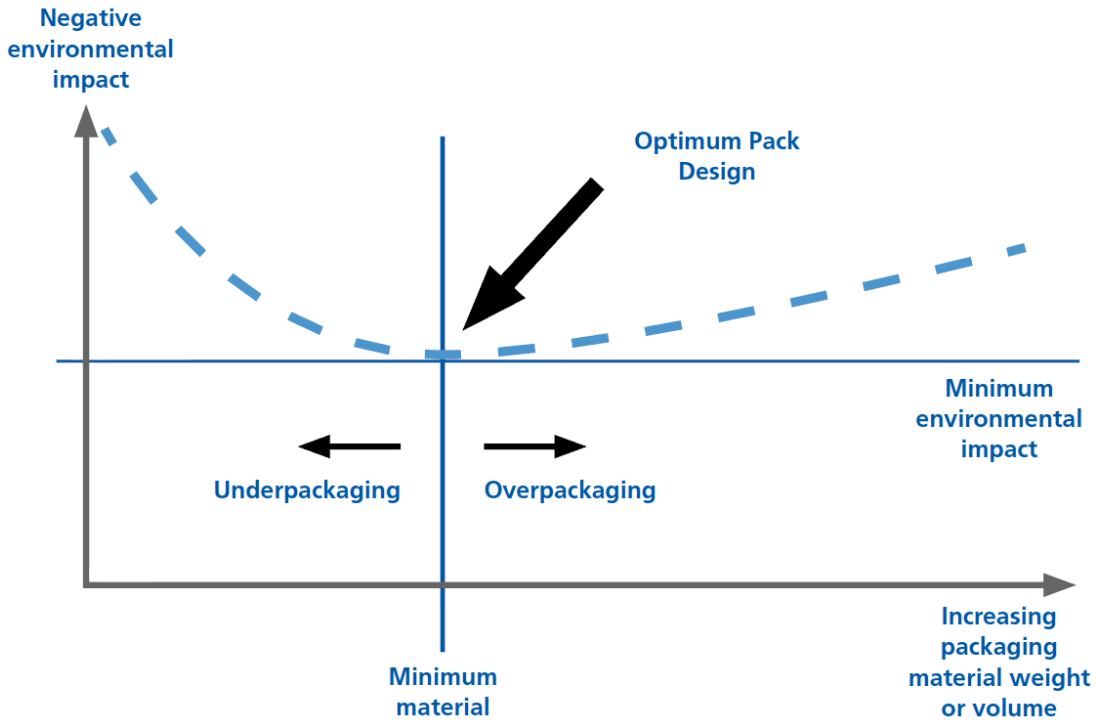

Figure 6 - Optimum Packaging (Consumer Goods Forum, 2010 adapted from Erlöv et al., 2000)

This model (see Figure 6) shows that excessive packaging reduction would cause greater losses because of a higher rate of damaged products than equivalent over packaging.

The decision to reduce or increase the packaging thickness has to do with the relative rate of damaged products but also with different factors listed here:

- The ability to reuse packaging material. An effective transport packaging can be one which can fulfil its functions throughout several life cycles. However, a thin packaging is more likely to be damaged and hence no more usable.
- Stack ability. An efficient transport packaging must help to make use of the volume of the load units by making them stackable.

The return of packaging waste has been identified as an environmental concern from surveys undertaken in the early 1990s. The Commission of the European Communities directive on Packaging and Packaging Waste (1994) forced companies to reduce their use of packaging but also to collect and recycle packaging material. According to McKinnon (2003), since 1996, more and more companies are ISO14001 certified for the environmental management of their logistical system. To gain this certification, companies have, inter alia, to continuously improve their environmental performance and demonstrate a commitment to it. When transport distances are high, the benefits of returning packaging materials for reuse can be discussed and recycling, i.e. an open loop, is preferred.

Space efficiency is one of the best contributors to a good economic and environmental performance. It helps to ship as many items as possible in a fixed load unit such as a container. “Maximised vehicle fill is a key lever in optimising the use of transport. We aim to

utilise 100% of available vehicle load weight and/or cube" (University of St. Gallen, 2000). The space efficiency or cube utilisation is determined by the nature of handling equipment and packaging (McKinnon, 2003). The potential maximum cube utilisation can be increased by around 16% from 82% to 95% by replacing the Euro pallets by thin slip sheets (University of St. Gallen, 2000). However, a company's objective is not only to pack as many items as possible in a fixed load unit but also to optimize the handling efficiency and minimise the damage costs. In order to optimise these three factors at the same time (i.e. cube utilisation, handling efficiency, damage costs), the stackability of the product-packaging system is important (McKinnon, 2003). The height of the different pallets is to be considered because it must fit with the maximum available height. Shorter pallets would be more flexible to make a good use of the maximum available height. This is illustrated in Figure 7 below.

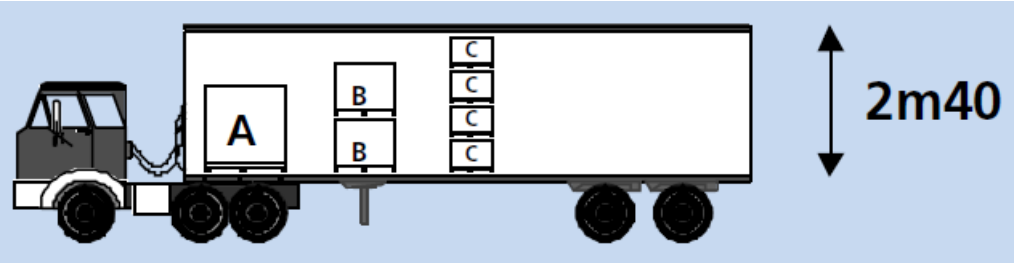

Figure 7 - Higher flexibility of shorter pallets (adapted from University of St. Gallen, 2000)

3.4.4 Unitisation

"Efficient Unit Loads are absolutely key in improving transport, storage and handling efficiency across the total supply chain" (A.T. Kearney, 1997). Although unit loads objective is to facilitate transport and handling, they also impact on storage and packaging and are used by many actors in the supply chains such as manufacturers, retailers and service providers. Therefore, unit loads are key cost drivers and their efficiency is critical. (A.T. Kearney, 1997; Hellström and Nilsson, 2011)

In the past decades, companies have competed between each other which resulted in each player optimising their part. This traditional approach has often been detrimental to the total optimum efficiency of supply chains. Nowadays, in a more fierce competition, supply chains are competing between each other to survive. This new approach forces different actors to avoid sub-optimisation and to strive for win-win solutions even if benefits are not directly equally spread and need to be shared through effective compensation mechanisms. (Christopher, 2011)

"To become more efficient, today's supply chains require further integration which will be driven by harmonising unit loads" (A.T. Kearney, 1997). Today, products are usually handled many times through the supply chain and often unpacked and repacked at different stages. Tertiary packed products are for instance unpacked to secondary packed products at the retail distribution centre to be stored on racks before being repacked at a tertiary level for shipment. These repacking operations take place because the different supply chain actors use different unit loads associated with different handling equipments sometimes. The actors have different areas of focus, different KPIs measuring unit load efficiency; they have a half chain view that

hinder change. For instance, a retailer is interesting in a unit load which fits its shelf dimensions while a manufacturer would be more worried about the possible bad fit to primary products or about the level of investment required. (A.T. Kearney, 1997)

In addition to common standardised load units used through the whole supply chain, benefits can be gained by reusing the load units to lower the operational cost and hence to write off the investment cost. There are numerous potential sources of quantifiable savings as well as non-quantifiable potential benefits. For instance, they would be to lower the packaging costs, to reduce wastage through reduced product handling, to reduce cost of disposal or recycling of waste packaging, to improve handling safety, to be ahead of increasingly stringent environmental legislations, to gain a public perception as 'green' and so forth. There are risks as well of reusing transport packaging at a supply chain level such as losing the control of the packaging costs, working with dirty and damaged packaging which can spoil the products, having insufficient storage space for empty load units and so forth. (A.T. Kearney, 1997)

However, transportation often has a significant environmental and economic impact compared to material handling; hence the optimisation of container or truck volume is of crucial importance. Therefore the load units' height should maximise height utilisation to improve volume utilisation of the trucks or containers. Relatively low heights are also synonymous of safe handling and flexibility. Stacking the load units is therefore necessary to maximise the height utilisation. (University of St. Gallen, 2000)

"Future changes will require a total supply chain perspective, a process-oriented approach and a strong emphasis on working together" (A.T. Kearney, 1997). A better integration between the different supply chain actors is required to avoid half chain views and sub-optimisations. With this cooperation, standardised load units, handling equipment and storage equipment can be defined to gain benefits and make savings through the whole supply chain. (A.T. Kearney, 1997; Christopher, 2011)

3.4.5 Materials

"Material selection is inherently linked to the economic, social and environmental value of a product-packaging system. While the properties of a packaging material and the process by which it is converted into a packaging component contribute to its effectiveness, strategies to optimise environmental performance are informed by an understanding of material life cycles" (Verghese et al., 2012). The four attributes of a sustainable packaging (i.e. effective, efficient, cyclic and safe) are investigated here.

Effectiveness

As Verghese et al. (2012) mentioned the material selection has an impact on the fulfilment or not of the different functions of packaging or its effectiveness. The material selection hence contributes to the environmental, social and economic benefits brought by packaging to the product-packaging system as a whole. On the other hand, the material may also contribute to the unsustainable effects of packaging. "There is no such thing as fundamentally good or bad packaging material: all materials have properties that may present advantages or disadvantages depending on the context within which they are used (ECR Europe and

EUROPEN, 2009)". The different materials have different specifications such as strength, relative density, quality, lifespan, corrosion, washability, impermeability etc. These specifications make them more effective in a specific context.

Efficiency

A holistic view on the product-packaging life cycle is necessary to assess the efficient aspect of packaging and to evaluate and compare the material to possible alternatives. Figure 8 shows the successive stages of a product packaging life cycle.

