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List of Abbreviations

BI	Business Intelligence
CCIS	Cold Chain Information Systems
CCL	Cold Chain Logistics
CCM	Cold Chain Management
FSC	Food Supply Chain
FSCM	Food Supply Chain Management
FSP	Food Service Providers
HACCP	Hazard Analysis and Critical Control Point
ISO	International Standards Organization
KPI	Key Performance Indicator
LSP	Logistics Service Provider
RFID	Radio Frequency Identification
SCCM	Smart Cold Chain Management
TMS	Temperature Monitoring Solutions
TSP	Temperature Sensitive and Perishable Products
TTI	Time-Temperature Integrators
WSN	Wireless Sensor Networks
STMS	Supplier of Temperature Monitoring Solutions
FFKM	Föreningen Fryst och Kyld Mat [the Swedish Frozen and Chilled Food Association]

I. Introduction

This introductory chapter reveals the background of the topic for the current master thesis. The problem statement is presented together with the purpose and research questions. The chapter ends with the delimitation section, followed by a thesis disposition describing its structure.

I.1 Background

The food industry is considered as one of the most important branches of the European Union's economy, playing a central role for the manufacturing and processing of agricultural raw materials and semi-finished products (Bigliardi & Galati, 2013; Manzini & Accorsi, 2013). According to the Swedish Food Federation, the food industry is the 4th largest industry in Sweden in terms of production value (170 billion SEK) and number of employees (55 000 people within 3500 companies involved) (Livsmedelsverket, 2014).

The significance of the food industry makes the supply chain management in this area an important agenda for public, business and research discussions (Van der Vorst, Beulens & Van Beek, 2005). Food Supply Chain Management (FSCM) is more complex compared to supply chain management in other industries due to the perishable nature of the product, high fluctuations in demand and prices, increasing consumer concerns for food safety and dependence on climate conditions (Shukla & Jharkharia, 2013). Montanari (2008) claims that a considerable amount of the products in the food supply chains (FSCs) are perishable and that their importance grows with the change in global food consumer trends. Nowadays, more and more consumers understand that food crucially influences their health. That is why the growing number of customers' concerns are about food characteristics such as safety, quality, freshness and nutritiousness (Gebresenbet & Bosona, 2012). Yu and Nagurney (2013) state that the quality and perishability associated with food products will continue to put pressure on the FSCs. Thus, food safety and quality assurance are priorities of many governments and multinational corporations. The regulations are strict and the customer's awareness is high. The fact that the food industry and all its actors are under special attention, due to the extra social responsibility, is beyond controversy (Pullman & Wu, 2012). Therefore, the perishability and the increased social responsibility lead to a greater interest in the food science, engineering and FSC (Kuo & Chen, 2010).

Report summaries from the Swedish Food Waste Reduction Project 2013-2015 state that in 2012, food waste in the Swedish FSC (except in the primary production) totaled more than 1.2 million tonnes, equal to 127 kg per capita. With respect to this, the Swedish government has a strategic goal to reduce the food waste by 20 percent by the year 2020 and invest heavily in project with a holistic perspective on the FSC (Livsmedelsverket, 2014). In addition, according to Olsson and Aronsson (2004) and Olsson and Skjöldebrand (2008), the Swedish chilled FSCs lack temperature control. As a consequence, Swedish products might be with lowered quality and shortened shelf-life.

In order to address the food safety and quality concerns in the complex FSCM, the present research will focus on the Cold Chain Management (CCM) in the sector. The cold chain is considered as the solution to the degradation of perishable goods. Such products, including meat, dairy products, fruits and vegetables, flowers, pharmaceuticals, and certain chemicals require special thermal and humidity handling. When it comes to the food products, around 60 percent require refrigeration in order to increase their post-harvest life (Mattarolo, 1990). Their quality degrades with time as there are ongoing chemical reactions and every delay in the transportation can result in spoiled cargo. Fortunately, lower temperature can

significantly slow this process. Thus, food companies rely on the cold chain to sustain the integrity of their products (Rodrigue, 2013).

This dependence, coupled with the increase in demand for temperature sensitive and perishable products (TSPP), results in a stable growth rate of the cold chain market (Tamimi, Sundarakani & Vel, 2010). The total capacity of refrigerated storage worldwide has increased by 20 percent for the last two years (Totaltrax, 2015; Supplychain247, 2014). Moreover, the demand for cold chain logistics (CCL) is projected to grow with 16 percent a year until 2019 (Totaltrax, 2015). As for the Coolchain Europe (2014) the cold chain trends in the European market are the supply chain integrity, compliance with the Good Distribution Practices regulations and cost-effective technology. Furthermore, temperature monitoring is regarded as the second area of concern in the cold chains after the expertise of the professionals (Coolchain Europe, 2014). Data monitoring technology and software are among the top focus areas mentioned by practitioners. Furthermore, improving quality and safety is considered as number one priority for logistics service providers (LSPs) of cold logistics. The majority (62 percent) of them plan to increase their investment in the field. In particular, 45 percent of them plan to invest in data loggers, devices and sensing technology (Coolchain Europe, 2015).

The importance of the food industry and the complexity of the FSCs are the basis of the research. Furthermore, quality and safety priorities and stable growth in the cold chain market, as well as the investment focus on monitoring technology are factors taken into consideration while deciding on the problematization area of the current research.

1.2 Problem statement

The dynamic food industry and the complexity of the FSCM make the achievement of the total excellence in terms of food quality and safety a challenge. Moreover, Olsson and Skjöldebrand (2008) state that previous research on food safety and traceability has been focused on the connections between one or more actors in the FSC, but not on the whole FSC. Therefore, the current research will aim to fill this specific gap.

Currently, the effective CCM is one of the most efficient tools for achieving acceptable quality and safety levels (Kuo & Chen, 2010). However, at the same time, the cold chain appears as the weakest point in the whole FSC of TSPP (Oliva & Revetria, 2008). The cold chains worldwide experience a loss of approximately 25 percent of the transported food, because of fluctuation in the temperature (Rodrigue, 2013). When it comes to the perishable food, the percentage is even higher – 35 percent have to be thrown before reaching the consumer due to insufficient cooling (Hülsmann, 2011). Therefore, the research in the area of the CCM is highly beneficial.

In the context of FSCM, an urgent issue related to the CCM is the following: “if any of the links or activities in the cold chain is missing or weak, the whole system fails” (Bharti, 2014, p.33). It means that even small temperature fluctuations and disruptions in the cold chain may be the cause of safety and quality problems and economic losses for the whole FSC (Hafliðason, Olafsdottir, Bogason & Stefansson, 2012; Hoorfar, Butler & Prugger, 2011; Hülsmann, 2011; Jedermann, Nicometo, Uysal & Lang, 2014; Labuza & Fu, 1995; Montanari, 2008; Raab, Bruckner, Beierle, Kampmann, Petersen & Kreyenschmidt, 2008). The inadequate temperature conditions throughout the cold chain can lead to food-borne illnesses, spoilage or reduced shelf-life (Aung & Chang, 2014; Hoorfar et al., 2011; Kuo & Chen, 2010; Montanari, 2008; Oliva & Revetria, 2008; Zhang, Liu, Mu, Moga & Zhang, 2009). Moreover, research in the performance of the cold chain shows that it is frequently

broken at different stages, leading to disturbances, which in turn reduce the hygiene and quality of the TSPP (Joshi, Banwet & Shankar, 2011). The causes of such ruptures are the lack of proper refrigeration, tracking or visibility, and insufficient employee knowledge and communication (Hülsmann, 2011).

In order to overcome the challenges and achieve effectiveness and efficiency in preserving the quality and safety of perishable food items, streamlined and well-maintained CCM and, in particular, temperature monitoring systems are crucial (Salin & Nayga, 2003). Latest industry reports state that the technology enabling better monitoring and analytics of the temperature in real-time will play a major role in many CCL networks. Thus, much research has been done on the advancement of this type of technology (Tai, 2014). However, according to Pacitti (2012), technology itself is only one part of the general solution. The alignment of science, technology and processes is an integrated approach for having ultimate control over the cold chain. In order to better utilize the temperature monitoring solutions (TMS), managerial techniques and practices should be applied. However, in the existing CCM literature this perspective stays relatively untouched (Arduino, Murillo & Parola 2013; Bogataj et al., 2005). Thereby, hardly any framework covers all crucial aspects to consider for the better utilization of TMS. This circumstance creates a research gap to fulfill with the present research.

1.3 Purpose and Research Questions

The purpose of this thesis is to explore how the food industry actors are handling the temperature monitoring of perishable products and to analyze how an integrated approach, combining technological and managerial perspectives to the temperature monitoring solutions, can contribute to the achievement of the quality and safety goals of the perishable food supply chain.

In order to fulfill the purpose of the current research the following questions have been addressed:

RQ1. What is the current application of temperature monitoring solutions in the cold chain management in Sweden?

RQ2. How can an integrated approach towards the use of temperature monitoring solutions contribute to the enhanced utilization of these solutions and to the achievement of the quality and safety goals of the perishable food supply chain?

1.4 Delimitation

In order to narrow down the scope of the study and increase its feasibility and reliability, several delimitations have been made.

Firstly, in terms of geographical location the research will be limited to the market of Sweden. Sweden is a mature food market with many domestic producers of raw materials, food ingredients, semi-ready and ready products and with wide distribution network. End customers in Sweden are very health-conscious, companies are socially responsible. The strong legislative initiative is present in Sweden. All these points make Sweden a very interesting object to be explored.

Secondly, from all the products in the food industry, the TSPP are the focus of the current research.

Thirdly, the focus within the CCM is the utilization of TMS and its contribution to the preservation of the food quality and safety.

Fourthly, among the actors in the CCL process (see Figure 2.3, p. 11), the paper focuses only on producers, LSPs, Food Service providers (FSPs), retailers and store owners, and thus exclude the farmers and customers perspective.

1.5 Thesis Disposition

For the convenience of the reader, the authors provide an outline of the thesis' structure (see Figure 1.1).

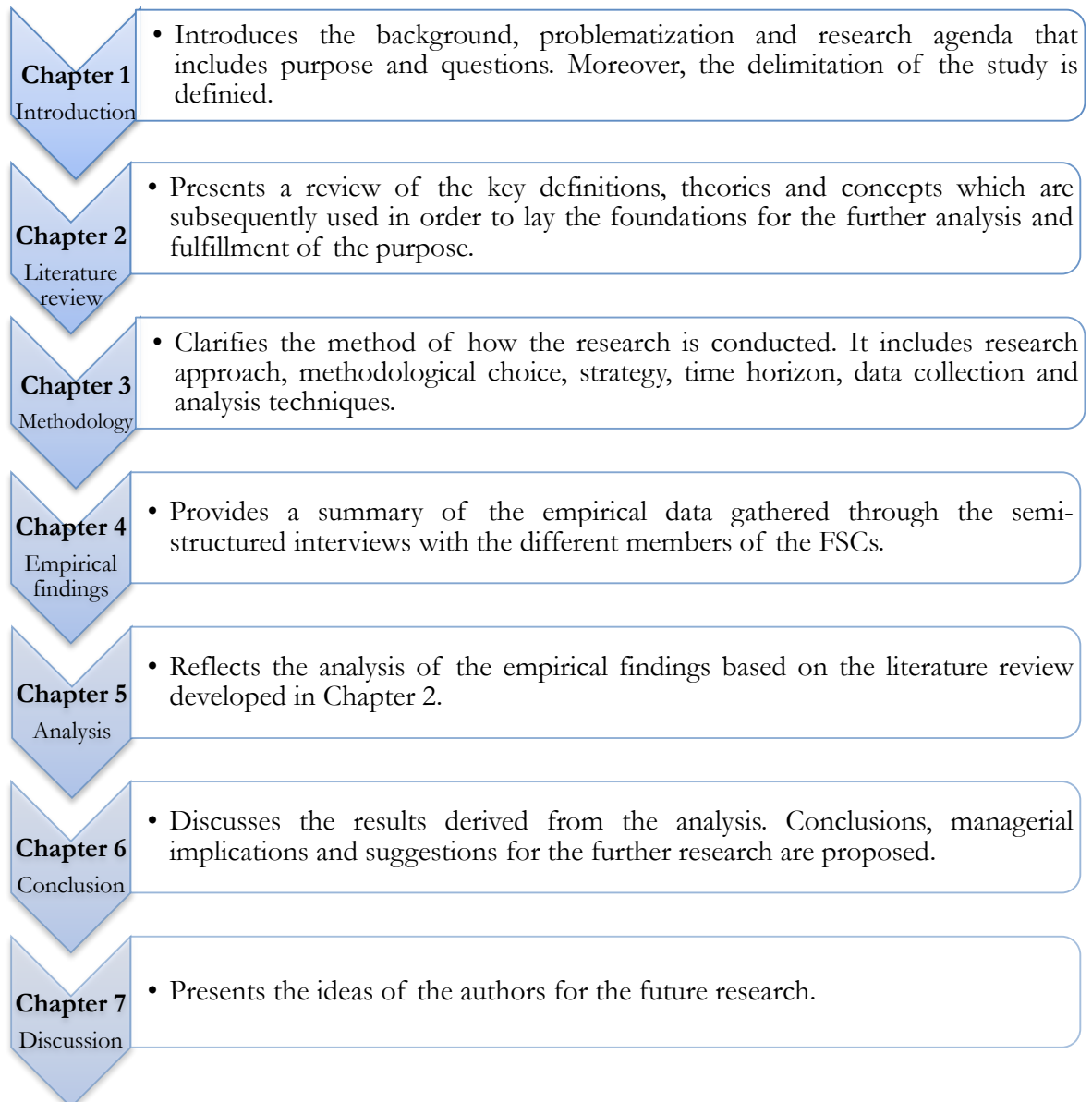


Figure 1.1 Thesis disposition.

