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Effects of Changing Packaging Material in Logistics Operation

Case SOK

Bachelor's Thesis

International Business

December 2015

KYAMK
University of Applied Sciences

Tekijä/Tekijät	Tutkinto	Aika
Niko Väyrynen	Tradenomi	Joulukuu 2015
Opinnäytetyön nimi Effects of Changing Packaging Material in Logistics Operation		30 sivua 1 liitesivua
Toimeksiantaja SOK		
Ohjaaja Lehtori Jagat Kunwar Bahadur		

Tiivistelmä

Opinnäytetyön tarkoituksena oli nähdä vaikutukset kierrätettävästä pahvilaatikosta uudelleenkäytettävään muovilaatikkoon siirtymisessä kuljetusmateriaalina. Vaikutukset opinnäytetyön kolmessa pää osa-alueessa on otettu huomioon, jotka ovat kuljetus, varasto ja kauppa.

Opinnäytetyössä on käytetty qualitatiivista metodia jonka avulla on saatu suurempi validiteetti. Koska sekä mielipiteitä, että tarkkaa tietoa osa-alueesta on tarvittu opinnäytetyössä, teki se qualitatiivisesta metodista paremman valinnan. Kyseinen metodi mahdollisti tarkennettujen haastattelujen suorittamisen valituille henkilöille.

Haastatteluista voidaan huomata, että vaihdolla on eri vaikutuksia osa-alueilla. Voidaan myös todeta, että perus prosessi ei muutu vaihdoksen myötä, mutta huomattavia hyötyjä voidaan saada varaston osa-alueella. Toisaalta vaihdos lisää kustannuksia kuljetuksen osa-alueella eikä sillä ole suuria vaikutuksia kaupan kannalta vaikkakin kauppa voi hyötyä vaihdosta jatkossa pienentyneen laitetarpeen muodossa.

Asiasanat
Logistiikka, Materiaali valinta, Toimitusketjun hallinta

Author (authors) Niko Väyrynen	Degree Bachelor of Business Administration	Time Decemeber 2015
Thesis Title Effects of Changing Packaging Material in Logistics Operation		30 pages 1 pages of appendices
Commissioned by SOK		
Supervisor Jagat Kunwar Bahadur, Senior Lecturer		
Abstract The objective of the thesis was to find out the effects of changing packaging material from cardboard box to reusable plastic crate. Effects in each of three main areas transportation, warehouse and store, were taken into consideration. Qualitative method were chosen for the thesis as it gave better validity and because both opinions and specific knowledge of the matter were needed, it made the qualitative method even more suitable, since it made specific interviews possible for targeted information. From the interviews it can be noticed that there are different effect for each area of the thesis. It can be seen that the core process would not be affected by the change, but it would bring benefits manly for warehouse part. However, the change would lightly increase costs in transportation and have only little difference within the stores. Although, stores can benefit the change in the future as a possibility for smaller and cheaper recycle equipment.		

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APPENDICES

Appendix 1.

1 INTRODUCTION

The topic of the thesis interests me, because I have worked in fruits and vegetables section at the store level in a local supermarket. During the time in the supermarket I have gained experience in handling the fruits and vegetables within the store. With the help of this thesis I will get a great chance to get familiar to the majority of supply chain related to fruits and vegetables and implement my studies into practice in this company case.

This topic is relevant for the commissioner company as they have investigated the matter earlier, but with the new warehouse starting its operations 2016 the questions surfaced once again as the new automated system to be installed forgives only small differentiation on the pallet profile. With cardboard boxes and fresh fruits and vegetable the company already has a standard to be matched with the profile of the box itself and the strength of the material used. In addition, there is also a need for special coating on certain products with high humidity.

A downside of non-coated cardboard is that it tends to get soft when it is exposed to humidity. Which in the worst case scenario results in collapsing a pallet and destroying the products inside. With plastic you do not have that problem as it endures humidity and keeps the same profile better than cardboard which has a tendency to bend.

However, bending is not a negative thing in every case as it prevents bruising of products during transportation. With the case of plastic crate, some extra softening material would be needed to allow it absorb similar forces conducted during transportation.

The thesis will be written from a point of view of the company SOK and the main objective is to find out if it is beneficial to replace cardboard boxes with plastic crates in products which cause the most disturbance in the supply chain. Another objective is to define what kind of effects the change will bring for the quality of the products during the supply chain.

This thesis is commissioned by SOK in order to recognize the benefits and costs related to issue of replacing cardboard boxes with reusable plastic crates (RPCs) in fruit and vegetable logistics. Due to the new warehouse in

construction, it is ever more important to find out if it is beneficial to make use of RPCs in logistics solutions.