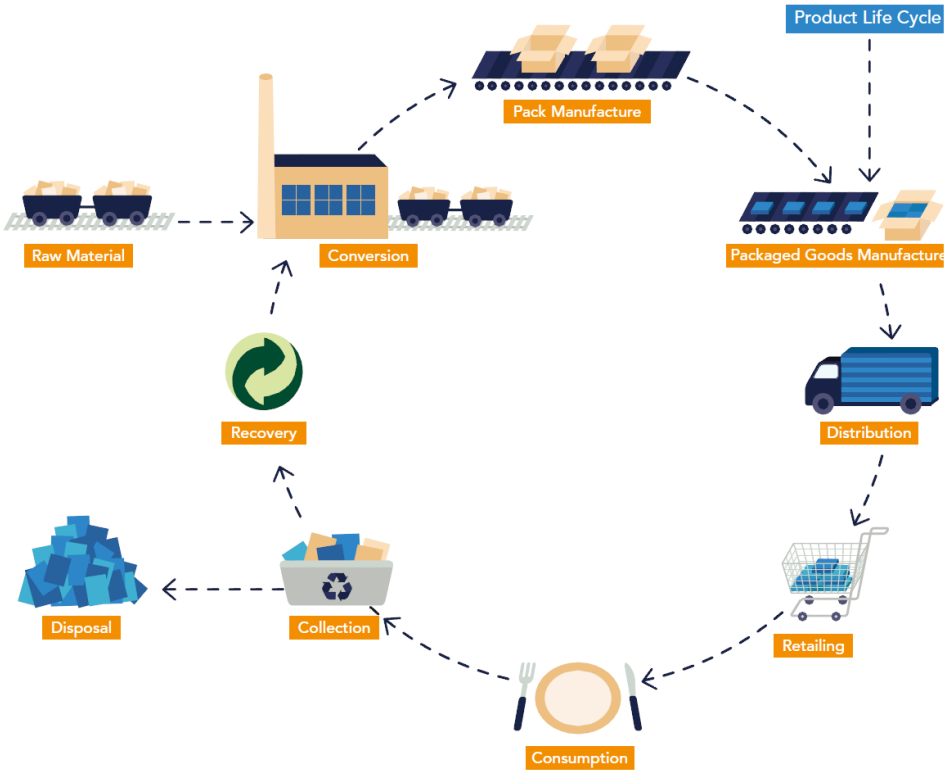

Figure 8 - Product-packaging life cycle (ECR Europe and EUROPEN, 2009)

Mapping the product-packaging life cycle gives an overview of the triple bottom line impacts of a product and its packaging at each stage. This helps to assess the efficient aspect of the packaging and hence make a decision about the best packaging material based on a sustainable consumption of material, energy and water for instance. This would result in an affordable material cost. A Life Cycle Assessment (LCA) can be carried out for the four different kinds of packaging (i.e. primary, secondary, tertiary and industrial). In this study, the packaging investigated is the tertiary packaging which means that what is called product in the LCA is actually an extended product including the primary and secondary packaging.

Cyclicality

A Life Cycle Assessment (see Figure 8) is also helpful to evaluate the cyclic aspect of packaging. Reusing material, at least for a certain number of cycles usually has many triple bottom line benefits. However, in some conditions this may be unsustainable because of a high environmental impact (e.g. a long distance between the manufacturing and consumption points) which can be associated with a high cost. Therefore, recycling is the second option. As

mentioned earlier, a closed loop recycling is the most valuable method because the packaging material is reprocessed back into the same application; down-cycling reprocesses the material back into an alternative with a lower value application (Lewis, 2012). The material selection can help to favour materials able to be reused or recycled in order to have long-term triple bottom line benefits.

Safety

The packaging material has to be safe towards people either manufacturers or consumers and towards the environment when stored or disposed throughout its whole life cycle. The Life Cycle Assessment is then helpful to evaluate the safety aspect at each stage.

4 CASE STUDY

This chapter contains the case study of this thesis where the conceptual framework (see Figure 5) is applied to a specific company.

It starts with a description of the focal company and its International Distribution Centre. Then, four initiatives contributing to an increased sustainability in transport packaging are presented. They cover four of the five categories presented in the theoretical frameworks chapter, namely Process, People, Environment and Unitisation.

4.1 Description of company X

In this section, company X's activity is described with its distribution network. It is followed by a more specific description of its International Distribution Centre and its layout.

4.1.1 Company description

Being a multinational company, company X has one International Distribution Centre at Poznan in Poland, which is a developed area with good infrastructure – a crucial issue for the daily shipments serving company X's sales units, partners and more than 8,000 customers worldwide (company X/corporate homepage). The International Distribution Centre deals with the receiving of goods from all suppliers, warehouse management, and distribution of goods worldwide. The warehouse operations used to be outsourced to a supplier in Germany who was seen to be an expert in warehouse operations. This supplier was also responsible for packaging. Later, a decision was made to insource the warehouse in order to have a better control of packaging and for financial reasons as well. Company X built its International Distribution Centre in 2012.[1]

Today's distribution network is presented below in Figure 9. Including the International Distribution Centre in Poland, there are two local distribution centres: the American Distribution Centre and the Joint Venture Distribution centre in Japan; and many sales units which are based on geographical regions – the Americas, Asia Pacific and Europe, Middle East and Africa, holding fully owned sales units in 25 countries.[2] Each unit holds experts in sales, application engineering, commissioning and service (company X/corporate homepage). The suppliers are all around the world in the USA, China and Europe but mainly in Sweden, Denmark and Germany for historical reasons.[3] Within Europe the transportation between the International Distribution Centre and the sales units and suppliers is mainly by road. However, to China and Japan for instance, besides containers shipments, daily air freight is also scheduled.

[1] Interview on January 15th 2012, with a Project Manager in Supply Chain Development at company X.
[2] Interview on December 17th 2012, with the Supply Chain Director at company X.
[3] See footnote # 2.

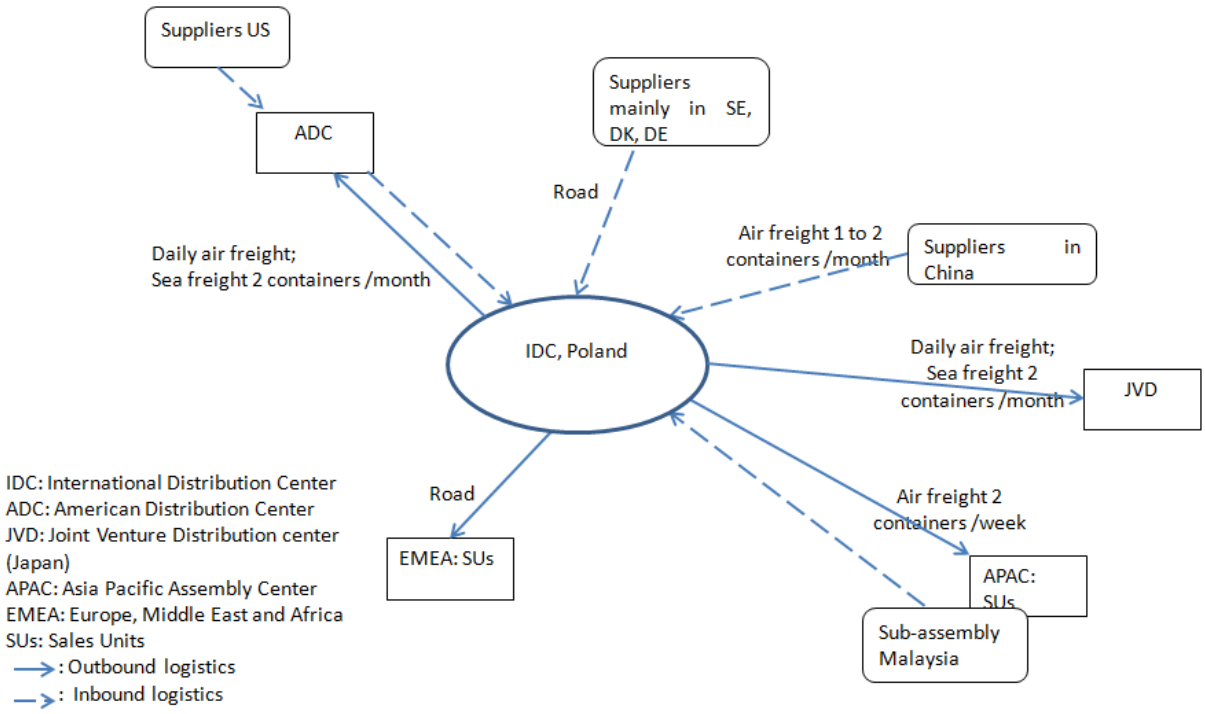

Figure 9 - Distribution network of company X

The outsourcing history of the warehouse and packaging has made company X lose knowledge on packaging. The cost for packaging material and transportation is a significant part of the company cost base. Moreover, a large portion of the total outbound volume is shipped by air which makes the financial impact of how they pack their products very significant. The annual cost for freight is approximately 35-40 MSEK, and for packaging about 7-8 MSEK.[4] The study focuses on the outbound logistics, from the International Distribution Centre to the sales units or to end customers.

4.1.2 International Distribution Centre description

The International Distribution Centre is a facility located near Poznan in Poland. Different activities are carried out there and are shown on the layout in Figure 10.

[4] Interview on December 17th 2012, with the Supply Chain Director at company X.

