

Reduced Food Waste By The Use Of Dynamic Shelf Life Sensor Technology?

- The case of milk and a RFID time- and temperature sensor

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Abstract

Title: Reduced Food Waste By The Use Of Dynamic Shelf Life Sensor Technology?
- The case of milk and a RFID time- and temperature sensor

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Issue of study: Food waste is a societal, economic and environmental problem that is commonly mentioned in media. It occurs throughout the whole supply chain, from the producers to the consumers. Researches mentions different ways to solve the food waste problem and one project, DYNAHMAT, focus on reducing food waste through a dynamic shelf life sensor. However, there exist few researches on potentials and barriers regarding reducing food waste with a dynamic shelf life sensor. There are also few researches on potentials and barriers for a dynamic shelf life sensor implementation.

Aim: The study aims at explore potentials and barriers for reducing the food waste in the supply chain by means of a dynamic shelf life sensor; on one hand for the total supply chain, on the other hand for each individual actor along the supply chain.

Methodology: An exploratory study with a case study approach. Data have been collected to understand the product's supply chain, and to find potentials and barriers with the dynamic shelf life sensor implementation. The collected data have been analysed with the chosen frame of reference.

Conclusions: The studied product's food waste mainly occurs at the consumer stage and that is where the dynamic shelf life sensor could have the greatest impact regarding food waste. The supply chain actors have to make different trade-offs to reach win-win situation with the dynamic shelf life implantation.

Key words: Food waste, food waste reduction, dynamic shelf life technology, RFID sensors and supply chain management.

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Preface

This master thesis has been written during the last semester of the master programme Technology Management at Lund University.

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We would like to thank all the interviewees and other persons that we had contact with throughout the study, without you this thesis could not have been done.

We have had both ups and downs but this thesis is characterized by a truly fun and fruitful time of our life.

Thank you!

Lund 2014-05-09

Caroline Lilja and Caroline Sjödah

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1 Introduction

This chapter aims to give a short introduction to food waste and the problem regarding food waste. Further on, are the problem description, aim, focus and objectives presented. The chapter ends with an outline of the study.

1.1 Food Waste Introduction

According to the European Commission's press release in October 2013, 90 million tonnes of food is wasted annually in Europe, and approximately one million tons of food waste is produced annually in the Swedish food chain. Almost one third of the purchased food goes to food waste globally whereof in Sweden, two-thirds still have good quality (European Commission, n.d.; European Commission, 2013; Jordbruksverket, 2011; Naturvårdsverket, 2013b).

Food waste occurs throughout the whole food supply chain; from the agricultural stage, through producers, distributors and retailers to the consumer level. Today is food waste reduction and an increase in resource utilization a prioritised field in many industrialized countries, as well as in Sweden (European Commission, n.d.; Naturvårdsverket, 2014b). An example of this is that the Swedish Environmental Protection Agency suggests milestones in order to decrease the food waste. Their suggestion is a 20 % decrease of food waste in Sweden until year 2020 (Naturvårdsverket, 2014a).

1.1.1 The Food Waste Problem

There are several problems related to food waste, e.g. societal, economic and environmental related problems. Firstly, it is a moral issue to waste food in the industrial countries when other parts of the world are starving (Stuart, 2009). Another problem is that the earth's resources are limited and should be used carefully (Ridoutt, Juliano, Sanguansri, & Sellahewa, 2010; Steinfeldt, Gerber, Wassenaar, Castel, Rosales, & de Haan, 2006). Also, financial resources are being wasted when the produced food is not used for consumption (Buzby, Hyman, Stewart, & Wells, 2011; Naturvårdsverket, 2011; WRAP, 2007; WRAP, 2010).

The Swedish Environmental Protection Agency states that the 20 % food waste decrease mentioned in the food waste introduction, would give Sweden a socioeconomic yearly saving of SEK 10 to 16 billion (Naturvårdsverket, 2013a; Naturvårdsverket, 2013b). In addition from these society- and economic issues, food waste also has an impact on the environment, and in Sweden approximately 3 % of the Swedish greenhouse gas emissions derive from food waste (Naturvårdsverket, 2014b).

Food waste is a problem in the whole supply chain and most of the food waste occurs at the consumer level. The Swedish Board of Agriculture has illustrated an

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example on how consumer's food waste impact the society, economy and environment (Jordbruksverket, 2011). This is illustrated in Figure 1.

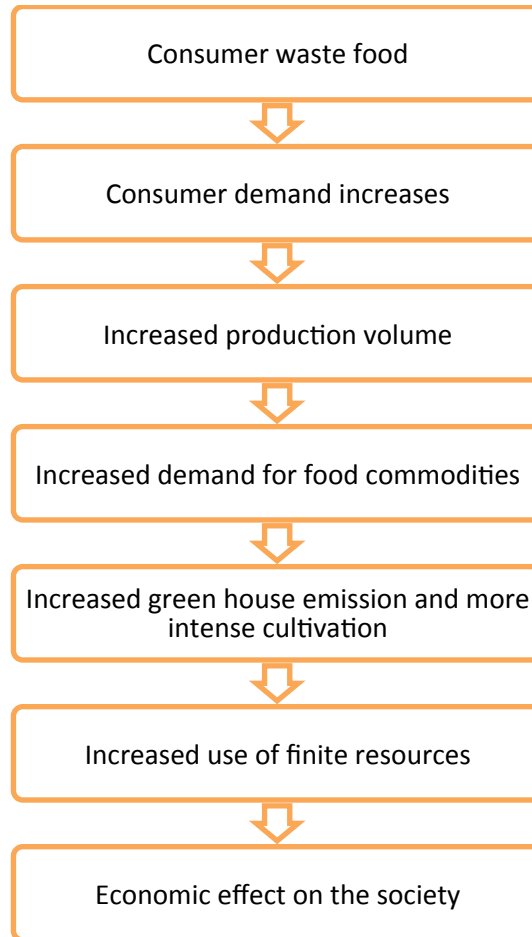


Figure 1. Consequences of consumer's food waste (Jordbruksverket, 2011)

1.1.2 Definition of Food Waste

Stockholm Consumer Cooperative Society distinguishes food waste into unavoidable- and unnecessary food waste. Unavoidable food waste is food that cannot be eaten, such as teabags and banana peel. Unnecessary food waste is food that can be consumed, but for some reason is not, such as crusts of bread or apple peel (Konsumentföreningen Stockholm, 2009).

The Swedish Environmental Protection Agency also divides food waste into two different types of food waste that are similar to the Stockholm Consumer Cooperative Society's definition. The Swedish Environmental Protection Agency mentions food waste as both avoidable food waste and inedible food waste. Avoidable food waste is food that could have been consumed if it was handled differently (Naturvårdsverket, 2013b).

This study will focus on the avoidable and unnecessary food waste and defines avoidable food waste as the Swedish Environmental Protection Agency and unnecessary food waste as Stockholm Consumer Cooperation Society. This study also includes food waste being poured down the sink or being rinsed out its package, such as milk and cream (Svensk Miljöemissionsdata, 2011). From now on when only mentioning food waste, it is referred to avoidable and unnecessary food waste.

1.1.3 Food Waste Reasons in the Supply Chain

As mentioned earlier food waste occurs throughout the whole supply chain, and there are several reasons behind it. In the agricultural food waste are caused by, for instance, bad weather conditions and insufficient treatment. Another reason mentioned in UK studies is that lots of food is thrown away during harvesting and production since their appearance and size do not meet the markets requirements and standards (Institution of Mechanical Engineers, 2013). Food waste at the production site occurs because of e.g. overproduction and stock management inefficiencies (European Commission, n.d.; Naturvårdsverket, 2013b).

The Swedish Environmental Protection Agency mentions that it is important to have a supply chain perspective when identifying where food wastes occur. The reason for this is because food waste may have its main source in another part of the supply chain. This means that it gets visible and measurable at another actor than the one that causes the food waste. An example of this is food waste that occurs from date rejections, due to expired shelf life. Date rejections can occur when the producing company do not have the opportunity to decrease its ordered amount of raw material. For example, when the customers demand were lower than expected. This leads to overproduction because the producing company cannot sell all their produced products since they are not able to decrease their ordered amount. Another example of date rejection is food waste that occurs from lack of information regarding a competing company's promotion, which will lead to unsold products and food waste (Naturvårdsverket, 2013b). These are examples on food waste causes and to be able to avoid them a successful supply chain is needed, but that can be difficult to accomplish since many supply chains do not have a supply chain perspective today (Naturvårdsverket, 2013b).

Food waste that occurs at the consumers is mainly due to expiration of the shelf life date, lack of knowledge and overestimated needs. In Sweden approximately 33 % of the consumers agreed that the expiration of the "best before" date is a main reason for their food waste (Konsumentföreningen Stockholm, 2009). "Best before" is the most common label and it is a recommendation date made by the producer. It implies that the product is useful a couple of days more, if it has been stored in right conditions (Konsumentföreningen Stockholm, 2011). The overestimation results in that the food is not consumed before it expires. (European Commission, n.d.; Jordbruksverket, 2011; Konsumentföreningen Stockholm, 2011; Naturvårdsverket, 2013a).

1.1.4 Definition of Cold Supply Chain, Chilled Products and Cold Storage

This study will focus on the cold supply chain and more specifically chilled dairy products. According to the Swedish Freezing Agency (2007) is a cold supply chain defined as the handling, storage and transportation under controlled temperature conditions from harvesting to the sales at the retailer. Further on, are chilled products defined as food that has to be stored under chilled condition, not frozen or deep frozen, to preserve the shelf life (Djupfrysingsbyrån, 2007). Another term often mentioned when reading about cold supply chains are cold storage, and it is defined in Sweden as storage of food under controlled conditions between the temperature of +8°C and the products freezing point (Djupfrysingsbyrån, 2007).

1.1.5 The DYNAHMAT Project

There exist several projects on how to decrease food waste and one project is DYNAHMAT. DYNAHMAT stands for decreased food waste through dynamic shelf life and is an inter-disciplinary industry project. Dynamic shelf life refers to the possibility to change a products shelf life expiration date depending on how the products have been treated throughout the supply chain. The project has chosen to enable with a dynamic shelf life sensor, which could measure the time and temperature. The information from the sensor will be communicated through radio frequency information (RFID) technology. DYNAHMAT took off during 2013 and is financed by VINNOVA, the Swedish Governmental Agency for Innovation Systems (VINNOVA, 2014). The project consists of fourteen companies, a consumer organisation, two industry clusters, nine researchers, and the Swedish food agency (DYNAHMAT, 2013).

The project state that it will bring benefits from economic, environmental and social perspective. The reasons for implementing the dynamic shelf life sensor technology are to lower food waste and help the actors optimise their supply chain throughout collaboration (DYNAHMAT, 2013). DYNAHMAT mainly focuses on chilled food products with high value or high-environmental impact or both (Göransson & Nilsson, 2013). The project has chosen three chilled food segments to begin the implementation of the dynamic shelf life sensor technology with. These focus segments are fish, meat and dairy products (DYNAHMAT, 2013). This study will have its focus on dairy products.

1.2 Problem Description

To meet the Swedish Environmental Protection Agency's goal until year 2020, the avoidable food waste needs to decrease with around one third compared to today's level (Naturvårdsverket, 2014a). In 2011 was the avoidable food waste approximately 224 000 tons and with an estimated value of SEK 2 billions (Naturvårdsverket, 2013b). According to Stockholm Consumer Cooperative Society (2009) 57 % of all food waste is avoidable food waste. Hence, food that could have been used to its main purpose, consumed by humans, becomes food waste instead. This results in e.g. environmental negative impacts and creates economical losses for the society, companies and consumers (Naturvårdsverket, 2011).

Today, the food producers are obligated to put on a printed shelf life expiry date on the products. However, it is difficult for the producers to predict the temperature of the products and if the recommended temperature is maintained throughout the supply chain. Temperature increases often have an impact on the products' shelf life, especially chilled perishable products with short shelf life. If the products are stored in the recommended temperature, they can often be consumed after its printed shelf life best-before date. Hence, some of the avoidable food waste could be reduced since one main reason for food waste is products best-before date (DYNAHMAT, 2013).

To be able to communicate the remaining shelf life of the chilled products, the products' flow throughout the supply chain have to be measured and logged. This means that all the firms within the supply chain needs to be a part of the dynamic shelf life sensor solution if it should be able to achieve its food waste reduction potential (DYNAHMAT, 2013).

Researches have different views on the dynamic shelf life sensor implementations outcome. As mentioned, it could lead to an extended shelf life as a result of a more secure cold supply chain. If it does, some claim that the producer will keep the products a longer time in their storage of finished goods and that they will make their productions batches bigger. Another scenario could be that the extended shelf life will gain the retailers and the consumers the most, given that the producers deliver the products as fast as they do today (Jensen, Båth, & Lindberg, 2013).

Few researches have been made on how the dynamic shelf life sensor technology, which the DYNAHMAT project focuses on, will affect the different actors in the supply chain. There are also few studies on the different potentials and barriers for the supply chain actors to reduce food waste and for a dynamic shelf life sensor implementation. Dairy products are interesting to focus on within the chilled perishable products with short shelf life. This due its high volumes and its sensitivity to temperature change. Especially milk is an interesting dairy product since it is the most commonly bought dairy product.

To contribute with more researches about dynamic shelf life sensors' impact on food waste reduction of chilled dairy food and the supply chain actors this study has come up with aims and objectives. The aims and objectives are answered throughout the study.

1.3 Aim, Focus and Objectives

1.3.1 Aim

The study aims at explore potentials and barriers for reducing the food waste in the supply chain by means of a dynamic shelf life sensor; on one hand for the total supply chain, on the other hand for each actor along the supply chain.

1.3.2 Focus

This study do, due to limited time, only take one chilled dairy product on the Swedish market and its investigated supply chain into consideration. The investigated supply chain contains of data collection from two dairy companies, two retailers, a consumer expert and researches. The investigated supply chain is more described in section 2.2. To decide which dairy product to map did the authors conduct interviews and read reports regarding chilled dairy products and its food waste. During the interviews the authors questioned what product or products in the investigated dairy supply chain the interviewee thought would be a good product to gain deeper understanding about. Milk was the most frequent answer and other products mentioned were e.g. whipped cream and soured milk. The actors were most interested of milk since it is the chilled dairy product with largest volumes and with short shelf life. Since the actors in the supply chain were most interested of milk, the authors made the decision to use milk as the study's case product. Therefore, the study's objectives are based on the chosen product, milk. The product decision is more described in chapter two, Methodology, in section 2.3.1.

Further on, the studied product's supply chain consists of three actors; the dairy companies, the retailers and the consumers. Due to limited time, this study excludes other types of customers such as industrial kitchens, and only focuses on the investigated supply chain.

This study focuses on a dynamic shelf life sensor implementation, which assumes that it is possible to use a dynamic shelf life sensor as the shelf life expiry date instead of today's the printed shelf life. The legal aspects are therefor not taken into account.

The dynamic shelf life sensor technology is based on the RFID sensor technology. The sensor measure time- and temperature and communicates the information through RFID technology. Since the RFID sensor technology is not fully applicable on chilled food products today, is it difficult to know the exact financial costs and technical devises related to the dynamic shelf life implementation. Hence, this study does not focus on the financial costs or technical devices related to the dynamic shelf life implementation.

1.3.3 Objectives

Based on this study's aim and choice of focus, this study has following objectives:

1. Presenting dynamic shelf life sensor technology in general and especially the RFID-based time- and temperature technology.
2. Mapping of the investigated milk supply chain and its food waste: where, how much and why?
3. Identifying potentials for milk's food waste reduction in the milk supply chain by using the RFID-based time- and temperature technology.
4. Identifying barriers for milk's food waste reduction in the milk supply chain by using the RFID-based time- and temperature technology.
5. Identifying and discussing business consequences of implementing the RFID-based time- and temperature technology in the milk's mapped supply chain.

Throughout the study are the more general term dynamic shelf life sensor used, and it includes the RFID time- and temperature sensor mentioned in the objectives.

1.4 Outline of Study

Chapter 1- Introduction	<ul style="list-style-type: none">•Introduction of food waste•Problem description•Aim and objectives•Outline of this study
Chapter 2- Method	<ul style="list-style-type: none">•Methodical Approach•Working process
Chapter 3- Frame of Reference	<ul style="list-style-type: none">•Supply Chain Management•Sales Strategies•Corporate Social Responsibility
Chapter 4- Dynamic Shelf Life	<ul style="list-style-type: none">•Presenting the Sensor Technology•Previous and Ongoing Projects•This Study's Dynamic Shelf Life Sensor
Chapter 5- Mapping of Waste	<ul style="list-style-type: none">•At Dairy Companies•At Retailers•At Consumers
Chapter 6- Potentials and Barriers	<ul style="list-style-type: none">•Regarding Food Waste Reduction•Regarding a Dynamic Shelf Life Sensor
Chapter 7- Analysis	<ul style="list-style-type: none">•Analysis Of Business Facts and Consequences
Chapter 8-Conclusions and Final Remark	<ul style="list-style-type: none">•Result•Generalizability•The Authors Thoughts•Criticism to this study and Further Research

Figure 2. Outline of study

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This study's outline is shown in Figure 2. The first introduction chapter aims to give a short introduction to the study and the chapters latter part consists of the problem description, aims and objectives. Finally, delimitations are displayed.

In the method, the chosen method approaches and working process is presented. The decisions and used tools are discussed and described, for example what product to follow and how data were collected. This chapter also includes a discussion about the study's credibility.

Chapter three includes the frame of reference. In this part the theories and previous reports within supply chain management, sales strategies and corporate social responsibility are presented.

Chapter four, five and six aims to answer objective number one, two, three and four. Firstly, on in chapter four are different technologies presented, as well as previous and on-going projects within the dynamic shelf life sensor technology. The chapter ends with an explanation of this study's dynamic shelf life sensor. After this chapter, objective two regarding the dynamic shelf life sensor will be answered. Chapter five consists of a mapping of the product, and find where, why and how much waste that occur throughout the investigated supply chain. In chapter six are potentials and barriers regarding food waste reduction and a dynamic shelf life sensor implementation presented based on collected data. This chapter aims to clarify each supply chain actors potential and barriers and aims to answer objective number four.

An analysis based on the frame of reference and collected data from chapter four, five and six is made in chapter seven, and the chapter aims to answer objective number five. During the chapter the business consequences are analysed and presented.

Chapter eight consists of results and authors thought. In this chapter is this study's generalizability and criticism to the study also discussed. The chapter ends with proposals for further studies.

2 Methodology

This chapter aims to describe the methodology in this study. The chapter starts with methodological approaches and chosen research strategies. Further on, is the study's working process presented and explained. The chapter ends with the credibility of this study.

2.1 Methodical Approaches Used in This Study

This study is an exploratory study, since it aims to gain deeper understanding of a problem and a concept (Sounders, Lewis, & Thornhill, 2007). The problem is food waste in the investigated supply chain, and the concept is the dynamic shelf life sensor. When using this research method it is important to be flexible since new data is collected throughout the study (Sounders et al., 2007).

To enable the study's aim and objectives a research strategy is needed. There exist several strategies to choose between for exploratory studies, such as case studies or surveys. The difference between the two research strategies is that the case study consists of qualitative data and surveys of quantitative data (Sounders et al., 2007). This study researches food waste in the product's supply chain and aims at increase the understanding about a dynamic shelf life sensor implementation, and has therefore chosen the case study strategy. A reason for choosing a case study strategy is since few units are researched more deeply regarding what is happening in those units when a concept is developing (Jacobsen, 2002). The advantages of case studies are that they often comprise many details and increase knowledge. Since only one case is involved, a dairy product's supply chain, it is difficult to draw any general conclusions. The generalizability is a common disadvantage among case studies (Yin, 2009).

Case studies usually accommodate a variety of data sources, which leads to deeper empirical descriptions (Eisenhardt & Graebner, 2007; Yin, 2009). Common data collection methods include; observations, interviews and documentary analysis, and they are often used in combination (Eisenhardt & Graebner, 2007; Sounders et al., 2007). This study's data collection consists of interviews, observations and literature searches. When collecting data it is important to be aware of the study's aim and objective to ensure that the data collection will accomplish them (Sounders et al., 2007).