2. Literature review

The literature review chapter contains a review of the existing literature, relevant to the problematization and research questions. It aims to provide the reader with a basic understanding of the topic and the investigated issues.

2.1 Connection between research questions and literature review

The logical links between the literature review and the RQs are crucial for the feasibility of the research. Therefore, in order to make these links clear Table 2.1 is developed.

Table 2.1 Connection between RQs and literature review

Research Question	Literature review section
RQ1. What is the current application of temperature monitoring solutions in in the cold chain management in Sweden?	2.2 Food industry of Sweden 2.4 The Cold Chain 2.5 Cold Chain Management 2.6 Technology for temperature monitoring and analysis
RQ2. How can an integrated approach towards the use of temperature monitoring solutions contribute to the enhanced utilization of these solutions and to the achievement of the quality and safety goals of the perishable food supply chain?	2.3 Perishable food supply chain management 2.5.3 Managerial perspective of CCM and temperature monitoring 2.6 Technology for temperature monitoring and analysis 2.7 Alignment of Technology, People and Processes 2.8 Collabotation within the FSCs

2.2 Food industry of Sweden

Since the paper is focused on the Swedish market, the authors present a general description of the local food industry, shaped by the main actors, the regulations and standards that they are obliged to follow.

2.2.1 Food supply chain actors

The Swedish food market can be divided into several segments: agriculture, food processing industry, retail and HoReCa (see Appendix 1) (Swedish Trade Chamber, 2013). The Swedish agriculture consists of approximately 67 000 farms, mostly small and located in the South of Sweden. The processing companies are also situated in the South. The market leaders in the processing industry are companies, such as the dairy producer Arla Foods and the meat manufacturers Swedish Meats, Findus Sverige and Kronfågel (European Commission, 2005). Moreover, the Swedish food industry is mostly domestically oriented, with one-third of the

food processing companies dealing with export. With this respect, the fish processing industry has formed clusters around Göteborg and on the East coast of the country (European Commission, 2005). The retail segment consists of 5 685 retail outlets, specialized in the sale of food, drinks and tobacco (European Commission, 2005). In contrast to other European countries, Sweden has a very high level of concentration in the food distribution. Approximately 90 percent of the distribution is handled by three largest retailers, namely ICA Group, COOP and Axfood AB. Another big retailer is Bergendahls, accounting for 6 percent of the distribution (Swedish Trade Chamber, 2013). Therefore, the large-scale retail is a major commercial channel in the country. In addition to the processing and retail segments, the HoReCa sector is occupying 20 percent of the Swedish food market. It is supplied by a few specialized wholesalers, including Martin & Servera (Axfood AB group), Menigo, Svensk Cater and ICA Meny (Swedish Trade Chamber, 2013; European Commission, 2005).

Entrup (2005) presents FSC as a chain that consists of the following actors: primary and industrial producers, wholesalers and retailers. This view is extended by a framework proposed by Fredriksson and Liljestrand (2015) and Pullman and Wu (2012), which add intermediaries such as distributors, food brokers and FSPs.

The Swedish food distribution structure is quite specific with many producers, very few wholesalers and many retailers. Normally in Sweden, the producers deliver to all wholesalers, while the wholesalers deliver only to a few retailers. *In most cases, the deliveries are regulated by the relationship between the wholesaler and the retailer, where the wholesaler and the retailer are often under the same umbrella of companies (Olsson & Skjöldebrand, 2008).

Fredriksson and Liljestrand (2015) and Pullman and Wu (2012) do not mention such crucial actors of the FSCs as LSPs. However, they are actively supporting the members with the physical and information flow of perishable logistics (Leuscher, Carter, Goldsby, Thomas & Rogers, 2014).

2.2.2 Regulations and standards

In response to the increased awareness and demand for food safety and quality, several laws, standards and industry guidelines were developed for the food industry (Aung & Chang, 2014). The European Community has a number of regulations and directives concerning foodstuffs. For example, directive 178/2002 requests mandatory traceability for all food and feed products sold within the European Union (Aung & Chang, 2014). The regulated area of traceability is the continuous temperature control in refrigerated vehicles, production facilities, loading-reloading points and verified standardized equipment (Kuo & Chen, 2009). Food companies should implement systems and procedures to keep track of their suppliers as well (Chillon, 2012). Moreover, within the United Nations, the ATP agreement regulates the terms of transportation of perishable products (FFKM, 2007; TFK, 2009).

The food and safety regulations in the Swedish food market are quite strict. Livsmedelsverket [The Ministry of Food and Agriculture] is responsible for food safety and food quality, through institutions such as The National Food Administration and The Swedish Board of Agriculture. The National Food Administration is responsible for the control of food safety and inspections of plants handling food, whereas the Board is the Government's expert authority on agricultural and food policy issues. In addition, companies are certified under internationally recognized quality assurance schemes such as Hazard Analysis and Critical Control Point (HACCP), International Standards Organization (ISO) 9001, ISO 14001 certifications and British Retail Consortium (BRC) scheme. Appendix 2 presents more detailed information on the certification bodies and schemes. Moreover, according to the legislation, food producers in Sweden are required to label their products with best-before date and storage temperature. The 'best before' date shows how long it is expected to have satisfactory

quality with the assumption that it is stored in compliance with the instructions (Livsmedelsverket, 2014; Aung & Chang, 2014).

Compliance with the regulations appears to be one of the biggest challenges in the cold chain industry. It obliges the companies to be accountable at every single point of the supply chain, which requires significant investments and management control efforts. In this respect, Trebilcock (2011) supposes that governmental regulations will push the development of technology in the supply chain. The food industry will start using temperature monitoring software and technologies such as Radio Frequency Identification (RFID) and sensors on a large-scale.

2.3 Perishable Food Supply Chain Management

The concept of supply chain management is of high importance when it comes to the TSPP, because of factors such as the short shelf-life, wide range of products, strict traceability requirements and need of temperature control (Hoorfar, Butler & Prugger, 2011; Kuo & Chen, 2010). Moreover, perishable FSCM requires more advanced objectives, rather than just cost or responsiveness like in traditional supply chain management (Van der Vorst et al., 2012). The very high service level required in the perishable FSC further complicates its management (Katsaliak, Mustafee & Kumar, 2014). The most important quality parameters for the perishable FSC are time and temperature. In the perfect case, in order to ensure the high food quality, the temperature has to be monitored and kept within the legal ranges along the whole FSC (Lutjen, Dittmer & Veigt, 2013).

2.3.1 Perishable food products

The TSPP are those products that have a shorter shelf-life than non-perishable, and are the subject to decay or spoilage (Hsu, Hung & Li, 2007). Hsu et al. (2007) state that perishable product rapidly decrease in value over time. Van der Vorst et al. (2012) explain that a perishable product should meet the following criteria: high rate of deterioration, need of specific storage and transportation conditions and obsolescence date. For the purpose of the current research, the last definition will be taken into consideration.

When it comes to the temperature sensitivity, Fredriksson and Liljestrand (2015) divide the TSPP in four subgroups: *ambient* (ambient temperature - grain, wine, bread), *chilled* (1.5°C to +18°C), *frozen* (-10°C to 12°C) and *deep frozen* (-18°C - berries, ice cream, butter, concentrated juices, deep frozen meat, poultry, fish).

2.3.2 Perishable Food Supply Chain Goals

An additional pressure exists in the perishable FSCM because of the high importance of quality and safety issues in the consciousness of governments and consumers (Wang & O'Brien, 2009). The rising awareness about food safety and quality is mainly due to the increased number of food and waterborne diseases (World Health Organization, 2002; Koutsoumanis, Taoukis & Nychas, 2005). For example, foodborne diseases are the cause of death for around 1.8 million people annually (Raab, Petersen & Kreyenschmidt, 2011). Thus, objectives such as quality and safety should be a priority in the FSCM. Manzini and Accorsi (2013) introduce an integrated framework for FSC assessment emphasizing on four key goals, comprising simultaneous control of quality, safety, sustainability and logistics efficiency of food products and processes along the whole FSC, from farm-to-fork (see Appendix1; Figure 2.1). The present research, however, is going to address only the quality and safety goals, as they are recognized as priorities from the cold logistics providers (Coolchain Europe, 2015).

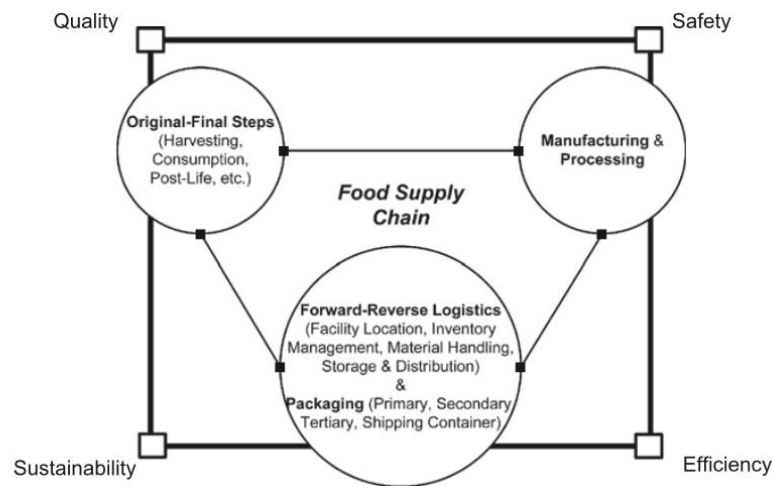


Figure 2.1 Goals of integrated FSCM and control (Manzini & Accorsi, 2013, p.256).

Food safety is an issue of great global interest, because of the globalization of international trade, the global food crisis and the rising consumer awareness. Even the topic of this year's world health day was food safety (WHO, 2015). In order to control it, scholars suggest the use of qualitative risk assessment tools. Food quality refers to the maintenance of stable and superior quality that meets the consumer requirements. The management of quality assurance involves quality control systems, cooling technologies and temperature monitoring along the chain. Moreover, the quality assurance should be controlled on holistic level in the farm-to-fork process (Chillon, 2012).

2.3.3 Perishable Food Supply Chain Process flow

The following process diagram of the perishable SC (see Figure 2.2) displays the basic stages in the FSC and the product and information flow between them. The process starts with the collection or production, their testing, quality control and storage in the plants, their logistics and distribution, retail storage and sell before expiration. The quality control and sold-before expiration stages in the process imply the focus on quality and safety control. Normal arrows stand for the product flow, while the dotted arrows stands for the information flow or the flow of customer orders. Retail and customers orders triggered the process, while at the same time outdated products have to be discarded.

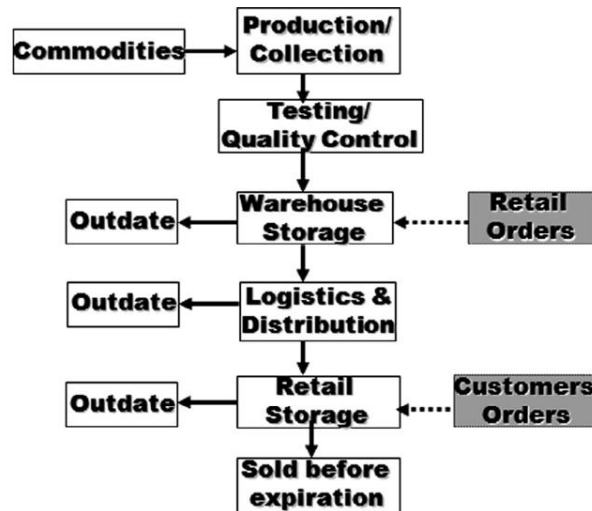


Figure 2.2 Flow diagram of perishable product SC (Katsaliaki, Mustafee & Kumar, 2014, p.4046).

According to Katsaliaki, Mustafee and Kumar (2014), managing of perishables requires competent decision-making. The goal is to match in a cost-effective manner the demand and supply, while maximizing the value for the whole supply chain. Moreover, the process should be managed in a way minimizing the outdates and ensuring the product freshness in the point of sale. As success factors the authors regard the rational system planning, improved communication among the actors, well-coordinated and fast distribution channels and the clarification of organizational goals.