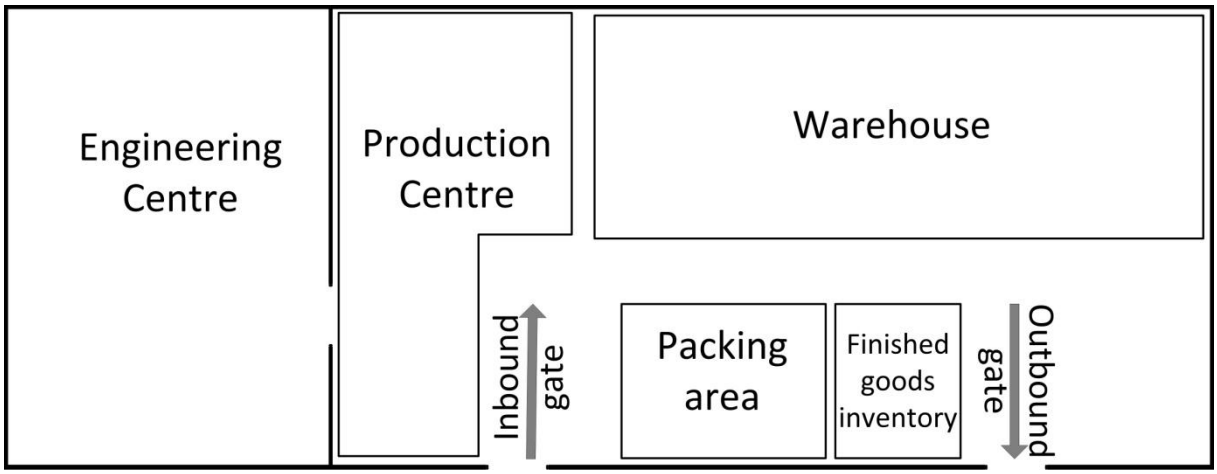

Figure 10 - International Distribution Centre shop floor layout

The facility shop floor is three-fold. One part, called 'Engineering Centre', is dedicated to the assembly of complete production lines with conveyor systems. These projects are usually unique. That is why they require to be built and tested there instead of closer to the final customers. After being assembled, they are cut into modules and shipped to their customers. The second part, called 'Production Centre', is as its name suggests an area where some components are manufactured. For instance, profiles are bent. The third part consists of the warehouse where components are stored and the packing area where these components are packed before shipment. This study focuses on transport packaging related to components and then on the third part just described.

4.1.3 Activity description

The process flow in this third area between inbound and outbound is as follows:

- Components are received by truck at the inbound gate.
- Components are stored in the warehouse after being temporarily stored in a buffer stock.
- When a customer order is released, the components are picked and packed in the packing area.
- After being temporarily stored in a finished goods inventory, the customer orders are shipped via the outbound gate.

Company X's customer orders consist of components that can be described in three segments. There are small and light items packed in small carton boxes and shipped as parcels. There are relatively small and medium size items which can be packed in half euro pallets or euro pallets. Finally, there are long goods that need to be packed in long pallets or long carton boxes. Customer orders are shipped worldwide to sales units, directly to final customers or to two local warehouses (in the USA and Japan).

4.2 Improvement initiatives

In order to answer the research questions presented in chapter 1, four improvement initiatives are investigated. In this section, they are described as well as their empirical data which is used in the upcoming analysis.

4.2.1 Lean process

This initiative objective is to reduce non-value-added activities in order to enhance the packing process efficiency. A current state map, its associated Spaghetti diagram and its drawbacks are described below and used as empirical data for the upcoming analysis.

Packing area layout

The packing area is illustrated in Figure 11 below.

The packaging materials are stored on the racks. Long pallets, collars, tubes and carton boxes are stored on the short rack at the bottom of Figure 11. The long rack on the right contains different standards of corrugated cardboard, half euro pallets, euro pallets, strip rolls, paper rolls, carton sheets etc. In addition to packaging material on the racks, there are also a paper machine which shapes paper into small protecting paper rolls, a roll of strips which is used to close the consignments (pallets or carton boxes), a scale which looks like a manual forklift and is used to weight pallets before shipment and an electric stapler which is used inter alia to assemble the different carton sheets into a long carton box for shipping profiles. Except the paper machine and the electrical stapler which are connected to power or to the pressurized air system, other equipments are movable.

When an order is released, goods arrive from the warehouse in the picked goods area along the main aisle. The orders are then packed either in the parcel area or in the main area in the middle depending on the order size. Afterwards, packed orders are stored at the top of the map in a finished goods inventory before shipment to customers.

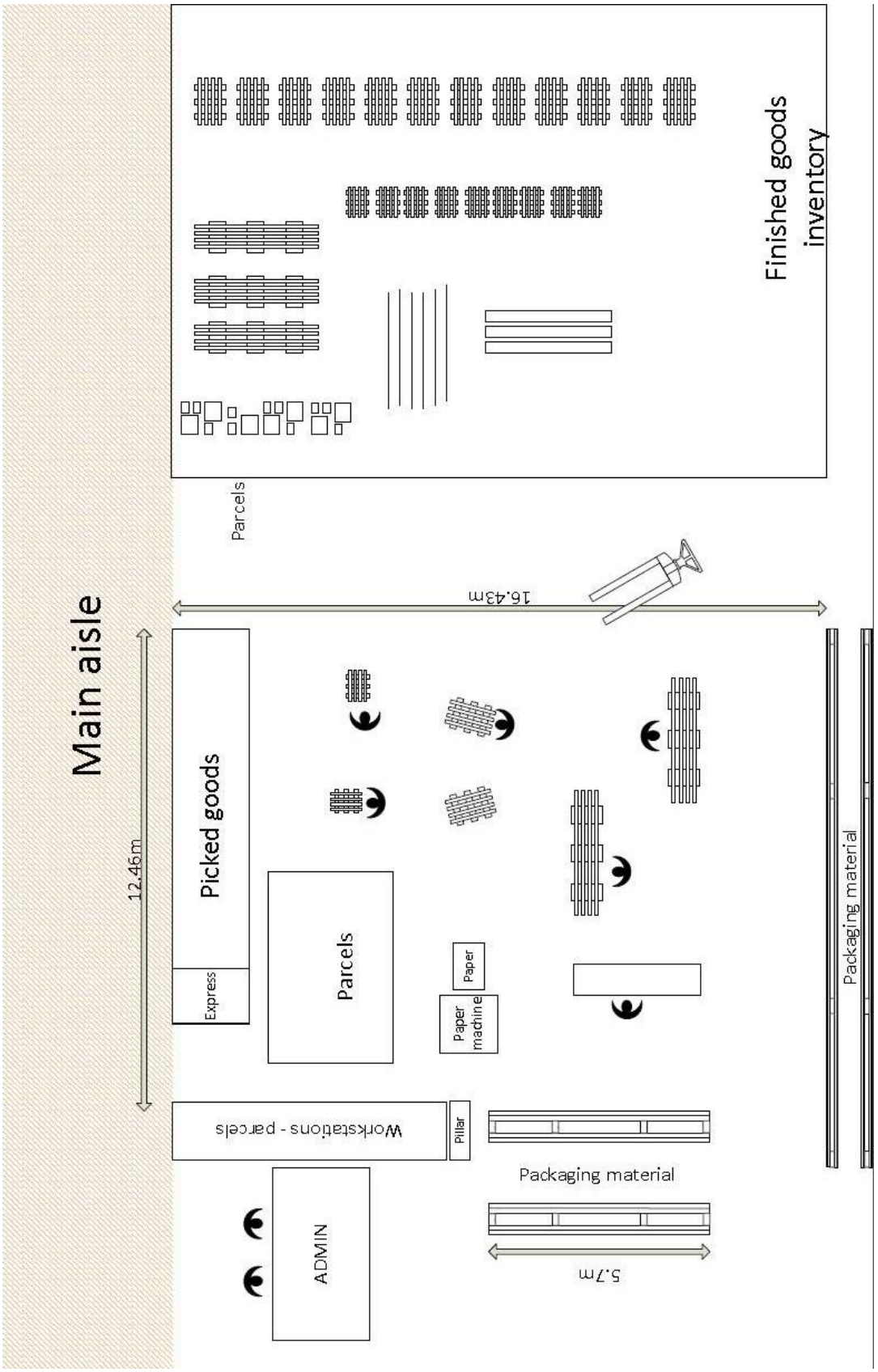

Figure 11 - Current packing area layout

Packers' operations

In order to have an overview of the packing assembly process, an example of the different actions carried out by a packer is described below. A customer order that needs to be packed in a euro pallet has been chosen. This example is then mapped using a Spaghetti diagram in Figure 12.

1) Check the customer order items according to the picking list, and bring the goods to the working station.
2) Pick the right pallet standard and place it on the floor.
3) Fetch a collar and put it on the pallet.
4) Fetch carton sheet(s) and put them on the pallet. Fetch corrugated cardboard.
5) Start packing the components (heavy components first) and put corrugated cardboard around.
6) Continue filling up the pallet and place more collars if needed (three collars are used in this example).
7) Fill all empty space with paper rolls and/or corrugated cardboard.
8) Fetch a cover and put it on the pallet.
9) Close and fasten the pallet with plastic strips.
10) Weight the final pallet.
11) Write the customer order on the cover.
12) Transport the pallet to the finished goods inventory.