The topic was analyzed with qualitative method and the focus was on interviews concerning the main areas of the thesis. Interview data was analyzed in order to find answers for the research questions that are related to quality, material handling, costs and store point of view. By conducting the interviews on persons selected by their position in the company, enabled valid information about the matter. As some specific knowledge about the topic was needed the qualitative interview was the best choice of method for the thesis.

2 RESEARCH QUESTIONS

The aim of the thesis is to find out the effects of changing packaging material in fruits and vegetables logistics. The research questions to be answered in the thesis are: How does the change from cardboard box to reusable plastic crate affect quality? How does the change from cardboard box to reusable plastic crate affect material handling in the supply chain? What impacts on costs would the change from cardboard box to reusable plastic crate have? How the change from cardboard box to reusable plastic crate will affect stores?

Research questions are approached by looking at the key performance indicators (KPI) related to topic:

Quality: Products and material

Material handling: Transportation and automated warehouse

Costs: Example cases and estimations

Store: Opinions and effects

Focus will be on the effects that the change from cardboard to plastic would have on each main area of the thesis: transportation, automated warehouse and store. In addition, product wise the focus is on the problem products mentioned by the commissioner to find out how much will the change from cardboard to plastic crates affect the problems caused by their transportation material of such products. However, some products may require extra packaging material in order to prevent bruising during transportation. As a

reference, data gained from a warehouse in Norway will be compared to data gained from interviews, since it has similar automated system in use.

The most important metrics are: Quality; how does the plastic affect the quality of products transported within the plastic crate. Automated system; what kind of demands does it have on pallet profile and how much the plastic crates would affect the efficiency of the warehouse process. Costs; how much extra costs will it bring to the process if the crates are changed to plastic ones. The biggest weight on results is given to warehouse benefits followed by product quality.

The commissioner of the thesis wants to find out the effects of changing their packaging material. Their interest of the matter is partly driven by the new warehouse in construction which contains new automated systems. From experience it is known that some products transported in cardboard refuse to keep their desired profile and thus cause problems on warehouse flow, so it is important to identify the improvements that a change from cardboard to plastic could bring.

3 CONCEPTUAL FRAMEWORK

The conceptual framework related to the thesis is logistics and more precisely material handling, transportation and warehousing. Theory to be reviewed in the thesis relates to the key points afore mentioned. Packaging material decision relate to material handling and unitization in logistics. Furthermore, quality management and measuring the impact of a change are important factors to be searched upon. Also secondary data related to the matter such as old researches and articles that are relevant to the case are taken into consideration.

3.1 Material handling

Material handling can be divided into three sections packaging, unitization and handling system. Furthermore, packaging can be divided into two types, which are primary and secondary packaging. With effective unitization a company can get benefits such as better usage of space, easier handling and movement of goods throughout the supply chain. Efficient unitization is most advantageous when a company is using mechanized or automated warehouse. (Fawcett, McLeish and Ogden. 1992, 93-104).

3.2 Packaging and unitization

There are essentially two types of packaging: Primary packaging and Secondary packaging. In addition, both types can serve as a platform for information. Primary packaging can be used as information source for customers about the product it contains, where secondary packaging is commonly used for providing information about the unit during transportation and warehousing. Primary packaging means the layer right next to the actual product, for example a bag or a wrapper to protect the product. Secondary packaging has a larger role in the packaging operations as it functions as stackable unit, holding multiple units of products within. Form of secondary packaging can be for example strong cardboard box or a plastic box, which can be stacked into pallets to create transportable units. With efficient unitization a company can utilize its transportation and warehousing capacity. (Fawcett, McLeish, Ogden, 1992, 93-100). Advantages of unitization, such as increased productivity, standardization of units and decreased level of damaged goods. Disadvantages, such as capital investments, replacement costs and imbalance of material movement mentioned by Fawcett, McLeish, Ogden, (1992) indicate that the overall benefit gained from unitization outweighs its mentioned disadvantages. Effective unitization is especially beneficial in the case of automated warehouse, since many material handling mechanics favor specific units.

3.3 Comparison of materials

The following table 1 contains comparison of the reusable plastic crates and cardboard box example by Finnish packing association. Information about the plastic crates are from the companies websites accessed 11 December 2015. Since the crates does not have exactly same dimensions some similar height, width and length crates are compared. The results are not fully comparable, since the companies present the amount counted on different pallets. From the measurements it can be seen that plastic crates are thicker than cardboard boxes and thus leave less room for products within.