2.2 Case Study Design

This study has a single-case design with a holistic view, which contains of a case context and a case (Yin, 2009). The case context is the Swedish food industry, and the case is the investigated supply chain. The investigated supply chain is primarily based on data from two dairy companies, two retailers, one consumer expert and

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researches. In 2012, the two dairy companies had around 76 % market share of the Swedish milk deliveries (Jorsbruksverket, 2012) The retailer had approximately 7,3 % of the Swedish six largest general dealers in 2013 (Delfi, DLF and Fri Köpenskap, 2013). The investigated supply chain is based on data availability.

This study's supply chain starts when the milk meets the package, because most of the waste occurs in the later part of the supply chain. The supply chain ends when the consumer throws the package away. The authors thought it was important to include the consumers since reports showed that the majority of food waste occurs at consumer level (Jordbruksverket, 2011). The investigated supply chain consists of three steps, shown in Figure 3.

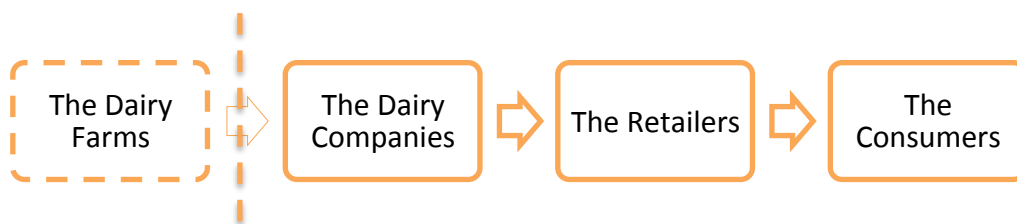


Figure 3. This study's supply chain actors

This study focuses on one product and its package, and what impact a dynamic shelf life sensor could have on the supply chains actors. The dynamic shelf life sensor is placed on each milk package since most of the food waste occurs at the consumer level.

2.3 Data Collection

The data collection methods used in this study is described in this section, and the used methods are interviews, observations and literature search. This section is followed by a presentation of the working process in this study. In the working process is it described when the authors used the data collection methods and for what reason.

2.3.1 Interviews

There are different structures on interviews and the authors conducted unstructured- and semi-structured interviews. Interviews were chosen since it is seen as primary data and it contributes with relevant information for the study, since the focus is the study's aim and objectives (Björklund & Paulsson, 2010; Eisenhardt & Graebner, 2007). The authors conducted through interviews with people that had various knowledge areas within the study's problem and concept. This was done to get a diversified description of the aim and objective (Eisenhardt & Graebner, 2007). In total, the authors did conduct 20 interviews throughout the study. All the interviews were about one hour long, and both of the authors attended at the interviews to get more objective impression of the answers. The interviewee's answers were noted by one of the authors and some of interviews were recorded and transcribed. The interviews were time consuming; but the

authors thought it was worth it due to the focus on the interviewees' knowledge within the study's objectives.

The authors conducted un-structured interviews with only a few prepared themes. In un-structured interviews majority of the questions are based on the situation and previous answers (Jacobsen, 2002). During the un-structured interviews the authors got much information; however not all did contribute to the final report. Even though it did not contribute to the final report it eased the authors understanding for the problem and the concept.

The authors also conducted semi-structured interviews with more prepared questions than the unstructured interviews. Semi-structured interviews enable comparison of the data from the interviews and enable consistency in asking questions (Jacobsen, 2002). During the semi-structured interviews, the authors asked other situational questions.

2.3.2 Observations of the mapped supply chain

To get a deeper understanding of the supply chain and its food waste, the authors made observations. The observations are seen as primary data since they are conducted to get an objective view of the study's aim and objectives. The observations also ensured that the authors understood the written reports and interviews about the product flow correctly (Björklund & Paulsson, 2010). Both authors attended the observations to make sure that both understood the product's flow. During the observations, the authors asked questions to confirm their thoughts and improve their understanding (Sounders et al., 2007). The observations were time consuming, but a necessity for the authors to acquire knowledge about the setup of the supply chain.

2.3.3 Literature Search

A literature search was chosen to get an overview over the study's problem and the concept, in a not time consuming way. The authors searched for information at LUBSearch, Google scholar and written reports by e.g. Sweden's National food agency. The keywords used in the literature search were; food waste, food waste reduction, dynamic shelf life technology, RFID sensors and supply chain management.

Since literature searches are secondary data, and it is often written in other purposes, the authors tried to question the material to make sure it was relevant to this study (Björklund & Paulsson, 2010; Sounders et al., 2007).

2.4 Working Process

This study had six major working steps in its working process: product decision and building a frame of reference, present the dynamic shelf life sensor and its technology, mapping of the product's flow, the dynamic shelf life sensor's potential and barriers, the dynamic shelf life sensor's business consequences in the supply chain and discussion, results and generalizability. The working process's aim was to fulfil the aims and objectives, and it is shown in Figure 4.

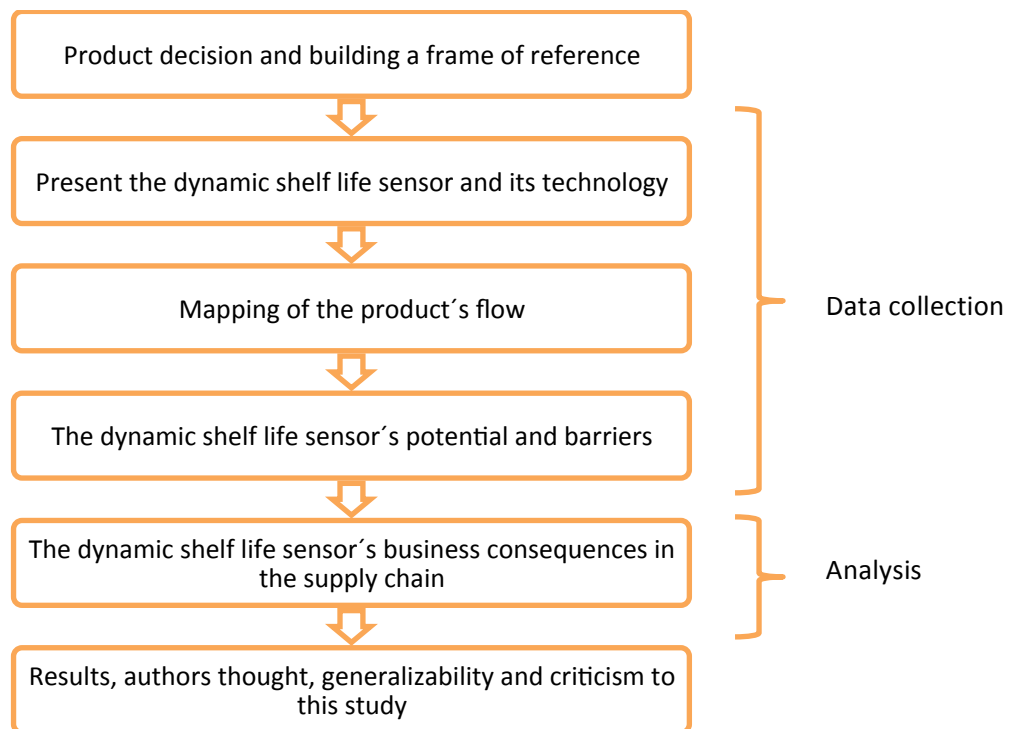


Figure 4. This study's six working process steps

The six working process steps are explained further in this chapter. In all the six steps the decisions taken and its consequences will be displayed. The first working process step was product decision and building a frame of reference.

2.4.1 Product Decision and Building a Frame of Reference

The first step aimed to decide what product to follow and to get a basic understanding that was needed to conduct the frame of reference. How the authors worked in this step is shown in Figure 5.



Figure 5. How the authors decided the product and frame of reference

The authors started to do a literature search to get a basic understanding of previous research about food waste and dynamic shelf life. After the literature search the authors conducted un-structured interviews, which aimed to collect knowledge and information about what product to follow, food waste and prepare the person for future interviews by informing them about the study.

The un-structured interviews were conducted with people having experience within the areas; market development, environment and food waste. During the initial unstructured interviews, the authors asked what product or products in the dairy supply chain the respondent thought would be a good product to study regarding the dynamic shelf life sensor technology. This was done to know which product that was the most preferable product to begin the dynamic shelf life sensor technology implementation with.

The authors came in contact with the interviewees through the DYNAMAT project and food waste reports, and were chosen based on data accessibility and knowledge. The majority of the interviewees came from companies within dairy products supply chain although some worked at companies and governmental agencies not included in dairy products supply chain, but with knowledge within the subjects. The interviewees also helped the authors to get in contact with other people with knowledge at their company or network.

The dairy products mentioned during the unstructured interviews were listed and the most frequent answer was milk, and therefore the authors decided to study the milk's supply chain. Consequences of the product selection were that the study focused on a high volume product and the authors contacted companies with a connection to milk.

After the un-structured interviews, the authors made another literature search. The literature search gained a deeper knowledge about previous and on-going research on dairy food waste and supply chain management. After the literature search, the frame of reference were decided and conducted. After this first step, a deeper understanding of the dynamic shelf life technology was needed.

2.4.2 Present the Dynamic Shelf Life Sensor and Its Technology

The second step was to describe the dynamic shelf life sensor technology. This was done to get more insight in the dynamic shelf life sensor technology, answer the

study's first objective and to be more prepared before future interviews. To collect the data needed, the authors had un-structured interviews, and they made a literature search.

The un-structured interviews were conducted with an expert within dynamic shelf life sensor technology and a dairy company employee with experience from previous projects within similar sensor technology. The authors came in contact with the expert through the DYNAHMAT project and the dairy company through persons working with food waste at the department Packaging Logistics at the Faculty of Engineering at Lund University.

During the un-structured interviews, the authors also got help from the expert with designing a fictive dynamic shelf life sensor. This was done since the RFID sensor technology exists today, but there is no convenient solution for the packaging material business. Another reason was that the DYNAHMAT project had not defined their final dynamic shelf life sensor. The fictive sensor was used in interviews to have a sensor to proceed from and to ease the understanding. The designed fictive sensor is only an example on what the technology can do. With the prototype sensor, the authors could explain a simplified sensor during the interviews, which facilitated the interviewees understanding and increased the authors' credibility. The authors did not focus on the technical aspects of the sensor; they were more interested in how the sensor technology could affect the supply chain.

The authors also made a literature search to get a deeper understanding of the technology, previous projects and on-going projects within dynamic shelf life sensor technology. The authors may have been affected by the sensor expert regarding what other projects to look at to get an understanding. However, projects mentioned by the sensor expert were also mentioned both on the previous unstructured interviews and in reports found during the literature search.

After this step, a fictive dynamic shelf life sensor had been explained and the authors had written about the dynamic shelf life sensor technology and previous and on-going projects within the dynamic shelf life sensor technology.

2.4.3 Mapping of the Product's Flow

The third step in the working process was to map the product's flow to get knowledge about where, how much and why waste occurs. According to the Swedish Environmental Protection Agency (2013b) mapping is a good way to find out where in the supply chain waste occur.

The mapping was done through un-structured interviews, observations and a literature search to get a complete understanding of the products flow. In this process step the authors came in contact with the interviewees through the DYNAHMAT project and persons working with food waste at the department Packaging Logistics at the Faculty of Engineering at Lund University. The interviewees were based on data availability, and that they had knowledge about

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milk and food waste. This study's supply chain actors and data collection methods during the mapping are shown in Figure 6.

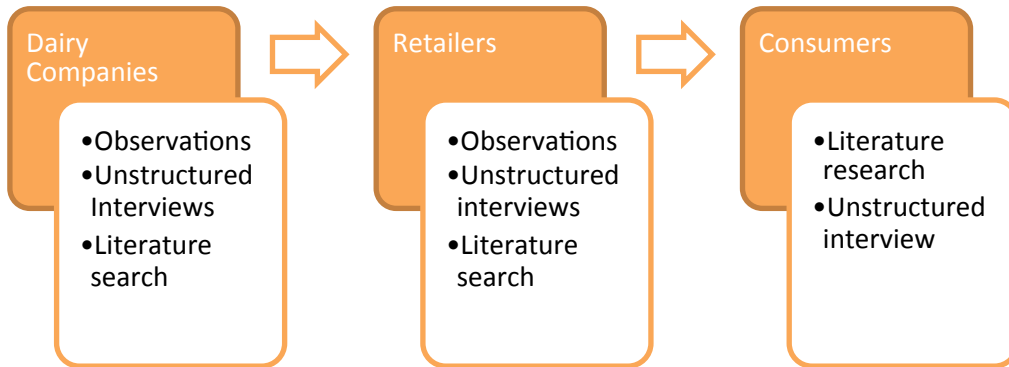


Figure 6. The study's supply chain and the authors' data collection methods during the mapping of the product's flow.

The un-structured interviews were conducted with representatives from two dairy companies, one retailer and one consumer society. The authors also had interviews with a representative from a distribution company, even though the dairy companies are responsible for the distribution in the chosen supply chain. This was done to get a more complete view.

The observations were made at one of the above-mentioned dairy company and the above-mentioned retailer. During the observations, the authors walked the product's flow together with people working at the company and the authors asked interview questions at the same time. All the major actors along the milk's investigated flow and the data collection methods are shown in Figure 5. The amount of food waste was described in percentage since that was the available data from the interviews and reports.

After the mapping of the product's flow, the authors had more understanding about the studied supply chain and the second objective regarding mapping the milk's flow were answered. The authors also had a basic understanding for what effect a dynamic shelf life sensor could have in the supply chain.

2.4.4 The Dynamic Shelf Life Sensor's Potential and Barriers

The fourth step in the working process was to gain understanding about the dynamic shelf life sensor's potential and barriers in the milk's supply chain, both regarding food waste reduction and implementation. To get more understanding, the authors conducted semi-structured interviews. To understand the different potentials and barriers with a dynamic shelf life sensor along the supply chain the authors carried through semi-structured interviews based on the business model named Business Model Canvas. Osterwalders' Business Model Canvas were used as a base for the interview guideline since the authors thought it covered many important areas and is commonly used (Osterwalder & Pigneur, 2010). The business model consists of

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nine blocks that cover four major areas: customers, offer, infrastructure and financial viability (Osterwalder & Pigneur, 2010). The authors searched for different business model and chose Business Model Canvas since they found it simple to understand, due to the nine blocks.

The semi-structured interviews were conducted with people working at companies along the product's supply chain. The authors conducted semi-structured interviews with representatives from two dairy companies, two retailer companies and one consumer society. The dairy companies were the same companies that got interviewed during the mapping. However, one additional retailer was interviewed to get more understanding. The second retailer company that also got interviewed had approximately 50 % of the market when looking at the Swedish six largest general dealers in 2013 (Delfi, DLF and Fri Köpenskap, 2013).

The semi-structured interviews were also conducted with companies not directly connected to the studied supply chain but with experience in dairy products in order to get a broader perspective on the dairy supply chain. The authors also interviewed people with specific knowledge in food waste and dynamic shelf life technology.

After the semi-structured interviews, the authors combined all data from both the mapping and the data regarding the dynamic shelf life's potential and barriers and put it into a table (Appendix I). This was done to get an understanding over the dynamic shelf life sensors potential and barriers to decrease food waste and the dynamic shelf life's implementation.

2.4.5 The Dynamic Shelf Life Sensor's Business Perspective

The analysis in this study is based on the decided frame of reference and the collected empirical data. Figure 7 explains the procedure.

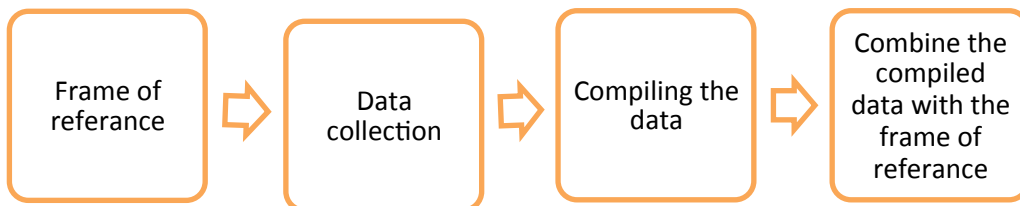


Figure 7. The analysis procedure of finding the dynamic shelf life sensor's business perspective

Based on the collected data throw-out the previous working steps the authors conducted a table that showed how the different actors affect each other with a shelf life implementation. The author divided the data based on their impressions during the interviews and observations.

The authors then combined the conclusions they could draw from the empirical data with the frame of reference (Björklund & Paulsson, 2010; Saunders et al., 2007). The analysis is often based on the authors own thoughts and to make sure that the

readers are able to draw its own conclusions the authors tried to motivate and describe the analysis made (Björklund & Paulsson, 2010).

2.4.6 Results, Authors Thought, Generalizability and Criticism to This Study

In this last part of the study are the authors summarising the results, and its consequences. The authors are having a discussion in the section called the authors thoughts. A discussion is mainly based on the authors' experiences from the study (Björklund & Paulsson, 2010). The discussion was based on the data collection, analysis and other experiences that the authors got throughout the study. It was conducted through a brainstorming where the authors wrote down their thoughts individually on small papers. Then they went through the small papers together, and it turned into the discussion. The study's generalizability and criticism to the study are also discussed in the chapter. The chapter ends with the authors' suggestions on further researches.

2.5 Credibility in This Study

To measure study's credibility, three measures can be used: validity, reliability and objectivity. Validity is described as if the study measures what it is supposed to measure. Reliability refers to if the study's data collection and analysis would be similar if the study were being repeated numerous of times. Objectivity denotes in which level the authors values influence the study (Björklund & Paulsson, 2010). This part ends with criticism of the used sources.

2.5.1 Validity

To ensure high validity the authors collected the primary data together, i.e. both attended the interviews, and in this way the authors helped each other to stay focused on the purpose. The authors also worked with triangulation, i.e. they tried to ensure the statements from more than one person (Sounders et al., 2007). An example of this was that authors often conducted interviews with more than one representative at each company (Eisenhardt & Graebner, 2007). The authors did also use more than one data collection method in most cases to get a fair view of the aim and objectives (Sounders et al., 2007).

2.5.2 Reliability

To increase reliability the interviews had the same structure, with background explanations and questions. Control questions were also asked during the interviews and triangulations were done when it was possible (Björklund & Paulsson, 2010; Sounders et al., 2007). To increase the reliability, the authors tried to conduct interviews with more than one employee to decrease the subjective approach to the study's problem and concept (Sounders et al., 2007).

2.5.3 Objectivity

One way to increase study's objectivity is to explain all decisions and assumptions (Björklund & Paulsson, 2010). To increase the objectivity in this study the authors have tried to explain all the decisions made in this chapter's working process.

3 Frame of Reference

The frame of reference consists of supply chain management theories, corporate social responsibility and creating shared value. The frame of reference is built on a literature search and are later on analysed with the empirical data.

3.1 Supply Chain Management

Since the mid-1990's researchers within logistics, operation management and marketing have tried to describe supply chain management (Lambert, Garcia-Dastugue, & Croxton, 2005; Mentzer et al., 2001). Today, the supply chain management concept is increasing in attention and it is getting more important and discussed (Lambert & Cooper, 2000). Supply chain management could be described as a systems approach looking at the supply chain as a single entity rather than fragment of actors focusing on its own performance (Christopher, 2011; Ellram & Cooper, 1990; Houlihan, 1988; Tyndall, Gopal, & Partsch, 1998). It is a philosophy aiming to integrate supply chain actors to develop innovative solutions and create customer value by including boundaries of both logistics and other functions within the firms and the supply chain. It is essential to understand the customers' requirement and value in supply chain management and the philosophy drives the members in the supply chain to have a customer orientation (Ellram & Cooper, 1990; Mentzer et al., 2001; Tyndall et al., 1998).

It should be noticed that what have been called supply chain management, as a philosophy is actually supply chain orientation. It is not until the supply chain orientation is implemented across the different actors in the supply chain it is called supply chain management (Mentzer et al., 2001). To summaries it could be seen as a supply chain orientation is the management philosophy and the supply chain management is the actions to realise the philosophy (Mentzer et al., 2001). How they are connected to each other are shown in Figure 8.

3.1.1 Supply Chain Orientation and Supply Chain Management Definitions

There does not exist any worldwide-accepted definition of supply chain management (Naslund & Williamson, 2010). Mentzer et al. (2001) makes the definitions of supply chain orientation and supply chain management as:

Supply chain orientation is defined *"as the recognition by an organization of the systemic, strategic implications of the tactical activities involved in managing the various flows in a supply chain."* (p. 11).