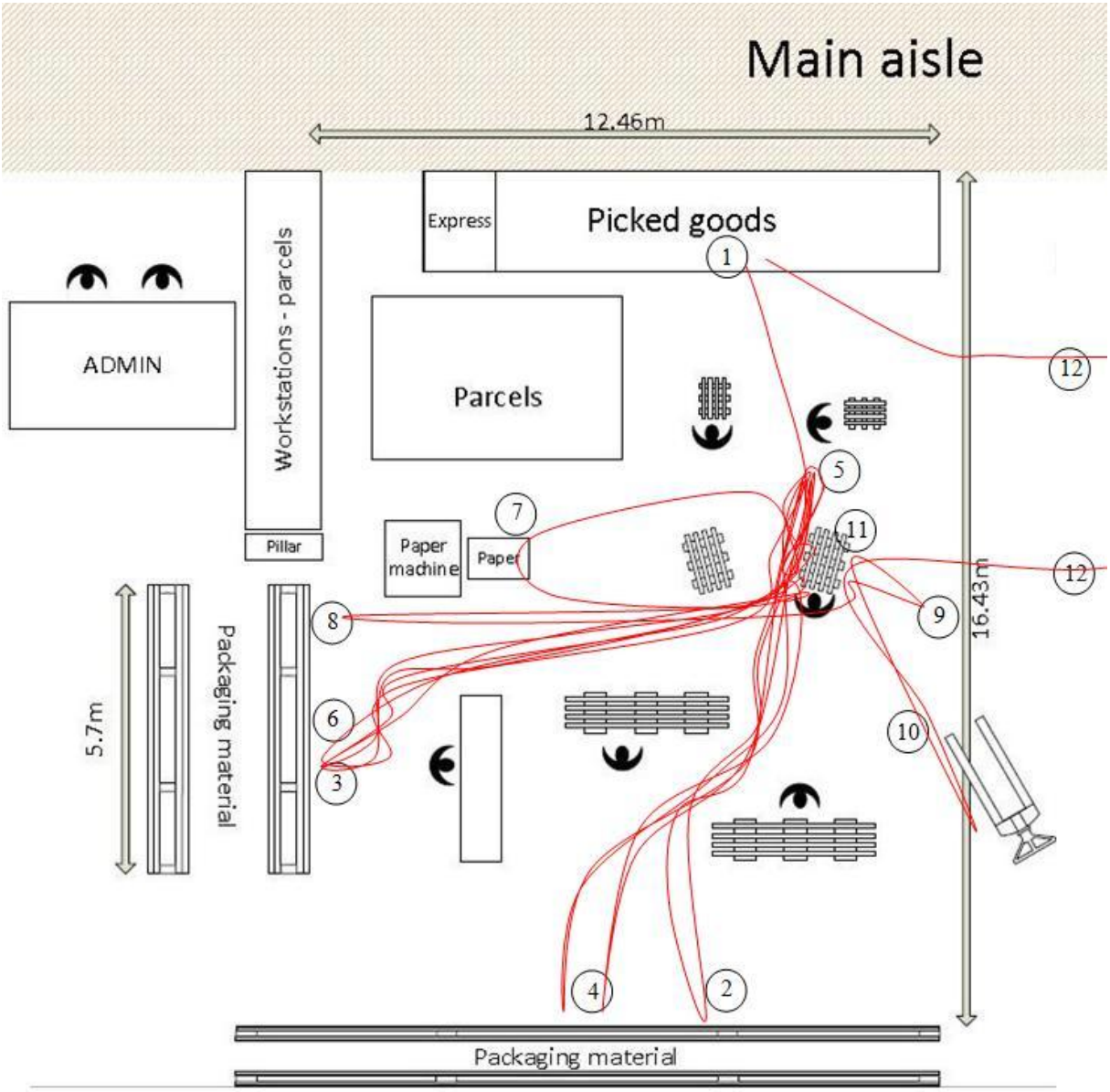

Figure 12 - Spaghetti diagram for a euro pallet customer order on the current state layout

Drawbacks of the current state layout

There are many inefficiencies of the current state layout that are visible in Figure 11 or Figure 12.

There is no clear distinction between the packing of the different kinds of goods. Bowen and Spear (1999) emphasized the importance of a direct flow in Toyota's successful processes; here the pathway for every product is not direct. In fact, there is no clear flow within the packing area. This area is designated for packing and nothing more is specifically detailed, except maybe the parcels area. According to the space available around them, packers decide where to settle their pallet before starting to pack a customer order.

Among the seven types of waste listed by Liker and Meier (2006) we can easily find some in the current packing process:

- **Over processing** (or incorrect processing): packing materials have been excessively used. For example, packing papers are overused to fill in the empty space between components but also between components and the top cover. The packing process also differs from one operator to another.
- **Unnecessary movement**: as shown in the Spaghetti diagram, operators have a long walking distance when packing a customer order. The time operators spend walking is not spent working on the actual 'product' and hence does not contributed to the process efficiency or quality.
- **Defects**: Sometimes, operators (usually non-experienced operators) are mistaken in the load unit choice or in the packing methods within the load unit to protect components. Therefore, the packaging has to be redone if the mistake is found out. If not, the damage risk is higher.

From an ergonomic point of view, packers are stood up during their whole working time. When packing into pallets which is the main part of their work, operators need to squat and bend because there are no working stations at human height. Moreover, the products to be packed are put on the floor. In the long run, this is not efficient and may lead to musculoskeletal disorders.

4.2.2 Standardised packing methods

This initiative objective is two-fold. One goal is to better understand current operators' packing practices. A second goal is to settle some best practices examples for different packaging materials and open the door for future improvements.

The empirical data mainly comes from the interviews to shop floor operators. The interview guide includes eleven questions, in which four are designed to get basic data, and the remaining ones are to know the packing situation, and more importantly to find the areas for future improvement. The most interesting questions and their associated answers are described below:

Q1 Are you satisfied with your work at company X?

All of the operators rated high or very high satisfaction. The reasons given are: a reputed company, a good management, and a non-heavy workload.

This question was designed to evaluate the overall motivation of the employees, since their motivation has a great impact on the work quality.

Q2 Have you had any training from company X and if yes, how have you been trained?

All of the operators said they had been trained. Their perception is that they are trained by their colleagues. It consists of learning by looking at colleagues' packing methods. Afterwards, they are ready to pack on their own. If they have questions, they turn to their colleagues whom act as supervisors.

This question was designed, on the one hand, to see if the company is aware of the importance of training; and on the other hand, to see if the employees well understood what they had been taught.

Q3 Do you need to follow standards when packing, regarding the operation sequence?

The standards in their mind are:

- Heavy components should be at the bottom and usually the beams as well;
- Standards come from their learning and experience;
- There are limits in the pallets height depending on the country of destination. For some countries, there is also weight limits;
- Well protecting the goods by thinking of how I would like to receive it as a customer. Some operators said that they pack the best way they think it should be.

This question was designed to know the packaging situation in the company especially how standardization looks like. It is also to check if the operators follow standards if any.

Q4 How good do you think the packing process is, regarding the easiness to handle, the efficiency and your safety?

Easiness to handle: It is easy to handle most of the time, and it is not easy when they run out of material or when they have a high workload. Sometimes it can be difficult since the packing area is crowed and a quick material flow is needed.

Efficiency: It is efficient and much better after the 5S implementation.

Safety: Two third of the answers agreed that it is very safe and there are no accidents, except some finger injuries due to cutters, which is mainly because of their carelessness. The others felt it is not very safe because there are forklifts around and operators running sometimes. There are also high racks very close to the working area but operators do not wear helmets.

This question aimed to get data about potential improvement of the process handling, efficiency, and safety.

Q5 Do you have an even workload?

The workload is uneven. Sometimes, operators need to prolong their working day time, or even work during weekends. When the workload is high, they help each other. For instance, pickers could come to help packers.

This question was designed to evaluate the packing workload, and how the operators react to it, e.g. if they feel stressed about it.

Q6 What do you think can be improved in the packing process?

The improvement ideas were:

- Receive the picking list earlier not to be stressed and to have a more even workload;

- Have more workers;
- Have clear marking on the floor indicating the specified areas;
- Place packaging materials at the same place to enable the operators to find them faster.

This question was an open final question to get input from shop floor operators' opinions about future improvement.

4.2.3 Cyclical packaging

This section belongs to the category 'Environment' because of its strong link with the environmental impact. A closed or open loop potential of packaging material between sales units around the world and the International Distribution Centre in Poland is evaluated. The packaging materials at stake are pallets, collars, covers, tubes and beams (see pictures in Appendix B).

Table 6 shows the dimensions and purchase prices of the packaging material at stake. The dimensions are the one of the smallest cuboid that surrounds the material. As pallets can be gathered by two with one upside down, the height is adapted. Prices are confidential hence the 1200*800 pallet price is indexed to 100.

Table 6 - Dimensions and indexed prices of packaging materials

Material	Model	Price	Length (mm)	Width (mm)	Height (mm)
Collar	3200*800	357	4000	230	60
Collar	3200*1200	382	4400	230	60
Collar	2400*800	314	3200	230	60
Collar	800*600	86	1400	230	60
Collar	1200*800	132	2000	230	60
Pallet	1200*800	100	1200	800	105
Pallet	3200*800	432	3200	800	105
Pallet	3200*1200	575	3200	1200	105
Pallet	2400*800	386	2400	800	105
Pallet	800*600	86	800	600	105
Cover	1200*800	46	1200	800	10
Cover	800*600	21	800	600	10
Cover	3200*1200	564	3200	1200	50
Cover	3200*800	489	3200	800	50
Tube	Ø38	7	3100	42	42
Tube	Ø45	11	3100	49	49
Tube	Ø70	14	3100	74	74
Tube	Ø100	21	3100	104	104
Tube	Ø135	29	3100	139	139
Beam	1160*40*60	18	1160	40	60
Beam	760*40*60	18	760	40	60
Beam	1160*80*60	43	1160	80	60

A survey has been designed and sent to different sales units (see Appendix C). The results give an explicit knowledge about existing methods and situations in different countries. Here is a summary of the answers. They are not all described separately because of their similarities.

The packaging material volumes received by each sales unit are rather low except for the sales units in the USA, China and UK. The packaging material is usually in very good conditions but it happens that pallets have damaged feet or that long collars are bent and fractured due to material handling and transportation. The packaging material is usually reused to ship goods to final customers but there are leftovers, which might allow a return flow, because the components sometimes need to be repacked at the sales unit. Depending on sales units, the leftover material is either scrapped or given to a recycling company. The costs of handling and managing packaging materials are a floor space cost and labour cost to keep organised until used or disposed and hence low costs.

There are different costs involved in a return flow of packaging material. This leads to the following equation in order for the International Distribution Centre and the sales unit to make a return flow worth it.

$$transport\ cost + handling\ cost < purchase\ price\ of\ the\ material$$

4.2.4 Standardised load unit selection

This initiative objective is to define best practices rules in order to select the right load unit when packing a customer order. Today, it is up to operators to choose what they think is the best.

During the one-week visit to the International Distribution Centre, three sets of experiments were carried out. They are called (1), (2) and (3) in the following of the report. Three customer orders had been selected because of their interesting characteristics. (1) is interesting because of the characteristics of the items packed which were bent and hence space utilisation was not easy to optimise inside the load unit. (2) and (3) are interesting because of the variety of items with long goods as well as cardboard boxes.

In these three sets of experiments, the customer order items have been packed in two different ways as illustrated in Appendix D:

- (1) One half euro pallet vs. One carton box
- (2) One euro pallet and one long pallet vs. One long pallet
- (3) One long carton box and one euro pallet vs. One long pallet

The dimensions of the pallets are as follows (in mm). The different heights are not given because they mainly depend on the customer orders.

- Half euro pallet: 800*600
- Euro pallet: 1200*800
- Long pallet: 3200*800

- Long carton box: 3100*200

For each set of experiments, different characteristics have been measured or noticed such as:

- Length, width and height
- Gross weight
- Time spent
- Number of packing operators working
- Transport packaging material used (this excludes small cardboard boxes that are product packaging).

For each set of experiments, different characteristics have been calculated:

- Gross volume
- Cost of packaging material
- Transport cost
- Labour cost

Regarding the transportation cost, two fictive destinations and transportation modes have been chosen. They are road transportation to Germany and air transportation to the USA. These two alternatives may help to figure out if the destination and transportation mode can influence on the transport packaging choice.