Product	Reusable plastic crate IFCO/EPS	Cardboard recommendations
Dimensions	Inside: EPS: (154/186) 577mm x 380mm / 389mm x 284mm IFCO: (167/185) 578mm x 372mm / 378mm x 272mm Outside: 600mm x 400mm / 400mm x 300mm Folded: IFCO: 34,3mm EPS: 30mm Height varies	Inside: 588-597mm x 392-398mm / 392-398mm x 294-298mm Outside: 600mm x 400mm / 400mm x 300mm Height varies
Material	IFCO: Food grade Polypropylene EPS: High density Polyethylene	Corrugated cardboard
Properties	IFCO: temperature range -10C - +60C Delivery quantity per truck 52 / 26 pallets (15080(4x3)/7540(6x4)) EPS: temperature range -15C - + 30C	Bending stiffness: 40N Edge crush test: 15,5 kN/m
Number of crates per pallet	IFCO: (ISO pallet) 140 units, 14 layers, 7kg/per 55 units, 11 layers, 16kg/per Folded: 580/290 EPS: (Euro pallet) 128 units, 16 layers 7kg/per 56 units, 14 layers 18kg/per Folded: 608/304	(Euro pallet) 11 / 16 layers 15kg/per depending on the height

Table 1. Material comparison.

3.4 Warehousing

Warehousing has many benefits for the company regardless of its related costs and investments that has to be made in order to keep the warehouse functioning well. As mentioned by Fawcett, McLeish and Ogden, (1992, 113-122) warehouse can function as a buffer for fluctuations in supply and demand or as a way to shorten the lead-time gap. Also, it can provide room for anticipated seasonal stock fluctuation. On the other hand, it enables work in progress stock keeping for assembly and break-bulk operations as well as the cost benefits from economies of scale, since the company can hold the excess units for later use. Depending of the purpose of the warehouse, the efficiency can be maximized in many ways. However, the main objectives are to maximize the use of space and to minimize unnecessary movement and handling of the goods. Those factors can be affected by designing the layout of the warehouse to match the desired purpose.

To utilize the possibilities that warehousing provides for closing the lead time gap the company can, for example use the work in progress stock to speed up the manufacturing time of ordered goods by customers. As forecasting goes hand in hand with the stock levels of the warehouse and is often a reason for some problems that can occur, such as either having too much or too little in stock. By managing to close down the lead time gap the company also reduces the risk involved to long periods of forecasting. This can be achieved by increasing the visibility of demand and moving to more demand driven nature of supply chain. Demand penetration point should be pushed as far upstream as possible, so that in ideal thinking "(…) *nothing is purchased, manufactured or shipped unless there is a known requirement"* (Christopher, 2011, 85).

3.5 Transportation

As Finland is the country that the thesis is mainly concentrated on, it means that when thinking of inland transportation there are only two viable possibilities: road and rail transportation. Since, inland waters are so limited it makes no sense to widely use water transportation as a go to transportation method. Also, air transportation in most cases would be too highly prized as an inland transportation method. In Finland there are relatively good railway connections in the southern part of the country but when going up to north the

routes are quite limited which makes it hard to use railway as a main transportation method within Finland. In addition, as the railway company is owned by the government and it functions in monopoly positions in Finland, which makes it uncompetitive choice regarding prices. However, it could prove to be an effective method in the southern part of the country as well as a method of trade between Finland and Russia. All in all, road transportation proves to be the most successful and flexible to use within Finland's inland transportation. Also, considering the good quality of the roads, high standards in vehicle conditions and low corruption makes Finland one of the safest countries to transport within.

Considering the international choices of transportation, water transportation proves to be effective due to good port connections at the southern and western Finland. In addition, good connections to east makes railway transportation a viable method to that direction. However, road transportation should not be neglected as international transportation, as it still is the most flexible method. Air transportation is one of the most expensive, but also one of the fastest methods and thus could be situationally a valid choice as international transportation method. Since Finland is basically considered as an island when it comes to transportation decisions, it makes the water transportation the most viable international transportation method in most cases.

3.6 Reverse logistics

Reverse logistics means the flow from customer to manufacturer, where traditional forward logistics is the flow from manufacturer to customer. With the SOK case the company can utilize reverse logistics and add value to its operations by using the space in empty trucks returning to distribution center. Meaning that when the truck driver unloads the shipment in store, it can load the truck full of empty pallets, trolleys and crates. This system is already in use, but can be utilized more if the volume of reusable plastic crates increases.

3.7 Inventory costs

True cost of holding inventory is formed of many individual pieces that might be hard to see as a one large costs of holding stock. The true cost of inventory

is formed from pieces such as cost of capital tied to the inventory and also costs related to the actual storing and handling of the stock. In addition, obsolete, damaged and deteriorated units during the storage process add to the total cost as they directly equal as loss of profit and on top of that, such items require extra workforce to be handled and removed. Also, the stolen or lost goods are a part of the total cost of inventory, in addition to insurance payments that the company has to pay to prepare for unexpected occurring's. Last but not least are the management costs related to the whole storage process which add to the total true cost of inventory by Christopher (2011, 69-70).

3.8   Total cost of ownership

In total cost of ownership approach the costs during the whole life cycle of a certain product/service is taken into consideration. The visible cost can be seen as a tip of an iceberg, where addition to the visible price, things like transaction costs, delivery terms and transportation costs, quality requirements, inventory costs, environmental impacts and end of life recycling should be analyzed as a part of the total cost of ownership during the whole life cycle. (Cousins et. al, 2008).