Supply chain management is defined as *"The systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes*

of improving the long-term performance of the individual companies and the supply chain as a whole.” (p. 11).

3.1.2 Characteristics of a Well-Functioned Supply Chain

According to Lee (2004) a top-performing supply chain consists of three important but different qualities. The first quality is that the supply chain needs to be agile and be able to react on sudden changes in the environment. Secondly, the supply chain should adapt over time as strategies and market structures progress. Lastly, the interest should be aligned between all actors in the supply chain and the supply chain should optimize the systems performance when maximizing the firm's interests.

Christopher (2011) describes a successful supply chain as a system that could perform responsiveness, reliability, resilience and relationship in a better way than its competitors. The characteristics Christopher (2011) and Lee (2004) mentions are in line with each other even though they use different terminology. When a supply chain fulfils these characteristics it is a successful supply chain, which could gain sustainable competitive advantage (Christopher, 2011; Lee, 2004). According to Porter (1980) competitive advantage can be either having a cost-leadership or having a focus on differentiation.

As shown in Figure 8, do Mentzer et al. (2001) also mentions consequences such as lower costs and improved customers value and satisfaction. Customers' value and satisfaction are recurring characteristics for creating competitive advantage through a successful supply chain (Giunipero & Brand, 1996; Langley & Holcomb, 1992; Mentzer et al., 2001). Christopher (2011) also mentions customers' value and believes that it could be achieved through using the supply chains capabilities and competencies by managing core processes better than their competitors. Further on, does Christopher (2011) points out the focus on seeking innovative ways to create more value for the customers.

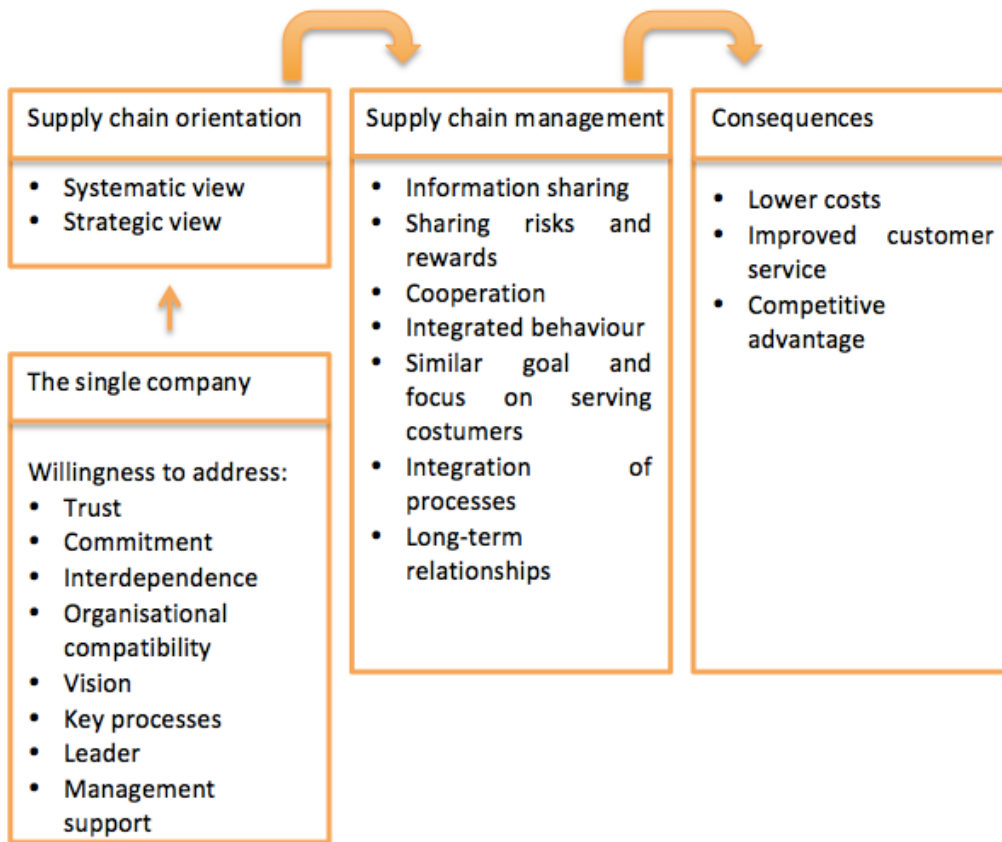


Figure 8. This figure illustrates how supply chain orientation becomes supply chain management, and the consequences of supply chain management (Mentzer et al., 2001)

According to Mentzer (2001) there are seven key activities that need to be fulfilled to create a successful implementation, and when these are fulfilled the characteristics and consequences above have the possibility to be realized. As seen in Figure 8 are these seven key activities; sharing information, sharing risks and rewards, cooperation, integrated behaviour, similar goal and focus on serving customers, integration of processes and partners to build and maintain long-term relationships. Many of the key activities are related to an integrated supply chain, such as information sharing, integrated behaviour, cooperation and integration of processes (Fabbe-Costes & Jahre, 2006; Mentzer et al., 2001).

3.1.3 An Integrated Supply Chain

As mentioned are many of the key activities that Mentzer et al. (2001) mentions related to supply chain integration. The result for a single company will depend on the company's management ability to integrate with the supply chain (Lambert & Cooper, 2000). However, the academia does not have a shared view and definition on the integrated supply chain concept. At the same time, researchers have different views on which levels a supply chain can or should be integrated to (Fabbe-

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Costes & Jahre, 2006). Stevens (1989) is one of many researchers that believe that the integration concept can exist on different levels and three levels are mentioned; the strategic level, the tactical level and the operational level. Fabbe-Costes and Jahre (2006) mentions layers instead of levels, and these levels are flows, processes, systems and actors. The first one, flows, is the most core layer, and it affects the other three. Moreover, flows can be divided into material flows, information flows and financial flows.

The academia mentions these and other features that are needed to create an integrated supply chain. These features are, for example, information sharing and creating win-win situations for all actors.

Create Win-Win Situations for All Actors

An integrated supply chain should create win-win situations for all actors in the supply chain by maximising their own interest at the same time as they optimize the performance of the supply chain. Successful supply chains are those that constant looking for win-win situations for the whole network, based upon mutuality and trust (Christopher, 2011; Lee, 2004; Seidmann & Sundararajan, 1997).

According to Christopher (2011), creating win-win thinking is one of the main challenges when achieving a network- based approach in the supply chain. To manage win-win situations for the supply chain actors there is a need to find a balance between the customers' service level, low inventory investments and low unit costs. If the supply chain is integrated, it could achieve both high service level without having influences on the costs. It is also important that all actors find ways to share risk, costs and rewards of doing business in a fairly distributed way, across the involved actors. However, to accomplish the balance the supply chain have to work with trade-offs. Usually it is the trade-offs that is a challenge since the supply chain actors' focus more on their company instead of having a supply chain focus (Stevens, 1989).

Information Sharing

Information sharing is one of the flows that are included in Fabbe-Costes and Jahre (2006) layers, and it can be seen as a core of supply chain collaborations (Fawcett, Osterhaus, Magnan, Brau, & McCarter, 2007). If the supply chain succeeds with its information sharing, it can lead to a more responsive and agile supply chain (Fabbe-Costes & Jahre, 2006). However, many supply chains do not know what information to share and do not understand how to create a competitive advantage with the shared information (Fawcett et al., 2007). If the firms do not truly understand why they should integrate their supply chain it results in that, they do not share important information and the idea of integration falls (Bagchi & Skjoett-Larsen, 2003). Another challenge related to information sharing is creating an open solution, which often originates from fear that sensitive business information is falling into competitors' hands and lack of trust. The supply chain actors do also see the

creating of IT platforms as a challenge (Bagchi & Skjoett-Larsen, 2003; Christopher, 2011; Lee, So, & Tang, 2000).

When supply chains share information it has, in most cases, impact on the production scheduling, inventory control and delivery plans. It is seen that the order data have higher variance than the actual sales. This could result in e.g. the actors which only focus on order data will be misinformed by the demand pattern and believes the variance is bigger than it is (Lee, Padmanabhan, & Whang, 2004). According to Lee et al. (2000) is it mainly the manufacturer that gains benefits from information sharing, e.g. inventory reduction and cost reduction. The retailers in a supply chain do not obtain any direct benefits from sharing information alone (Lee et al., 2000). This means that manufacturers are the ones who should initiative to the information sharing and give incentive for the retailers to share information e.g. could logistics cost be shared between the two actors (Yu, Yan, & Cheng, 2001).

3.2 The Cold Supply Chains and Chilled Products

As mentioned in the introduction cold supply chains handle, storage and transport products' under controlled temperature conditions. Further on chilled products need to be stored under chilled conditions to preserve the shelf life (Djupfrysningsbyrån, 2007). During the last years the level of sold chilled food products have increased (Naturvårdsverket, 2013a).

Chilled food handling are often challenging for supply chains, due to perishable products, short shelf life and various product selection. Many products are temperature sensitive and it is therefore important to secure e.g. the temperature throughout the whole supply chain (Aung & Chang, 2014; Mena, Adenzo-Diaz, & Yurt, 2011). The cold supply chains complexity increases with the many variants of products, different temperature levels on different products and consumers expectations regarding new product launches (Aung & Chang, 2014; Naturvårdsverket, 2013b).

One challenge for the cold supply chains is found in the interconnections between the supply chain actors. The reasons for this are for instance; the employees' knowledge level, handling procedure and the communication between actors. All these aspects have a big impact on the cold supply chain (Olsson & Skjöldebrand, 2008).

The temperature during the supply chain has an impact on the quality of the products. Lower temperature in the food supply chain has potential to increase the shelf life for chilled products. Longer shelf life as a result of colder storage temperature would probably lead to less food waste, but there are a couple of barriers that need to be overcome before the waste decreases. For example needs the printed shelf life be extended since the product has longer shelf life when it has been kept in lower temperatures otherwise does not the consumer know that the product still is good (Jensen et al., 2013).

3.2.1 Milk - A Chilled Dairy Product

Milk has the tradition on being a basic food product in Sweden, and it has been a source to nutrition since the Stone Age. Today is the milk consumption decreasing, and it has decreased with approximately 30% since the 1980s. Some of the reasons behind the declining are that people are drinking more water and soda and because of peoples change in food habits to dishes with less milk. At the same time have new recipes arisen, such as smoothies and coffee drinks (Arla Foods, n.d.).

Today, Sweden have around 4 500 dairy farmers and 19 dairy companies that yearly produce approximately 2 900 000 tonnes of raw milk, and of these tonnes of raw material are 30 % used for drinking milk. Except milk for drinking use, milk's primary product can also used for other fields of application, e.g. cheese and butter (LRF, 2013). This study is focusing on the drinking milk consumed in households, and further on mentioned as milk. In Table 1 are some fast facts summarised about milk (LRF, 2014).

Table 1. Fast facts about milk (LRF, 2014; Mjölkrämjandet, 2006; Svensk mjölk, 2014)

Fast Facts about Milk	
Recommended storage temperature	+ 8 °C (Mjölkrämjandet, 2006)
How many litres of drinking milk is produced each year?	870 000 tonnes in 2013, whereof 127 000 litres were ecological milk (LRF, 2013)
How many litres are consumed per capita each year?	89,4 litres in 2012 (Svensk mjölk, 2014)
Milk price	
Dairy Companies purchase price	Around SEK 3,3 in 2012 (LRF, 2013)
Consumers price Milk 1,5%, per litre	SEK 8.45 in 2012 SEK 8.59 in 2013 (LRF, 2014)
Consumers price Ecological milk 1,5%, per litre	SEK 10.25 in 2012 SEK 10.15 in 2013 (LRF, 2014)

Milk is a perishable product that has to be kept in cold storage; the recommendation is below eight degrees Celsius. If milk is placed in a room-tempered room, its taste and shelf life will decrease. However, a proper stored milk package, i.e. with no cold breakages, will maintain its taste several days after the printed best-before date (Mjölkrämjandet, 2006; Naturvårdsverket, 2014). In a study by the Swedish National Food Agency the results show that milk is one of the products that can have longer best-before date, which could decrease the food waste (Naturvårdsverket, 2014).

3.3 Prices Depending on Quality

Another aspect to take in consideration when looking at food waste is that today perishables are handled by the first in first out principle independently of the shelf life. This could sometimes be inefficient since the products could be handled in a different way and thereby the shelf life could differ. If it were possible to know the condition of the product, different sales strategies could be used. Since the customers have an expectation on the product that it should be the best class and if it is not perfect they take another piece. If the quality is communicated to the customer they know what they get and do not become disappointed (Oliva & Revetria Diptem, 2008).

3.4 Forecast and the Effect of Not Knowing the Demand

A company's demand is mainly calculated by forecasts. Forecasts are built on statics and historical data, which makes it difficult to know the future demand pattern for a product in the supply chain. The uncertain demand forecast results in that all actors need to have an inventory and safety stock higher than they believe they will sell to guarantee delivery. In each step down the supply chain the variation gets higher which requires even bigger inventory levels than the last actor in the supply chain (Lee et al., 2004). This phenomenon is known as "the bullwhip effect" and could according to Lee et al. (2004) be characterized as demand disrupting. By sharing point-of-sale data and increase the lead-time, the demand disruption could be lowered. In a supply chain with high bullwhip effect the controllability decrease, since it becomes harder to counter the demand disruption (Naturvårdsverket, 2013b).

3.5 Corporate Social Responsibility

Corporate social responsibility (CSR) is a term often mentioned and there exist several definitions on CSR and elements that often are mentioned in articles about CSR are according to Buchholz (1991):

1. Companies are responsible for more than its production of goods and services at a profit
2. The company's responsibility includes helping to solve social problems, and particularly those problems they are creating
3. In overall does a company have a broad constituency compared to only the stockholders
4. Companies have effects and impacts that are broader than marketplace businesses
5. Companies performs a wider range of human values than it is able to be caught by only a focus on economic values

There exist different views on the CSR approach and Schwartz and Saiia (2012) mention two outlines, a broad view of CSR and a more narrowed view. The broad

view's approach believes that the company is obligated to go beyond profit to take their social responsibility, compared to a more narrowed approach by Milton Friedman that believes a company's aim is to maximize its profit (Friedman, 1970; Schwartz & Saiia, 2012). The five elements above focuses on companies' responsibility to go beyond the economic profit maximization and it is a broader view compared to the narrowed views of CSR. In the sections below are the different approaches described shortly.

3.5.1 Potential CSR Effects

There exist different views on companies that work with CSR and its effects, whether it can lead to long-term consumer relationships and financial performance (Gadeikiene & Banyte, 2013; McWilliams & Siegel, 2001). Some argue that the company's CSR initiatives can result in added value for its consumers and the society as a whole (McWilliams & Siegel, 2001). Further on, do researchers say that it is essential to creating sustainable, meaningful and unique value to its consumers to be a successful company (Gadeikiene & Banyte, 2013; McWilliams & Siegel, 2001).

McWilliams and Siegel (2001) define CSR as "actions that appear to further some social good, beyond the interest of the firm and that which is required by law" (McWilliams & Siegel, 2001, s. 117). McWilliams and Siegel (2001) along with other researchers believe that a company's work with CSR can derive from the customers and consumers demand (Jose, Rugimbana, & Gatfield, 2012; McWilliams & Siegel, 2001). Consumer oriented CSR are e.g. when a company is working with pesticide-free products. Then the consumers are indirectly supporting and rewarding the company's work with CSR when they purchase the company's products. McWilliams and Siegel (2001) also believe that CSR based on consumer demand can result in a strengthen reputation regarding quality and reliability, this is especially important, for example, for food products. Other reports, such as one made of CSR Europe is also mentioning the positive effects of CSR on company's brand (CSR Europe, 2008)

There are different key determinants of the consumer demand for products with CSR characteristics these are; marketing to make the consumer aware of the CSR attributes, the product price, consumers' preferences, demographics and the substitute products price (McWilliams & Siegel, 2001).

The first key determinant is marketing aiming to make the consumers aware of the CSR attributes. Today are many companies working with CSR, and they are often using their CSR work in their marketing, as a way to reach their key consumers. This is since their key consumer often values their CSR attributes. Some companies use their CSR work to differentiate themselves. Doing so, it is important to make the consumer aware of the differentiation through marketing, otherwise might the consumer not pay attention to the CSR attributes (CSR Europe, 2008; McWilliams & Siegel, 2001)

McWilliams and Siegel (2001) also mention that consumers' income may have an affect if the consumers will purchase the product with CSR attributes. They see a

pattern that low-income people are more price-sensitive compared to wealthy persons that more easily can pay additional for CSR attributes. They also state that the substitute products price have an effect on if the consumer purchases the product. If there is a significant differentiation in price, the consumer will most likely purchase the product without the CSR attributes. The demand is also affected by other determinates, such as price of substitute products, demographics and preferences.

3.6 Creating Shared Value

Another perspective, when it comes to business strategies, is the shared value concept. The concept can according to Porter and Kramer (2011) be defined as *“policies and operating practices that enhance the competitiveness of a company while simultaneously advancing the economic and social conditions in the communities in which it operates”* (p. 6). The shared value concept has its focus behind the company’s own value creation and short-term financial performance and focuses instead on finding connection between societal and economic progress. The shared value creates innovation and productivity growth in the global economy and gives benefit to the society (Porter & Kramer, 2011).

The shared value concept states that the company should focus on finding the opportunities for a competitive advantage created from building social value proposition into corporate strategy. Furthermore are there a connection between the competitive advantage and social issues. For example, the environmental impact, energy use, employee skills and supplier access and viability have an effect on both a competitive advantage and company’s productivity. By i.e. utilize the energy in a better way gains benefits to both the competitive advantage and the society (Porter & Kramer, 2011).

The difference between CSR and shared value is that the CSR is focusing on doing good, is forced by external actors and separated from profit maximization. The shared value is an internal force and focusing on integrating the social work with a profit (Porter & Kramer, 2011).

4 Dynamic Shelf Life Sensors

This chapter begins with describing smart packaging and two different technologies within smart packaging: the time- and temperature indicators and the radio frequency identification (RFID) sensor technology. After the explanation are two projects presented, one previous project carried through for 15 years ago and one on-going project. This chapter ends with an explanation of the fictive dynamic shelf life sensor.

4.1 Intelligent Packaging

Intelligent packaging, also called smart packaging, is a package that can sense changes in the surroundings and inform users about these changes. It also refers to a package that contains a sensor, which are able to notify if the food is impaired. To be able to sense, the package must contain a special device, this chapter mentions two different devices: external time and temperature indicators and internal radio frequency identification (RFID) sensor technology. Han et al. (2005) points out those important device characteristics are; easy to use, cost effective and be able to handle numerous tasks (Han, Ho, & Rodrique, 2005).

There are different types of devices, e.g. external indicators and internal indicators. External indicators are attached outside the package; examples of these indicators are time-and temperature indicators, TTI: s (Han et al., 2005). The TTI: s are often an etiquette or sticker placed on the product, and its appearance change after time and temperature (Taoukis & Labuza, 1989). The second type, internal indicators, is placed inside the package, for example biosensors, time- and temperature sensors and carbon dioxide indicators (Ahvenainen, 2003). The internal sensors need a communication-tool that can communicate its information to the users. Today is it common with the radio frequency identification technology to communicate the status of the internal indicators (Ruhanen et al., 2008).

Today there are several technologies competing to display shelf life information about the package or product. Two common technologies in cold supply chains are the above-mentioned time- and temperature indicators and the radio frequency identification sensor technology. These technologies are examples of how the internal and external sensors can communicate with their surroundings. Other technologies exist, but they are often more expensive and bigger (Ruhanen et al., 2008).

4.2 Time and Temperature Indicators

As mentioned, a time-and temperature indicator (TTI) is an external device placed outside a package and is able to measure for how long a package has been exposed

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for a certain temperature (Taoukis & Labuza, 1989). TTI: s has been available on the market for over twenty years and it is usually a simple label that indicates the remaining shelf life through a colour scale (Göransson & Nilsson, 2013).

A TTI can be used throughout the whole supply chain and on different product types, such as meat, milk and fish (Lu, Zheng, Lv, & Tang, 2013). It can also be placed on different package levels, e.g. the secondary or primary package. Usually the producer, the distributor and the retailers use it, but it is unusual that the information is shared among the firms within the supply chain, even though it is possible and can result in product quality improvements (Göransson & Nilsson, 2013).