5 ANALYSIS

In this chapter, the analysis is based on the theoretical framework presented in chapter 3 and the case study initiatives introduced in section 4.2 in accordance to the abductive research approach previously described in chapter 2.

The chapter is divided into four sections corresponding to the four initiatives undertaken.

5.1 Lean process

In this section, a future state layout built by the authors is introduced with its associated Spaghetti diagram. This helps to make comparisons with the current state layout.

Future state layout

The future packing area is illustrated in Figure 13 below.

The short rack at the bottom would contain carton boxes for parcels, wooden covers for long pallets, and cardboard materials for long carton boxes. The long rack on the right would contain at human height wooden beams to strengthen long pallets, wooden bricks used to make long carton boxes possible to handle with a forklift, and corrugated cardboard and carton sheets. Other materials such as rolls of plastic, paper and so forth are stored higher on the racks. One of the main differences with the current state layout is the presence of different packaging materials in the middle. There are euro and half euro pallets, collars and covers, corrugated cardboard and carton sheets. These materials are closer to the packers whom do not need to cross any area where they can meet forklifts. There are also long pallets and long collars closer to the packing area related to long goods.

The working area for long goods is four meters distant from the racks in order to allow forklifts to operate on the racks. However, since this seldom happens and as materials on the racks are only moved at the end of the day when there is no more packing activity, beams picked areas and even the working station for packing profiles are overlapping with the area available for forklifts.

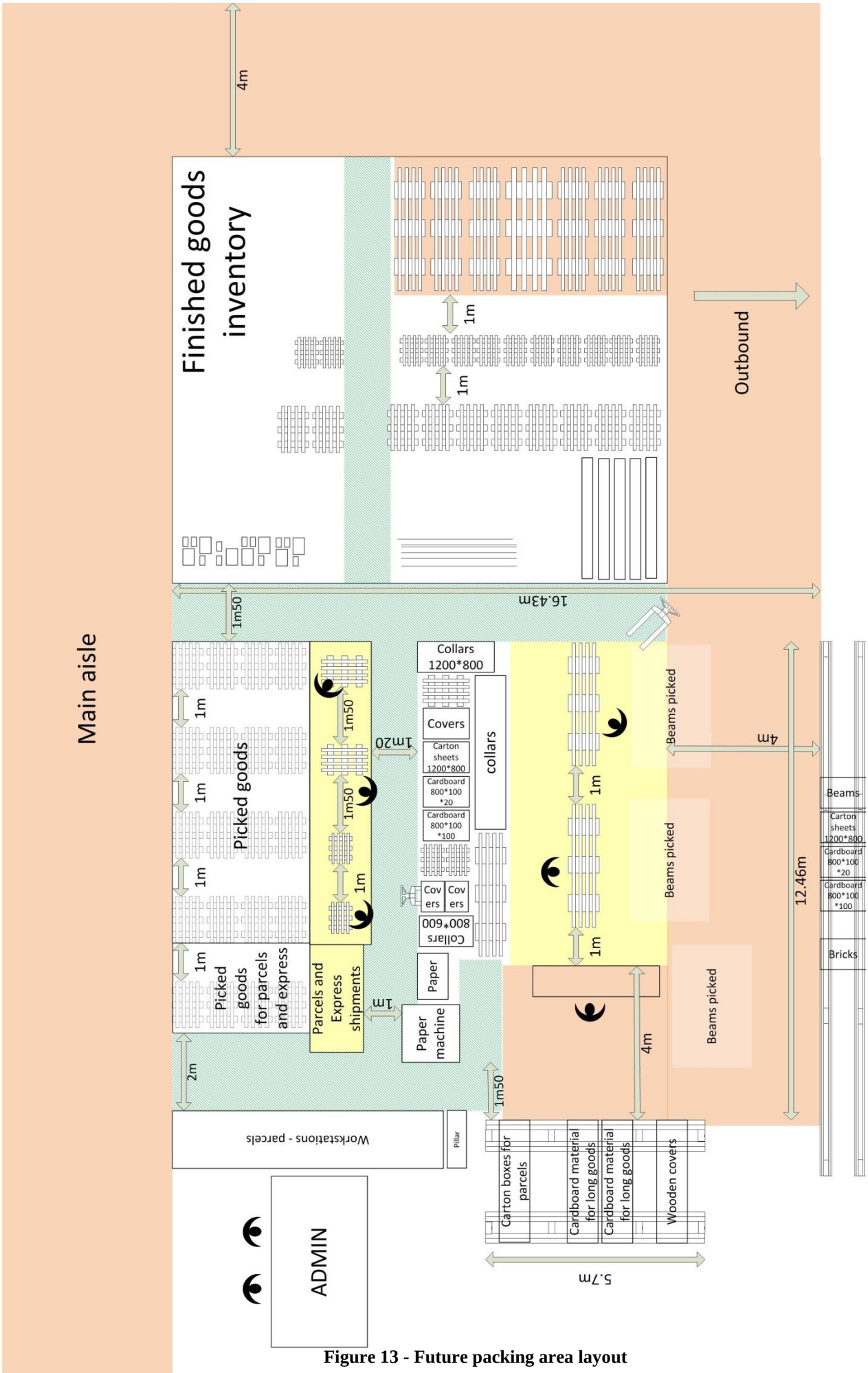

Figure 13 - Future packing area layout

Legend:

- Area available for forklifts
- Working area only
- Pedestrian area with manual forklift

Packers' movement

The packing process is different due to this layout change even if the different operations described in section 4.2.1 are still the same. A Spaghetti diagram has been drawn on this future state layout in Figure 14.

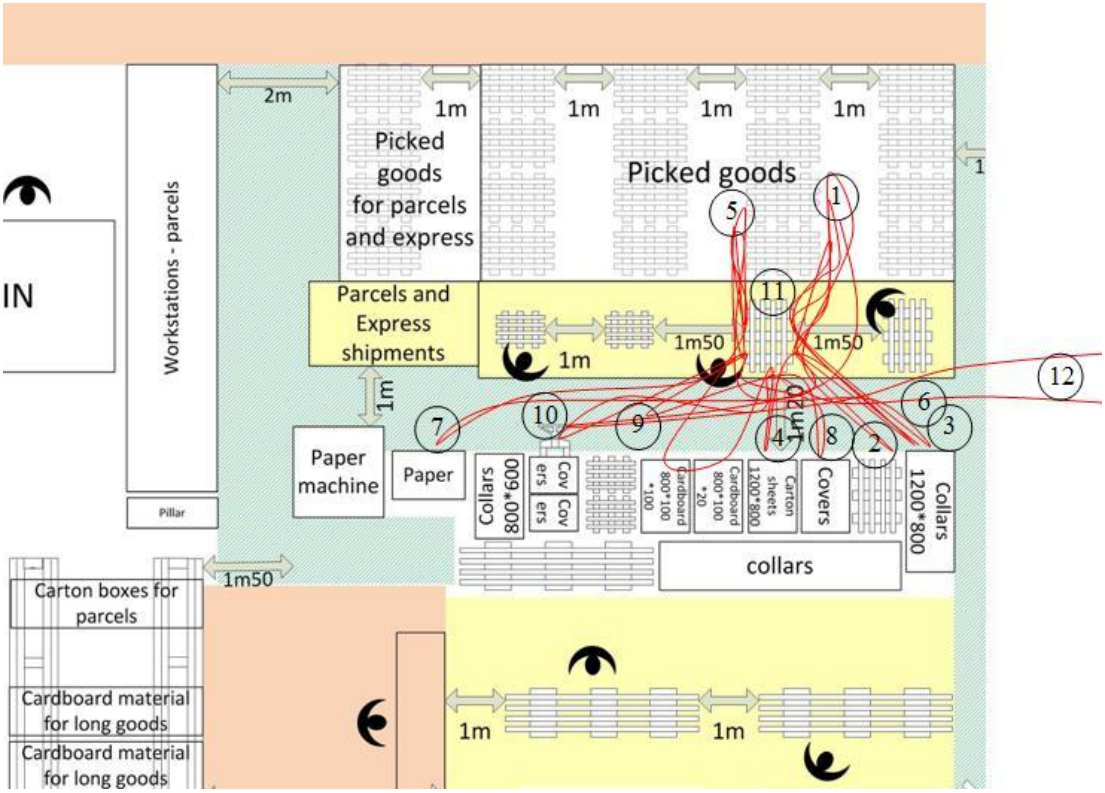

Figure 14 - Spaghetti diagram for a euro pallet customer order on the future state layout

5.2 Standardised packing methods

In this section, the results of the operators' interviews are analysed to get a better knowledge of current packing methods and a packing guidebook with several cards settling some best practices is introduced.

Current packing method

There are some positive aspects that came up with the operators' interviews:

- Employees are highly motivated
- Employees received practical training when they were hired. Then, they keep learning by watching and asking.
- Employees embraced previous changes such as the implementation of 5S.

There are also issues that came up with both the interviews and observations in the workshop. They are listed with their symptoms and direct consequences in Table 7 below.

Table 7 - Issues, symptoms and consequences of current packing methods

Issues	Symptoms	Consequences
No clear standard/work specification	➢ Each operator packs as he thinks it is the best ➢ New operators need to ask colleagues when they have problems ➢ Packaging materials such as paper or corrugated cardboard are overused to fill up pallets and remove any void	➢ Packing quality is not good due to variations ➢ Increased damage risk ➢ Heavy dependence on experienced employees ➢ Personal habits can be wrong, and prosper
Lack of specific roles during peak times	➢ Every available operator in the warehouse can help packing during peak times, quite often pickers.	➢ Packing quality is not good due to variations ➢ Increased damage risk ➢ Chaos in peak times ➢ Underperformance
Lack of safety consideration	➢ Working positions not at human height ➢ No clear distance set between the working areas and the racks ➢ No separation between pedestrians and forklifts ➢ Operators' unwillingness to wear gloves or helmet	➢ Potential safety hazards ➢ Low ergonomics of the working environment ➢ Lack of confidence of forklift drivers with operators walking around

Packing guidebook

A guidebook has been created (see Appendix E). Its objective is to guide operators to use packaging material in a right way. It could be used to train operators about the best packing practices. It today consists of four cards described below but it is also a frame for adding new cards or rules in the future.