With the case of plastic crate pooling companies, it must be investigated which of the parts of total cost are included into the visible cost of the product/service. For example, it should be investigated if there could be additional cost related to delivery terms or prices to different countries and if there could be changes to inventory holding cost during transportation or warehousing.

3.9   Total quality management

In total quality management the company adopts a continuous improvement mentality and strive to minimize defects. Prevention of the problems is more emphasized than detection methods. The role of customer perceived quality is what determines whether the company has succeeded on providing what the customer wants. All in all, everyone in the company has somehow direct or indirect influence on the quality of the service/product the company is providing. Cost of quality (COQ) is formed from four aspects that are prevention cost, which includes the costs regarding the prevention of defects

during the process, for example planning, controlling and improving processes. Appraisal cost is formed from inspection costs to assess the quality like material inspections. Next two parts are internal and external failure cost. Internal failure cost results from defects found before the product/service is provided to customers as external failure cost means that the defect is found after the product/service is reached the customer and is formed from complain settlements, repairs, loss of sales and loss of customers. ISO 9000 certification is awarded for achieving the standard on quality that is recognized around the world. Standards are set to encourage continuous improvement and ensuring customer satisfaction. (Swink, et al., 2011).

3.9.1 Deming wheel

The Deming wheel or plan, do, check, act (PDCA) approach is widely known quality improvement tool. By utilizing the tool a company can solve problems and increase quality during a time cycle. First a problem or situation should be identified and the think how it could be solved or reached. After making the plan it should be implemented into action after which the results should be checked and analyzed if other problems or ways of doing has surfaced. After reviewing the results and see what corrective actions should be taken and make a new plan on how to solve or achieve the situation. (Swink, et al., 2011).

3.9.2 Six sigma

Six sigma is an approach where the standard deviation is minimal. Meaning that defect ratio is close to six sigma level. A company can see in which sigma level it is at the moment by calculating defects per million opportunities. Six sigma can be used for example to measure how much closer to six sigma a certain change in the process can be lead. DMAIC approach is used to first define the requirements and the situation at the hand. Then the current situation is measured and analyzed to see how the process is now and what can be improved. After the improvements are made a control systems is to be set up to ensure that the process variables stay within desired range. (Swink, et al., 2011).

3.10 LCA

With life cycle analysis or assessment, a company can determine the effects of a product/service during the whole life cycle. There are life cycle tools like GaBi software which can help to see for example carbon and water footprint of the process and other metrics that help to increase sustainability. (Thinkstep)

4 METHODOLOGY

The main method to be used in the thesis is qualitative method. Interviews are conducted for the main parts of the thesis; logistics process, warehouse process and store. In addition, relevant background data is gathered from associated persons. As a reference data, an interview will be conducted for a person representing a similar warehouse in Norway that is under construction in Finland.

Data sources for this thesis are mainly going to be information gained from interviews and background information gathering from related persons. Primary data is to be collected by interviews conducted to persons related to key aspects of the thesis. Secondary data is gained from presentations, notes and books.

In order to increase the reliability of the thesis, some mathematical data related to certain operations will be analyzed and used as triangulation method, which will increase the reliability of the thesis. (Ghauri and Grønhaug 2005)

4.1 Choosing a method

Qualitative method suits this thesis best as with the help of interviews with a professional in the area will provide a wide and informative view at the whole process which the thesis is focused to. Compared to quantitative method, qualitative method gives better validity on the matter, since performing a questionnaire for a large amount of people who might not know enough about the topic this thesis is focused upon, could give a wrong or not so relevant information that would be required and desired by the commissioner. However, quantitative method can be used effectively as a triangulation

method for the thesis, since it would increase the reliability of the information gained from interviews if the quantitative data would reveal similar factors.

4.2   Sample

Individuals for the interviews have been selected according to their position within the organization which makes them the most reliable source for the particular information that the interviews aim to gather. This can be seen as purposive sampling, which is a method where the interview sample is handpicked according to the qualities or specific information of the interviewee. Purposive sampling has been used for the interview sample in order to secure a level of knowledge about the questions asked in the interview. As the interviewees work in a position related to the key areas that this thesis is concentrated on, the selection of the most important interviews was clear. In addition to the three main parts of the interview (transportation, warehouse and store), information about the case Norway is used as a triangulation method for the interview information, since a full interview did not succeed in Norway due to time constrains. Moreover, additional smaller interviews were conducted with reusable plastic crate companies and so called ground-level workers to see their point of view of the matter.