2.4 The Cold Chain

The next section of the literature review is dedicated to the cold chain, the CCM and the CCL in attempt to provide a good basis for the understanding of the cold chain infrastructure and framework of operation.

A cold chain is a supply chain that ensures the integrity and quality of the product through temperature and humidity control (Arduino et al., 2013; Bharti, 2014; Faisal, 2011;). According to Rodrigue (2013), the main purpose of the cold chain is to protect the integrity of TSPP from the point of production and processing, through each of the transport stages – handling, loading, unloading, and storage – and may even extend to storage at the consuming household. In addition, Salin and Nayga (2003) explore a value-based concept of the chain and assume that the cold chain preserves value and as such is a necessity for the global food trade. The main differences between normal and cold supply chain are presented in Appendix 3.

According to Rodrigue (2013) a cold chain is a science, a technology, and a process. Science, because of the requirements for understanding of chemical and biological processes concerning perishability. Technology, as it relies on physical infrastructure and software in order to ensure the proper temperature conditions along the chain. Process, since it involves a series of logistics activities. The successful alignment of these elements of the cold chain is crucial.

2.4.1 Cold Chain Management

CCM refers to the proper temperature control throughout all stages of the cold chain. The ultimate goal of CCM is to minimize the temperature fluctuations of the products in transit and thus preserve their freshness, wholeness and quality (Bharti, 2014; Kuo & Chen, 2009; Salin & Nayga, 2003). The CCM mission is the planning and control of an efficient and effective flow and storage of TSPP, in order to meet the customer requirements (Bogataj, Bogataj & Vodopivec, 2005; Christopher, 2011; Mattoli, Mazzolai, Mondini, Zampolli & Dario, 2010). CCM is defined also as an infrastructure network with temperature and humidity control through the supply chain cycle (Tamimi et al., 2010).

2.4.2 Cold Chain Logistics

CCL encompasses all the processes and equipment needed to ensure proper temperature-controlled environment. It includes all activities related to temperature control logistics services within the production, processing, packaging, storage, transportation, distribution, retail display and household refrigeration of TSPP (Aung & Chang, 2014; Casper, 2007). The CCL and in particular the food transport refrigeration is considered to be a critical link in the food chain and has to be managed with the relevant importance (Manzini & Accorsi, 2013; Tassou, De-Lille & Ge, 2009).

The generic CCL process (see Figure 2.3), includes pre-cooling and cold storage in the farm, processing, packaging and cold storage in the production unit, storage during the distribution and by the consumers, and refrigerated transportation in between the different participants in the chain (Joshi, Banwet, & Shankar, 2009). According to Rodrigue (2013), the high level of control throughout all of the stages is essential for the temperature integrity. In this respect, vertical integration is a common strategy in the food industry. Moreover, the shipment integrity depends on operations such as the shipment preparation, modal choice, customs procedures, the last mile transportation and quality assurance. Therefore, taking into account the TSPP characteristics, its routing weather conditions, cost/perishability ratio, time for customs inspection, final storage delivery and quality control are very important for the integrity of the shipment. All of these processes have a high risk of integrity breach, and therefore require special attention (Rodrigue, 2013).

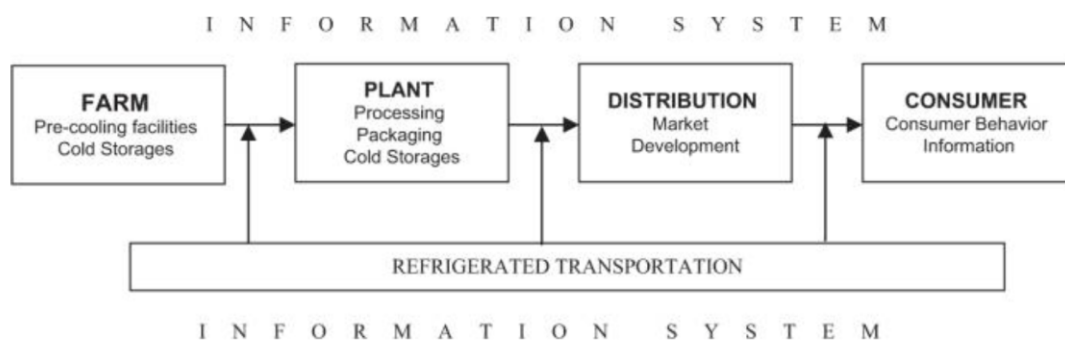


Figure 2.3 CCL Process (Joshi et al., 2009).

CCL has a different characteristics compared to normal logistics. The critical factors of control are time and temperature, the management orientation is towards the product instead

of the process, the focus of the indicators is quality over productivity, the performance assessment is based on cost and food safety and the variability impact is the product quality (Silva, 2010). Therefore, the logistics stage of the FSC is crucial for the food quality and freshness of the perishable products (Silva, 2010; Trebar, Lotric, Fonda, Pletersek & Kovacic, 2013). The freight during CCL is called a cool cargo. More details, how the cool food cargo can be handled during transportation follows in the next section.

2.4.3 Food Transportation

The refrigerated containers or reefers are the most common refrigerated cargo unit transported globally. A reefer can be a van, small truck, semi-trailer or standard ISO container. The reefer's role is to maintain the temperature, not to cool it down. Thus, a storage or loading-unloading facility is required for pre-handling of the shipment. The reefer's biggest advantage is the diversity of temperature settings, which allows the transporter to handle a wider range of TSPP. Moreover, the reefer is compatible with the infrastructure in the global logistics terminals and has quite a versatile nature. The negative aspect of the reefers' usage is the dependency on electricity. Moreover, the in-transit temperature in a single shipment may vary. It depends on the product placement in the truck. Those products that are closer to the doors may have a temperature different to those that are located near the refrigeration unit (Rodrigue, 2013).

The most common difficulties during food transportation refer to the preservation of temperature integrity along the cold chain. There are several points within the chain that have a high potential risk for breach, namely during transportation, trans-shipment and in the storage. During transportation, the risks are of power shortage, technical issues with the equipment, poor air conditioning or bad insulation. Sometimes a human mistake can be the cause of disruption as well. During loading and unloading, a potential for exposure to ambient condition is high, while in the storage the biggest problem is with the absence of or improper temperature control equipment (Rodrigue, 2013).

Source loading significantly reduces the risk of breaches in the cold chain integrity and extends the shelf-life with up to 25 days (Rodrigue, 2013). Moreover, the concept of intelligent container is very beneficial for the food integrity. The intelligent container is a reefer with an additional control unit, which is able to make decisions regarding the transportation conditions. Multiple sensors, positioned between the products, transmit wirelessly the data to the control unit in the reefer, which in turn sends it to the central control unit (Lutjen et al., 2013).

The unique handling requirements of perishables inevitably lead many actors of the food industry to outsource logistics services, especially in terms of temperature-controlled transportation and warehousing. This allows manufacturers and distributors to concentrate on their core competencies. The success of the FSC is partly premised on the reliable cold chain providers. However, it is essential to consider the potential negative effects of outsourcing such as difficulties in the monitoring and measurement of contractual performance as well as planning and control problems (Hsio, Van der Vorst, Kemp & Omta, 2010).

2.4.4 Managerial perspective of CCM and temperature monitoring

A badly managed cold chain can lead to serious quality and safety problems. The purpose of maintaining the quality and integrity of the TSPP requires efficient equipment with guaranteed thermal characteristics, appropriate operating modes and proper information system (Bharti, 2014; Faisal, 2011; Hafliðason et al., 2012). From an engineering point of view, CCM involves temperature monitoring, equipment installment, rapid distribution and

effective power solutions for the reefers (Salin & Nayga, 2003). However, understanding the management tools is also of high importance (Bogataj et al., 2005).

According to Oliva and Revetria (2008), the key tasks of CCM are the cold chain integration and securing the food safety, by performing a product characteristics analysis and assigning the correct temperature conditions, given the product at hand. The tasks also involve effective and continuous temperature monitoring, together with the establishment of an appropriate customer service level and the development of specifications and standard operations procedures.

According to Montanari (2008), temperature monitoring and data tracking are the two main priorities in the CCM. Aung and Chang (2014) and Bogataj et al. (2005) also admit the importance of temperature control for food safety and of visibility for the quality management.

Continuous control and monitoring of temperature is the hardest management task in the cold chain (Aung & Chang, 2014; Bruckner, Albercht, Petersen & Kreyenschmidt, 2012; Hafliðason et al., 2012; Kuo & Chen, 2009; Montanari, 2008; Raab et al., 2011;). Maintenance under the optimum temperature is essential from the very early stage of harvesting or production. The temperature management is harder in the case of mixed perishable cargo, as temperature requirements for different products are diverse (Aung, Chang & Kim, 2012). Chilled food is mostly threatened by temperature abuse (Aung & Chang, 2014). Even with a well-maintained quality assurance system, quality can be affected negatively by temperature fluctuations (Oliva & Revetria, 2008). That shows the possibility for insufficient temperature control and undetected temperature abuses on different stages of the cold chain. Therefore, it can be assumed that temperature monitoring is a key success factor within the CCM. However, there is no research in the field of CCM that clearly states what is the added value of investment in cutting-edge temperature monitoring technology.

Temperature management is the most challenging activity in the cold chain as it directly affects quality and at the same time it is hard to continuously control it. Thus, a lot of research has been conducted on the effect of dynamic temperature conditions on the quality and shelf-life (Bruckner et al., 2012; Jedermann, Nicometo, Uysal & Lang, 2014; Raab et al., 2011; Tamini, 2010;). These researchers state that the connection between temperature and quality is highly critical. Therefore, the improvements of the quality and safety monitoring management systems in the CCL process is regarded as an important research topic (Aung & Chang, 2014).

Aung and Chang (2014) suggest a Smart Cold Chain Management (SCCM) framework (see Figure 2.4) for excellence in the managerial functions of tracking and traceability. Every product has an attached RFID tag and every facility in the chain has Wireless Sensor Network (WSN) system. The SCCM system integrates the information from both places in the cold data center. The information is received through internet connection. All the actors in the chain are collectively responsible for the maintenance of the quality and the value creation in the supply chain.

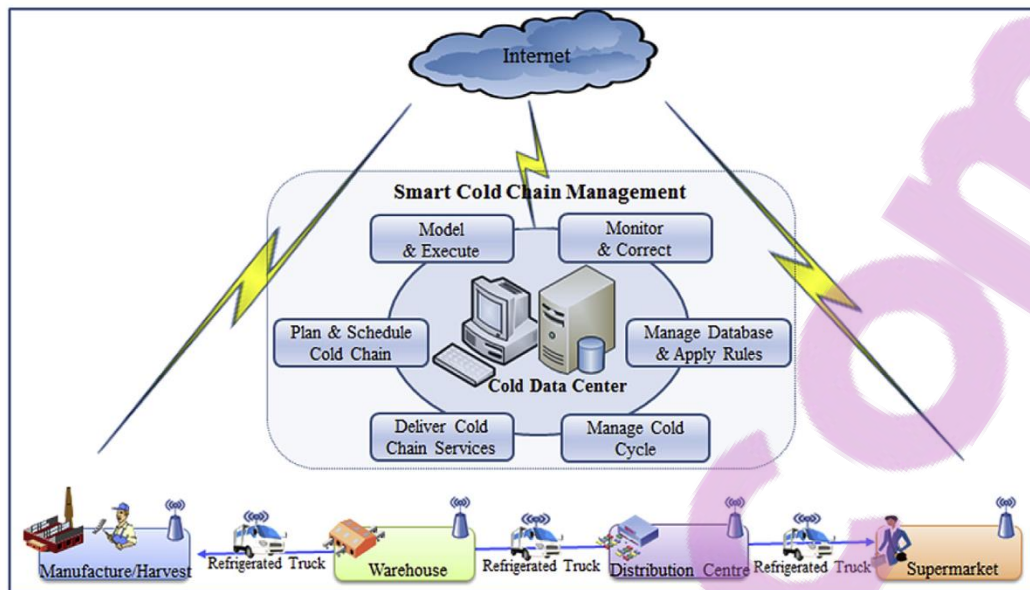


Figure 2.4 Smart CCM System (Aung & Zhang, 2014, p. 205).

The management should ensure the smooth implementation, by aligning the proposed SCCM system with the current business processes and with the technical skills of employees. In the following subchapters detailed information on the technological means will be presented.

2.5 Technology for temperature monitoring and analysis

Data collection and the analysis of product date are beneficial for the decision-making in CCL and thus for the enhancement of the quality of CCM (Kim, Aung, Chang & Makatsoris, 2015). In particular, a continuous temperature monitoring system, which controls the proper temperature environment along the entire perishable FSC, is the core of efficient CCM (Hoorfar et al., 2011). The technologies used for temperature monitoring are vast, but still their implementation is not common or is advancing slowly in the FSCs. That is why the Chillon project (2012) appeals for simpler tools with short detection time, enabling quick response and decision-making curve.