Paper roll

Paper usage has been observed and many different practices take place today. After being shaped in the paper machine, the paper is either rolled or folded in two or just directly used without being fold. After a consultation with managers, the best practice has been decided to be to roll the paper because it makes it stronger in one direction. Therefore, if used in this specific direction, the roll can protect well by preventing every item from moving even heavy drive units.

Profile

When profiles are packed either in a long carton box or in a pallet, they can damage each other because of vibrations during pallet handling and transportation. Profiles are usually cut with a saw and, even if they are deburred, the ends are still sharp and might damage other surrounding items. Therefore, a rule is settled to add carton strips between two profile edges. Between a profile edge and a profile end, if the profiles are crossed, a corrugated cardboard (20mm thick) is needed.

To avoid friction and reduce movement between profiles, the latter can be tied up together with plastic foam in groups of two or four depending on the size of the profiles. This is also a substitute to carton strips between profile edges.

Corrugated cardboard (20mm thick)

Corrugated cardboard is used to protect items from getting damaged by hitting surrounding items or to prevent items from moving. In a tube, a small piece of corrugated cardboard is used at both ends to fix the profile. In a pallet, corrugated cardboard is used between items and collars to avoid shocks and friction.

Wooden beam

Wooden beams are used to strengthen the structure of long pallet consignments especially when they are several collars. They are sometimes used in very high euro pallet consignments for the same reason. In long pallets, they are often screwed in the middle but observations showed that this is maybe not a clear rule. Therefore, the rule is to screw two wooden beams distant of fifty centimetres in the middle of a long pallet or one in the middle of a high euro pallet; on the top collar for both of them. If an item prevents that, the wooden beams must be screwed where possible but an extra collar should not be added for that matter.

5.3 Cyclical packaging

In this section, the potential of implementing a closed loop packaging is evaluated by defining the most valuable materials.

Value for volume material

When a shipment of packaging material takes place, it consists of a full load unit either a container or a small truck. Then the objective is to fill up the load unit as much as possible. In fact, the transportation cost is the same if the load unit is empty or full. The handling cost is supposed to be independent of the fill rate because it is rather low compared to the transportation cost. But all the different packaging materials do not have the same value for volume. In Table 8, packaging materials are ranked according to their value for volume ratio. The 1200*800 pallet ratio is set to 100.

Table 8 - Value for volume ratio of different packaging materials

Material	Model	Value for volume ratio
Beam	760*40*60	1053
Beam	1160*80*60	776
Collar	2400*800	728
Beam	1160*40*60	690
Collar	3200*800	661
Collar	3200*1200	640
Cover	1200*800	490
Cover	800*600	490
Collar	1200*800	487
Collar	800*600	447
Cover	3200*800	390
Cover	3200*1200	300
Pallet	2400*800	195
Pallet	800*600	171
Pallet	3200*800	164
Tube	Ø38	152
Pallet	3200*1200	145
Tube	Ø45	130
Pallet	1200*800	100
Tube	Ø70	87
Tube	Ø100	62
Tube	Ø135	47

As can be seen, in average, beams have a better ratio than collars, than covers than pallets and finally tubes. This means that the overall benefits (for the International Distribution Centre and the sales unit) would be higher to return only collars than pallets for instance.

5.4 Standardised load unit selection

For each set of experiments previously described in section 4.2.4, the transportation, labour and packaging costs have been calculated. There are two total costs for each set because of the two transportation options, i.e. a road shipment to Germany or an air shipment to the USA. The packaging cost is calculated as the sum of all the packaging purchase prices of the items used (e.g. pallet, paper, strips, cardboard, etc.). The transportation costs are calculated by using the transporters tariffs, the gross weight and the gross volume. The labour cost is calculated as the product of the operator recovery rate, the time spent to pack the customer order and the number of operators whom worked on it. Sometimes, two operators work at the same time on one customer order because the latter is big or because of difficult handling due to big or heavy components.

The results of each set of experiments are respectively shown in Table 9, Table 10 and Table 11 below.

Table 9 - Packaging, labour, transportation and total costs of the first set of experiments

Packing alternative	Transportation cost		Packaging cost	Labour cost	**Total cost** Germany	**Total cost** USA
	air USA	Road Germany				
Half euro pallet	80 €	22 €	13 €	2 €	37 €	95 €
Carton box	51 €	22 €	9 €	2 €	34 €	63 €

Table 10 - Packaging, labour, transportation and total costs of the second set of experiments

Packing alternative	Transportation cost		Packaging cost	Labour cost	**Total cost** Germany	**Total cost** USA
	air USA	Road Germany				
Euro pallet + long pallet	1 318 €	120 €	164 €	26 €	310 €	1 508 €
Long pallet	1 225 €	120 €	139 €	23 €	282 €	1 387 €

Table 11 - Packaging, labour, transportation and total costs of the third set of experiments

Packing alternative	Transportation cost		Packaging cost	Labour cost	**Total cost** Germany	**Total cost** USA
	air USA	Road Germany				
Long carton box + euro pallet	323 €	44 €	43 €	18 €	106 €	385 €
Long pallet	491 €	72 €	78 €	13 €	163 €	582 €

In the first and second sets of experiments, all the different costs are lower or equivalent in the advantage of the carton box and the long pallet respectively. In the third set of experiments, all the costs are in favour of the long carton box and the euro pallet except the labour cost, which is minor though, because this alternative takes more packing time (15 minutes more).

A main result of these three experiments is that labour cost is much lower than packaging cost which is equivalent to road transport cost which is much lower to air transport cost. This is shown in the two equations below.

$$Labour\ cost \ll Packaging\ cost \ll Airfreight\ transport\ cost$$

$$Labour\ cost \ll Packaging\ cost \approx Road\ transport\ cost$$

6 DISCUSSION

This chapter presents a discussion of the four initiatives results to evaluate their potential to make transport packaging more sustainable.

The chapter is divided into four sections corresponding to the four initiatives undertaken.

6.1 Lean process

In this part, the advantages of the future state packing area layout are discussed.

Clear product flow

By dividing the packing area into three working zones (parcels, long goods and euro and half euro pallets), the different flows are more direct and can be defined more clearly. There is a single location for every packaging material on the shop floor and work stations are designed for a certain kind of container packing.

However, this fixed layout at first glance is flexible. For instance, if during peak times there are many euro pallets or half euro pallets to pack, the area designed for long goods packing can adapt and be used for smaller consignments without major inefficiencies. On the contrary, packing a customer order in a long pallet in the area designed for euro and half euro pallets would be more inefficient. That is why the long goods area is larger to overcome an increase in the demand.

Last but not least, the rows of packed orders in the finished goods inventory are set in another direction to allow an easier transport between the packing area and the outbound via the finished goods inventory.

Safer working environment

With the different zones clearly marked on the floor (area available for forklifts, working area and pedestrian area), operators are almost always in a non-forklift zone. Then, they will feel safer not to have to pay attention all the time to forklift movements. Forklift drivers would benefit from that as well as there will be fewer persons walking around in the area available for forklifts which currently slow them down.

Walking reduction

As can be seen on the two Spaghetti diagrams in Figure 12 and Figure 14, the walking distance hence time is reduced in the future state layout. This means that the operator will be more focused on his real work, i.e. packing. At the same time, this buffer stock of packaging material has to be refilled sometimes. As the workload is uneven, the objective is to refill it during slack times when the run out time is less than one day while keeping the material reachable. For instance, there is no point to refill the pallets pile if it rises up to three-meter high then. Moreover, an earlier detection of packaging material shortage can be achieved when the last pallet of packaging material is removed from the rack. Such shortages have high consequences on the packing quality.

Ergonomics

Even if the walking distance has been reduced, the ergonomics of the working stations has not been improved. The main issue is the need to kneel and fold when packing. One solution could be to have an elevator which can raise the pallet to adapt its height to the operator and lower it when adding collars.

Conclusion

This initiative has shown that the potential of improving the process is high. The benefits are not only a better usage hence sustainability of transport packaging but there are also much greater with a general increase of safety and motivation for instance. As a result, the overall quality would be increased as well as the throughput time.

The product flow is much more visible and standardised. This is a first step towards future improvements. The packaging material is closer to the operators which make him focus more on the packing phase of his work. The working environment is safer because of defined areas.

6.2 Standardised packing methods

In this part, the benefits of the guidebook previously described are discussed from several perspectives.

Company development perspective

From the company's view, the guidebook enables a unitized way of packing at company X and creates a standard for future changes. It is a guarantee of packing quality because it would avoid variations between operators no matter their experience. This guidebook is also a way to keep the intellectual property within the company, instead of depending at a too high extent on operators' experience. The knowledge would not be lost because of the operator turnover rate.

Operator perspective

Regarding the operators, having a guidebook and clear rules would make them feel more secured. In fact, they would share responsibilities on packing quality with managers since the working methods would be standardised. This working standards or best practices must be collegially defined by managers together with the most experienced operators. This would make operators feel trusted and increase their willingness to be part of the company. As the work is not difficult from a technical point of view, new operators would be able to do a work of equal quality than experienced operators thanks to the guidebook.

Management perspective

The guidebook can be used for training purposes when an operator is hired. It can also be consultable in the workshop if an operator is wondering about a good packing method. Then, when the guidebook is implemented, less supervision and control of the packing quality is needed. The relationship between managers and operators is also facilitated because the guidebook acts as a link between them and they are more aligned.

Conclusion

This initiative has shown the great potential of standardising operators' working methods to improve the packing quality hence sustainability. The benefits of the implementation of the guidebook are numerous. The most obvious is the reduction of variations in the current ways of packing which help to start a continuous improvement cycle. Then, the achievement of this initiative is more the idea of creating a guidebook rather than the first cards presented in Appendix E.

6.3 Cyclical packaging

In this part, a return flow of packaging material from worldwide sales units to the International Distribution Centre is discussed both regarding the environmental and economic perspectives. The authors give their opinion about how it can be implemented.

Environmental aspect

When considering a return flow, the actual environmental benefit, if any, could be examined.

Regarding countries overseas, transport distances are high but container vessels would navigate even without this packaging material container. This means that the additional negative impact on the environment of this container is rather low for the maritime transport. The container also has to be shipped with another transport mode to make a door-to-door shipment but these distances usually carried out by road are considered as short in this study.