The disadvantage with using TTI: s on chilled packages is that there is a risk that the temperature on the package is not the same as inside the package, which can mislead the actors along the supply chain and consumers (Hydbom, 2014a). However, the interest for TTI: s has increased since the beginning of the 21st century, and today there are several firms working on developing the technology (Göransson & Nilsson, 2013).

4.3 Radio Frequency Identification Sensor Technology

Radio frequency identification (RFID) is a wireless identification system and includes an RFID reader, tags, local software and back-end system. An RFID tag consists of a microchip connected to an antenna that sends data to an RFID reader. All RFID tags have unique identification number, communicated through the reader. There exist several types of RFID tags; active, passive or semi-passive tags, they differ in how to communicate and if they have a power source to the microchip (Ruhanen et al., 2008).

Table 2. Different types of RFID tags (Ruhanen et al., 2008)

Types of RFID tags	Features
Active	Contains a power source e.g. a battery to power the microchip, the tag sends signals to the reader. Can be read from approximately 35 meters.
Passive	Has no power source, the reader gives the tag energy so it can send information
Semi-passive	Has a power source, but the tags do not use it to send information, the information is spread in the same way as a passive RFID tag
Sensor	Can be used in all the three types of RFID tags, it enables signals about the products status, for example temperature

As seen in Table 2, it is possible to combine the RFID technology with sensor tags to collect information, e.g. temperature, pressure, biological growth and humidity (Jung, Yeo, Lee, & Pyo, 2007; Ruhanen et al., 2008). In cold supply chains, an RFID sensor tag can display food's features such as time, location and environmental information (Ruhanen et al., 2008). To have a functioning RFID based sensor system; reliability, data sharing, efficiency and sensor precision is needed (Abad, Nuin, Zárate, Juarros, Gómez, & Marco, 2009). One of the major challenges mentioned in the food industry has been the implementation of the technology into consumer packaging, and one common reason is high costs (NVC, 2012).

4.4 Previous and On-going Initiatives

This study focuses more deeply into two RFID sensor technology projects within food supply chains, the Bioett case and the Pasteur project. The Bioett case was a time-and temperature biosensor-project that started about fifteen years ago in Sweden. The Pasteur project consists of an RFID sensor tag and is an on-going project in Europe. The data collected through interviews and reports written about the projects.

4.4.1 Bioett

Bioett was founded in the end of the 20th century, and it was a time- and temperature biosensor, TTB, solution (Hydbom, 2014a). The sensor measured effect of temperature on enzymatic reactions (Bioett Technologies, 2007). Bioett aimed to ensure the temperature and quality of the goods between the supply chain actors. The Bioett solution included a biosensor tag using a chip-less RFID technology, placed on the goods, a communication device and a database (Aditus Science AB, 2007). The biosensor was read when it passaged a new interconnection in the supply chain and all actors had access to the information (Göransson & Nilsson, 2013). When Bioett's TTB was released on the market the solution was cheaper than many of its competitors and the company got some customers, such as Skånemejerier and

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Findus (Hydbom, 2014a). However, the company struggled with some challenges, e.g. to convince customers that their solution were profitable. At the time, Skånemejerier implemented the TTB on their secondary packages for some of their products. Skånemejerier did, however, not see many advantages with putting a TTB on their secondary packages. The people working with Bioett at Skånemejerier thought it was good, however it did not result in any additional values and the customers, retailers, were not ready to pay extra for the device. Skånemejerier implemented the technology to ensure that they were responsible, and it was an extra temperature control. It was also a benefit that they got an objective view of their business and to guarantee that the retailers got the right products. Skånemejerier used the technology for a while, but the company is not using the technology today (Dairy Company B, 2014a).

Other challenges for Bioett were that many actors in the supply chain were not ready to display their weaknesses, and they were also afraid about the TTB: s impact on the supply chain relationships. At the same time, Bioett's technology, the RFID sensor tag, was not a widespread technology, which lead to high investments due to no available standards (Göransson & Nilsson, 2013). However, today is the RFID technology a wider used technology in e.g. supply chain management (NVC, 2012).

4.4.2 The Pasteur Sensor Tag

The Pasteur sensor tag is developed by an on-going European founded project, named PASTEUR project. It aims to track and display the food's quality and to display the actual remaining shelf life, and the project focuses on meat and fruit products. The Pasteur sensor tag combines RFID with sensors measuring e.g. temperature, humidity and quality. The tag is not attached to each product, but on e.g. containers or tertiary packages, and it responds information about the food freshness status. It intentions is to ease distributors' supply chain planning and optimize the supply chain, and this will minimize food waste (Holst Centre, 2009).

According to Netherlands Packaging Centre, NVC, a packaging association with over 550 company members, all firms along the supply chain will gain from the Pasteur sensor technology. The association mentions producer benefits; it will be easier to be certain about the products quality. The freight forwarder will be beheld that something is not correct regarding the products temperature, which will affect the quality. Further on will the retailers be able to check and control the product quality on the shelves. Lastly, if the sensor tag is placed on each package, the consumer will be able to see the product's quality at home with their cell phone (NVC, 2012).

4.5 This Study's Dynamic Shelf Life Sensor

This study proceeds from a fictive dynamic shelf life sensor, which was used and described during the data collection. The fictive sensor was created through interviews and a literature search. Below is the dynamic shelf life sensor, used in this study, described.

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The dynamic shelf life sensor is placed on every consumer milk package, and it is placed inside the packaging material since the sensor aims to measure the product's temperature (Hydbom, 2014a). The dynamic shelf life sensor is an active RFID sensor, which means that it stores information the whole time to make sure all the information is available. Further on the sensor measuring time and temperature to secure the product's quality regarding the time the product has been exposed to a certain temperature (Hydbom, 2014b). Then an expiring shelf life date is calculated through an algorithm based on the time- and temperature (Båth, 2014). The expiring shelf life date is communicated through RFID readers, and there exist several devices that can be used throughout the supply chain. The consumer uses its cell phone to communicate with the sensor (Hydbom, 2014b). In addition to the expiring shelf life date, the dairy companies gain sales information from the retailers, since they are able to see when the product is leaving the retailers. Figure 9 shows an example of an RFID – system to ease the understanding for the fictive dynamic shelf life sensor used in this study.

Based on the interviews and literature search, the authors assumed that the production cost could be approximately SEK 0.5-0.6 in the beginning. With a volume increase the production cost will decrease to around SEK 0.3. Further on in this study, the described sensor is the dynamic shelf life sensor the authors are referring to when writing *the dynamic shelf life sensor* or *the sensor*.

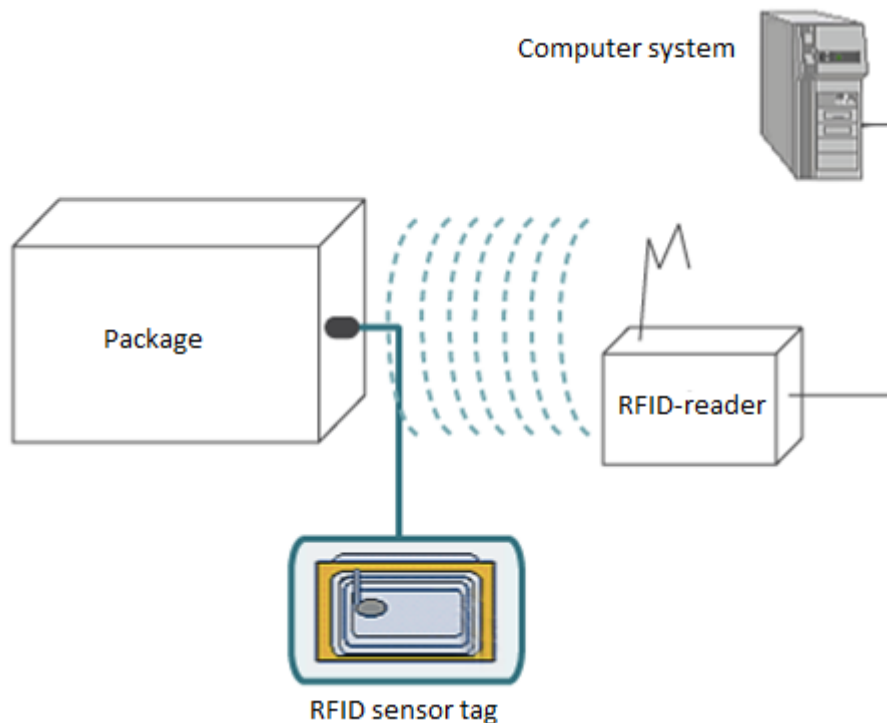


Figure 9. An example of an RFID –system (GS1 Sweden, n.d.)

5 Mapping of the Fresh Milk's Supply Chain

In this chapter, the studied milk's supply chain is described, and it is shown where, how much and why food waste occurs. The chapter is divided into three parts: the dairy companies, the retailers and the consumers. In these three parts, the data is collected through interviews and reports. The interviews were made with persons working at dairy factories, dairy companies, retailers and experts within consumer behaviours. The reports were mainly from Swedish Governmental Agencies.

In this chapter, there are a couple of terms that have to be explained in order to avoid misconceptions. These terms are the dairy companies, the retailers and the consumers. With the dairy companies, the retailers and the consumers this study refers to the investigated actors in the studied supply chain.

The investigated milk supply chain consists of three major steps and it starts at the dairy company in the dairy factory, and then the dairy company distributes the milk to the retailers who put the milk upon their shelves. It stands on the shelves until the consumer buys the product and brings it to their home. The supply chain ends when the package is thrown away at the consumer level. The milks major supply chain steps are illustrated in Figure 10.

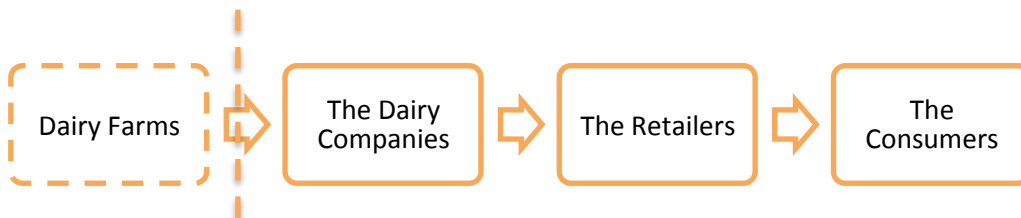


Figure 10. The milks supply chain from the dairy companies to the consumers

5.1 The Dairy Companies

This part is based on interviews and observations made at one dairy company's dairy factory and interviews with another dairy company. Other data is from interviews with retailers and reports mainly published by the Swedish Environmental Protection Agency.

When the milk reaches the dairy factory, it goes through several steps before it is ready to be delivered to the retailers. Before the milk meets the package in the dairy factory it has been separated and standardized, homogenised and pasteurised (Dairy Company A, 2014b). The steps after the milk is packaged are shown in Figure 11. As shown in Figure 11, it is the dairy company that distributes the milk to the retailers in this supply chain. This flow regards fresh milk, other milk products with longer shelf life normally passes a distribution centre (Dairy Company A, 2014b).

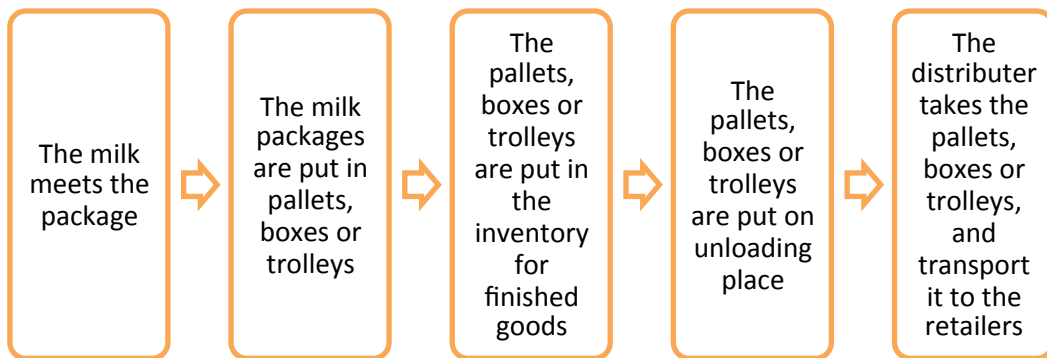


Figure 11. The milk's flow through the dairy factory. It starts when the milk meets the package and ends when the distributor takes the products to the retailers (Dairy Company A, 2014b)

The lead-time from embarkation to unloading is usually 24 hours, but during weekends the lead-time is 60 hours due to e.g. staffing costs. It is regulated by the Swedish National Food Agency that all food products in Sweden should be marked with an expiry date, use-by or best-before date, and a storage temperature (Naturvårdsverket, 2013a). It is the dairy companies that have the responsibility to mark the product with the best-before date and the storage temperature. According to the Swedish Environmental Protection Agency (2013a), the Swedish producers answer that they calculate the shelf life from experience regarding similar products and the assumption that the cold chain never breaks. The shelf life date for milk is nine days after during the main part of the year and during the summer the shelf life becomes eight days, due to higher temperatures and bacterial growth during the summer (Dairy Company A, 2014b). Another aspect regarding the printed shelf life is that the interviewed dairy company used the printed shelf life as a control parameter in their production-, inventory- and ordering system.

After the milk is packaged it is placed either on pallets, in boxes or trolleys, and they are placed in the finished goods inventory. In the finished goods inventory, the milk is awaiting shipment to the retailers. Before the shipment, the personnel place the pallets, boxes or trolleys at the unloading area. When the distribution driver arrives he or she puts the products into the truck and take it to the retailers (Dairy Company A, 2014b). When the truck reaches the retailer, the driver places the milk at a cold storage area (Retailer A, 2014d).

An informal rule says that the milk belongs to the dairy companies one third of its shelf life, and then it has to be sent to the retailers. The retailers are very strict about securing their 5-6 days of the shelf life and return the milk if there are too few remaining shelf life days (Dairy Company A, 2014b; Retailer A, 2014d). The accuracy, results in that the dairy company are very accurate about deliver milk with many days left on the shelf life.

5.1.1 Food Waste at Dairy Companies Level

The percentage of total waste that occurs at the dairy company from the packaged milk is around 0.1 % of the sold volumes (Dairy Company B, 2014d). The waste caused after the packaging occurs through date rejections, which is when the products have too few remaining shelf life days due to the above-mentioned informal rule. Date rejections derive from e.g. too long time for the milk at the finished goods inventory. The milk is in the inventory of finished goods too long mainly because the milk is unsold, which originates from a miscalculated demand, overproduction or too big production batches (Dairy Company B, 2014d). A miscalculation can e.g. source from retailer promotions, both own promotions and competitor's promotions. Another source of miscalculations is holidays and feasts when it is especially difficult to predict the demand (Bacigalupo, 2012). Overproduction is another example on how food waste occurs e.g. since the dairy factory produced too much milk compared to the ordered quantity. When there is an overproduction of milk, the dairy factory does not have enough time to deliver the already packaged milk that is waiting in the factory of finished goods, thus its turns into food waste. One of the dairy companies mentioned that sometimes their minimum batch sizes are higher than the sellable volume. This results in that the dairy company cannot get all their milk sold within the limits of one third of the shelf life at the producer level and the milk goes into food waste (Dairy Company B, 2014d).

Another reason for food waste is if the dairy company delivers too many packages to the retailers, due to picking errors, the milk is then returned to the dairy factory. When the milk is returned it could be sent to another customer if it has enough remaining shelf life days, the cold chain has not been broken, and the control of the products have not left the dairy company. Otherwise, the milk reworks into fermented milk products or becomes food waste. If the transportation between the dairy company and the retailer has not had the right temperature the entire load is sent back to the dairy company and becomes food waste. Food waste can also derive from the service the dairy company offers to their bigger customers. The service is that they take the retailers' unsold milk in return to the dairy factory. The milk is returned due to shelf life expiration or damaged packages (Dairy Company A, 2014b). Figure 12 summarise all mentioned causes to food waste at the dairy company. According to the interviewee at the dairy factory, the dairy factory could remove approximately five full-time employees if all the food waste were removed (Dairy Company A, 2014b).

The food waste that occurs in the dairy factory is reworked to fermented milk products, and milk that is returned from retailers turns into pig feed (Dairy Company A, 2014b; Naturvårdsverket, 2013b). In some cases the unsold milk are sold to selected customers for a reduced price (Dairy Company B, 2014d).

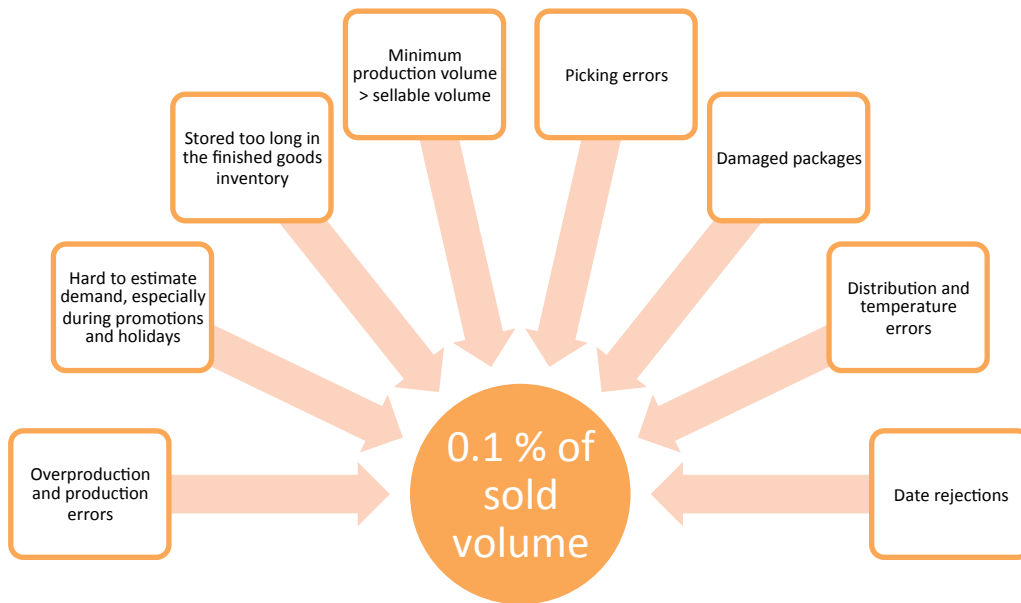


Figure 12. Reasons behind the food waste at dairy companies

5.2 The Retailers

The data in this part is from interviews and reports written by experts within food waste at retailer level. The interviewed persons were either working at retailer stores or the retailer's central organisation.

When the dairy companies milk delivery reaches the retailer, it is normally placed in a cold storage area. If the temperatures during the transportation have not fulfilled the requirements the milk is returned to the dairy company, or if the delivered amount is incorrect the surplus milk is returned back to the dairy company. After the storage area, the retailer personnel place the milk in the shelves and make it available for consumers. Finally, the consumer takes the product, buys it and brings it home (Andersson, Köhlerstrand, Lindqvist, Mellgren, & Rydmark, 2010; Retailer A, Wholesaler worker, 2014d). The milks flow at the retailer level is illustrated in Figure 13.

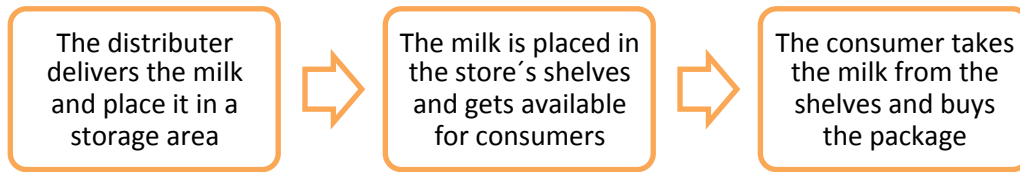


Figure 13. The milks flow at the retailer level (Retailer A, 2014d)

When the best-before date is close some retailers decrease the milk price to be able to sell the milk. If the best-before date has passed, larger retailers have the possibility to return the milk to the dairy company for free since it is a service the dairy company provides. The retailers do still pay the full price for the milk but do not need to take care of the food waste. The retailer staffs collect the milk that should be returned in the trays, boxes or trolleys and then it is returned to the dairy company during the next milk delivery (Andersson et al., 2010; Eriksson, 2012; Retailer A, 2014d). All trays, boxes and trolleys are included in the return system and are only transported between the dairy company and the retailer (Dairy Company A, 2014b).