Shi, Zhang and Qu (2010) propose a framework for a monitoring system in the cold chain (see Figure 2.5). There are modules for data collection, communication and processing. The arrows in the Figure 2.5 stand for the information flow, and it is in both directions in order to facilitate data linkages between the CCL vehicles and the control centers. The data collection module consists of different devices, which are normally tagged on the product or the transportation equipment. The communication module transmits the information from the data terminal to the control server via different networks or cellular options. Finally, the data is processed in the control server. After a process of analytics, the data with information about the food quality is ready to be used for further decision-making.

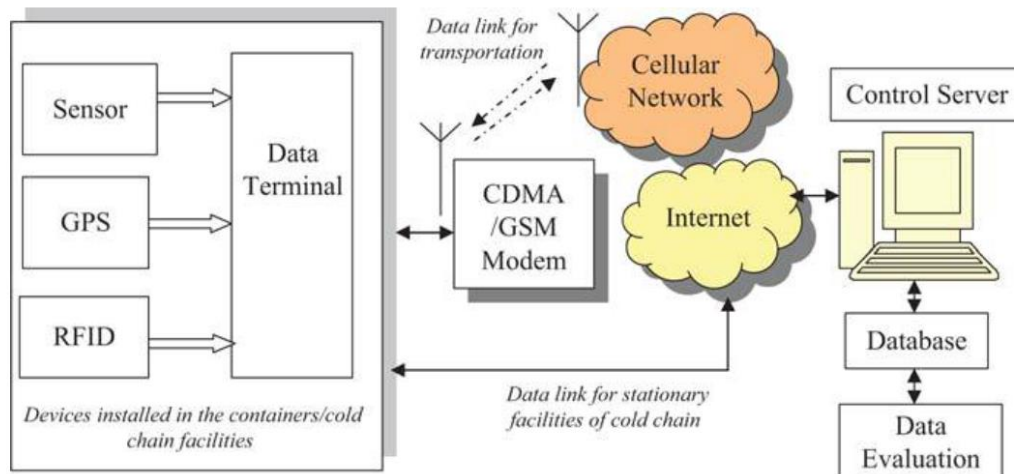


Figure 2.5 Framework for cold chain monitoring (Shi, Zhang & Qu, 2010, p. 598).

The monitoring system can include technologies such as GPS for navigation, geographic information system for vehicle routing and optimization analysis, RFID, WSN, barcodes and enterprise resource planning software.

2.5.1 Technology for capturing temperature data

Nowadays, both static and wireless solutions can monitor the cold chain and reduce risks in transit. For data capturing, the use of electronic data loggers, Time Temperature Indications (TTI) and RFID, especially together with WSN can be applied. Automatic identification and data capture is also an emerging field in temperature monitoring within the CCM (Kim et al., 2015).

Electronic Data Loggers

Electronic data logger is a device which records data with a built-in sensor and memory chip. With such recorders the users have to extract the data manually and thus break the cold chain (IPI, 2012). A data logger is the cheapest option for data collection and nowadays considered as quite ineffective tool. Instead, intelligent or smart cold chains use advanced analytics and modeling (Hafliðason et al., 2012).

RFID

Many researchers have studied new technologies for temperature monitoring in the cold chain, but among the most studied is the RFID and especially in combination with WSN. The focus is on its contribution to the visibility within the CCM (Kim et al., 2015; Trebar, et al., 2013). As a result, RFID is considered a very beneficial technology for the food industry as it facilitates the tracking and tracing of food quality and safety problems. The different actors of the FSC can monitor their products from fork-to-farm in terms of temperature and traceability (IPI, 2012; Kim et al., 2015; Trebar, et al., 2013). Its applicability is further strengthened by the European project 'RFID from Farm-to-Fork' (European Commission, 2012), showing how RFID technology can be incorporated in the traceability systems in the FSC. Moreover, RFID is widely used in case of dispute over the responsibilities for disruptions in the cold chain, especially in the long export roads of fresh produce products (IPI, 2012).

RFID tags are electronic devices that are able to exchange information without physical contact, by catching the radio waves with the help of a tag and a reader (Hoorfar et al., 2011;

Zhang et al., 2009). The tag stores the collected data, while the reader emits and receives radio waves and this way allows processing of the collected data. It is simple to operate, and at the same time can withhold large amount of data. RFID can be equipped with special sensors for temperature, humidity and gas. Therefore, it can support an effective and efficient temperature control systems, and be of great use in the CCL (Haflidason et al., 2012; IPI, 2012; Kelepouris, Pramataris & Doukidis, 2007). Moreover, it can upgrade the quality management, food logistics processes and the supply chain management, especially when used in combination with WSN systems (Hoorfar et al, 2011). The combination of RFID with WSN is a very flexible and powerful solution for monitoring the cold chain. With the help of this combination, an actor can monitor the whole chain irrespective of place and time. Therefore, in comparison with data loggers the management of the cold chain is not interrupted (Kim et al., 2015). The main purpose of WSN is to support the decision-making and management of the cold chain. Currently they are not widely used in the food cold chains (Haflidason et al, 2012).

However, a significant barrier for the implementation of RFID technologies is the cost and the fact that they require deep and integrated informative system. These characteristics make the technology quite unpopular among the small and medium companies in the industry, which account for 99 percent of the European food market (Manzini & Accorsi, 2013).

Time Temperature Indicators (TTIs)

The use of TTIs has also been a focus of a substantial research, but their implementation started only recently. TTIs are simple and inexpensive labels, normally attached to the packaging of the TSPP (Chillon, 2012). Their main purpose is to show the temperature history and to send warnings in the case of temperature abuse. The different indicators are based on different temperature-dependent enzymatic, chemical or microbiological reactions. Such reactions cause a color change in the labels, signifying the freshness of the product. The higher the temperature, the faster is the color change (Chillon, 2012).

Moreover, the information the TTIs hold can be used as an input for a shelf-life prediction model and thus a TTI can be used as a decision-making tool, in terms of assurance of the quality and safety of the perishable product. Moreover, the TTIs can lead to improvement in the warehouse management, by adopting a strategy in which the products with the shortest remaining shelf-life are sold first, namely 'least shelf-life, first out' (LSFO) (Jedermann et al., 2014).

A combination between chemically based TTIs and RFID chips is being researched under the Chillon project (2012) and is considered as a good future option for better temperature control (Hoorfar et al., 2011).

2.5.2 Technology for analysis of temperature data

A key driver for a better performance in the CCM and supply chain management is an adequate, accurate and timely database, facilitating important operational and managerial decision-making. Good data is the basis for good decision-making. Innovations in the IT sector enable better communication and information sharing in the supply chain. Intelligent algorithms have been developed and embedded in a graphical user interface in order to translate the multi-varied sensor outputs into easy to perceive predictions for product quality and remaining shelf-life. The value of information sharing in the supply chains is widely discussed in the literature, however not in terms of temperature data.

By the introduction of holistic inter-organisational information management systems, also known as real-time Cold Chain Information Systems (CCIS), software suppliers grasp the opportunity and take a holistic approach to the entire supply chain. The CCIS do not only

provide a monitoring service for perishables, but also offer an excellent analytical and trend tool where all stored data can be translated and used to maintain or improve the continuous cold chain (BT9-tech, 2015). CCIS combine the real-time temperature monitoring with heat transfer model, predictive models and risk management tools. Thus, it allows to integrate the new temperature monitoring technologies with IT solutions (Hoorfar et al., 2011).

Traceability system proposed by Chillon (2012) is an example of a technology that connects the collected temperature data with its usage for different analysis. It can be conceived as an integrated Chain Information Management System. The system collects all the relevant data and then calculates the remaining shelf-life, thus minimizing the hazardous cases in the chain and fastening the response in risk situations. In such information system, there are usually different modules such as decision support system for risks predictions, supply chain management module, geographical information system. Mobile management unit for automatically transmission of temperature data and temperature sensors (T-sensors) are fundamental parts of the system as well. The benefits of such types of systems rely on three components: the active tag (T-Sensor), the reader (data acquisition and management unit) and the mobile management unit (Chillon, 2012).

A challenge for the analysis of temperature data is the lack of data in some of the stages of the cold chain. The information gap between actors in the cold chain is considered as a considerable weakness. This gap arises either from their inability to share information because of the lack of technology or their unwillingness to share information because of the lack of trust (Chillon, 2012).

2.6 Alignment of Technology, People and Processes

As mentioned before the process and technology harmonization is crucial for the successful implementation of the cold chain objectives, e.g. food safety and quality goals. Unfortunately, this practice is often neglected by the management. For example, Ireland (2005) emphasizes that during the implementation of technological projects, the management most often does not pay the needed attention to the business processes and the culture of the people. As presented in Figure 2.6, only when a company aligns the people and processes with the technology, a class A performance is achieved.

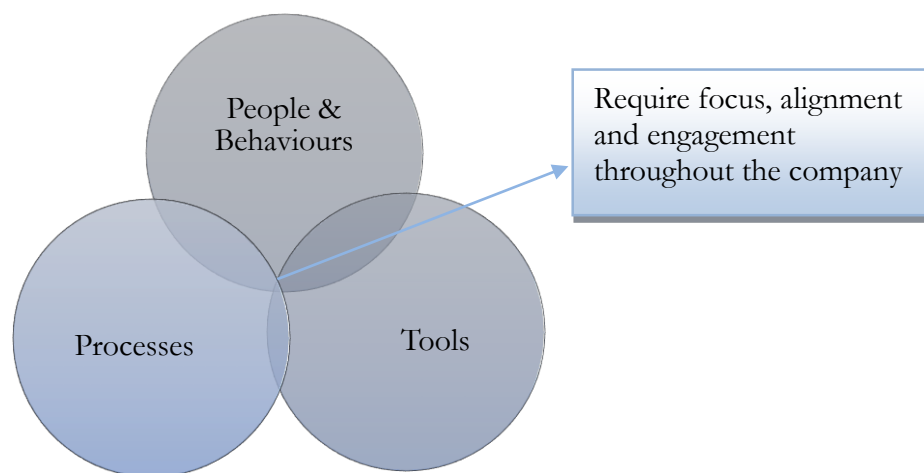


Figure 2.6 Alignment of Process, People and Technology (Ireland, 2005, p. 131).

The big data analytics will become an integral part of many business processes in the coming years. The machine-to-machine communications will generate lots of temperature data and this data would be able to be integrated in other business systems – such as enterprise resource planning, customer relationship management and Business Intelligence (BI) (Tai, 2014). Supply chain BI consists of applications, infrastructure, tools, and best practices and facilitates the access to and the analysis of information. Thereby, it can optimize the decision-making process and thus enhance performance.

Moreover, BI technologies provide different snapshots of business operations. Common functions are reporting, online analytical processing, analytics, data mining, process mining, business performance management, benchmarking and predictive analytics (Kumari, 2013). Thus, supply chain BI is of great importance when it comes to reporting key performance indicators (KPIs), business management process and may help for the optimization of the CCL. According to Olivia (2009), the success factors for the adoption of BI are effective communication, collaborative culture, innovation and application of system thinking, which is a unique approach to problem solving that views problems as part of a whole system.

The success of Supply chain BI, such as CCIS, requires more than just technology. It is not only the installment of the hardware and software, the people and the process should be considered as well (see Figure 2.7) (Major, 2014).

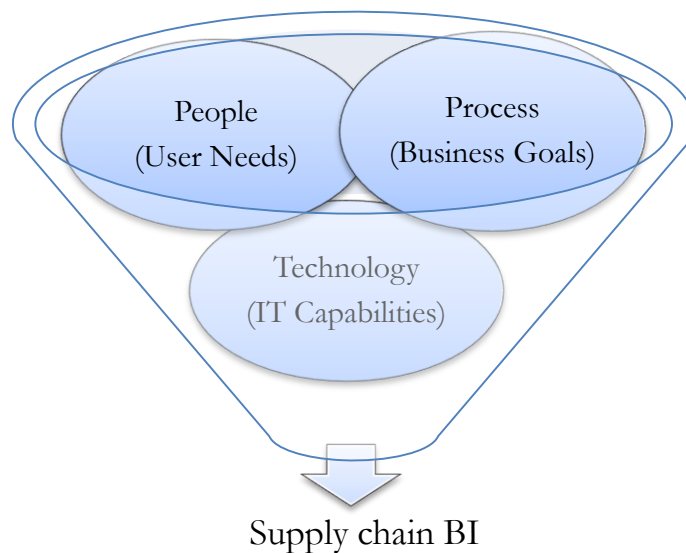


Figure 2.7 Supply Chain BI (Major, 2014).

The technology is very costly, but its capabilities enable a better decision-making process. When information has to be pushed to different participants in the supply chain, advanced BI can be applied. As far as people are concerned, it is essential that the user needs and skills are aligned with the business needs. Sometimes additional training for development of KPIs and data-driven decision-making is required. Moreover, the processes should be designed with the goal to support data-driven decisions. The corporate standards, standardization and documentation of the processes and business goals have to be incorporated. Therefore, the three important aspects of the effective supply chain BI (people, process and technology) should be aligned.