The sample consists of nine interviews in total, including two interviews with logistics operations representatives, in order to find out the effects on transportation and warehouse point of view. In addition, to find out the store point of view, three retail chain representatives were interviewed in order to get a wider picture of the value perceived at that end of the supply chain. Also two shop workers were interviewed in order to get more on hand point of view on the matter. Finally, representatives of the two reusable plastic crate pooling company were interviewed in order to compare their basic operations and pricing strategy.

Larger sample size could have enabled more reliable overall opinions about the topic, as for now the sample size is rather limited partly due to time constrains. However, the current sample provides enough information in order to make relatively correct assumption about the matter.

4.3 Interviews

The interviews were conducted in order to find out the opinions of the key area representatives, which are transportation, warehousing and store, about the effects of a change from cardboard box to plastic crate in fruit and vegetables. In addition to their opinions about the matter, specific questions related to their position were added to find out the area specific information concerning the mentioned change. Moreover, smaller interviews with workers in the fruit and vegetable section in the store will be held in order to get a wider picture concerning the stores point of view on the matter. In addition, interviews with two reusable plastic crate pooling companies were conducted to find out information about their operations.

Interviews were conducted in a semi structured way, as there were common questions to each interviewee and then specific questions tailored according to their position. Interview sessions were successfully conducted at the working premises of the interviewees. However, the three interviews with the store representatives were held in Finnish due to the wishes of the interviewees. It seemed that some of the questions were too similar which lead to similar answers to a few questions, but on the other hand, it enabled gaining the intended and specific information which the interview aimed to gather.

Every participant was willing to talk openly about the matter and accepted to be interviewed without much of a hesitation. That mindset enabled a relaxed and open atmosphere for the interviews as the interviewees did not feel forced to answer any sensitive questions. In addition, they got a chance to get familiar with the questions beforehand so that they could be better prepared to give wide enough answers.

The main interview recordings varied at length from 18 minutes to 30 minutes which felt as a suitable amount of time to spend on the questions. One hour were reserved for a whole interview session, including unrecorded pre-interview introduction and going through the reasons why these interviews are conducted, followed by post-interview wrap up where the interviewees were asked how they felt about the interview and the subject.

4.4 Case Norway

A series of questions were sent to the representative of Norway´s warehouse in order to get information and user experiences of different boxes in the automated warehouse. In addition, questions regarding the Norway case were asked from Finnish workers who have visited and been in training at the Norway´s warehouse.

Plastic totes are by many considered cheaper regarding life time costs, but loss of boxes, cleaning, return transport and handling, and administration are often underestimated. There were some minor problems with cardboard boxes when the operations started at the automated warehouse, most of which were caused by humidity. However, there has not been any major problems or delays related purely to cardboard boxes. There is a number of plastic crates going through the warehouse and it can be seen that they are much more stable and can support much more weight. The most noticeable improvement with plastic totes could be with heavy fruit and vegetable units.

4.5 Case oranges from Spain

Due to size of the plastic crates, the amount of products that can be shipped in a pallet is reduced. Taking an example case of importing oranges from Spain, for now with cardboard boxes, the company is able to move 64 crates of oranges in a pallet. However, with the plastic crates the amount is reduced to 60 crates. Thus to import the same amount of products, more shipments must be made which increases the transportation costs. If that amount is analyzed with price by weight, since with every shipment the company loses four crates which totals to amount in kilos. By calculating the cost per kilo and converting it straight to price it means that by using plastic crates the inbound procurement price would rise around two cents per kilo.

4.6 Pooling companies

Pooling means providing an amount of products into circulation within the organization for amount of money deposit, which depends on the volume of units and their circulation speed.

Small interviews are conducted with representatives of two possible plastic crate pooling companies in order to find out their basic operations and to compare the products and services they provide.

4.6.1 IFCO Systems

IFCO could provide green plastic crates in two different base size: 40cm x 30cm and 60cm x 40cm, they also have possible height variations for each crate size. Benefits that the crates provide are strong structure, which means that it can hold heavy loads, waterproof frame, reduced damages to products, stable in transport and the fact that the crate is reusable and will be washed before each circulation makes it a hygienic solution. In addition, as the crate is foldable, it saves space in return logistics and it can also be effectively used in displays. The crates has a ten year life cycle (Fraunhofer, 2009) and after that they will be granulated and used as a material for new crates. The crates reduces waste at retailer's point of sale compered to one way packaging solutions which have to be disposed.

IFCO provides the following pooling solution for fresh produce. They provide the crates to agreed growers from where the goods are shipped to retail distribution center, from there the goods are forwarded to sales outlets. Used empty crates are returned to distribution center, possibly with other empty trolleys and pallets. From distribution center they are collected, inspected and washed by IFCO. Then the cleaned crates are again sent to growers and the cycle starts again. IFCO has a washing facility in Finland and several in Europe.