5.2.1 Food Waste at Retailers Level

Ericsson (2012) quantified six Swedish supermarkets food waste, whereof the dairy department was one of the studied departments. Ericsson (2012) found the top eight dairy products with the highest percentage of waste and four of them were different milk products. Milk represented approximately 20 % of the dairy department's waste and about 0.2 % of purchased milk turned into waste. Of the four top milk waste products, one product had a lower percentage of waste, compared to the others, that was the milk with extended shelf life (Eriksson, 2012). One reason for this can be that the milk product has a longer time to become sold, which decreases the risk to be unsold and then it affects the percentage of waste (Retailer A, 2014d). The Swedish Environmental Protection Agency (2013b) has also conducted a study about eight retailers waste, and it shows that approximately 0.8 % of the purchased milk turns into waste (Naturvårdsverket, 2013b).

The most common cause of milk food waste is the best-before date (Eriksson, 2012). The best-before date has an effect on the consumers' behaviour since the consumer usually does not want to buy the milk if the best-before date is close. If there are milk packages with longer shelf life left in the shelves the consumer most often chose the product with longest remaining shelf life (Dairy Company A, 2014b; Jordbruksverket, 2011). Other reasons for milk waste are promotions or holidays, which affects the consumer flow and demand. Promotions and holidays make the predictability more difficult for the retailers, because of the insecure demand. The unpredictable demand leads to waste since the retailers often buys more to be secure that they will not run out of stock (Bacigalupo, 2012; Dairy Company A, 2014b). New personnel do also have a greater problem with forecasting because of

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lack of ordering experience, resulting in price decreases or returns (Retailer A, 2014d). Reasons for waste in smaller stores is that many do not have the possibility to have many deliveries since there are often a delivery cost if they order to small quantities, which in combination with uneven flow of customers causes milk waste (Andersson et al., 2010). Smaller retailers do not have the same opportunity to return milk as the larger retailers (Dairy Company A, 2014b). All reasons for the cause of milk food waste at the retailers are shown in the Figure 14.

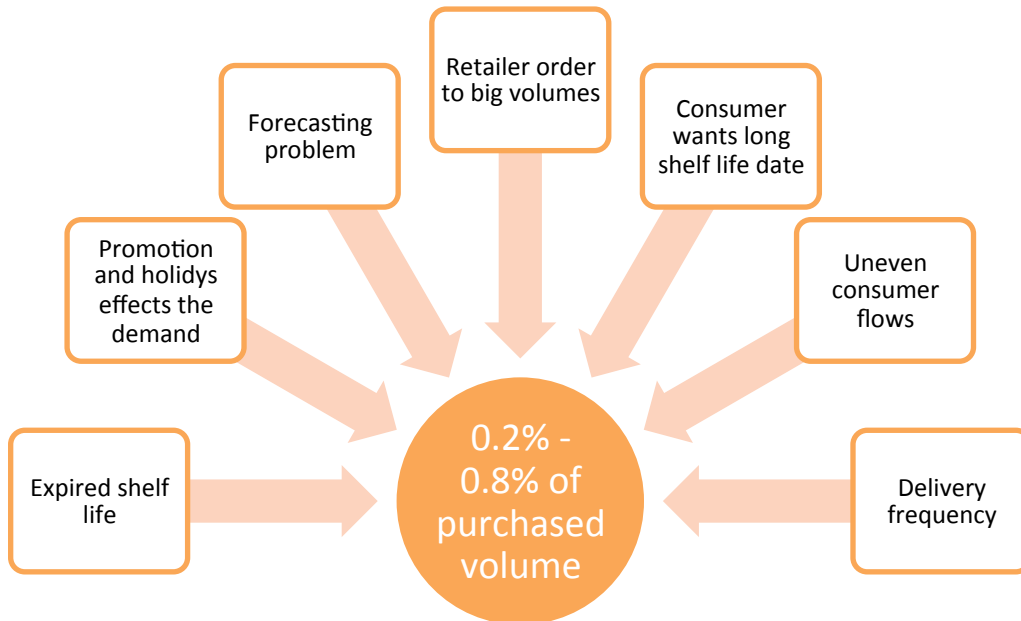


Figure 14. Reasons behind the food waste at the retailers

5.3 The Consumers

This part is based on interviews with a consumer behaviour expert and reports written by, for example, WRAP and the Swedish Environmental Protection Agency.

After the consumers have bought the milk package at the retailer, the consumer brings the milk to its home and put the milk package into its fridge. It stands in the fridge until it should be consumed. Figure 15 shows the milk flow from retailer until the milk package is thrown away.

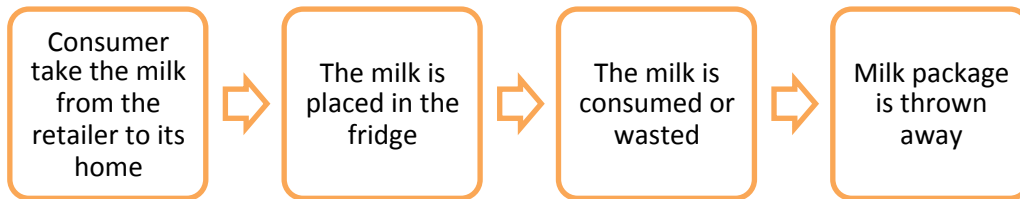


Figure 15. The milks flow at the consumer level

5.3.1 Food Waste at Consumers Level

Milk is one of the products that are most thrown down the sink in the households (Konsumentföreningen Stockholm, 2010; WRAP, 2009). However, it is difficult to know how many percentages milk that are thrown away and many reports mentions dairy products waste instead of only milk waste. According to a study from the Stockholm Consumer Cooperative Society, an average Swedish household throws down 0.75 litres in the sink per week where dairy products accounted for 27 %. The dairy products consisted mainly of milk and curdled milk (Konsumentföreningen Stockholm, 2010). An average Swedish family consist of 2.22 persons and drinks 89.4 litre of milk per person and year (Statistics Sweden, 2014; Svensk mjölk, 2013). If it is assumed that the 27 % mainly consist of milk, the milk food waste per person and year becomes 4.7 litres and 5.2 %. See calculations below:

$$\frac{(0.75 * 52) * 0.27}{2.22} = 4.7 \text{ litre milk waste per person and year}$$

$$\frac{4.7}{89.4} = 5.2 \% \text{ milk waste per year}$$

Food waste occurs because many of the consumers do not consume the milk after its passed best-before date, even though the milk is often consumable after its passed best-before date. However, many consumers do not smell or taste the milk before throwing it away, since they believe that it is disgusting to taste the milk, and it is therefore thrown down the drain (Jordbruksverket, 2011; Livsmedelsverket, 2013). Other reasons for not consuming the milk are because of lack of planning before purchasing, which means that the consumer do not have enough time to consume the milk before the best-before date expires (Jordbruksverket, 2011; Ungert, 2014). Milk food waste also occurs because of incorrect portioning, meaning it is leftover when eating cereals, drinking tea or coffee (Bacigalupo, 2012). Figure 16 summarises all mentioned reasons behind the milk food waste at the consumers.

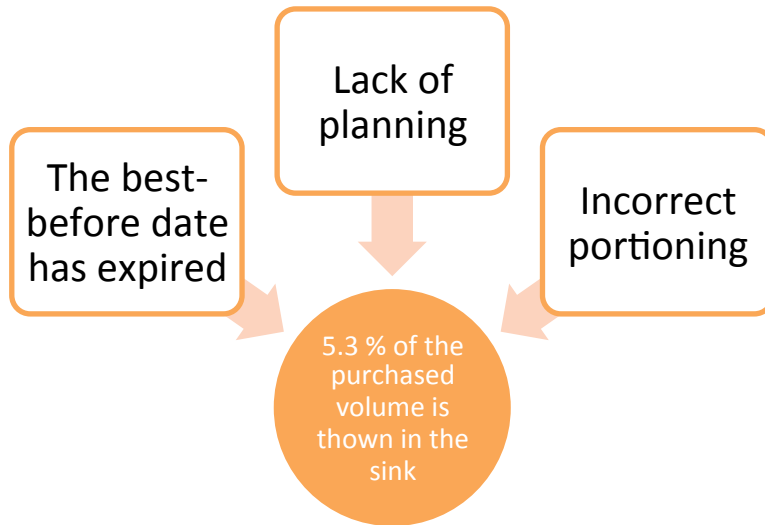


Figure 16. Reasons behind the food waste at the consumers

5.4 A Summarisation of This Chapter

In this chapter, the milk’s supply chain has been described. In all parts, the milk’s flow and the reasons behind its waste have been described. In Figure 17, it is shown where and why waste occurs.

The Dairy Companies 0.1 % food waste of produced volume	The Retailers 0.2-0.8 % food waste of purchased volume	The Consumers 5.2 % food waste of purchased volume
<ul style="list-style-type: none"> •Overproduction •Date rejections •Miscalculated demand •Production error •Minimum production batches > sellable volume •Damaged packages •Picking errors •Distribution errors 	<ul style="list-style-type: none"> •Expired best-before date •Promotions & holidays effects the demand •Forecasting problems •Few delivery times to small retailers •Uneven flow of consumers •Order too big volumes •Consumer wants long shelf life 	<ul style="list-style-type: none"> •Do not consume the milk after the best-before date •Lack of planning •Incorrect portioning

Figure 17. A summary of where, how much and why food waste occurs

6 Potentials and Barriers For Implementing The Dynamic Shelf Life Sensor

In this chapter, potentials and barriers for food waste reduction by using the dynamic shelf life sensor are presented. This chapter also goes through and describes potentials in a dairy supply chain and barriers for implementing a dynamic shelf life sensor solution. The chapter presents each supply chain actor's potentials and barriers separately and over all supply chain effects by an implementation.

This chapter is divided into four major parts; the dairy company, the retailers, the consumers and overall supply chain effects. Each of the four parts consists of five sections; potentials for food waste reduction with a dynamic shelf life sensor, potentials for the dynamic shelf life sensor, barriers for food waste reduction with a dynamic shelf life sensor, barriers for the dynamic shelf life and effects with a dynamic shelf life sensor. I.e. firstly are potentials presented in each part, followed by the barriers and finally the effects are presented.

In this chapter the authors have categorized the answers from interviews and findings from reports in order to get a well-structured description of potentials and barriers from each actor in the studied milk supply chain. Since the interviewees had different views and opinions, some data could be seen as both potentials and barriers. Table 3 shows the structure of the presentation of potentials and barriers for implementing the dynamic shelf life sensor technology in the supply chain for each actor.

Table 3. The structure of the presentation of potentials and barriers for each actor in the supply chain

Actors	
Potentials for food waste reduction	↓
Potentials for the dynamic shelf life sensor	
Barriers for food waste reduction	
Barriers for the dynamic shelf life sensor	
Effects of implementing the dynamic shelf life sensor	

The assumed potential food waste reduction described in this chapter occurs when the cold supply chain and its procedures and routines are secured.

6.1 The Dairy Companies

One of the interviewed dairy companies had about 0.1 % waste of milk between they packaged the milk and the delivery to the retailers. As mentioned in the mapping of the milk supply chain, there are several reasons behind the waste: miscalculation in demand, too long storage time in the finished goods inventory, overproduction, production errors, minimum production volume is bigger than sellable volume, picking and distribution errors, damaged packages and date rejections.

6.1.1 Potentials for Food Waste Reduction

As mentioned in the previous chapter, when more than one third of the product's total shelf life time has expired or the produced quantity are too big, the dairy companies do not send the milk to the customers and it becomes fermented milk products instead (Dairy Company A, 2014b). If the sensor could ensure that the products have been stored under good conditions, i.e. below the recommended temperature of eight degrees, and that the cold supply chain is secured then the milk could be sent to the customer instead of becoming fermented milk products (Dairy Company A, 2014c; Dairy Company B, 2014d). This could decrease the food waste that occurs from the too long storage time in the finished goods inventory and from overproductions.

Today, if there have been any problems regarding the temperature during transport, the entire load is wasted. If the products had a dynamic shelf life sensor, products unaffected by the temperature could be identified and does not have to become food waste (Distributor, 2014). In these situations the food waste from distribution would decrease.

Since the sensor should be an open solution the dairy companies could get information from the retailers when the products were sold, which could result in higher responsiveness in the production. A higher responsiveness in the production could result in a more accurate production planning and the food waste derived from demand estimation problems and overproduction could decrease (Dairy Company A, 2014b; Dairy Company B, 2014c).

6.1.2 Potentials for the Dynamic Shelf Life Sensor

Today interest and knowledge about the environment has increased, which have resulted in a higher focus on food waste and the environmental impact of the food (Distributor, 2014). With the sensor, the dairy companies environmental impact might decrease since the amount of returned milk from the retailers could decrease, which in turn will have an effect on the trucks weight and thereby the environment impact through decreased fuel consumption.

With a sensor, the dairy companies could get valuable information about the supply chain, the consumer's purchase habits and shelf life (Packaging Material Company A, 2014c). By logging the temperature and share the information the supply chain and

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the products increase their safety and makes an objectively self-monitoring possible. All responders thought that it is positive to show that the actors in the supply chain manage to keep the cold supply chain unbroken (Dairy Company A, 2014b; Retailer A, 2014b; Distributor, 2014). Since the temperature during the transportation and storing will be logged and saved there will be no discussion about which part of the supply chain that did not maintain the temperature (Dairy Company A, 2014c; Dairy Company B, 2014c).

The dynamic shelf life sensor has potential to both increase the product's added value and the dairy companies communication with the customers and consumers. Dairy Company B thought that the sensor could increase their innovative image and strengthen the brand to increase sales (Distributor, 2014; Dairy Company B, 2014b; Dairy Company B, 2014c; Dairy Company A, 2014b). According to the interviewed distributor the sensor could also be seen as a way for the dairy companies to compete with private label products by differentiate their own products with the dynamic shelf life sensor (Distributor, 2014). One of the interviewed at Dairy Company B said that if the sensor could tell the history behind the milk it could be worth some small money (Dairy Company B, 2014b). It has been noticed in social medias that consumers are interested in the persons and animals behind the product (Dairy Company B, 2014b). If the sensor could combine the shelf life information and the dairy company's connection to the farmers and animals it has a bigger potential (Dairy Company B, 2014b).

6.1.3 Barriers for Reducing the Food Waste

Dairy Company A does not see any potential for the sensor to minimize the food waste at their production site. Further on, if the sensor reduces the food waste at the retailers the volume of returned milk that today becomes pig feed will decrease (Dairy Company A, 2014b). Dairy Company B is also mentioning that milk food waste is not a big problem for them today (Dairy Company B, 2014b).

6.1.4 Barriers for the Dynamic Shelf Life Sensor

One of the barriers mentioned were that the profitability in the dairy industry is low and the margins for milk are tight. This means that the dairy company believe it is hard to implement a sensor that should cost around SEK 1. One of the interviewee said, when talking about milk, the cost has to be around SEK 0.01 (Dairy Company B, 2014a; Packaging Material Company A, 2014a). Further on are the business benefits for implementing a sensor highly related to the milks cost since it is a low value product (Dairy Company A, 2014c).

In the interviews the authors also asked if the dairy companies could see a potential competitive advantage with the sensor implementation. The interviewed dairy companies see a low first mover advantage which results in low incentive to implement a dynamic shelf life sensor (Dairy Company A, 2014c; Dairy Company B, 2014c).

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Interviewees at Dairy Company A mentioned that their production- and warehouse management systems are built on the printed best-before date. If the sensor replaces the printed best-before date the whole production system and warehouse management system needs to change (Dairy Company A, 2014b). Since the production- and warehouse management systems will change from being based on static information to being based on dynamic information, will this result in new routines and procedures (Retailer A, 2014a).

A number of the interviewees at the dairy companies did not see any potential of the gathered information about the products and did not think the forecasts would be improved by more detailed information from the retailers. Some retailers have an automatic ordering system to the dairy company and the dairy company thinks it works well. This results in that the dairy company does not see any potential of the information to and do not believe the sensor will add any value compared to today (Dairy Company B, 2014a; Dairy Company B, 2014b).

Figure 18 summaries all food waste causes occurred at the dairy company and shows if the dynamic shelf life sensor has potential to decrease the food waste in each aspect. The thumbs up indicate that the food waste could decrease, and a horizontal thumb indicates no change regarding food waste.

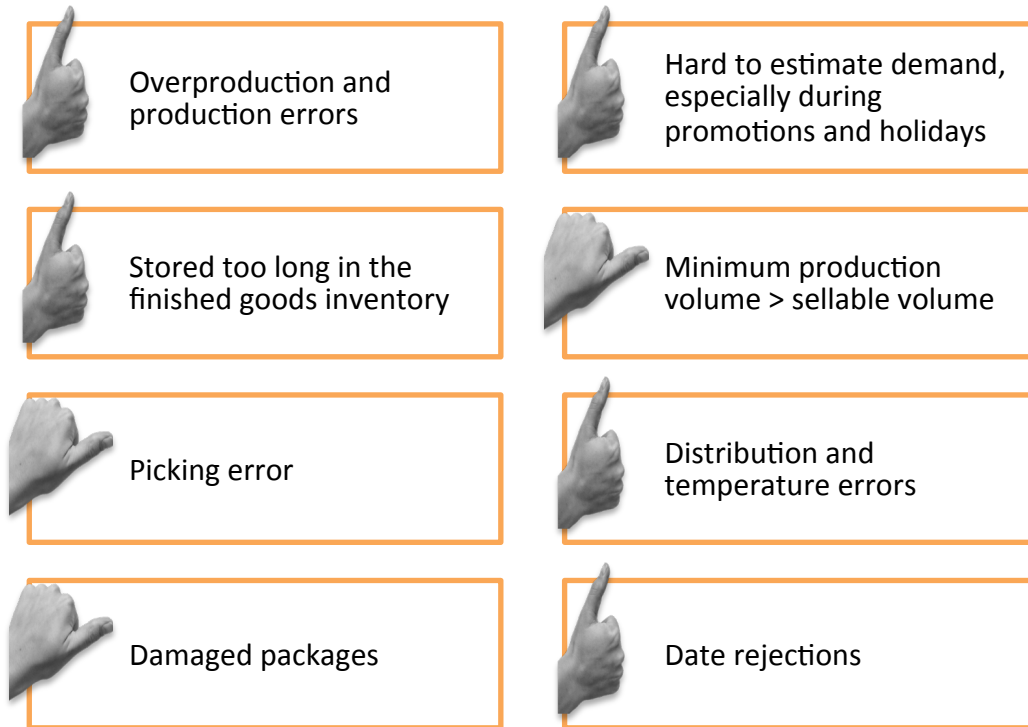


Figure 18. Summary of the dynamic shelf life sensor's effect on the dairy companies food waste

6.1.5 Effects of Implementing the Dynamic Shelf Life Sensor

The effects for the dairy companies will depend on if the printed best-before date will be kept or the dynamic shelf life sensor will replace the printed best-before date. If the sensor replaces the printed date the production and warehouse management system will as mentioned earlier need to be adapted to the dynamic shelf life sensor, which could be a costly implementation (Dairy Company A, 2014b).

To successfully implement the dynamic shelf life sensor, a lot of training is required. The personnel at the dairy companies need to understand the sensor and the supporting information systems and their customers need to be educated about how to treat the products. The consumers also have to be educated in order to increase awareness of the benefits of a dynamic shelf life sensor (Dairy Company B, 2014c). The dynamic shelf life sensor system needs to be marketed in a clear and communicatively way, to give the consumers a good understanding of what the sensor will communicate and why is it important to keep the product stored in the right temperatures. This will require a big marketing campaign by the dairy companies (Dairy Company B, 2014c; Dairy Company B, 2014b; Retailer A, 2014c).

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As mentioned earlier, the dynamic shelf life sensor will help the consumers to learn how they should handle the milk to retain as much of the shelf life as possible. Dairy Company B pointed out that this could result in a lower number of complaints to the dairy company's customer service especially during the summer when they normally have their peak (Dairy Company B, 2014a).

If the sensor reduces the number of returned milk packages the volume of milk that becomes pig feed will decrease. This results in lower income generated by the pig feed products for the dairy company. Another effect of a reduction of the returned milk packages is less workload for the personnel. One of the interviewee's at Dairy Company A, assumed that the personnel force could be lowered by five employees if all returned packages would disappear (Dairy Company A, 2014b).