2.7 Collaboration within the FSC

The effective FSCM requires careful consideration and control over the existing relationships between the different actors at all stages of the supply chain (Grimm, Hofstetter, Joerg & Sarkis, 2014). Collaboration between suppliers and customers is considered as competitive strategy in today's global supply chains (Manzini & Accorsi, 2013). Therefore, the success of the whole network is highly dependent on the level of interaction and collaboration of all parties in the FSC (Xiaoqiang & Yongbo, 2013). Only with collaborative efforts of all actors, the consumers' expectations for total quality control over the whole farm-to-fork process can be met (Kumar & Nigmatullin, 2011).

The presence of competition on the market is inevitable. However, there is a type of collaboration when the actors of the same level simultaneously compete with each other and cooperate (Lacoste, 2012). It is called co-competition and is regarded beneficial in terms of meeting operational challenges in the cold chain. Moreover, it enables the actors of the chain to pursue common industry goals, such as food quality and safety. Co-competition among the FSC actors helps them to achieve a synergetic effect and improve product quality, reduce product waste, shorten the lead times and increase the overall supply chain visibility and traceability. Furthermore, such collaborative co-competition can facilitate the implementation of capital-intensive equipment, technology and knowledge development in the name of the overall operational efficiency (Madhavan Nair, Lau & Gu, 2013).

Among Olsson and Skjöldebrand's (2008) suggestions for improvement of the distribution structure of the Swedish food industry is the increase of collaborative partnerships or strategic partnerships among the actors. Moreover, accurate data and information transfer coupled with good relationship management are considered critical for the reduction of the risks in the physical and information flows in the Swedish FSCs.

2.8 Summary of the literature review

The food industry of Sweden is the focus of the research, and as such, important information concerning the actors and active regulations is discussed. Furthermore, the perishable FSCM goals and process are reviewed, together with the success factors for the assurance of the food quality and safety from farm-to-fork.

The literature on CCM is quite scarce. Even the small amount that exist includes research mostly on the technological advancements in the sector and their applications for the improvement of temperature monitoring and quality control. Little is written on the managerial perspective of temperature monitoring. At the start, important definitions such as the cold chain, the CCM and the CCL process are introduced, for the purpose of the better understanding of the cold chain operations. Further, the temperature monitoring solutions for capturing and analysis of temperature data are presented. The chapter ends with the alignment of process, people and technology and collaboration perspective. Nevertheless, these frameworks are not specifically dedicated to CCM, the authors took them into consideration, while building the conceptual model for better utilization of TMS.

3. Methodology

This chapter introduces the outline of the method, which is used to conduct the present research. The method is chosen in accordance with the research purpose and questions. A discussion of the research approach, methodological choice, strategy, time horizon, techniques and procedures for data collection and analysis is presented. Furthermore, issues of data trustworthiness are addressed.

The outline of the following chapter is developed based on the elements of the research “onion”, presented by Saunders, Lewis and Thornhill (2012): research approach, methodological choice, strategy, time horizon, techniques and procedures for data collection and analysis (see Figure 3.1).

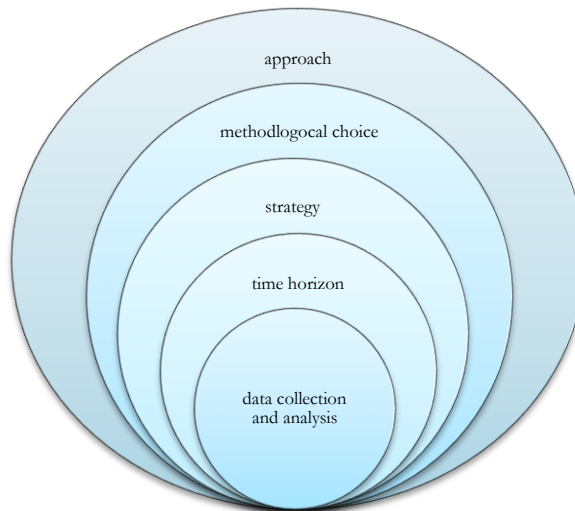


Figure 3.1 The research “onion” (Saunders et al., 2012).

Moreover, considerations on the trustworthiness of the research will be presented at the end of the chapter.

3.1 Research Approach

According to Saunders et al. (2012), three research approaches can be applied: deductive, inductive and abductive. Deductive approach is described as “moving from theory developed through academic literature to data” (Saunders et al., 2012, p. 144). The availability of sufficient literature is a significant prerequisite for the use of deductive approach. Inductive approach follows the opposite path: moving from data to theory or conceptual framework. This approach is compatible with the lack of prior theoretical knowledge. The third approach is abductive, that combines elements of inductive and deductive.

For the purpose of the current paper, a combination between induction and deduction is applied. The lack of sufficient prior knowledge about the managerial approach to the utilization of TMS in the CCM made it difficult to develop a theoretical framework. However, the literature review enabled the authors to gain general understanding and develop interview outline. Thus, empirical findings contributed most to the development of theory. During the analysis stage, the authors matched the empirical findings with the theory.

Therefore, in relation to the purpose and amount of the literature in the specific area of study, a combination of deduction and induction is the most appropriate. Inductive reasoning is used to discover the phenomenon and patterns around it, while deductive reasoning verifies and enriches the discovered patterns under certain assumptions.

The research questions of the current paper are aimed to discover relatively new phenomenon of a managerial approach to the utilization of TMS. Thus, the study is considered as explorative.

The authors started the research with a broader perspective on the challenges for achieving the quality and safety goals of the perishable FSCM, then narrowed it to the temperature fluctuations as the most significant problem and funneled it down to meeting these goals with the advanced TMS and integrated approach to their utilization.

3.2 Methodological choice

In order to achieve comprehensive findings and as a result to develop a valuable framework, it is important to achieve coherence between the purpose and methodological choice.

Since the purpose of the present paper is to explore the relatively untouched topic of enhanced utilization of TMS through an integrated approach (combining technological and managerial perspectives), a qualitative research method is applied. This flexible semi-structured method allows the authors to explore the phenomenon and generate theory and concepts. Moreover, qualitative methods rely on non-numerical data, which was the prevailing type of data provided by the case companies.

3.3 Research strategy

The research strategy is crucial for defining the way of answering the research questions and thus fulfilling the purpose of the study (Saunders et al., 2012).

The above-mentioned methodological choice limits the choice of strategies to those exclusively or partly linked with qualitative research design. Such strategies include archival research, case study, ethnography, action research, grounded theory and narrative inquiry.

Case study strategy is chosen for the present research. The case study strategy is aligned with the exploratory nature of the research design. It means that this strategy allows the authors to see from different perspectives the analyzed phenomenon in a real-life context and develop in-depth conclusions (Baxter & Jack, 2008).

Case studies can be conducted by using different approaches. According to the terminology of Yin (2009), the case study strategy of the present paper is multiple and holistic. A multiple case study enabled the authors to explore and compare the research issues in and within the different cases and therefore replicate the findings across cases. A holistic case study explores the phenomenon on a global level, and tries to draw conclusions about it (Baxter & Jack, 2008). The relevance of a holistic research in the current paper is magnified by the need of continuous temperature control and the common goals of all actors in the FSC. Thus, this thesis is a holistic multiple case study of the usage of TMS in the food industry of Sweden and of an approach to their enhanced utilization.

The authors took into consideration that the multiple case study approach requires comparison between the cases and understanding of the overall case as a result (Baxter & Jack, 2008). This circumstance is reflected in the choice of the method for analysis described further.

3.4 Time horizon

The time constraints and potential access to primary and secondary data were estimated at the preliminary phase of the research. As the study was conducted in a particular time slot, a cross-sectional study of the phenomenon has been made (Saunders et al., 2012).

3.5 Data collection

Hox and Boeijs (2005) recognize two types of data: primary and secondary. While the first type refers to data that is collected for a specific study, the secondary data is information that “was originally collected for a different purpose than the study at hand” (Hox & Boeijs, 2005, p. 593). The use of multiple data sources is common for the case study strategy and it enhances the data credibility (Yin, 2003).

3.5.1 Secondary data collection

For the purpose of the current paper, the authors collected secondary data from academic journals, reports, conference proceedings, books, newspapers, European Union and Governmental reports and statistics, food and CCL industry market reports and company white papers. In addition, internet sources are used to gather background information about the interviewed companies, as well as to be able to follow the latest updates concerning the TMS technology.

3.5.2 Primary data collection method

There are three interview techniques – structured, semi-structured and unstructured. Saunders et al. (2012) suggest semi-structured or unstructured (in-depth) interviews for qualitative and exploratory studies. The significant difference between the two is the level of control that the interviewer has over the interaction (Harrell & Bradley, 2009). The semi-structured interview gives more control over the interviewee answers than the unstructured interview. In semi-structured interviewing, a pre-determined list of themes and questions is used as a guide. In the unstructured, the researcher has a clear idea of the area and specific issues to explore, but very low level of control over the answers of the participants. Since there was little prior research on the managerial perspective of TMS usage for CCM, semi-structured interviews were conducted. They allowed the authors to consider valuable insights on the utilization of TMS for CCM, which were not included in the prior literature. The authors had the flexibility to adjust and add questions where needed.

There are three ways of conducting semi-structured qualitative interviews – face-to-face, telephone conversation and internet-mediation (Saunders et al., 2012). All of the ways were used in the current research.

3.5.2.1 Outline of the interview

Bryman and Bell (2011) suggest the clarification of general and specific areas of research, as a starting point of the process of interview outlining. In the present research, the CCM is the general research area, while the technological and managerial perspectives on TMS are specific. Within the managerial perspective, there are three subtopics: people, process and collaboration. Based on this, all the interview questions are divided into three parts that are reflected in the Figure 3.3.

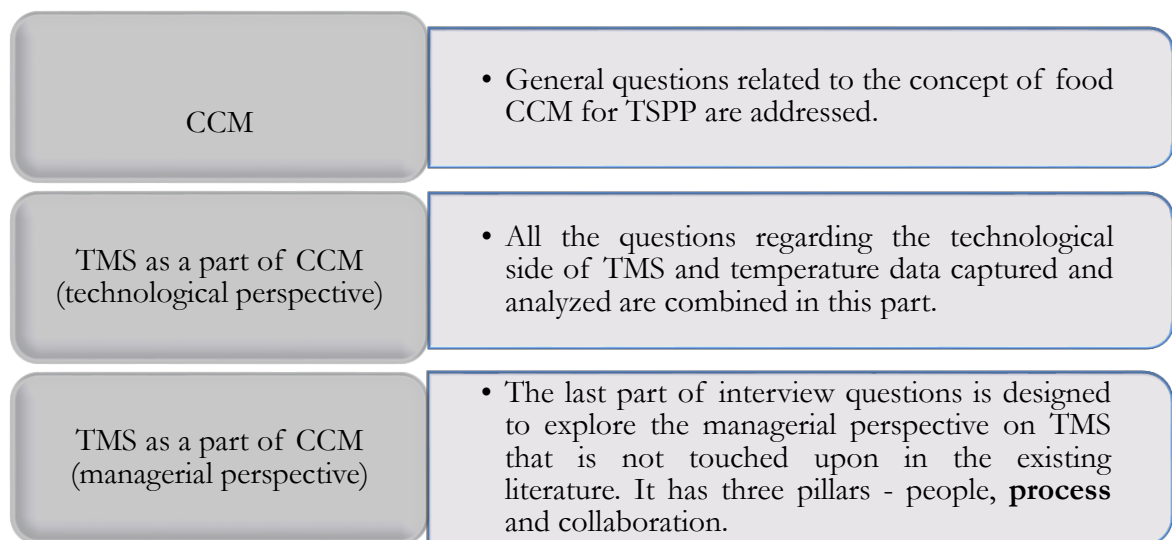


Figure 3.2 Sections of the interview guide.

In the end, two different outlines were designed – one dedicated to the actors of the FSC and one to the suppliers of TMS. The final outlines of the interview are included in Appendix 4 and 5.

3.5.2.2 Selecting samples for the interview

There are two widely used sampling techniques: probability and non-probability sampling (Zikmund, 2000). The latter is a technique applicable in case of pre-guaranteed equal chance for case selection, while the former relates to non-defined chance for a single case to be selected from the pool (Saunders et al., 2012). Within the non-probability technique, samples can be identified based on certain factors such as quota, purpose or volunteer (Wilson, 2014).

In the present research, a combination of two non-probability techniques, purposive and snowball is used. The authors selected the most suitable cases within the Swedish market based on the purpose and research questions. However, authors tried to recruit further relevant contacts once a stable contact has been established.

A list of potential cases was created based on the FSC actors, including almost all perishable food producers, grocery retailers, wholesalers and LSPs, dealing with TSPP. Besides these actors, the suppliers of TMSs were included to gain additional insights of the field.