Pricing of the IFCO crates varies from country to country, meaning that the crates can be provided cheaper to some locations. A study conducted by Fraunhofer Institute shows that their plastic crate could reduce the packaging damage rate up to 4% along the whole fresh produce supply chain. The study concludes that most of the damage to plastic crates in retail store are due to external reasons whereas one way packaging damages are caused by various reasons such as instability, modular inconsistency, external influences and wrapping. At distribution center and warehouses, the cause of damage is quite similar as plastic crates have been damaged by external influence and wrapping whereas cardboard box damage is mainly caused by instability,

external influences and wrapping. In addition, IFCO has ISO 9001 and HACCP certification.

4.6.2 Euro Pool System (EPS)

Euro pool system (EPS) would provide crates according to the needs of the retailer or grower. They have various height options for 60cm x 40cm and 40cm x 30cm crates. Crates provide benefits such as waterproof frame, can handle heavy loads, reduced damages to products, stable in transport and the fact that the crate is reusable and will be washed before each circulation makes it hygienic decision. It is also mentioned that these crates are optimal for automated warehouse. In addition, as the crate is foldable, it saves space in return logistics and provides good conditions to products with its ventilation holes. Each of their crates have ten year life cycle and are fully recyclable.

EPS has a following pooling cycle: EPS will provide minimum five pallets of empty crates to grower/producer from where the goods are transported to the retail distribution center. From there they are moved to retail outlets from where they are returned to distribution center when empty. Then EPS will pick them up at distribution center and takes them to washing facility. The washed crates are sent to growers when they require another set of crates and the cycle start again. EPS has several washing facilities in Europe and will invest one in Finland if the volume of crates is high enough.

EPS stated that they have same price range for all European destinations and that they will not charge a fee if their crates are damaged during the supply chain, but the crates should be kept safe so that they are not stolen. They also have a study conducted by Fraunhofer which states that their crate could reduce packaging damage rate up to 4% compared to one way packages. In addition, the EPS has ISO 9001 and HACCP certification and BRC standard for packaging and packaging materials.

4.7 Packaging damage rate comparison

If the 4% packaging damage rate is compared to a sample of over 3 million crates imported per year, the 4% reduction in packaging damage rate would add up to approximately 130 thousand crates. If an average price per crate is converted to that four percent, it would mean over 1 million euro savings due to reduced damage rate.

5 RESULT ANALYSIS

Analysis of results is done by thematic analysis in order to find out similarities from the interviews. Similar or same things mentioned by different persons representing different areas is an indication of valid and reliable data for the company. Research questions are compared to the interview data and then the information closely related to the thesis topic are picked from the interview transcript. Then other relevant information are picked from the interview data to see what additional information arise during the interviews. If there are common things mentioned in the interviews, it means that the data gained is more reliable. However, as the interviews are just opinions of the related person about the matter, the answers cannot be straight assumed to be correct. Still, the information can be presented to be relatively reliable if same or similar things are mentioned by persons representing different areas.

5.1 Interviews

After conducting the interviews, in addition to conversations with relevant persons, a clearer picture has formed about the issue. There were couple noticeable similarities in most of the interviews, in fact most of the interviewees said that citrus fruits would be a product group that would benefit from the change the most. Also, everybody agreed that plastic crate is stronger and the fact that it endures humidity is a huge benefit for every area, especially in warehouse. All in all, the topic of changing to plastic crates got a positive feedback from all interviewees. However, one strongly stated that it is a negative thing that the plastic crates are not made in Finland or by Finnish company.

5.1.1 Transportation

The main points from the interview in a summarized manner are as follows. The core process would not change in any way. However, benefits are gained from easier and faster picking, moisture resistance which is a large benefit and also that the plastic box can take harder hits before it brakes. It is hard to say about costs other than return logistics costs would rise a bit, in addition to inbound transportation costs due to increased shipments, but the total cost between cardboard box and plastic crate would not change that much that it would be easily noticeable. In addition, we can only assume what future brings

to costs between cardboard and reusable plastic, but if viewed at this moment, it seems that plastic would be the go to option for transportation and warehouse point of view. It would be much easier for the automation if most of the boxes would be the same profile than if every different cardboard box profile would be added separately to the system.

About the product quality, it can be seen that plastic crate would increase the quality in a sense that air flows much better within the pallet unit, which affects the contamination process decreasingly. There has also been a case that some products have absorbed cardboards smell and taste into itself due to too high amount of reused cardboard fibers in the boxes. There is a regulation for how much a box can have reused fibers but it is extremely hard to tell if a box has too much of those fibers and this would not happen with plastic crates. There are some products that should not be changed to plastic crates from cardboard. However, one product group would benefit the most from the change and it is citrus fruits like oranges, mandarins and grapefruits. In addition, some local products such as carrots and maybe potatoes and other root vegetables could benefit a lot. In addition, there has to be set a geographical line, for example Mediterranean Sea, to where it is reasonable to send those plastic crates, since the cost will be too high to send boxes to USA or South America for example. However, there are few far away locations that would benefit the change, but certainly it is not profitable to change the full volume to plastic crates.