If the sensor is placed inside the packaging material, the cost for the material will increase. When dairy companies implement the dynamic shelf life sensor system they need to invest in a reading system and software (Hydbom, 2014a).

Table 4 summarise potentials and barriers for the dairy companies with the implementation of the dynamic shelf life sensor.

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Table 4. Potentials and barriers for the dairy companies

Potentials and barriers for dairy companies	
Potentials for food waste reduction	<ul style="list-style-type: none"> • Food waste that occurs from overproduction, demand estimation problems, too long storage in the finished goods inventory and distribution and temperature errors could decrease. • The main reasons for the food waste decrease are because of the increased information sharing and the temperature control on each package.
Potentials for the dynamic shelf life sensor	<ul style="list-style-type: none"> • The awareness of environmental impact has increased. And a sensor could lead to a reduced environmental impact. • Information from retailers about consumer purchases and behaviour could make the forecasts easier. • The safety regarding the transportation temperature will increase since the sensor creates a self-monitoring of the distributors. • Potential to strengthen the brand.
Barrier for reducing the food waste	<ul style="list-style-type: none"> • A negative attitude to a dynamic shelf life sensor implementation on milk at some of the dairy companies.
Barriers for the dynamic shelf life sensor	<ul style="list-style-type: none"> • There are no problems regarding milk food waste according to one of the dairy companies. • Since there are low profitability and margins in the dairy industry the dairy companies see it as hard to carry the cost for a dynamic shelf life sensor. • The production and warehouse management system is built on the printed best-before, and it is costly to change. • Some dairy companies do not see the benefit of sharing information.
Effects cause by the dynamic shelf life sensor implementation	<ul style="list-style-type: none"> • The effects on the dairy companies highly depend on if the printed best-before date is kept or the dynamic shelf life sensor replaces it. Either way there is a need for education and marketing in order to inform the actors in the supply chain about the dynamic shelf life sensor. • The sensor could lower the number of complains and the workload for the personnel working with returns could decrease.

6.2 The Retailers

As mentioned in the chapter about mapping of the milk's supply chain, the amount of food waste caused at the retailers is between 0.2 % and 0.8 % of the purchased milk volume, depending on from which study the data is taken. The reason from food waste at the retailers is expired best-before date, promotions and holidays change the demand, forecasting problems, order too big volumes, the consumer wants to buy products with long shelf life, uneven consumer flow due to purchasing patterns, and that small retailers have few deliveries per week.

6.2.1 Potentials Food Waste Reduction

One interviewee at Retailer A, believes that if there was a sensor at the milk packages the food waste could decrease (Retailer A, 2014b). One example is that normally, during feasts and national holidays, the demand is hard to predict. The unpredictability often results in high stock levels, and eventual food that cannot be sold since the best-before date has expired or is close to expiring. If the sensor could ensure that the product has been stored and transported under right conditions these products that today becomes food waste could be sold (Retailer A, 2014c). This could result in; food waste that occurred from expired best-before date could decrease.

6.2.2 Potentials for the Dynamic Shelf Life Sensor

Previously the milk has been a price-sensitive product but lately this has changed since the milk selection at many of the retailers has increased (Retailer A, 2014a). When the interviewed retailers do not get the milk sold, the dairy companies offer a free service to bring the milk back to the dairy. If the retailers return less milk to the dairy companies, it means that more of the milk is sold in the store. This results in economic gains and creates less food waste, but this assumes that the milk is not thrown away in the households instead (Distributor, 2014). If the retailers handles the milk below the recommended temperature, +8°C, it could result in less number of orders since the milk may increase its shelf life and thereby the retailers could order bigger quantities at the same time. Less number of ordering times could result in less workload for the personnel both in time to place the orders and delivery time (Retailer A, 2014c).

The dynamic shelf life sensor could affect the retailers' credibility and strengthen the retailers' brand (Retailer B, 2014). The consumers could get the feeling that the retailers have a neat and tidy store when they see that the products in the store have been treated in a good way (Dairy Company B, 2014b). The dynamic shelf life sensor could also create the possibility to get individual pricing. If the products have many days until the expiration date, the product will get a higher price and when it is few days left the price decreases (Dairy Company B, 2014c).

Another potential that was mentioned during the interviews was that the sensor gives the retailers an objectively self-monitoring, which could lead to better procedures and processes (Distributor, 2014; Retailer A, 2014b; Retailer B, 2014).

6.2.3 Barriers for Reducing the Food Waste

During the interviews it has not come up any barriers for minimizing the food waste at the retailer level.

6.2.4 Barriers for the Dynamic Shelf Life Sensor

The interviewee at the consumer society mentioned an important aspect for the retailers. If the consumer wastes less milk the retailers will sell less milk (Ungert, 2014). Today the retailers do not want to sell milk when the best-before date has expired, and many consumers are not interested in buying milk with short or expired best-before date (Retailer A, 2014d). Therefore does the retailers use the first-in-first-out principle to keep the milk as short time as possible in the shelves. With the dynamic shelf life sensor, this policy has to be changed since the shelf life could vary between different deliveries (Retailer A, 2014a). The result of the dynamic shelf life sensor could be that a new ordering procedure to the dairy companies is required. With the dynamic shelf life sensor system will it become harder to predict when the best-before date occurs and thereby when it is time to order the milk. If the milk stores in higher temperature than recommended, the shelf life will decrease. This could create problems to the retailers since if they had planned for a certain shelf life, and when it is treated wrong the shelf life becomes lower and thereby the milk becomes food waste faster. This could result in that the retailers do not have any milk in the store (Retailer A, 2014c). Since all products will have their own identity and expiration date, it will require that every product has to be scanned individually to be able to know each product's expiration date. This would add a lot of workload to the personnel in the store (Retailer A, 2014c).

A barrier to the dynamic shelf life sensor implementation is that today is it already possible for the retailers to monitor the trucks transportation temperature. This is done manually when the retailers believe that there have been some problems with the temperature and the distributor have not fulfilled the requirements (Retailer A, 2014a). This means that there already is a way for the retailer to measure temperatures if the retailer would preferable. This is, unfortunately, not often done on milk transports since it is not seen as a sensitive product.

Figure 19 summarises all food waste causes occurred at the retailers and shows if the dynamic shelf life sensor has potential to decrease the food waste in each aspect. The thumbs up indicate that the food waste could decrease, and a horizontal thumb indicates no change regarding food waste.

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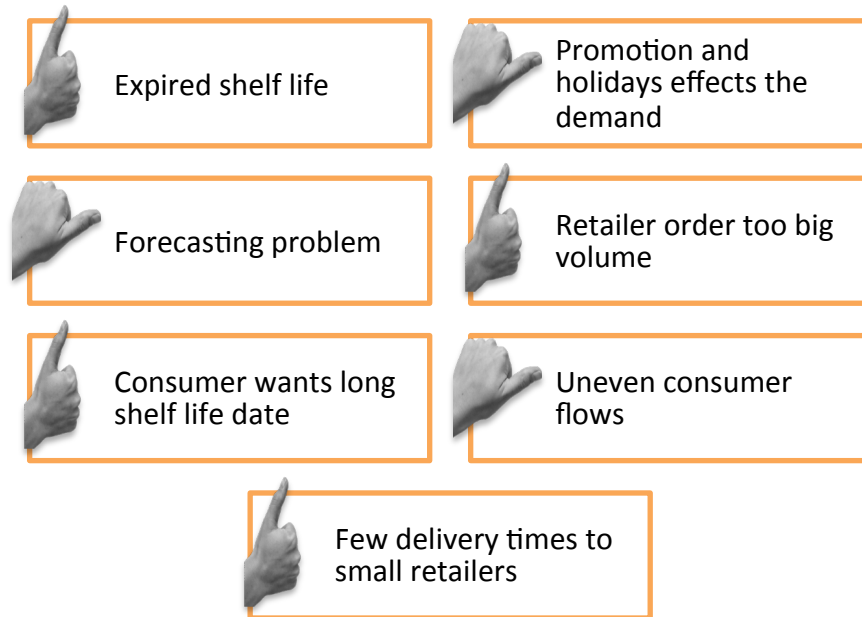


Figure 19. Summary of the dynamic shelf life sensor's effect on the retailers food waste

6.2.5 Effects of Implementing the Dynamic Shelf Life Sensor

The biggest effect for the retailers is the new ordering procedure. The ordering procedure needs to be more agile and flexible since the shelf life will be flexible (Retailer A, 2014c). Another effect the retailers will get from a dynamic shelf life sensor is that when the consumers waste less food they will buy less food (Ungert, 2014).

Table 5 shows a summary of potentials and barriers with the implementation of the dynamic shelf life sensor for the retailers.

Table 5. Potentials and barriers for the retailers

Potentials and barriers for retailers	
Potentials for food waste reduction	<ul style="list-style-type: none"> The dynamic shelf life sensor could affect the food waste if it shows that the products have been kept in perfect condition and thereby could be sold after the printed best-before date.
Potentials for the dynamic shelf life sensor	<ul style="list-style-type: none"> Milk has lately become less price-sensitive which could indicate that the consumers could pay a little extra for the sensor. The sensor could strengthen the retailers' brand by increasing the creditability. The retailers could get economic benefits from more précis ordering volumes and fewer returned packages. The retailers will also get a self-monitor of the routine and procedures. Another potential with the dynamic shelf life sensor is the possibility in implement individual pricing.
Barriers for reducing the food waste	<ul style="list-style-type: none"> No barriers at the retailers level were identified
Barriers for the dynamic shelf life sensor	<ul style="list-style-type: none"> Retailers do not want to sell products with expired best-before date. Since the shelf life will be dynamic the expiration date will differ between different batches since they could have been treated differently. It will become harder to predict the expiration dates and it will require a new ordering procedure. If consumer's food wastes decrease, the retailers will sell less milk.
Effects cause by the dynamic shelf life sensor implementation	<ul style="list-style-type: none"> The retailers have to implement a new ordering procedure.

6.3 The Consumers

The consumers are the actor in the supply chain that wastes the most food. Based on reports and studies have the authors calculated that the consumers waste about 5.2 % of their purchased milk volumes. The most common reason for the milk to

become food waste is expired best-before date, lack of planning and incorrect portioning.

6.3.1 Potentials for Food Waste Reduction

If the consumer embraces the technology, an understanding about how the milk should be treated could increase. This results in that the milk's shelf life increases and thereby the consumer has a longer time to consume the milk before it becomes inedible. This could thereby reduce the food waste (Dairy Company B, 2014a; Dairy Company B, 2014c). The dynamic shelf life sensor system will hopefully teach the consumer how to treat their dairy product in a way that retain the shelf life as long as possible. The sensor could have the greatest effect and potential on reduction of the food waste at the consumer that today waste a lot of food (Retailer A, 2014c). Primarily the food waste occurred from expired best-before date and lack of planning will decrease.

6.3.2 Potentials for the Dynamic Shelf Life Sensor

With the sensor, the consumers understand the freshness of the milk in an objective way and how their behaviour affects the expiration day. This could result in more aware consumers that understand that milk is consumable after passed best-before date (Household appliances company, 2014; Hydbom, 2014b; Packaging Material Company A, 2014c; Ungert, 2014).

6.3.3 Barriers for Reducing the Food Waste

One barrier for reducing the food waste is that most consumers do not think they wastes food but believe other people do (Livsmedelsverket, 2014; Ungert, 2014). This could result in that the consumer does not believe they need a dynamic shelf life sensor. Another barrier for the dynamic shelf life sensor and food waste reduction is the consumers' attitude to the expiration date. The consumers do not consume the milk after the printed best-before date passed. The best-before date is an indicator on what date the milk is better before, not inedible after (Dairy Company A, 2014c).

6.3.4 Barriers for the Dynamic Shelf Life Sensor

If the consumers have to scan the products to know the expiration date, the consumers could experience the procedure complicated, and they will not use the function of the sensor. If the consumers also need to download an application to their cell phone it becomes even more complicated procedure (Dairy Company B, 2014b).

Since most of the consumers like to buy milk with long remaining shelf life, there is a need to make the consumers understand that the milk could be consumed if the sensor shows that the milk has been treated in a good way (Dairy Company A, 2014c). To get the consumers to look at the dynamic shelf life sensor instead of the printed best-before date, the consumers need to trust the new technology and understand that the date the dynamic shelf life sensor shows is more precise than the printed shelf life (Dairy Company A, 2014c). Another aspect is that many consumers have a high price-focus when purchasing their milk and food, this

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indicates that the consumers do not want to pay extra for a dynamic shelf life sensor (Dairy Company A, 2014c; Ungert, 2014).

Not all consumers know which temperature to store the milk in and do not know how the milk should be treated to get the best shelf life (Household appliances company, 2014).

There is a risk for increased consumer price as a result of increased cost for the actors in the supply chain when the dynamic shelf life sensor is implemented. Studies have shown that many brand owners want to transmit their costs to the consumer (Finnish Competition and Consumer Authority, 2012). If the supply chain actors do not fulfil their part of the supply chain the cost for those mistakes will then probably affect the consumer by increasing the consumer prices (Retailer A, 2014c).

Figure 20 summarises all food waste causes occurred at the consumer level and shows if the dynamic shelf life sensor has potential to reduce the food waste in each aspect. The thumbs up indicate that the food waste could decrease, and a horizontal thumb indicates no change regarding food waste.

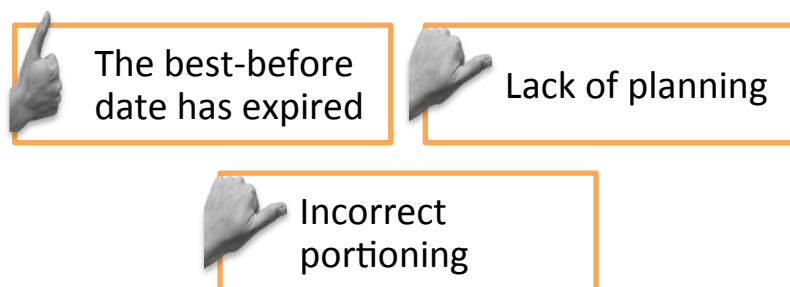


Figure 20. Summary of the dynamic shelf life sensor's effect on the consumers food waste

6.3.5 Effects of Implementing the Dynamic Shelf Life Sensor

By introducing a dynamic shelf life sensor the consumers will waste less food as long as they trust the technology. Less food waste results in fewer purchases of milk from the retailers and which in turns leads to that the consumer saves money (Retailer A, 2014c; Ungert, 2014). The consumer will lower the temperatures in the fridge, which is preferable for all chilled perishable (Dairy Company B, 2014a).

Table 6 summarise potentials and barriers for the consumer with the implementation of the dynamic shelf life sensor.

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Table 6. Potentials and barriers for the consumers

Potentials and barriers for consumers	
Potentials for food waste reduction	<ul style="list-style-type: none"> • If the consumer embraces the technology, food waste caused by best-before date can decrease. • The increased attention to the milk could affect the food waste caused by lack of planning and incorrect portioning.
Potentials for the dynamic shelf life sensor	<ul style="list-style-type: none"> • Understand the freshness in an objective way and the consumers learn how to treat the milk in a correct way.
Barriers for reducing the food waste	<ul style="list-style-type: none"> • The consumers do not think they waste food and thereby do not think they need the sensor. • There has to be an attitude change about the best-before date.
Barriers for the dynamic shelf life sensor	<ul style="list-style-type: none"> • If the consumers believe that the procedure to download an application and to scan the products is complicated will there not be any effect of the sensor. • Today most of the consumers wants to buy milk with long shelf life left and to change that behaviour the consumer need to embrace the technology. • If the sensor increases the dairy companies' costs there is a risk that the consumer price increase since brand owner often transfer their cost to the consumer prices. • The consumers have high price focus.
Effects cause by the dynamic shelf life sensor implementation	<ul style="list-style-type: none"> • The consumers will waste less food as long as they trust the technology. Then it results in fewer purchases of milk, which in turns leads to, the consumer saves money and learns how the milk should be treated.

6.4 Overall Supply Chain Aspects

The dynamic shelf life sensor does also have effects on the supply chain in general. The overall supply chain aspects from the data collection are mentioned and described in following sections.

6.4.1 Potentials for Food Waste Reduction

When procedures and processes are secured the food waste will decrease since all involved personnel in the supply chain will know how to treat the products in the recommended way and under which conditions (Retailer B, 2014). The consumers also have to embrace the technology, and if they do it could affect the whole supply chain. If it is assumed that the dynamic shelf life sensor could reduce all the avoidable food waste of milk, the authors have calculated that every consumer will purchase 2.7 litres less milk per year. This results in a total reduction of 25 650 tonnes milk annually for the retailers and dairy companies. The calculations are shown in Appendix II.

6.4.2 Potentials for the Dynamic Shelf Life Sensor

The dynamic shelf life sensor gives an objective measurement of the temperature in all stages in the supply chain. This will result in fewer discussions about who in the supply chain that not have fulfilled their undertakings (Hydbom, 2014b).

Today's best-before date system with the printed shelf life date has been the same for many years, and it has to come an updated way to illustrate when the food becomes inedible (Retailer A, 2014c). Since the sensor technology have become much cheaper than it has been in previous projects it will be more likely that the dynamic shelf life sensor technology will breakthrough this time (Distributor, 2014). It is also positively that the sensor does not affect the ability to recycle the package (Hydbom, 2014b).

An interviewee at the Packaging Material Company A, mentioned that cost savings is not an innovation by itself, which means that if a new shelf life system should be an innovation it could not only focus on costs and cost saving. However, cost savings can be a consequence of innovation, and it could also be a driving force for innovation (Packaging Material Company A, 2014c).

6.4.3 Barriers for Reducing the Food Waste

A general barrier for the whole supply chain is that before procedures and processes are secured the food waste will increase since the personnel in the supply chain do not know exactly how the products should be treated (Retailer B, 2014).

6.4.4 Barriers for the Dynamic Shelf Life Sensor

The sensor system requires high initial investments for all actors in the supply chain. Development is needed for software-, scanning-, and a common system that can communicate with all actors and give the required information to all other actors in the supply chain. Those activities are all costly and require a lot of resources (Hydbom, 2014b; Retailer B, 2014). An integrated solution is needed and all actors

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need to accept the solution otherwise the implementations will not work (Hydbom, 2014a).

If the cold supply chain is not ready to be shown in public, it could give consequences for the dynamic shelf life sensor implementation and its reputation and thereby the sensors possibility to decrease the food waste (Distributor, 2014).

6.4.5 Overall Effects of Implementing the Dynamic Shelf Life Sensor

The overall effect with the implementation of the dynamic shelf life sensor is it that it creates a social economic benefit, regarding the environment, food waste and food safety (DYNAHMAT, 2013). Since the food waste is assumed to decrease, and the food waste is a social economic problem, which have an impact on the environment.

Table 7 summarise potentials and barriers for the overall supply chain.

Table 7. Overall supply chain potentials and barriers for the whole supply chain

Potentials and barriers for the overall supply chain	
Potentials for food waste reduction	<ul style="list-style-type: none"> When all routines and procedures are secured the food waste will decrease at the retailers and dairy companies.
Potentials for the dynamic shelf life sensor	<ul style="list-style-type: none"> The dynamic shelf life sensor gives an objective monitoring of the temperature in all stages in the supply chain.
Barriers for reducing the food waste	<ul style="list-style-type: none"> The food waste will increase before procedure and processes are secured.
Barriers for the dynamic shelf life sensor	<ul style="list-style-type: none"> It is not sure if the supply chain is ready to be public for the involved actors and if not it could lead to big consequence.
Effects cause by the dynamic shelf life sensor implementation	<ul style="list-style-type: none"> The sensor technology will create a social economic benefit regarding the environment, food waste and food safety.

7 Analysis of Business Facts and Consequences

In this chapter empirical data collected from interviews, reports and observations are combined with the previously written frame of reference. The chapter aims to draw conclusions from the empirical data based on the frame of reference.

In previous chapters, the collected data and an explanation of sensor technology and the dynamic shelf life sensor were presented. Further on, was the investigated milk supply chain mapped, and it was pointed out where, how much and why food waste occurs. Also, potentials and barriers for food waste reduction and the dynamic shelf life sensor within the studied milk supply chain were presented. With that in mind, this chapter mainly focuses on analysing the collected data based on researches and theories. It also analyses consequences with a dynamic shelf life sensor implementation.