Regarding countries within Europe, return flow are usually carried out by small trucks hence by road. The negative impacts due to harmful emissions are not negligible. Other modes such as intermodal transport with rail and road transport could be considered.

At the same time, a return flow would prevent from manufacturing new pallets, collars, etc. which would reduce energy and water consumptions and material extraction.

This study has not investigated more about whether such return flows are environmentally friendly but is more focused on the economic potential.

Economic aspect

As shown earlier in Table 8, the packaging materials do not have the same value for volume ratio and some materials are more valuable than others because they contribute to a higher total packaging material value in the load unit (container or truck). Then, there should be incentives for the sales units to ship these materials back first.

A return policy can be used to define the return shipments. Thus, the sales unit would be paid proportionally to the material shipped and would pay for transportation and material handling. In order to encourage sales units to ship first the most valuable items, they could receive a higher share of the profits for these items. It means that if they receive 70 percent of the purchase price for most items, they could receive 75 percent of the purchase price for the most valuable items. This would be an additional incentive for them. In fact, even without this higher share it is already more beneficial for them to ship the most valuable items because it

would increase the total packaging material value which is the sales unit revenue in this transaction.

When the transport cost is too high because of long distances, then a local resale or finally recycling has to be considered. In medium distances, the return can exclusively focus on beams and collars for instance which have the best value for volume ratio in order to keep a certain margin in the transaction.

Conclusion

The cyclical packaging initiative has shown that the closed loop potential is quite high if the right packaging materials are preferably returned. Then, both the environmental and economic aspects can be optimised. In order to implement closed loop initiatives, profits have to be shared between partners. However, incentives must be defined to clearly encourage win-win relationships.

6.4 Standardised load unit selection

In this part, the three sets of experiments are discussed in regards to different factors and the authors give their opinion about their best solutions.

First set of experiments

In the first set of experiments, even if both total costs, for a shipment by air to the USA or by road to Germany, are lower for the carton box, the total cost is pretty similar for the road shipment to Germany. Thus, other factors can come into play. The wooden half euro pallet seems to be stronger than the carton box but does not have better statistics regarding the damage rate. In fact, they are not handled by the same equipment and seeming stronger, transporters might be less careful with the half euro pallet. However, a half euro pallet looks more professional than a carton box with sticky tape. Customers might be more satisfied by receiving a wooden half euro pallet than a carton box because of the aesthetic aspect. If it has to be stored, a half euro pallet might also be more easily handled by the handling equipment. The authors would recommend using the carton box as packaging alternative for such customer orders if the choice has to be unilateral. If a different packaging alternative is allowed depending on the transportation mode, then the authors would recommend using a carton box for the air shipment to the USA and a half euro pallet for the road shipment to Germany.

This set of experiments can be generalised to all customer orders that can be possibly packed in a half euro pallet or a carton box. Road transport to Germany can be generalised to road transport to any European country and air transport to the USA to air transport worldwide.

Second set of experiments

In the second set of experiments, both total costs for a shipment by air to the USA or by road to Germany are clearly lower with the sole long pallet. However, the transportation cost by road to Germany is equivalent for both packaging alternatives. One might say that the packaging cost, which makes the two packaging alternatives differ for a road shipment, is linked to the customer order at a high extent and this cannot be generalised but actually by

using two load units it is more likely that the packaging cost would be higher. Hence, the obvious solution here is to use a long pallet alone for such customer orders.

In a similar way to the first set of experiments, road transport to Germany can be generalised to road transport to any European country and air transport to the USA to air transport worldwide.

Third set of experiments

In the third set of experiments, both total costs for a shipment by air to the USA or by road to Germany are clearly lower with a combination of a euro pallet and a long carton box. However, as mentioned before in section 5.4, even though it is a minor cost, the labour cost is higher for the combination of a euro pallet and a long carton box compared to a sole long pallet because the packing time is fifteen minutes higher. Therefore, during peak times, as availability and punctuality might be crucial, using a long pallet instead for such customer orders can be recommended but it must only be as a last resort. Other initiatives such as extending operators' working time must be studied before. Hence, the obvious solution here is to use the combination of a euro pallet and a long carton box for such customer orders.

In a similar way to the previous two sets of experiments, road transport to Germany can be generalised to road transport to any European country and air transport to the USA to air transport worldwide.

Conclusion

The standardised load unit selection initiative has shown that it is possible to have a holistic view about what different packaging alternatives cost including the packaging, transportation and labour costs. This helps to assess the packaging alternatives and to come up with the best solutions. Even though it is linked to three specific customer orders and to two destinations, these experiments can be generalised to most of the customer orders because they include almost all the load units. The implementation of such standards would homogenize the operators' choices and be a starting point for continuous improvement of the load units.

7 GENERAL CONCLUSION

This chapter concludes this master thesis by answering the two research questions.

RQ1 "What are the available strategies that can contribute to an increased sustainability in transport packaging?"

A purpose of this master thesis was to contribute with a general conceptual framework showing different improvement strategy possibilities when it comes to enhance transport packaging sustainability. A sustainable transport packaging covers four pre-requisites which are effectiveness, efficiency, cyclicality, and safety (Lewis, 2012). These pre-requisites must be considered during the cradle to grave cycle of the packaging material.

The available strategies that can contribute to an increased sustainability in transport packaging have been gathered in five categories in this study namely Process, People, Material, Environment and Unitisation. The 'Process' category deals with product flows at the working area where improvements could bring a better consumption of packaging materials. The social perspective is also taken into consideration; for instance workers' safety issues at the packing process. In the 'People' category, the target is shop floor operators who are actually packing. The objective is to check the effectiveness and efficiency of the operators' work at the same time and attention is put to their psychological needs. The 'Environment' category focuses on reducing packaging material waste by evaluating packaging reuse or recycling for instance. The 'Unitisation' category involves the transport load unit alternatives considering their costs and effectiveness for different actors in the Supply Chain. The 'Material' category checks the suitability of the packaging materials, trying to match packaging material properties with their functions, which includes their cyclical potential as well.

Thus, the above five categories are considered being the most suitable areas fulfilling sustainability requirements in transport packaging.

RQ2 "How to implement improvement strategies to a complex industrial context?"

Using a case study with an industrial company, four initiatives have been implemented in this master thesis. In order to implement them, the five categories have been investigated starting by evaluating the current issues in the current ways of packing. Observing operators and interviewing relevant persons have given a good overview of current issues.

In the Process category, starting from the drawing of current layout and recording the movement of an operator in a specific packing process, problems directly came up. The redesign at the plant by specifying materials, equipment, and people locations makes the product flow clearer and smoother. Efficiency is highly improved by implementing a lean layout.

In the People category, a study of the packing operators should be the first step to see if the packing process and transport packaging materials are used in a right and standardised way. When there are not common packing methods, standards should be agreed upon. They will be

used to train new operators as well as to answer possible questions or oblivions at the packing area.

In the Environment category, a closed loop of transport packaging materials should be aimed to. A pre-study for knowing the fate of packaging materials after they left the “cradle” is important to get knowledge about their lifecycle. This knowledge lays a foundation to find a good solution for dealing with the materials after they have completed their usage. Setting proper policies for motivating partners on the whole supply chain on returning back the packaging materials is a good example. When closed loop or not possible because of some obstacles such as too long distances, then resale or recycling can be considered.

The Unitisation category strives towards defining standardised transport packaging load unit. In order to select the best standard for different actors in the Supply Chain and avoid sub-optimisation, a holistic view is necessary. Different factors have to be taken into account. They were the transportation, labour and packaging material costs in this study. The best standards are not always obvious and other factors usually more qualitative might be used to decide between the different alternatives.

8 RECOMMENDATIONS TO COMPANY X

In this chapter, recommendations are given by the authors to company X.

Based on the key findings in this project, there is a great potential for company X to reduce transport packaging and transportation costs, hence enhancing sustainability in transport packaging.

Create lean process

Regarding the process, working towards lean is highly recommended. The redesign of the layout is a good start for improving the process. The new layout will specify locations of equipment, materials and people. This helps to get better material flows and remove waste at the packing area. What should be kept in mind for the management is that the redesign of the layout is just a start. It needs to be maintained to function as expected. Management should be aware that it is probable that at the beginning, operators would not get used to the new layout and mess is likely to appear.

Standardize packing methods

One of the biggest issues found out at the shop floor in this study is the clear lack of unitized way of packing, which causes quality problems. Creating a guidebook describing the right use of different packaging materials as well as common mistakes is suggested. However, due to time limitations of the authors, the guidebook presented in Appendix E is far from being complete. It is highly suggested that by involving the manager and shop floor operators, a collection of best practises can be made. Though it takes time, the utility is worthwhile considering the future training for new operators as well as a problem-solving reference at the work place. The guidebook is a living document which should be continuously updated when better practises are established.

Build a closed loop for packaging material

Both from the economic and environmental perspectives, returning back packaging materials from sales units around the world can be beneficial even with long distances. Benefits of returning packaging materials back depend on the materials. This knowledge about the most valuable items is important to have when introducing return flows to the sales units. What should be kept in mind is that benefits should be shared between the sales units and the International Distribution Centre to sustain a win-win relationship. A return policy is a good way to encourage sales units to transport back the most valuable materials and must clearly show the preferences of the International Distribution Centre towards certain packaging materials. Crediting sales units with a higher share of the purchase price for the most valuable items is one way to encourage them to return first these items. The authors suggest writing down clearly the ratios between the return price and the purchase price in the return policy for the different materials.

Select the right load units

When selecting a transport packaging load unit, instead of giving full freedom to the operators, rules should be defined. The choice of a transport packaging load unit should consider at least the transportation, packaging material, and labour costs. The study showed

that labour cost represents a small share of the total cost. Therefore, during peak times, it is recommended to hire more operators instead of postponing orders or storing packed orders longer.

To gain a more holistic view on the impacts of selecting different load units, the authors recommend carrying out more experiments with different combinations as well as with the same combinations but different items. Other factors can also be taken into account such as customer satisfaction. The accumulated knowledge should be shared with operators to help them to select the right load units faster.

9 FURTHER RESEARCH

In this chapter, further research ideas are presented.