5.1.2 Warehouse

Handling of the plastic crates/totes in automated warehouse is much easier than cardboard boxes because plastic keeps its profile and the stacks would not start to lean during the warehouse time because of humidity. Softened or damaged cardboard boxes, due to humidity or long and harsh transportation, can cause pallet units to lean that much that it will not go through the automation, the limit for leaning pallet units is 50mm, or in a worst case the whole unit can collapse and increase costs as working time, cleaning costs as well as damaged or perished goods. This problem would be minimized with plastic crates/totes. Product quality vise, the plastic crates have better air flow which means that the products keep their freshness better during the warehouse time. There are some products that have caused the most troubles

at the warehouse, which are citrus fruits for example. All in all, from the point of view of warehouse there are no real downsides concerning plastic crates.

5.1.3 Store S (SALE)

From the point of view of small store, the main benefits of plastic crates are that it reduces the amount of waste in stores and that the crates will take less space when folded to trolleys than cardboard boxes. The only way that the plastic crate will be useful is that if the products will be in the same crate from producer to customer, since if the products are moved to plastic crates somewhere in the middle of transportation, it would decrease the product quality. In addition, because there is always someone's money tied up in this kind of situation it depends how the costs are distributed, if the change would affect the price of product increasingly for store or customer, it would mean that the change is not beneficial. However, if the crates are used for display the products it would be much easier to plan and execute neat displays with plastic crates than cardboard boxes, but for small stores there would not be much use, since the space is quite limited for fruits and vegetables. Important for the small stores is that there is option for smaller batch size if the demand is low.

5.1.4 Store L (PRISMA) and M (S-MARKET)

For large and medium sized stores the change could increase the working efficiency at the shop floor and reduce cardboard waste, which again can lead to a future benefit of enabling purchase of smaller and cheaper equipment for cardboard compressing for example. The high cycle speed is important so that there would not be any storage problems for empty crates, pallets, trolleys and other boxes. Crucial thing is that the products have to come from the producer to end customer in the same box, since extra handling or changing the box during the transportation will decrease the quality of the product.

Plastic crates could be beneficial for products such as citrus fruits, cucumbers and cabbages for example. In addition, some seasonal high demand products could benefit from plastic crates. Also the capability to form stable stacks from plastic crates is useful for store as it is for all parts of the supply chain. However, if the products start to increasingly come as more than 2m high single pallet, it would make it harder for the shop floor worker to make it low

enough so that it can be displayed. In addition, if the products which are in plastic crates are somehow more expensive to purchase for stores and then for customers, it would not make sense to buy those. After all, it can be seen that the most benefits are gained for transportation and warehouse, the benefits are somewhat minor from the point of view of the store. However it is still positive change if the cost level remains the same or decreases.

5.1.5 Shop floor worker interviews

The fact that plastic endures humidity is beneficial, since sometimes the cardboard boxes are so soft that they cannot be displayed. Otherwise, there would not be much of a difference between cardboard boxes and plastic crates from the point of view shop floor worker. However, mentioned by one worker, it is really negative thing if the plastic crates are not made in Finland or by Finnish company, because at this time we all should try to support Finnish economy.

5.2 Pooling companies

Two mentioned companies have quite similar products that they can offer and both have the similar kind of pooling cycle where the company takes care of all transportation other than the transportation between retail distribution center and retail outlet. The main difference between the pooling companies is their pricing strategy. IFCO has prices varying from country to country as EPS has the same price for the whole Europe for example. Based on the information available, a company cannot be preferred over other. However, since the actual costs could not be analyzed in this thesis there can be differences that could lead to one company being more suitable option. During the interviews both companies were eager to give necessary information and were really interested about the possible co-operation with the commissioner company. Especially EPS sees Finland as potential country to spread its operations.

5.3 Cost calculations

Based on a study made for SOK, as can be seen in Table 2, that moving from cardboard boxes to reusable plastic crates the estimated savings could be up to 1mlj euro/year for automated warehouse. The savings are combined from cleaning costs, working hour lost and the waste caused due failed packages.

In addition, the benefits that plastic crates bring with automated system can be between 150 thousand and 200 thousand euro/year.

The increased cost for transportation are related to return logistics and the additional handling of the crates. Their combined costs move between 110 thousand and 150 thousand euro/year. As plastic crates occupies a bit more space in the transportation, the amount of extra loads needed is ranging between 25 and 1 and is based on x% volume of the fruit and vegetable products, this adds up to 200 thousand euro/year as extra transportation cost divided by top eight countries. In addition the estimation of approximate increase of costs by using plastic crates instead of cardboard boxes is around 500 thousand and 600 thousand euro/year more. It can be seen that benefits for warehouse out weights the increased costs for transportation. Based on these estimations the approximate savings per year could be around 250 thousand when using reusable plastic crates.