More than 70 initial letters were sent to various members of the Swedish food and CCL market. In the letters, the authors presented their background, the research project, purpose of the study and brief interview outline.

Finding contacts with companies from the final list proved to be challenging. However, finding the right person within the company appeared to be much more difficult. This issue was partly solved by the usage of the world's largest professional network – LinkedIn, where the responsibilities of the contact are presented. In all other cases, a great amount of waiting time was spent on redirecting from one employee to another.

3.5.2.3 Case selection

As a result, eleven companies located in Sweden were interviewed. All of these companies have a significant market share and expertise in the analyzed area. The producers are two of the biggest dairy producers in the country, the retailers' collective market share is approximately 70 percent, and the LSPs are among the biggest LSPs in the Nordic region, dealing

with the TSPP. The suppliers of TMS are manufacturers of TMS for both transportation and cold storages. Moreover, the interviewees were responsible for the quality control, logistics solutions and technology. Therefore, all samples are representative. Table 3.1 provides contextual data of the interviews.

Table 3.1 Contextual data of the conducted interviews

Company	Interview Date	Participant	Interview Type	Interview Duration (min)
Producer 1	2015-03-20	Project manager, Logistics solutions	Skype	45
Producer 2	2015-03-18	Logistics manager	Phone	60
Retailer 1	2015-04-08	Quality coordinator Affärsområde Logistik	Face-to-face, Stockholm	75
Retailer 2	2015-04-08	TF Chef CR Logistic	Phone	45
LSP 1	2015-04-16	Manager Industrial Development	Phone	75
LSP 2	2015-03-17	Warehouse Manager	Skype	40
FSP 1	2015-04-15	Logistics Team Leader, Domestic Transport	Face-to-face, Jönköping	75
FSP 2	2015-04-15	Logistics Manager	Face-to-face, Jönköping	45
Store 1	2015-04-27	Store Manager	Face-to-face, Jönköping	60
Supplier of TMS 1	2015-04-09	Head of Sales	Skype	40
Supplier of TMS 2	2015-04-10	Head of Sales	Skype	30

After getting the permission, interviews were audio-recorded. Interviewers took notes in order to sustain the concentration and generate points for clarification. Later, the recordings were transcribed through a software and sent back to the participants for corrections and approval. The interviews were conducted in English.

Due to the sensitivity of the topic and the nature of the data in the food industry, all of the participants insisted on keeping confidentiality and anonymity. This stands as a reason for naming the companies as in Table 3.2.

3.6 Data analysis

In order to generate meaningful findings, it is essential that the approach to analysis is consistent with the research questions, the applied strategy and the nature of data collection techniques (Saunders et al., 2012).

For the present thesis, template analysis is chosen. This data analysis method provides the possibility to be adapted to the precise needs of the investigators (King, 2012). Thus, flexibility was regarded as important criteria for the choice of this method, since the authors

investigate a barely researched phenomenon and the template was changed several times during the research process.

At the initial stage, categories were developed from the prior theoretical knowledge about TMS for TSPP in the food industry. Later, These predetermined categories were amended through the empirical data collection and analysis. Therefore, the analysis of the empirical findings of the current paper relies on categorization, unite data and exploration of themes, patterns and relationships.

3.7 Trustworthiness of the research

When conducting the present research, issues of data quality such as credibility, transferability, dependability and conformability have been taken into consideration. These criteria for trustworthiness are aligned with the qualitative research design applied (Shenton, 2004).

Credibility or according to the terminology of Saunders et al. (2012) construct validity, refers to the extent to which “the study measures what is actually intended” (Shenton, 2004, p. 64). In order to provide a high level of credibility the authors use various methods e.g. the use of iterative questioning during the semi-structured interviews and the examination of prior theoretical knowledge to evaluate the degree to which the findings of the present thesis correspond to previous research findings.

Transferability or external validity refers to the extent to which “research findings can be generalized to other relevant settings or groups” (Saunders et al., 2012, p. 194). As qualitative research is not able to generate statistical generalization, only analytical generalization is discussed. The careful selection of representative samples for the interviews combined with the concentrated distribution structure of the Swedish food market and the rich description of the analyzed subject of TMS, contribute to a higher level of potential generalizability of the present study.

Dependability or reliability reflects the situation if “the work were repeated, in the same context, with the same methods and with the same participants, similar results would be obtained” (Shenton, 2004, p. 71). In order to ensure the dependability of the research, the detailed and circumstantial description of the research design and all stages within it are presented earlier in the chapter. The maximum possible level of transparency is provided to allow other researchers to replicate the study.

Conformability is the “avoidance of bias and subjective selection in the research” (Saunders et al., 2012, p. 676). The design, conduction, transcription and interpretation of the interviews in the thesis are guided by the principles used to overcome the interview and interviewee bias and errors.

Furthermore, Saunders et al. (2012) state that ethical concerns should be engaged at all stages of the research, from formulating the topic to reporting the findings. Therefore, in the present thesis particular attention is given to the principles of the research ethics and morality.

3.8 Limitations

There are number of limitations related to the methodology of the present research. First of all, a language barrier is identified as a particular challenge. The native language of most respondents is Swedish, while the language of the interviews was English due to the re-

strictions of researchers. Thus, considerable efforts have been made on clarification and confirmation of the information. Secondly, within a case study strategy it is recommended to use several data collection techniques to validate the empirical findings (Baxter & Jack, 2008). However, the companies were not able to provide any relevant internal documentation or statistics that could be used for this purpose. Furthermore, all studied companies assigned only one final respondent. Thus, the empirical findings within one company cannot be confirmed or extended by some other perspective. Moreover, only three out of eleven interviews from the final list were conducted via face-to face meeting. Thus, researchers had no chance to capture emotions and behavior of respondents which is considered important (Saunders et al., 2012). Finally, research quality is highly dependent on the systematic and objective approach to all stages. However, as it stated by methodological experts, in the qualitative study it is always difficult to maintain and assess rigorousness.

3.9 Summary of the method

Based on the purpose, research questions and availability of prior theoretical knowledge in the topic, a combination of deductive and inductive research is selected. The study is qualitative with explorative nature as the focus of the present thesis is on the investigation of the utilization and advancement of TMS in the CCM of perishable food. In order to get a deeper understanding of the phenomenon in real-life context, a holistic multiple case study strategy is employed. The primary data was collected through semi-structured qualitative interviews and was analyzed through template analysis. Since data collection and analysis took place in one specific point in time, the time horizon is cross-sectional. Finally, the aspects of data quality, ethics and limitations are addressed.



4. Empirical Findings

This section presents the empirical data collected through the interviews with different actors of the FSC in Sweden. The chapter is divided into three parts. First of all, the background of all companies is presented, followed by the information about the current application of TMS in the cold chain of Sweden. The chapter ends with the findings regarding the managerial perspective on TMS.

4.1 Company Background

In order to introduce the contextual settings, Table 4.1 displays some general information about the interviewed case companies.

Table 4.1 Company Background

Company	General Information	Products/Services
Producer 1	One of the largest in the Scandinavian region; Supplies milk-based products to more than 100 countries	Fresh dairy products (esp. milk-based)
Producer 2	A strong market position in the southern part of Sweden and in the Nordic region of Europe	Dairy and juice
Retailer 1	One of the major players in the Swedish grocery markets; Has approx. 1 500 stores of different concepts	Groceries
Retailer 2	Among the leaders of the Swedish food retail business; Has more than 600 stores around the country, especially strong in Northern part	Groceries (incl. organic and allergy-tailored)
LSP1	Owns more than 1 300 food-classified trucks; Presents 9 logistics business units in Sweden, Denmark, Norway, Finland, France and Spain	Transportation and warehousing solutions for fresh, chilled and frozen foodstuffs, parcels
LSP2	The supply chain division of one of the world-leading contract logistics partner presented in more than 60 countries	End-to-end logistics solutions for different industries
FSP1	Sweden's leading restaurant and commercial kitchen specialist; Has more than 30 sales offices and 15 warehouses	Full range of solutions for restaurants and catering industry
FSP2	Leading food wholesaler and distributor in the Skåne region	Various food services designed for restaurants, hotels, bars
Store 1	Belongs to regional group having a strong position in the Southern part of Sweden	Groceries (esp. fresh products)
STMS1	Group of companies, that has Scandinavia, UK, Germany, Holland, Belgium and the Baltic regions as main markets	Manufacturing of commercial chilled and hot food equipment
STMS2	Its headquarters are in Germany, but it exports all over Europe	Refrigerating equipment, TMS for transport and full range of monitoring services

4.2 Findings

This section presents the findings of the current processes in the CCL, current application of TMS and managerial perspective on these technologies.

4.2.1 Current CCL processes and application of TMS in Sweden

(1) Producer 1

Due to the temperature sensitive nature of the dairy products, Producer 1 implements a very strict temperature management policy: chilled products must be carried at exactly +5 °C. Producer 1 explains that they consider two critical stages in the CCL process – storage (incl. warehousing at production facility and distribution centers) and refrigerated transportation. The company owns and controls its cold terminals and fleet. However, the transportation is partly (20 percent) outsourced to LSPs. Therefore, the company admits that it does not have the full control over the temperature in the end-to-end supply chain. Producer 1 states that they usually discuss the temperature terms with their vendors, but not directly with the transportation contractors. That is why Producer 1 pays much attention to the selection of vendors for logistic services. They require standards for food quality and safety from their LSPs, who according to the law take the responsibility over the goods. Producer 1 states that the regulatory environment influences a lot on their decision-making.

An online alarm system is used in the storage, while electronic data loggers are used to capture the temperature data during transportation. In all the company fleet, the refrigeration aggregates are environmentally friendly. As for Producer 1 these devices are used from most of their LSPs. Only one out of four LSPs applies a different technology. In all cases, this function is done manually. Moreover, the logistics manager states that the driver and the fleet manager are in constant contact during the transportation. In terms of data analysis, Producer 1 says: *‘if the temperature is correct – there are no actions; if it is not correct – we try to find possible reasons and recall the products’* (Personal communication, 2015-03-20). They aim for zero recall, but if anything should happen, they have procedures to trace the products. Therefore, apart from disruption cases, the temperature data is not analyzed and used for any planning.

Producer 1 and most of its transport providers do not use the cutting-edge technology, because the current is satisfactory. They state the following reasons for that: the high cost and the need for alignment with the present system and key processes. However, they consider the implementation of new technology that will be able to bring efficiency and effectiveness in temperature monitoring and cold chain management. By the efficiency, they mean cost, while effectiveness refers to the quality of products and minimum of waste. Moreover, they consider real-time data as a means to achieve a higher level of flexibility and reactivity. In addition, they consider that the high number of door openings requires advanced refrigeration unit, which can pull down and recover temperature extremely efficiently in order to maintain product temperature.

(2) Producer 2

For Producer 2 the quality and temperature control starts at the point of collection of the milk, then it is further checked at the entrance to the manufacturing process and when the finished product is ready for transportation. Producer 2 ensures the end-to-end product quality with such TMSs as Winlog in the warehouse and Guard Systems in the trucks. WinLog is a generic logging software that enables the user to trace multiple logging devices. The collected data can be monitored in a real-time or be stored in a database for later review. At the moment, Producer 2 uses only the second option. The Guard GS Fleet Temp System provides full control of the temperature during transportation. It is web-based and allows the company to manage the temperature with the help of an alarm system, temperature mapping

and reporting. The system reports the temperature at every kilometer or each 5 minutes. The temperature sensors are positioned according to the good distribution practices. The company has its own fleet and outsources only a small part of their outbound logistics. The data is always captured digitally in their systems, which leads to the continuous flow of temperature data during storage and transportation. The company does not experience any problems with the current technology. They monitor continuously the temperature data and take actions if problems occur. However, they do not further analyze the data.

The company claims to experience very seldom disruptions in the cold chain. Their logistics manager says disruptions may happen, referring to the cases of insufficiently cooled down products before transportation, and points out the short lead-time as a main cause. It could also happen that a product is frozen, during the transportation. The company shares that despite all careful control and risk assessments modeling, something unpredictable can always happen. However, they affirm that nevertheless the cause, in cases of disruptions, the company always has the option to go back the chain and trace the processing of the product, as well as go forward in the supply chain and recall all spoiled products.

The company believes that the current technology is cost efficient and is a good solution for the temperature monitoring. They do not experience any problem with it, but they do admit they can be more efficient with the usage of better technology. However, at the moment, the standards for high quality and freshness are met by the present systems. The company highlights that they are ready to embrace new technology in the name of quality: *'But strength also brings responsibility. Every day people rely on us to deliver fresh milk and other dairy products—all safe, top-quality, with good flavor and healthy contents'* (Personal communication, 2015-03-18).