Follow-up of the four implementation initiatives

A new process layout has been emphasized earlier to improve the process efficiency. The walking distance has been reduced and proved with a Spaghetti diagram. It would be interesting to measure the actual financial benefits brought by this new process layout. A first indicator can be to calculate the reduction of the walking time and distance between the two layouts, which would contribute to the reduction of the labour cost in a certain time period. Feedback from the employees would also be of high value since there are possibilities to continuously modify and improve this layout.

A guidebook with standardised packing methods has been started in this study. Evaluating the benefits of these standards on the work quality would be interesting. At the same time, adding more cards to this guidebook is necessary as well as continuously improving the existing cards.

A value for volume ratio has been calculated. It provides company X with the most valuable items to return. However, this does not take into account the environmental impact of such material returns. A complete life-cycle analysis on these materials from cradle to grave could be carried out to investigate whether it is sustainable or not and not only if it is economically viable. This life-cycle analysis could also take into account an open loop alternative with local reusing or recycling.

Three sets of experiments have been done at the International Distribution Centre and give a good knowledge base to select the best load units. Other experiments can of course be carried out but packaging alternatives must not be limited to existing load units at company X.

Implementation of a new initiative

Even if Material has been seen as an improvement category with potential to contribute to a higher sustainability in transport packaging, no implementation initiatives have been carried out during this study. It would be very interesting to investigate the different packaging material properties and the packaging requirements for protecting, transporting, and storing the components. This could help to select the best materials.

Other possible strategy categories

The previous five improvement categories have been researched in this master thesis. However, a sixth category - management, is excluded in this study based on the available empirical data and relevance priority at the beginning of the study. Thus, it can also be interesting to go deeper into the management field in order to, for instance, evaluate communication at the working place between managers and operators.

Broadening the scope

This study has been limited to the outbound logistics between the International Distribution Centre and local Distribution Centres or Sales Units or end customers. As packaging materials are also used upstream in the supply chain by suppliers, it would be interesting to see how the

same packaging materials can be used throughout the whole supply chain and not only with a half chain view. Unifying transport packaging in the complete supply chain can be seen as a long term goal.

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Appendix A: Interview to packing operators

Our topic is about transport packaging sustainability. We would like to know how operators can influence it. A 1 to 5 scale is used as a measurement scale if needed during the interview.

1) How long have you been working at company X?

2) How many years have you been working within packaging field when you start working at company X?

3) How would you rate your satisfaction about the routines of your work?

1Very poor	2 Poor	3Average	4Good	5 Very good

4) Did you have trainings on packaging from company X?

- ☐ Yes
- ☐ No

Comments:

5) Did you know your job specifications when you started to work?

- ☐ Yes
- ☐ No

Comments:

6) How much do you think your job (packing) influences the company's economic and environmental aspects? (1-5)

Economic aspect:

1Very low	2 Low	3 Middle	4 High	5 Very high

Environmental aspect

1Very low	2 Low	3 Middle	4 High	5 Very high

7) Do you need to follow a standard when packing, regarding the sequence?

- ☐ Yes
- ☐ No

Comments:

8) How good do you think the packing process is, regarding the easiness to handle, the efficiency and your safety? (1-5)

Easiness to handle:

1 Very uneasy	2 Uneasy	3. Average	4 Easy	5 Very easy

Efficiency:

1 Very inefficient	2 Inefficient	3. Average	4 Efficient	5 Very efficient

Safety:

1 Very unsafe	2 Unsafe	3. Average	4 Safe	5 Very unsafe

9) Do you have an even workload?

- ☐ Yes
- ☐ No

Comments:

10) Do you sometimes feel stressed (or in a rush) because of the workload?

Never	Sometimes	Often	Always

Comments:

11) What do you think can be improved in the packaging process?

Appendix B: Packaging material

This is the packaging material which is concerned in the cyclical packaging initiative.

Pallets

Collars

Covers

Tubes

Beams

Appendix C: Packaging questionnaire

The survey is to understand what happens to the packaging materials (pallets, lids, collars, beams and tubes) after shipment from the International Distribution Centre (IDC). Please fill in this Word document directly and email it back to us.

1. What are the monthly volumes of the following packaging materials (pallets, covers, collars, tubes) you receive from the IDC?
   If you don't know the real volume, please try to estimate it and say that "it is an estimation".

Material	**Dimensions**	**Monthly volume**
Pallets	1200*800	
	800*600	
	3200*800	
	3200*1200	
	2400*800	
Wooden covers	1200*800	
	800*600	
	3200*1200	
	3200*800	
Collars	1200*800	
	800*600	
	3200*800	
	3200*1200	
	2400*800	
Tubes	3100*2*ø38	
	3100*2*ø45	
	3100*2*ø70	
	3100*2*ø100	
	3100*2*ø135	
Beams	760*60*40	
	1160*60*40	

Comments:

2. Are the packaging materials in good condition when you receive goods from the IDC? (tick the box by clicking on it)
   - Pallets Yes ☐ No ☐ *Comments:*
   - Covers Yes ☐ No ☐ *Comments:*
   - Collars Yes ☐ No ☐ *Comments:*
   - Tubes Yes ☐ No ☐ *Comments:*
   - Beams Yes ☐ No ☐ *Comments:*

3. How do you deal with the different packaging materials (pallets, covers, collars, beams, tubes)? If several cases are right, please estimate the proportions scrapped, reused and recycled.
   ☐ The material is scrapped
   ☐ The material is reused
   If reused, in which way (e.g.: send to final customer, send back to the IDC)?
   ☐ The material is recycled
   If recycled, in which way (e.g.: sell to recycling company)?

Comments:

4. What are the costs involved in your handling and managing of packaging materials?

Comments:

5. Do you think that there is a better way to deal with the packaging material you get from the IDC both from an economic and environmental perspective?

Comments:

Thank you!

Appendix D: Three sets of experiments

First set

Half euro pallet vs. carton box


Vs.


Second set

Euro pallet and long pallet vs. long pallet


+

Vs.


Third set

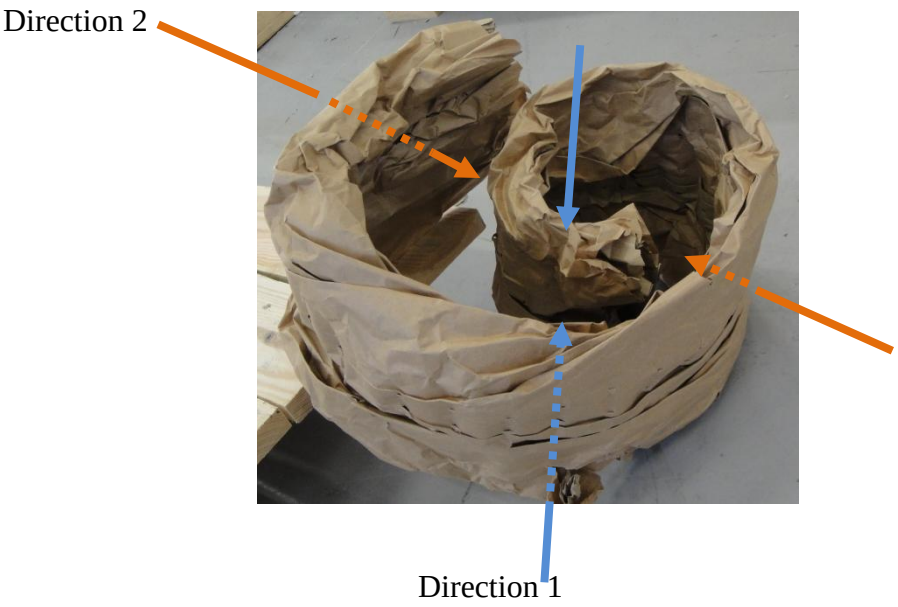
Long carton box and euro pallet vs. long pallet


+

Vs.


Appendix E: Guidebook

Paper roll



The paper roll is strong and protects well in the direction 1.

The paper roll is soft and hardly protects in the direction 2.

1: Do not prevent any movement

2: Wrongly oriented

3: Do not prevent any movement

4: Right, prevent the drive unit from moving

Profiles

Different ways to pack profiles

Alternative 1: Plastic foam to group profiles by two or four depending on their size

Alternative 2: Carton strips between profile edges

Corrugated cardboard is needed when there is a cross of profiles or between profile edges with profiles of different weight.

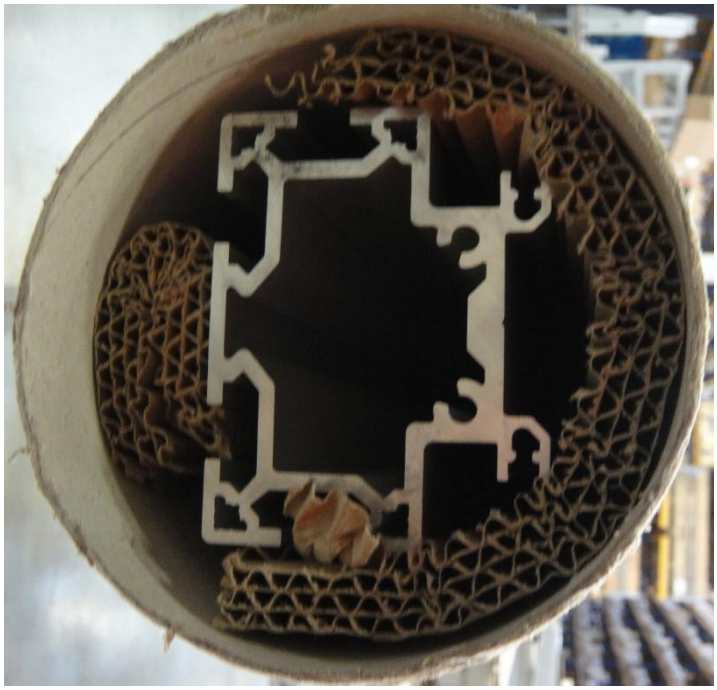
Wooden beams

Wooden beams are used to strenghen the pallet. Two beams must be screwed on one of the top collars at the center of the pallet. They must be approximately distant of 50cm. If items in the pallet prevent from doing that, the beams must be screwed where there is space.

In the middle of the pallet

Too distant

Corrugated cardboard



Around the profile in a tube at both ends

On both sides and ends of pallets

If there is a cross of profiles