7.1 Analysis of Business Facts

To begin the analysis, understanding for how the different actors in the studied supply chain can affect each other by the dynamic shelf life sensor implementation is needed. The authors have made an illustration shown in Table 8 to summarise previous insights. Table 8 shows what happens if an actor in the left column implements the dynamic shelf life sensor and how the actor, in the top row, can be affected by the implementation. For example if the dairy companies implements a dynamic shelf life sensor the consumers could get an objective temperature control of the entire supply chain. The table is based on the empirical data and the author's observations throughout the study.

From Table 8, some conclusion could be made. If the dynamic shelf life is implemented, all investigated supply chain actors have potential to reduce their food waste levels. However, there are also other consequences with an implementation, such as if the dairy companies implement the sensor the retailers will have to share information to the dairy companies. Some of the investigated actors have initial costs related to the implementation with the dynamic shelf life sensor, for example, the dairy companies and retailers need to invest in software and reader system to enable the solution. Additionally the dairy companies need to invest in marketing to inform the consumers the added value with the dynamic shelf life sensor.

All actors in the studied supply chain could get a self-monitored effect of the temperatures with the dynamic shelf life sensor. This could result in new routines and procedures for all actors; especially the dairy companies and the retailers could be affected. At the dairy companies, it is mainly the planning that could be affected. Further on, many of the retailers' personnel need to adjust their working routines and ordering procedures.

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It has been seen that there are some environmental gains with implementation. It is mainly the dairy companies that could gain environmental effects, since their emission from the transports could be lower with fewer milk package returns from the retailers.

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Table 8. The table shows what happens if an actor in the left column implements a dynamic shelf life sensor and how the actor, in the top row, can be affected by the implementation

	Dairy Companies	Retailers	Consumers
Dairy Companies	<ul style="list-style-type: none"> • Food waste reduction • Increasing marketing costs to inform the users • Adjust the computer system to the dynamic shelf life sensor • Investments in software and reader system • Adjust working routines to the dynamic shelf life sensor • Get an objective temperature control • Be able to see the product's temperature information throughout the supply chain • Lower environmental impact due to reduced amount of returned packages from retailers • Higher cost for packaging material 	<ul style="list-style-type: none"> • Food waste reduction • Information sharing e.g. sales data • Investments in a reader system and software • Adjust working routines to the dynamic shelf life sensor • Get an objective temperature control • Be able to see the product's temperature information throughout the supply chain • New ordering procedures • Risk for increased purchasing price of milk 	<ul style="list-style-type: none"> • Less reclamations and complains • Positive attitude to the brand, which can lead to increased sales • Get an objective temperature control • Be able to see the product's temperature information throughout the supply chain
Retailers	<ul style="list-style-type: none"> • Decreased number of ordering times • Reduced amount of returns from retailers to dairy companies • Reduced amount of milk that turns into pig feed • Information sharing about e.g. sales data 	<ul style="list-style-type: none"> • Food waste reduction • Could sell all purchased milk instead of returning milk packages after best-before expiration • Buy milk more seldom, since they are able to sell their purchased milk 	<ul style="list-style-type: none"> • Risk for increased prices • Positive attitude to the brand and retailers, which can lead to increased sales • Objective temperature control
Consumers	<ul style="list-style-type: none"> • Less reclamations and complains • Positive attitude to the brand, which can lead to increased sales • Get an objective temperature control • Be able to see the product's temperature information throughout the supply chain 	<ul style="list-style-type: none"> • Risk for increased prices • Positive attitude to the brand and retailers, which can lead to increased sales 	<ul style="list-style-type: none"> • Food waste reduction • Save money • Increased consciousness of food treatment and fridge temperatures • Download an application to their phones • Objective temperature control

7.2 Analysis of Business Consequences

In this section aspects connected to supply chain management, CSR and shared value are discussed. After the analysis of the different areas, the section ends with a summarising conclusion of the analysis.

Mentzer et al. (2001) points out the importance of supply chain orientation before a supply chain management perspective, and its consequences can be achieved. During the data collection have the authors perceived a hesitation regarding the dynamic shelf life sensor. One reason why the actors do not truly believe in the sensor technology could be the lack of supply chain orientation. If they had the systematic and strategic view, which the supply chain orientation requires, the actors probably would have a more positive view on the sensor technology.

7.2.1 Information Sharing

As Christopher (2011) mentions, a well-functioned supply chain manages their core processes better than their competing supply chains. Majority of the interviewees were hesitating regarding if a competitive advantage could be created with a dynamic shelf life sensor. To achieve a competitive advantage information sharing could be a key activity. During interviews with people working with planning, it appeared that sharing information, such as sales information would be useful in their work. If sales information is the base for prognostications instead of order data, the consequences of the bullwhip effect could decrease (Lee et al., 2004). Better prognostications and forecasts, which could lead to miscalculated demand, cost reduction and demand disruptions are consequences that could be lowered (Lee et al., 2004). Miscalculated demand was one reason for food waste at the dairy companies. According to Lee et al. (2004) an uncertain forecast and demand leads to a higher safety stock to be able to guarantee delivery. Information sharing also results in more responsive and agile supply chains, which manage changes in demand and meets the customer demand faster (Christopher, 2011; Mentzer et al., 2001).

During the interviews mainly the production planners pointed out the benefit from information sharing. Some of the other interviewees at the dairy companies did not truly see the value the dynamic shelf life sensor could create. Bagchi and Skjoett-Larsen (2003) mentions that an important aspects regarding supply chain integration is the understanding of information sharing. If the actors in the supply chain do not truly understand why to integrate and why to share information, the actors will not share the required information. This results in the idea of supply chain integration falls. As Lee et al. mention (2004) it is mainly the dairy companies in a supply chain that obtains benefit from information sharing. This indicates that the dairy companies could gain benefits but some of the interviewees had not realised the potential of increased information sharing.

Today some dairy companies and retailers already share information, and depending on how much information they are sharing it will affect the potential food waste

reduction with the dynamic shelf life sensor. Regarding the information sharing did the authors not recognise any direct potentials connected to the retailers and the consumers. The consumers will not be directly affected by the information sharing, but their purchases and habits will be logged and give valuable information. Since this mainly benefits the dairy companies there has to be other winnings for the retailers to create a win-win situation (Lee et al., 2000).

7.2.2 Win-Win Deals for All Supply Chain Actors are Needed

The supply chain management theory focuses on win-win situations and that all actors have to be involved to get the implementation in the supply chain to be realized. Therefore is it important with a supply chain management focus when implementing the dynamic shelf life sensor. A successful supply chain is e.g. when a win-win situation is created for all actors and when the supply chain actors trust each other. A win-win situation can be difficult to manage, since with the dynamic shelf life sensor the actors' have different potentials and barriers. The actors are also affected by each other differently. To find win-win situations in the supply chain there has to be a change in the companies mindset and leave the individual profit maximisation, and change to supply chain profit maximisation (Christopher, 2011; Lee, 2004; Seidmann & Sundararajan, 1997). An example of a complex supply chain situation regarding creating win-win situations is that with the dynamic shelf life sensor the dairy companies can gain more information about the consumers demand, which can decrease the dairy companies food waste and safety stocks. At the same time, the dairy companies can lose resources to their pig feed production. The dairy companies lose resources to their pig feed production if the retailers are able to sell all their purchased products; then the retailers do not return any unsold packages.

Another example is that the consumers can possibly reduce their food waste the most. However, the interviewees are not sure that they are willing to pay extra for the dynamic shelf life sensor. If the consumer wants to decrease their food waste maybe they need to make a trade-off and chose if they want to decrease food waste or buy cheaper milk. Stevens (1989) mentions that there have to be trade-offs for each actor in the supply chain to be able to profit maximise the whole supply chain. Even the retailers have to make trade-offs, if they implement the dynamic shelf life sensor, the consumers could possibly reduce their food waste, and they probably buy less milk. The authors have on the other hand recognised opportunities for the retailers to reduce costs regarding unsold packages.

An important consequence with the dynamic shelf life sensor is the investigated supply chain actors will also need to trust each other, meaning they have to share information and believe that it is for their own good as well. It is when the supply chain work as a network that competitive advantages can be created towards other supply chains (Christopher, 2011; Lee, 2004; Seidmann & Sundararajan, 1997).

As Mentzer et al. (2001) mention, all actors need to have supply chain orientation to be able to get supply chain management and the preferred consequences. During

the interviews the authors have seen that the studied supply chain actors do not see any potential win-win situations, they mostly focus on their trade-offs instead.

7.2.3 Food Waste Reduction Can Lead to Decreased Revenue Streams

One critical aspect with the dynamic shelf life sensor is if the consumer wastes less food they will also buy less food from the retailers. According to the authors' calculation, see Appendix II, every person will purchase 2.7 litres less milk per year. This results in a reduction of 25 650 tonnes annually for the retailers and dairy companies, which stands for about 3 % of the annual sales of milk. This gives the retailers and the dairy consumers a reason to not become a part of the dynamic shelf life sensor system. To compensate for the lost revenue the retailers and dairy companies have to get new revenue streams or decreased costs. One way for the retailers to compensate is that they are able to sell more of their purchased milk instead of returning it back to the dairy companies, since when they return milk they do not receive any money from the dairy company. The returning system is only a service from the dairy companies.

From interviews, there have been seen some first mover advantage to implement the dynamic shelf life system. Some of the interviewees at the dairy companies believe that if they implement the sensor consumers could choose to buy their milk instead of the competitors. This indicates that the sensor could give benefits that make the supply chain more competitive to their competitors supply chain (Christopher, 2011). This is also a way to get new revenue sources.

A new opportunity that opens for the retailers and the dairy companies with the dynamic shelf life sensor is the introduction of individual pricing strategies. The milk could then be priced after its individual quality. If the quality is communicated to the consumers, they know what they paid for and do not become disappointed (Oliva & Revetria Diptem, 2008). This could result in lower levels of food waste both at the retailers and the dairy companies.

7.2.4 Competitive Advantage Through Consumer Value

As mentioned in the frame of reference, one recurring characteristic in a theory about well-functioned supply chain is the customer value and satisfaction (Giunipero & Brand, 1996; Langley & Holcomb, 1992; Mentzer et al., 2001). Based on the interviews the authors have perceived a certain hesitation among the dairy companies and retailers if dynamic shelf life sensor is a value adding technology and if the milk food waste reduces. One reason for the hesitation is the actors' difficulties seeing that an additional value is created with a dynamic shelf life sensor and that there is a consumer need for the technology. It has also been raised that the technology could be complicated for both the consumers and the retailers and thereby hard for the supply chain to embrace. As mentioned in previous studies one of the main aspects to consider is the consumer usability (Lee et al., 2000).

However, other interviewees had a positive approach to the technology and thought it is a value adding solution that can lead to a reduction in food waste. The consumer

expert has a belief that the dynamic shelf life sensor is value adding for the consumers since the consumers can save money, they are consciousness regarding the earths limited resources and that it is unethical to throw away food. Further on, the supply chain management researchers argue that is it essential to have a consumer orientation to get a successful supply chain management (Ellram & Cooper, 1990; Mentzer et al., 2001; Tyndall et al., 1998). At the interviews, it has been hard for interviewees to clearly define the customer value and customer need with the dynamic shelf life sensor. Food waste reduction seems according the interviews and reports to be a social need but if the dynamic shelf life sensor is the way the consumer wants to decrease their food waste level with, is hard to say.

7.2.5 The Cold Supply Chains and Their Challenges

In the cold food supply chains is one major reason behind food waste the broken chilled chains. To keep the cold supply chain in the right temperature are important both for the human safety and for keeping the shelf life of the product (Oliva & Revetria Diptem, 2008; Olsson & Skjöldebrand, 2008). The main challenge is found in the interconnections between the supply chain actors. The reasons for that are for instance; the employees' knowledge level, handling procedure and the communication between actors. All these aspects have a big impact on the chilled supply chain (Olsson & Skjöldebrand, 2008).

The interviewees' had different views on how secure the cold supply chain were during the interviews. Some actors were ensured that their part of the supply chain were secured but thought that other parts of the supply chain could improve. With a dynamic shelf life sensor, it would be no doubts regarding if or who that have not fulfilled their part of the supply chain. There are possibilities to manually control the transportation temperature in the truck today but the problem with the monitoring is that it measures the temperature at one point in the truck, which could be misleading information. The product temperature and the temperature in the truck do necessarily not need to be the same. For example if a truck has not been able to keep the temperatures the whole distance the entire load does not need to be wasted if it were possible to differentiate consumable products from the inconsumable products. The dynamic shelf life sensor could then indicate which product that has been affected by the temperature changes and thereby the food waste could be lowered.

7.2.6 Innovation Without Focus on Profit Maximization

Even though there were a lot of hesitations during the interviews about the dynamic shelf life sensor, many interviewees thought that the dynamic shelf life sensor would become reality in some sensor solution. When the innovation does not clearly lead to cost reduction, the authors have noticed a barrier for the studied actors to see potentials and barriers except increased costs. This could be a result of the vague customer need but also a fact of the companies constant profit maximisation. Studies regarding the success of other sensor solutions have shown that there is a big importance of cost efficiency (Han et al., 2005). Han et al. (2005) agree with the

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cost aspect and mentions important characteristics for devices like dynamic shelf life sensor are: easy to use and cost effective.

In contrast to the individual companies profit maximisation Porter and Kramer (2011) mentions there could be gained competitive advantage through shared value between social profit and company profit. Porter and Kramer states that an innovation could both gain the society and the companies profit. Since this is a new and different approach compared to the classic profit maximisation, it could be hard for the companies to understand the whole meaning. The dynamic shelf life sensor could be seen as an innovation both giving value to the society and the individual company. Society could gain benefits from reduced food waste and the supply chain actors from the dynamic shelf life sensor.

7.3 Dynamic Shelf Life Sensor and Corporate Social Responsibility

Corporate Social Responsibility (CSR) can be defined as “actions that appear to further some social good, beyond the interest of the firm and that which is required by law” (McWilliams & Siegel, 2001, s. 117). Food waste is a problem that is socially, economic and environmental (Jordbruksverket, 2011). The implementation of a dynamic shelf life sensor can be seen as a company’s work with CSR and in the case that they are helping to solve social problems that they are a part of creating (Buchholz, 1991). Based on the CSR and empirical data are there several potential effects with a dynamic shelf life sensor implementation.

7.3.1 Stronger Brand Through Marketing

During the interviews, one of the advantages the supply chain actors mentioned about a dynamic shelf life sensor implementation was their ability to strengthen their brand. One of the dairy companies mentioned that an implementation would lead to evidence that they are innovative. Other interviewees also mentioned the ability to secure that they were keeping the right temperature, which would lead to a quality assurance that could have a positive affect on their brand. Another advantage was that the dynamic shelf life sensor could increase consumers’ trust to the dairy companies, but only if it measured the temperature correctly. When the consumers trust the dynamic shelf life sensor they can decrease their food waste levels since they would probably not throw milk that is consumable. McWilliams and Siegel (2001) agree with the interviewees regarding the dynamic shelf life sensors ability to strengthen their brand. McWilliams and Siegel (2001) and CSR Europe (2008) believe that a product with CSR attributes can result in a strengthen reputation regarding quality and reliability, this is especially important, for example, for food products (McWilliams & Siegel, 2001).

However, the majority also mentioned high marketing costs due to the dynamic shelf life sensor implementation, which is needed to inform the consumers about the device. McWilliams and Siegel (2001) also mentions that informing the consumers is essential to succeed with the implementation since the consumers must be aware of the product’s CSR attributes, and understand the additional value.

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They mention that one way to succeed with informing the consumer is through marketing (McWilliams & Siegel, 2001). This means that marketing can be seen as a key success factor for the dynamic shelf life sensor.

McWilliams and Siegel (2001) also mention that a company's marketing strategy should be aimed for its key consumers to be able to make the CSR product profitable (McWilliams & Siegel, 2001). During the interviews the authors could not get the information about who the key customers for the dynamic shelf life sensor would be. This can make a marketing strategy more complicated since it is the key customer that values and wants to support their product with the CSR attribute (McWilliams & Siegel, 2001).

7.3.2 The Consumers Willingness to Pay

During the interviews, the interviewees had different views on whether the consumers would be willing to pay additional for a milk package with a dynamic shelf life sensor. Some of the interviewees thought that the consumers would not pay additional for milk with a dynamic shelf life sensor and that it would only create additional value. Other argued that consumers support the solution and consumers that waste a lot of milk would probably be willing to pay an additional price. According to the Swedish National Food Agency (2014) many consumers believe that they do not throw food but other people do. This indicates that the consumers that would have gained benefits from the dynamic shelf life sensor do not understand that they need the sensor and therefore do not pay anything extra for it. McWilliams and Siegel (2001) write about how price can affect if the consumers purchase a product with CSR attributes or not. They mention that income and substitute products price is parameters that can affect the consumers regarding if they are purchasing a product with CSR attributes. Low-income people are often more price-sensitive and if there are a significant price differentiation the consumer are most likely going to buy the milk without the CSR attribute (McWilliams & Siegel, 2001). The consumers' price-sensitivity has also been confirmed at the interviews with the consumer expert. The interviewees also mentioned that consumers are not quite as price-sensitive today regarding milk as they used to be as a result of the increased milk selection. This could be seen as a potential for the consumers' willingness to pay for the dynamic shelf life sensor.

McWilliams and Siegel (2001) also mention the importance to know the key consumer before pricing, and if the key consumer is willing to pay additional. As mentioned above, the interviewees have not given the authors any answer to this. To know if there are a demand and if this solution is profitable it is important to be aware of the key consumer (McWilliams & Siegel, 2001). However, the authors have got indications that the consumers that have a willingness to pay for ecological products could have the willingness to pay for the dynamic shelf life sensor.

7.4 Summing of the Analysis

As mentioned, there are several different potentials and barriers for the supply chain actors in the milk supply chain. To be able to gain the potentials there are a couple of key success factors. One key success factor is to get the consumers to realise that they are wasting food. When that is achieved the second key success factor is to get the consumers to embrace the technology, this could be done by the third success factor: marketing. To get full the effect from the marketing it is important to know the key consumer. Which key consumer the dynamic shelf life sensor has could the authors not deduce from the interviews or the written sources. When the key consumer is defined, it becomes possible to specify the marketing and the pricing strategy to the target group.

During interviews it has not been clarified if there is economic gains for the actors in the supply chain but the dynamic shelf life sensor implementation can be seen as the companies CSR or shared value work. According to Porter and Kramer the shared value creates innovation and productivity growth in the global economy and gives benefit to the society.

Other key success factors are creating win-win situations for the supply chain actors and information sharing. These two could lead to a more competitive supply chain, which can create competitive advantage against other supply chains.

8 Conclusions and Final Remarks

In this chapter the studies objectives are answered, the generalizability is discussed, and the authors thoughts are presented. The chapter ends with criticism to the study and future research.

8.1 Answering This Study's Objectives

This study contributes with an understanding regarding food waste reduction and the dynamic shelf life technology. It increases the understanding about potentials and barriers for food waste reduction using the dynamic shelf life technology in the investigated milk supply chain. Further on it clarify the supply chain actors' business consequences with an implementation of the dynamic shelf life sensor. The study has five objectives that are answered in the study and summarised below.

Presenting dynamic shelf life sensor technology in general and especially the RFID-based time- and temperature technology

There exist various technologies to display how a product has been treated throughout the supply chain. This study focuses on the radio frequency identification (RFID) sensor technology. The sensor measures time and temperature to secure the product's quality regarding the time the product has been exposed to a certain temperature. An expiration date is then calculated, based on the time- and temperature information. The technology has developed the previous years, and today the RFID sensor tags can communicate more information than products' remaining shelf life through time- and temperature. This study's fictive sensor is also able to share information, such as sales information, between the dairy companies and retailers through a mutual computer system.

Mapping of the investigating milk supply chain and its food waste: where, how much and why?

The authors conducted a mapping of the milk supply chain to see where, how much and why food waste occurs. The result was that the food waste occurs throughout the supply chain, from the dairy companies to the consumers. At the dairy companies, 0.1 % of the sold packaged milk volumes become food waste. Common food waste reasons at the dairy companies are; miscalculation in demand, too long storage time in the finished goods inventory, overproduction, minimum production volume is bigger than sellable volume, picking errors, distribution errors, damaged packages and date rejections.