(3) Retailer 1

Retailer 1's responsibility for the temperature management starts with the collection of products from the manufacturer's facility and ends after the final delivery to the store. Each product is checked for temperature, freshness, labeling, etc. Then, a pre-surveillance of the temperature before the products is loaded on the vehicle occurs. If the temperature is right, the product is loaded on the truck. During the transportation, there is surveillance as well. When the goods are delivered to the store, they are manually checked, labeled and registered. Once the goods enter the cold store, the responsibility is transferred to the storeowners. During the transportation, the temperature is checked by data loggers. There is an alarm system in the warehouse, which signalizes if the temperature is not right. Retailer 1 shares the temperature information upon request and there is no analysis of the data as it is historic. The shelf-life time of the products is not managed based on the temperature data.

In the case when Retailer 1 outsources the transportation function, it is the responsibility of the LSPs to ensure it is proper and the contract terms are fulfilled. Retailer 1 requires the transport provider to have such technology for temperature control that enables reporting when needed. They do check what technology their providers use, but they ask for information only in case of disruption. Moreover, their control activities of their providers through random audits.

Retailer 1 considers that the level of information sharing among partners depends on the type of relations and its value. Contractors are always willing to share the information with them. With the suppliers it depends on how many interlinks there are between them, how much they supply from them and how far away they are located.

According to Retailer 1, the current system in use for temperature monitoring is sufficient to meet the goals in terms of quality and safety. Although, admitting that new and modern cold chain systems could improve efficiency, there are several barriers to why Retailer 1 does not

transact to a more modern system, such as the high cost, constantly evolving technology and uncertain business conditions. If any of these conditions would change, an implementation of a new system could be considered in the future.

(4) Retailer 2

The company explains the management of the product and quality flow as follows. Retailer 2's responsibility starts when they pick up the ready-for-distribution products from the producers' site. Then, at this point, the first temperature check takes place, right before the products are to be loaded for transportation. During transportation, there are temperature data loggers, which collect the temperature data. The company follows the standard of +4 °C for all chilled products. The products are then transported to the relevant company terminal – frozen, dry, fresh and non-food. Retailer 2 separates the three flows of dry, fresh and frozen goods and makes the delivery in separate trucks due to the temperature difference. Therefore, the temperature control is in place if the transportation is to the frozen or fresh terminal and for some non-prescription drugs in the dry terminal. After that, the products are distributed through different direct and indirect channels, either straight to the store or through wholesalers and hubs. The responsibility of Retailer 2 ends at the doorsteps of the store facilities, where the temperature is checked again manually.

Retailer 2 outsources most of its transportation to leading CCL providers. The only transportation infrastructure of Retailer 2 is trailers, which are used for intermodal transportation in the Southern part of the country. Many suppliers are located in Southern Sweden, which makes convenient the filling of train-set going back to the north.

In the contract terms with their LSPs, Retailer 2 requires certain quality standards - all chill products to be transported at +4 °C aggregates in the truck. Moreover, Retailer 2 tries to specify and provide guidelines for the LSP in terms of food quality and safety. When the transportation is outsourced, in the meaning of the low, the responsibility and the risk assessment lies on the LSP. However, Retailer 2 strictly controls the temperature control process of the LSP and conducts regular audits, during which they check if they follow the contracted standard operations procedures and the Handbook for transportation. The main course of audits is product safety. In the end, the LSP is responsible to meet the regulation requirements for temperature control. Retailer 2 is trying to negotiate such contract terms in which the provider themselves make temperature tests and report the results. At present, the LSPs do not share temperature data with Retailer 2.

In addition, Retailer 2 has the same temperature standard agreement with the storeowners. They should sustain the temperature at +4°C. They try to help stores to be more efficient and ask them to check only the products with the highest risks. For example, they allow them to assume that if within one shipment, the ice cream products are within the proper temperature ranges, then all other products are. Only if they recognize that the ice cream has been improperly cooled, they have to investigate further the rest of the products in the shipment.

When it comes to the TMS that the LSPs use, Retailer 2 states they are trying to control it. They discuss with their partners what system they use and how these systems help them to fulfill the terms of the contract. Retailer 2 is aware of the usage of manual temperature data collection with data loggers and geographical positioning systems.

Retailer 2 is satisfied with the level of technology in use. However, the senior quality coordinator of the company believes that: *Real-time data is needed. If the store owners has it, then the manual control won't be necessary.* (Personal communication, 2015-04-08). In the present situation, the stores have to trust Retailer 2, who owns only 8 percent of the products throughout the distribution, that it will ensure the proper handling and delivery of the products. If the

stores have the option for real-time monitoring of the temperature, then they will not need the manual checks of the quality. To the best knowledge of the interviewee, no one in the industry uses real-time information systems for temperature - monitoring. As a major reason he points out the high cost and the still satisfactory capabilities of the manual control.

(5) LSP 1

As a transporter, LSP 1 is providing logistics solutions and when it comes to the temperature control, they are only responsible for sustaining the proper air temperature in the storage and their own trucks. They are not responsible for the product temperature. As LSP 1 is on the providers' side, they are very much limited to the contract terms and what the customers require from them. They always get information regarding the temperature control from the customers – it is written in the contract, the airway bill and the booking. If LSP 1 has the right, the temperature is checked when they pick up the cargo from their customers. After that, depending on the case, they ship it to their own storage place, terminal, customer's terminal or directly to the store. On arrival, it is usually the receiver's obligation to check the temperature of the shipment. However, if the contract requires it, they do it. Sometimes they are only responsible for the storage. It is up to the customers to decide, who is transporting their goods. According to their service leaflet, the product temperature should always be checked when the custody over the product is transferred from one supply chain actor to another.

In the own fleet of the LSP 1, the driver is responsible to set the required temperature manually in the truck aggregate. In addition, they have logging devices, which collect the temperature information during transportation and logs it into a computer system. Therefore, there is a constant human control in the truck and no device that can control the temperature management from distance. In the storage, there are temperature sensors and an online alarm system that signalizes to the technicians to investigate the problem and react accordingly. What is important for LSP 1 is the ability to go back and trace the temperature history, when disruptions occur. Therefore, they stick to the usage of *'temperature measuring devices, which are fulfilling the EU standards and which are able to log out the historic temperature data'* (Personal communication, 2015-04-16). These are the two major criteria.

The company does not have problem with the current technology. The Industrial Development Manager states that deviation from the temperature may happen. Usually, it is not the technology that causes it, but rather risks such as the mixed product shipments and the insufficient cooling down at the producers' site. As a transportation company, LSP 1 makes groupage shipments, in which they mix different food products, requiring different temperature intervals. In these cases, they secure a temperature interval between +2 and +8 °C for the chilled food. Moreover, they ensure the food quality with preliminary risk evaluations. The other risk is the insufficient chilling down time before transportation when the producers have tight manufacturing schedules. LSP 1 explains this with the fact that the pallets consist of different packages and sometimes the ones in the very middle are left not well chilled. In their opinion, this affects the temperature in the other stages of the cold chain. Therefore, they don't check every truck, as usually there is no problem with the cargo. There are two cases when they need the stored temperature information: the breach in temperature and when the customer requires a report.

When it comes to the plans of LSP 1 for technological updates, they have a business development unit, where temperature specialists constantly search the market for new equipment and technologies. Using the latest technology is very important for them, as they strive to be top performers in the branch. Therefore, they do invest in the latest technology if they see a reason in it. While purchasing technology the most important criteria is how

precise the technology measures, how sufficient the classification is, and the price. Moreover, the technology should match the calibration requirements. LSP 1 checks the performance of the technology on regular basis. They have a full-time worker dedicated to the good calibration of this technology. Sometimes the customers raise specific requirements, but in the common case they only demand an option for creation of a log list with historic temperature data. When it comes to sharing the temperature data they state it is a question of who owns the goods.

(6) LSP 2

The most cold chain operations of LSP 2 are dedicated to customers in the life science and healthcare industry. When it comes to the food industry solutions, the company has only one large customer in Sweden, the ice cream brand of one of the biggest fast moving consumer goods companies worldwide. For this customer, LSP 2 is responsible for temperature controlled transportation and storage. However, LSP 2 outsources the transportation function to LSP 1 discussed earlier in this section. They do discuss the temperature control terms in the negotiation process. LSP 2 provides a HACCP schedule to its transportation provider, emphasizing on the risk points for too high temperature. Moreover, LSP 2 pays attention not only to in-transit transportation, but also on loading and unloading points where disruption to the temperature might occur.

For the ice cream brand, LSP 2 requires $-18\text{ }^{\circ}\text{C}$ for all inbound and outbound shipments and $-23\text{ }^{\circ}\text{C}$ for the warehouse. The shipment is checked manually with a contact thermometer on arrival and dispatch, at 3 to 5 points per vehicle unit. In the case of any deviation from the required temperature, LSP 2 informs the sender immediately and provides a detailed report. In order to ensure the quality control of the transportation, LSP 2 makes a regular test by positioning a temperature data logger in the shipment. Then they analyze the data and send feedback together with the temperature graph to both the customer and the contractor.

In the warehouse, LSP2 uses a temperature monitoring system that logs the temperature once per every 5 minute. If the temperature exceeds $-23\text{ }^{\circ}\text{C}$ the alarm system signals for the improper cooling conditions. All the temperature data collected with the TMS is stored in an online database. The stored data is then used for basic analytics. The Warehouse Manager of LSP 2 claims that they experience no problems with the current system and that it ensures total temperature control. However, the manager admits there are cases of poor cooling, during the transportation process, approximately six times a year. In respect to this, the controlling of the refrigeration unit and following the trailer location in terms of routing is pointed out as important.

The LSP 2 attitude towards a more advanced technology is positive and they would prefer if their contractors use it. They do invest in good technology and are ready to pay in order to be the preferred provider for their customers. LSP 2 shows great interest towards the real-time temperature methods and express that it would be a good solution for replacement of the numerous manual checks. However, LSP 2 believes that a combination between an automatic system and human surveillance leads to the best results.

(7) FSP 1

The cold transportation and warehousing functions of the company are in-house functions of FSP 1, as they consider it as a source of competitive advantage. FSP 1 regularly checks all the products they receive from their suppliers before they register them in their cold distribution centers. During storage, the air temperature is monitored automatically. The system they use for temperature monitoring is Cool Guard.

Moreover, all the trucks and cold storages are equipped with an alarm system that is connected with the main database system. The opinion of the Logistics Manager about the current temperature monitoring system is that it meets the goals of safety and quality of products. However, the system lacks some extra functionalities, which are needed sometimes. For example, the technology in use does not provide an opportunity to analyze the data and to align it with the fleet model.

They do not use the latest technology. The main reason for that is price and the company is satisfied with the temperature monitoring technology. FSP 1 invests more in their people, than in technology. In order to deal with the cold management issues, the company sends their employees to courses and trainings.

The company considers that the current technology is simple and efficient enough. The initial and maintenance expenses are not high. Furthermore, this technology is fully aligned with all the key process and needs of the cold chain. Initially, the technology was chosen based on these processes.

The main reason that restrains us from the implementation of advanced technology is, obviously, cost. The initial price of the technology is very high, while the advantages that this technology might bring in our business are unclear. What is the value of paying twice more, if you get the same temperature data? Moreover, none of our competitors has it and none of our customers really requires it. Therefore, the company is not pushed by internal or external factors' (Personal communication, 2015-04-15).

However, the company is ready to consider the implementation of advanced technology in the future. They expect the market to dictate the new requirements. They are not ready to be a pioneer in the use of such technology.

(8) FSP 2

FSP 2 checks the temperature in two cases: when the products arrive at their storage facilities from their suppliers and during transportation. On arrival, it is usually the customer who checks the products. All the trucks in the fleet are equipped with screens that are connected with the temperature monitoring system. The one used by the company is Cool Guard. It is a wireless temperature monitoring system, which automatically measures and records the temperature, as well as sends signals and generates documentation, in case there are some deviations from the requirements. The company provides printed reports when their customers require it.

The technology used for temperature monitoring is not considered as advanced. On the market, there are technologies that are more progressive. However, the present temperature monitoring technology meets the requirements in terms of quality and safety. In most cases, the temperature data is not analyzed. The exception is when technical problems with the refrigerating equipment occur.

According to the internal statistics, most of the disruptions happen during transportation and preparation stages. Thus, the control focus is on temperature monitoring during the phases of loading/unloading and in-transit. Cold storages show temperature constancy. Tightening temperature control occurs during the summer peak, when refrigerating equipment is under pressure from high external temperatures.

(9) Grocery Store 1

For the Store 1 the flawlessness of the CCL processes is essential. They pay attention to all stages where the cold management is required. These stages are pre-acceptance and storage/display. According to the store manager, they check the products before accepting to

the storage or shelf displays, as the stage of transportation is out of their control. In some cases, Store 1 requires from their providers printed reports about the in-transit temperature.

When it comes to the storage and display, Store 1 has a temperature guidance manual that reflects all the temperature and humidity conditions required to sustain the original quality of fresh, chilled and frozen perishables. Based on this guidance, the employees responsible for that function take control over the temperature of products located in different areas.