	Warehouse	Transportation	Plastic crate costs
	-200 000	+150 000	+600 000
	-1 000 000	+200 000	
Total	-1 200 000	+350 000	+600 000
Total savings	250 000 euro/year		

Table 2. Cost calculations

5.4 Benefit scoreboard

Benefits that arise during the analysis of the interviews reveal that plastic crates provide the most benefits and the least negative impact for warehouse. It can also be seen that some products would have beneficial impact on their quality. An example of such products would be citrus fruits. However, some products might require extra softening packaging to keep the product quality as it is during the logistics process. An example of such products would be apples. There are also some products that would suffer from the change to plastic crates. An example of such products are low demand products and products that come from far away locations, as the costs would be increased too much. For transportation the costs would increase, but then again the empty crates would add value to return logistics and provide more stable pallet units. Store benefits for cost-wise could be reached in the future, but for

now there would not be that much of a difference except the fact that the plastic crates will not suffer from humidity and could be used more efficiently in displays.

Commissioner has given weights for the effects that are found with during the analysis of results. As shown in Table 3, the biggest weight (40%) is given on benefits for the warehouse, second is product quality (20%), then the effects on costs (15%), after that comes benefits for transportation and store (10%) and last the reduction of cardboard waste (5%)

Criteria	Weight	Plastic	Cardboard
Product quality	0.2	(Positive) -Air flow -Strong -Humidity does not affect the quality decreasingly	(Neutral/Negative) -Bending -Humidity weakens the quality
Benefits for transportation	0.1	(Neutral) -Easier handling	(Neutral) -Lighter
Benefits for warehouse	0.4	(Positive) -Easier handling -Possible cost reductions	(Neutral) -Can cause problems due humidity
Benefits for store	0.1	(Neutral) -Possible future benefits -Could increase working efficiency	(Neutral) -Problems with humidity
Reduction of cardboard waste	0.05	(Positive)	(Negative)
Costs	0.15	(Neutral/Negative) -Increase transportation	(Neutral) -Cheaper -Recycling

		costs	
		-Possibly decrease warehouse costs	
		-More expensive to purchase	
		-Long lifecycle	

Table 3. Weighted effects

6 CONCLUSION

Based on the findings it can be recommended for SOK to negotiate a possible deal based on the official offer from the pooling companies, for a problem percentage of fruit and vegetable volume to be moved to plastic crates in order to enable the benefits for the warehouse. New calculations about the effects of the change should be done with the whole life cycle in mind.

As a conclusion, it can be said that the most benefits from the change from cardboard box to reusable plastic crate are gained in the automated warehouse, as the benefits seem to be the largest in money as well as utility. Transportation wise the effects are more mixed, as the change would increase the costs and have minor benefits for handling. These results can be seen as answer for the research question: How does the change from cardboard box to plastic crate affect material handling in the supply chain? The change will affect positively the material handling in the warehouse as well as in transportation. However, the change would increase costs in transportation, but on the other hand could largely decrease costs in warehouse.

The answer for the research question: What impacts on costs would the change from cardboard box to plastic crate have? Can be seen from the previous sentence as the change would increase costs in transportation but decrease them in warehouse. The possible savings at the warehouse would out weight the increased costs in transportation. At the store point of view the change would not affect the current costs noticeably. However, future benefits that relate to costs could be cheaper equipment purchases. Answer for the research question: How does the change from cardboard box to plastic crate affect quality? Can be seen during the whole supply chain as due to the better air flow and the fact that humidity will not decrease the quality of the plastic

crate will have positive effect on product quality. In addition, the strength of the plastic as a material will decrease packaging damages and thus also decreases damages to products. However, since plastic is harder material and do not bend the same way as cardboard, some products such as apples would require extra softening material to prevent bruising during the logistics chain. Research question: How the change from cardboard box to plastic crate will affect stores? Can be answered so that it would not affect much for now, other than possible increased working performance and reduced cardboard waste. In the future the change could lead to monetary benefits due to cheaper equipment purchases.

Products that could benefits the most from the change to plastic crates, based on the interviews, are citrus fruits like: oranges, mandarins, clementine and grapefruits. Also vegetables like: cabbages, cauliflowers, broccolis and cucumbers. Mentioned products are usually quite heavy and problems with cardboard boxes and humidity are common. Thus these belong to a risk group that could cause problems in the automated warehouse. By moving the risk products, which can also be seen as particular percentage of fruits and vegetables, to plastic crates the possible problems in the warehouse can be minimized.

For a future research on the matter, a larger sample size would increase reliability of the results gained. In addition, the angle of sustainability and environmental effect should be analyzed in order to have better view on the overall impact of the change during the whole life cycle.

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Appendix 1

List of Tables