At the retailer level the food waste percentages are between 0.2 % and 0.8 % of the purchased milk volume depending on from which study the data is taken. At the investigated retailers, food waste mainly occurs from expired best-before date, promotions and holidays that affect the demand, forecasting problems, too big

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ordering volumes, the consumers want to buy products with long remaining shelf life, uneven consumer flow and that small retailers have few deliveries per week.

The consumers' stand for the majority of the food waste and approximately 5.2 % of the purchased milk become food waste at the consumer level. Food waste occurs since the best-before date expires, the consumers' lack of planning and incorrect portioning. Many consumers do not smell or taste the milk before throwing it down the sink; they are only taking the best-before date into consideration.

Identifying potentials for food waste reduction in the milk supply chain by using the RFID-based time- and temperature technology

All three of the investigated supply chain actors: the dairy companies, the retailers and the consumers have potentials for food waste reduction with the dynamic shelf life sensor. The potentials are based on the assumption that the supply chain actors are keeping the milk below the recommended temperature. When the milk is kept below the recommended temperature, it can often be consumed for several days after the best-before date.

Today the dairy companies and the retailers have an informal rule, saying that the retailers do not accept products with too short remaining shelf life days. Too short remaining shelf life days are when more than one third of the total shelf life has passed. If the sensor can ensure that the products have been stored in the recommended temperatures at the dairy companies, the food waste that occurs from too short remaining shelf life time or overproduction can be sent to the retailers. Further on, only the products that have been exposed to temperatures above the recommended during transports can become food waste instead of the entire load as it does today. Another supply chain potential is the increased information sharing, e.g. sales information, which has the potential to result in higher responsiveness in supply chain. This could affect the food waste that derives from miscalculated demands and overproduction.

The retailers also have the potential to decrease their food waste. Today food waste occurs from e.g. miscalculated demands, and the products become food waste since the best-before date expires. With the dynamic shelf sensor, the products actual expiration date can be shown, and the product could have a longer time in the shelves, meaning the potential that the products could be sold are bigger.

Food waste at the consumer level occurs since many consumers do not consume milk after the passed best-before date, even though it is still consumable. If the sensor indicates that the milk is usable the consumers could consume the milk after the best-before date instead of pouring it down the sink as many consumers do today. Today each consumer wastes about 4.7 litre of milk yearly. Since 57 % of all food waste is avoidable food waste the dynamic shelf life sensor could maximum decrease the milk food waste with 2.7 litres of milk per person and year.

Identifying barriers for food waste reduction in the milk supply chain by using the RFID-based time- and temperature technology

There are different food waste reduction barriers throughout the supply chain. The dairy companies major barrier is that they have a doubtful approach to the dynamic shelf life sensor at milk packages. They are also hesitating about if the sensor can decrease food waste at their dairy factories, even though some believe so. Today, the retailers often return their unsold packages to the dairy companies when the best-before date has passed. This is a service the dairy companies provide for free. However, the retailers are still paying full price for the purchased milk. The dairy companies use the unsold milk for their pig feed production. With the dynamic shelf life sensor, the dairy companies resources could decrease, which also is a barrier.

With the dynamic shelf life sensor implementation, this study has not come up with any barriers for decreasing the food waste at the investigated retailer level.

At the studied consumer level there are two major barriers for food waste reduction. The first barrier is that many consumers do not believe that they waste milk, which can affect the need and demand for products with the sensor. The second barrier is the consumers' attitude to the best-before date, meaning that they follow the best-before date instead of smelling and tasting the product. If the printed best-before date remains on the package, the consumers must trust the sensor and follow the proposed shelf life expiration date instead.

Identifying and discussing business consequences of implementing the RFID-based time- and temperature technology in the milk's mapped supply chain

If the dynamic shelf life sensor is implemented the supply chains actors have different potentials and barriers, hence the business consequences for the implementation varies. To get a competitive advantage, create customer value and customer satisfaction the supply chain needs to be integrated. Activities to increase the supply chain actors' integration are creating win-win situations and information sharing. Most of the business consequences could be seen as creating win-win situations for the supply chain actors, however, to succeed trade-offs are needed throughout the supply chain. An example is that consumers have the greatest food waste reduction potential. However, it is unsure if the consumers are willing to pay additional for the sensor. If the consumers want to decrease their food waste levels, maybe a price increase is needed. Information sharing is another key activity to create a responsive and agile supply chain. However, if the supply chain actors do not understand why information sharing is needed, it could affect the outcome. The reason behind that could be the lack of supply chain orientation at the actors in the investigated supply chain. When all actors have supply chain orientation, the win-win situations could be gained.

It has been seen that with the dynamic shelf life sensor implementation it is important with marketing. The CSR theory focuses on knowing its key customer and during the study the key consumer for the dynamic shelf life sensor have been difficult to describe. Since the marketing is important when launching a product with

a new CSR attribute, it is important to know whom it is created for to get the highest impact.

8.2 Generalizability

Generalizability is in what extent a study's results and findings are applicable in other circumstances and situations, such as other companies or supply chains (Sounders, Lewis, & Thornhill, 2007).

A case study gives a deeper understanding since only few units are studied (Jacobsen, 2002). The generalizability is usually discussed at case studies, since only one or a few situations are being investigated (Yin, 2009; Jacobsen, 2002). This results in a low external validity and poor basis for generalizing the single case (Yin, 2009). During the data collection the authors have tried to understand what answers that were specific to the product decision and what answers that were connected to the product and the dynamic shelf life.

Regarding the dynamic shelf life implementation this study has a low degree of generalization outside the food industry. Within the food industry the results can be applicable on other products, especially dairy products, other perishable products with short shelf life and products with short supply chains. Further on the results can be applicable on other industrial countries that are similar to Sweden. This is since reports made by WRAP and FAO are often mentioning the same food waste problems in UK and other industrialised countries regarding dairy products as Sweden. Reports by Swedish governmental agencies are also referring to e.g. WRAP and FAO in their reports when writing about food waste in Sweden. There are other aspects to take into consideration regarding the applicability on e.g. UK, other Nordic countries and Germany. These are aspects such as living standards and technological development, and these aspects are similar to Sweden. Hence, the dynamic shelf life sensor solution could be interesting and applicable on those markets as well. This reasoning is strengthened by the few similar projects that are on going in Europe, such as the PASTEUR project that involves several actors in the food supply chain.

As the analysis has shown, there are some supply chain issues that have to be considered before implementing the dynamic shelf life sensor. The supply chain issues are similar to Nilsson and Göransson's (2013) results in their study regarding supply chain issues with a dynamic shelf life implementation in general. This means that this study's result regarding supply chain issues have a higher degree of generalizability and can be applicable on other food supply chains than milk, such as meat and fish.

The supply chain issues are also applicable on supply chain outside the food industry. The reason is that the mentioned issues, such as creating win-win situations for all supply chain actors, are issues that are frequent mentioned in the

used supply chain management theories, without any connection to a specific industry.

8.3 The Authors Thoughts

During the study the authors have gained more understanding about food waste and the dynamic shelf life sensor technology. In this section some thoughts and insights are summarised.

In the problem description, it was mentioned that researchers have different views on the dynamic shelf life sensor implementations outcome. Some researchers argued that an extended shelf life date would mostly gain the producers since they would increase the products storage time in the finished goods storage. Other researchers pointed out the scenario that an extended shelf life would gain the retailers and consumers the most, and where the food waste would decrease (Jensen, Båth, & Lindberg, 2013). In this study, the authors have got the input and impression that it is possible that the extended shelf life gives the retailers more time to sell a product or more time for the consumers to consume the milk. If an extended shelf life should have an impact on the supply chain and the food waste, the author believes that it is important that the products would spend more time at the retailers and the consumers since it is at their levels most the food waste occurs.

During the study, the authors have also discussed what types of products that are suitable for the dynamic shelf life sensor. Today when the dynamic shelf life technology is relatively new within the food industry the authors believe that the most suitable products are perishable products with short shelf life, higher value compared to milk and high volumes. When the cost of dynamic shelf life decreases, it will be fewer hesitations about implementing the concept on low value products. For example, milk is a high volume product, but because of its low value are there hesitations about a sensor implementation in the supply chain. Meat and fish, on the other hand, are more expensive perishable products with high volumes but not as high as milk. It would probably be easier to decide to implement the sensor in their packages since the packaging cost is much lower related to the product value. However, this study has shown that the avoidable milk food waste could decrease with approximately 3 % of the sold milk volumes in Sweden with the dynamic shelf life implementation. If the same percentage is applied in more countries, such as the other Nordic countries or UK it could result in huge volumes of milk food waste reduction.

8.3.1 The RFID Time- and Temperature Sensor or a TTI

The authors believe that it can be hard to implement an RFID sensor on a milk package today since the sensor has a relatively high cost compared to the products value. Another alternative that can be seen as a preface for the RFID sensor could be to implement a time and temperature indicator (TTI), which is much cheaper than an RFID sensor. The TTI would not include the most supply chain benefits, but the temperature control and the indication of when the product becomes inedible could

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still be shown. Hence, the consumers are the actors that could have most potential with the TTI, and if they trust the technology the food waste could be reduced at the consumer level with a TTI.

The authors believe the preferable technology depends on what objectives the supply chain has with the dynamic shelf sensor. If the main focus is reduced food waste at the consumer level, it could be enough to implement a TTI. However, if the supply chain actors want benefits as information sharing and food waste reduction throughout the whole supply chain, the benefits gained by the RFID time- and temperature sensor is preferable. The self-monitoring aspects described in the chapter 6 and 7 could be gained by using both technologies.

8.3.2 The Dynamic Shelf Life Sensor Could be Placed at Different Package Levels

Another possible preface to an RFID time- and temperature sensor placed at every milk package is to place an RFID sensor at the secondary or tertiary package level. Then the supply chain could adapt to the technology to be able to share the temperatures in the cold chain. During interviews, it came up that it is not all cold chains that are ready to be shown in public (Distributor, 2014; Retailer B, 2014). To implement an RFID sensor at higher packaging levels could gain benefits such as, the supply chain actors that are not able to keep the cold chain could monitor their supply chain and improve it. This could result in a higher standard in the whole industry. The disadvantage with a sensor on the secondary or tertiary packaging levels is that the sensors do not meet the consumers, and as mentioned before it is at the consumer level the most food waste occurs.

The authors believe that it is important for the sensor to meet the consumer to get as high impact on the food waste as possible. However, to secure the cold supply chain an RFID sensor solution at higher packaging levels is a good alternative in the beginning.

8.4 Method Criticism

In this study's methodology chapter, the authors did present their research approach and strategies. The methodology chapter did also include the working process, and there are different aspects that may have affected this study's results and credibility regarding the data collection methods.

When the authors started working on this study one of the objectives was to find business models for the involved supply chain actors. However, after several interviews the authors realised that many of the interviewees had difficulties with discussing business models for the dynamic shelf life sensor. The authors believe that the interviewees were not ready to adopt the dynamic shelf life technology at milk packages. This made it difficult to talk about business models since the interviewees mostly thought about the barriers. With that insight, the authors changed the objective and focused on the business consequences with a dynamic

shelf life sensor implementation instead. Since the authors had semi-structure interviews and asked not only question related to business models, useful data were collected even though the objective changed. The authors could therefore use majority of the collected data. However, this affected the data collection process. It also affected the study's analysis and results, since all interviews were already conducted with the business model focus.

One weakness related to some of the interviewees' unwillingness to discuss the dynamic shelf life sensor implementation is that the authors could not in all cases get answers on how the interviewees believed the sensor could decrease their milk food waste. In those cases, the authors did use written reports and the knowledge they got from observations instead.

8.4.1 Criticism on the Written Sources

Throughout the study, the authors used both academic articles and reports written by governmental agencies and consumer societies. The used articles from academic journals can be expected to have high credibility since others often review them before publishing. When searching after information and previous research within food waste, the authors used information from e.g. journal articles or government authorities. The authors also used less credible reports from e.g. consumer societies, and they were used to get a better insight in food waste and its status in Sweden, since the availability to this information in academic articles was low.

When reading reports it is important to be critical about the information and its sources, and to compare the information with other reports and researches (Bryman & Bell, 2013). The authors discussed the used reports and reviewed its sources before using them in this study. Other researches about food waste were reports from other industrialized countries, such as UK, Spain or USA. Many Swedish reports from governmental agencies also got their information from international studies and, therefore, the authors thought the information were trustworthy. In this study those reports were assumed to refer to Sweden as well, even though there may exist differences between the countries. However, after discussions between the authors, the differences between the countries were assumed to not effect the result.

8.4.2 Criticism to the Interviews and Observations

Due to limited time among many of the interviewees, the authors had problems with getting persons with right knowledge and background in the business of their company and knowledge about food waste. In some cases, only a few people within the company had time to answer questions. This affected the variety and depth in answers that the authors were hoping for and the amount of collected empirical data. It also made it more difficult for the authors to draw conclusions from the empirical data regarding the study's objectives. One of the companies was in the middle of a re-organisation, which effected the authors since it was time consuming and difficult to find people with the right knowledge.

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During the data collection the authors also had difficulties with getting the percentage of waste at some actors along the supply chain, due to vague information and confidentiality. This had an impact on the study's objectives, and the authors tried to get information through a deeper literature search instead. The authors also had problems with observing the product during transports between the dairy company and the retailer, even though the dairy companies were responsible for the distribution. The authors carried through unstructured interviews with a distribution company to get a more complete understanding.

8.5 Suggestion on Future Research

Throughout the study have the authors found areas that would have been interesting to find out more about, regarding e.g. food waste and dynamic shelf life sensors. Based on these areas ideas have several suggestions for future research been created. In the list below the areas are listed.

- This study gained a deeper understanding about a dynamic shelf life sensor's potentials, barriers and business consequences in the milk supply chain. In future studies would it be interesting to see how the results differs between milk and other products, e.g. meat or fish that are products with higher value.
- This study proceeded from one defined dynamic shelf life sensor, namely the RFID time- and technology sensor. In future researches, it would be interesting to conduct the same study with another dynamic shelf life sensor. This to get aware of how the result differences, and to see what sensor that is suitable for high volume and low value products.
- In future researches would it be interesting to do a deeper and more quantified study about which of the food waste reasons that can reduce food waste the most with a sensor implementation. This would be interesting since then would it be easier to build an understanding on if the actors should invest in the technology, and for what reasons.
- In food waste reports is the environmental impact often mentioned, and this is an aspect that the authors have not focused on. However, it would be interesting to see how the environment can be affected by a dynamic shelf life implementation. Further on, it would also be interesting to see how the result differs between products.
- The authors have read about other methods to reduce food waste in Sweden. For example, some researches believe that food waste can reduce if the recommended temperature for chilled products decreases. It would be interesting to find how the methods differ and how they affect the food waste reduction. It would also be interesting to see how the different methods affect e.g. the environment.

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Appendix I

	Dairy companies	Retailers	Consumers	Overall supply chain
Potentials for food waste reduction	<ul style="list-style-type: none"> · Food waste the occurs from overproduction, demand estimation problems, too long storage in the finished goods inventory and distribution and temperature errors could decrease. · The main reasons for the food waste decrease are because of the increased information sharing and the temperature control on each package. 	<ul style="list-style-type: none"> · The dynamic shelf life sensor could affect the food waste if it shows that the products have been kept in perfect condition and thereby could be sold after the printed best-before date. 	<ul style="list-style-type: none"> · If the consumer embraces the technology, food waste caused by best-before date can decrease. · The increased attention to the milk could affect the food waste caused by lack of planning and incorrect portioning. 	<ul style="list-style-type: none"> · When all routines and procedures are secured the food waste will decrease at the retailers and dairy companies.
Potentials for the dynamic shelf life sensor	<ul style="list-style-type: none"> · The awareness of environmental impact has increased. And a sensor could lead to a reduced environmental impact. · Information from retailers about consumer purchases and behaviour could make the forecasts easier. · Potential to strengthen the brand. · The safety regarding the transportation temperature will increase since the sensor creates a self-monitoring of the distributors. 	<ul style="list-style-type: none"> · Milk has lately become less price-sensitive which could indicate that the consumers could pay a little extra for the sensor. · The sensor could strengthen the retailers' brand by increasing the creditability. · The retailer could get economical benefits from more précis ordering volumes and fewer returned packages. · The retailer will also get a self-monitor of the routine and procedures. · Another potential with the dynamic shelf life sensor is the possibility in implement individual pricing. 	<ul style="list-style-type: none"> · Understand the freshness in an objective way and the consumers learn how to treat the milk in a correct way. 	<ul style="list-style-type: none"> · The dynamic shelf life sensor gives an objective monitoring of the temperature in all stages in the supply chain.
Barrier for reducing the food waste	<ul style="list-style-type: none"> · A negative attitude to a dynamic shelf life sensor implementation on milk at some of the dairy companies. 	<ul style="list-style-type: none"> · No barriers at the retailer level were identified 	<ul style="list-style-type: none"> · The consumers do not think they waste food and thereby do not think they need the sensor. 	<ul style="list-style-type: none"> · The food waste will increase before procedure and processes are secured.

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			<ul style="list-style-type: none"> · There has to be an attitude change about the best-before date. 	
<p>Barriers for the dynamic shelf life sensor</p>	<ul style="list-style-type: none"> · There are no problems regarding milk food waste according to one of the dairy companies. · Since there are low profitability and margins in the dairy industry the dairy companies see it as hard to carry the cost for a dynamic shelf life sensor. · The production and warehouse management system is built on the printed best-before, and it is costly to change. · Some interviewees at the dairy companies does not see the benefit of sharing information. 	<ul style="list-style-type: none"> · Retailers do not want to sell products with expired best-before date. · Since the shelf life will be dynamic the expiration date will differ between different batches since they could have been treated differently. · It will become harder to predict the expiration dates and it will require a new ordering procedure. · If consumer's food wastes decrease, the retailers will sell less milk. 	<ul style="list-style-type: none"> · If the consumers believe that the procedure to download an application and to scan the products is complicated will there not be any effect of the sensor. · Today most of the consumers wants to buy milk with long shelf life left and to change that behaviour the consumer need to embrace the technology. · If the sensor increases the dairy companies' costs there is a risk that the consumer price increase since brand owner often transfers their cost to the consumer prices. · The consumers have high price focus. 	<ul style="list-style-type: none"> · It is not sure if the supply chain is ready to be public for the involved actors and if not it could lead to big consequence.
<p>Effects cause by the dynamic shelf life sensor implementation</p>	<ul style="list-style-type: none"> · The effects on the dairy companies highly depend on if the printed best-before date is kept or the dynamic shelf life sensor replaces it. Either way there is a need for education and marketing in order to inform the actors in the supply chain about the dynamic shelf life sensor. · The sensor could lower the number of complains and the workload for the personnel working with returns could decrease. 	<ul style="list-style-type: none"> · The retailers have to implement a new ordering procedure. 	<ul style="list-style-type: none"> · The consumers will waste less food as long as they trust the technology. Then it results in fewer purchases of milk, which in turns leads to, the consumer saves money and learns how the milk should be treated. 	<ul style="list-style-type: none"> · The sensor technology will create a social economic benefit regarding the environment, food waste and food safety.

Appendix II

Calculation Of Food Waste At The Consumers

Volume consumed milk per person and year: 87,4 litre (Svensk mjölk, 2013)

Persons per household: 2.22 (Statistics Sweden, 2014)

*Consumed milk per household: $2.22 * 87.4 = 198.5$ litres*

Milk food waste per household and year: 10.4 litre

$$\text{Percentage of milk waste per year: } \frac{10.4}{198.5} = 5.2 \%$$

Decreased Food Waste With Dynamic Shelf Life Sensor

Assumptions: The sensor could reduce all avoidable food waste (57 % of the food waste)

$$\text{Wasted litres of milk per year: } \frac{10.4}{2.22} = 4.7 \text{ litres}$$

Waste litres of milk per year with dynamic shelf life sensor:

$$4.7 \text{ litres} * 57 \% = 2.7 \text{ litres}$$

Decrease Of Produced Milk At The Dairy Companies

Assumption: Swedish population is 9.5 million peoples

Total volume of produced raw milk: 2 900 000 tonnes (LRF, 2013)

Percentage of raw milk becomes drinking milk: 30 % (LRF, 2013)

*Total volume of drinking milk: $2\,900\,000 * 30 \% = 870\,000$ tonnes*

$$\text{Percentage reduction with dynamic shelf life sensor: } \frac{0.0027 * 9\,500\,000}{870\,000} = 2.9 \%$$