For the purpose of temperature check and control, Store 1 uses recording thermographs or portable thermometers. They evaluate this technology as one of the simplest presented in the market. It satisfies the needs in terms of temperature monitoring. This technology does not have any extra functionality. It does not generate the type of data that might be useful for the further analysis or shelf-life predictions. Moreover, they do not consider the implementation of more advances due to the high cost and investment priorities.

In order to get a deeper understanding of the current application of TMS in Sweden, the interviews with the suppliers of such solutions were conducted.

(10) Supplier of TMS 1

STMS 1 states that maximum 20 percent of the cold storages recently supplied in Sweden were equipped with TMS based on the XWEB system. The XWEB is a web server that acts as a gateway to a Local Area Network of control and monitoring devices for the food industry. The XWEB can record, monitor and analyze data and status, manage alarms, and optimize appliances in applications such as refrigeration, walk-ins, food warming/ovens, lighting and energy monitoring.

STMS 1 mentions that the majority of customers implementing TMS in their cold storages are in the pharma segment and in child-care facilities. However, more and more segments, including the food industry are starting to be interested in TMS. They feel pressured by strict regulations in Sweden.

STMS 1 explains that the main drivers for companies to implement TMS were breakdowns of cold rooms due to the electricity interruption during the nighttime, personnel leaving the doors open by accident and faults of refrigerating equipment.

According to TMS1, *'advanced technology includes real-time data generation, remote control, alarm system and accessibility for all actors of the supply chain. Moreover, it should create a database for further analysis and decision-making'* (Personal communication, 2015-04-09).

The usage of advanced TMS helps to eliminate problems with cold rooms operations much faster. What is essential is that it enables the staff to get the alarm signals in time and to avoid food spoilage. STMS 1 believes that *'the implementation of advanced TMS allows the decrease of costs from product loss in the whole FSC'* (Personal communication, 2015-04-09) and is vital to protect the end customers in both retail and HoReCa sectors. Moreover, as advanced TMS record all working parameters and makes them downloadable from all the actors, they protect the cold room producers from being sued in cases of spoiled goods before or after storage.

According to STMS 1, its customers do not face challenges with the adoption of advanced TMS but in all cases personnel trainings are needed.

STMS 1 stresses that *'advanced TMS will definitely be wide spread in the future as the legislation becomes more and more focused on food storage standards'* (Personal communication, 2015-04-09) and their contribution to the food safety will be more visible. However, one should note that society could get more from TMS if it is used in the whole FSC and appropriate processes are worked out.

(11) Suppliers of TMS 2

STMS 2 differentiate three types of TMS: for the lorry, for the trailer-chassis and for transport-cooling devices or other technical equipment. The TMS for lorries can provide positioning information, motor data or even motor management, drivers' behavior, fuel consumption, transport order management, route instructions from the dispatcher, information about maintenance, security aspects. TMS for trailer-chassis can provide technical data about brakes, axels, load control, security aspects. TMS for cooling and other devices can provide temperature control, control of door switches, operation mode of the transport-cooling device and security aspects. Very beneficial functions are the remote control and precool of the trailer, as they ensure sustainability, flexibility and operational excellence.

Companies who are implementing TMS are searching for transparency, pre-delivery-information and intervention-processes in case of deviations. There is a huge number of TMS systems in the market and the company who is going to implement them should identify the main purposes of implementation, because one of the barriers is the purchase price of TMS and the communication costs.

STMS 2 states that they sell their equipment and offer services mainly to transport companies, rental companies and trailer body builders.

According to STMS 2, the use of simple TMS in the lorry is almost a standard in Sweden. Moreover, the advanced TMS will become a standard in the logistics business, as *'there is a need for the overall transparency of the entire supply chain'* (Personal communication, 2015-04-10) and security reasons will be the motivator. STMS 2 claims that synergy effect can be achieved if access to the data is granted to all stakeholders in the FSC, by a shared internet portal. Some solutions include cloud storage and machine-to-machine technology to transmission of the data. Thus everybody, can easily access the information about the transport conditions and tracking information in real-time.

4.2.2 Managerial perspective

The following empirical findings concerning the managerial perspective on TMS are grouped based on the outline of the interview. Since this is the particular gap in the literature the authors are trying to fulfill, the supply chain BI model (Major, 2014) and the review on collaboration within the FSCs inspired the categorization.

CCL Goals

Producer 1 considers CCM and temperature monitoring as a focus in the CCL. They realize that the proper temperature at each stage of the supply chain is crucial to sustain the quality of the products. Keeping temperature to sustain quality and safety is the mission of their CCM. They use HACCP schemes to evaluate and control food risks throughout the entire supply chain. In addition, all sites should be certified according to the ISO 2200 food safety standard. They express: *'When we produce dairy products, it is crucial that each product meets the high quality standards that give our consumers confidence in our products'* (Personal communication, 2015-03-20).

Producer 2 has a focus on the issues of price when discussing the KPIs. However, original quality, taste, health and other values are also very important and influence the cost–quality tradeoff. The company does recognize the wastage of food as a major problem and they are putting efforts to help the consumers to reduce their food waste. Producer 2 makes sure they follow all laws and regulations. They audit the truck drivers for execution of the company standard operations procedures during the transportation process. The company monitors

its processes by the implementation of a HACCP system. It is quality-certified according to ISO 9001, Global Food Safety Initiative and British Retail Consortium standards. Furthermore, the company has internal and external audits, as a part of their continuous improvement process in the plants.

Retailer 1 states that in terms of CCM, their mission is to transfer the product from the producer to the stores with the minimum impact on quality. Their main aim is to sustain the cold chain of the incoming products throughout the distribution channel. The safety and quality KPIs are what they are looking for. Retailer 1 does comply with the food quality and safety regulations and keeps the temperature to the regulations demand. In addition, they make internal audit to ensure that all the routines and regulations are in place. They also require following the standards from their suppliers and certification, which are approved by the Global Food Safety Initiative.

At present, Retailer 2 does not have specific KPIs dedicated to the CCL process, but there is a closer discussion for the development of such with their counterparts. Retailer 2 is negotiating with LSPs and the stores to develop a common KPI related to the temperature control and particularly to the reporting of temperature data. As for Retailer 2: *'cost is very important, but it can't go before product safety'* (Personal communication, 2015-04-08). They admit that dealing with chilled food is risky. What Retailer 2 is trying to do is assess the risk and put its value against the cost of it. Their ultimate goal is to find the smallest cost that can secure the product safety. However, in the end *'You can not adventure people's health and that costs'* (Personal communication, 2015-04-08). At present, the company is in search of KPIs that can express this cost-quality trade-off.

LSP 1 goals in the CCL process are focused on the delivery accuracy, on the delivery time, rather than on the temperature control. For them, the temperature management is an everyday operational process, rather than strategic one. They consider it very simple, however, they discuss it with their customers. At present, they comply with all EU directives connected to food traceability and safety, the translated standards for the Swedish market and the specific legislation connected to the frozen and chilled food. They focus on the legislation for transportation of animal products, such as meat and fish, as for fresh produce products there are only recommendations.

LSP 2 claims that an *'unbroken cold chain is a top priority'* (Personal communication, 2015-03-17) while designing their customers' tailored logistics solutions. However, at present the company does not have particular KPIs related to the temperature management in the CCL process.

FSP 1 states that in order to meet their customer requirements the focus of the CCL process is on sustaining quality, safety and traceability of all food products. They believe these goals are particularly important in the case of perishables. That is why the company regards control measures as vital for their success: *'Food safety is an important area. The entire flow of goods – from receipt to delivery to the customer – undergoes a broad and rigorous chain of control measures'* (Personal communication, 2015-04-15). All their cold chain processes meet the regulations of ISO and all sanity rules enforced in Sweden. Their main goal is as follows: *'Our priority is to deliver food that comes from our suppliers with the same qualitative characteristics. We want our employees to know and understand the importance of refrigeration and temperature data control. The price of mistake in our business is too high'* (Personal communication, 2015-04-15).

When it comes to the management of the perishable foodstuffs, the priority of FSP 2 is the continuous cold supply chain. For them, this is crucial in sustaining the original quality and safety of products. Moreover, it is the best way to comply with the existing legislation and required certification (industry certification system HACCP), concerned with foodstuffs.

FSP 2 invests in trainings, with the aim to develop the crucial knowledge about the KPIs of their cold chain – level of quality and safety. According to the opinion of the Logistics Manager, there is no place for dilemma about price or people's health: *'We want to ensure that products we deliver are safe and fresh. Healthy society is a better reward for us'* (Personal communication, 2015-04-15).

Store 1 describes the CCL goals in the following way: *'We want to sustain the original quality and safety of products that we sell, thereby meeting the demand from legislation and our customers'* (Personal communication, 2015-04-27). Nowadays, selling just fresh products of high quality is not enough. In most cases, customers assume that all the perishables they buy are produced from qualitative ingredients and are transported and stored in accordance with standards. Moreover, they do not require proof. The best proof for them is the superior quality. The goal of Store 1 is to minimize the amount of cases where customers could complain and meet all the customer requirements. Customers have a very clear perception of what they require from stores. For example, "Eco garden food" is an environmentally preferable way that is among the consumer trends together with eco-branded products.

User knowledge

Producer 1 educates and trains their personnel. They explain that quality and safety are the priorities at all stages. Moreover, besides education, the full alignment and integration between technology itself and key processes inside and outside the organization is needed to achieve superior performance.

Producer 2 feels obliged to educate their personnel in terms of the importance of temperature control. However, they have not developed a proper internal education on the TMS. They rely on the ones that suppliers of TMS provide with the installment of the products.

Retailer 1 considers that when it comes to the knowledge and competence in the temperature control, training and education are required. The suppliers of the temperature technology provide them with guidelines, but they also combine it with their own resources and experiences.

Retailer 2 supposes that the biggest risk for them, in terms of human mistakes, is during transportation, as they subcontract it and therefore do not have the full control over it. When it comes to their own people working in the terminals, they educate all of them in the basic use of foodstuffs and their temperature handling. The risk is outside Retailer 2, when the items are handled by other people. Thus, Retailer 2 insists on education of the drivers. They should know what might happen, what are the risks and how to keep the quality of the product in all cases. They are aware that the biggest LSPs have their own education systems, which Retailer 2 checks during their regular audits.

LSP 1 puts a lot of effort into educating their people. They have a manual, written instructions for the drivers. In addition, all the people that use TMS are trained by the manufacturers of chilling equipment.

LSP2 has a developed education system for its personnel and tries constantly to improve their knowledge and skills. The users of the TMS are provided with detailed guidelines, standard operations procedures and targets to follow.

FSP 1 believes that investments in education and training are crucial to achieve excellence in cold chain performance. The company organizes trainings for truck drivers and employees dealing with the temperature monitoring at warehouses.

In order to utilize the best temperature monitoring technology, FSP2 carefully educates their workers concerning the cold issues. The company invests in trainings, with the aim to develop the crucial knowledge about the KPIs of their cold chain – level of quality and safety. According to the opinion of the Logistics Manager, there is no place for dilemma about price or people's health: *'We want to ensure that products we deliver are safe and fresh. Healthy society is a better reward for us'* (Personal communication, 2015-04-15).

In order to comply with the established temperature norms, Store 1 pays attention to the knowledge of employees in this area. They check that all store employees are aware of different temperature regimes and ways to sustain it unbroken.

Collaboration

Retailer 1 considers alignment with the processes and believes that the collaboration is very important, and that in the future they will be much more integrated. Goals such as quality and safety do require collaborative effort. They will be able to comply with the food quality and safety regulations without high level of collaboration, but if they want to be efficient, they should embrace collaborative relationships. They believe the collaboration with others is the best way to solve the common problems and in the future, there will be more possibilities to do so. Retailer 1 states that when the suppliers are from abroad they are not a driving force in the food distribution channel. However when it comes to the national suppliers, they might be a pioneer for collaborative initiatives due to their market share.

Retailer 2 regards the level of cooperation and trust among the major players of the Swedish food industry as high. The reason for this unique cooperation is the shared goals and challenges for the whole Swedish FSC. Retailer 2 shares that they cooperate on a branch level with other retailers as well as on network level with other retailers, transport companies and producers. They do it through the Swedish Frozen and Chilled Food Association (Föreningen Fryst och Kyld Mat, FFKM), which develops best practices and standards for the industry. The goal of FFKM is to achieve an unbroken cold chain and thus ensure total food quality and safety and minimization of waste.

LSP 1 believes there is a deep collaboration on the temperature issues in the food industry of Sweden. They are member of the FFKM where they collaborate with producers, retailers and manufacturers of TMS. *'We work toward the development of common guidelines for the industry'* (Personal communication, 2015-04-16). Moreover, LSP 1 is involved in the work of a research institution, the Swedish Institute for Food and Biotechnology, which gathers companies and researchers to work together on projects related to the problems in the CCM in Sweden.

LSP 2 evaluates the level of internal collaboration in terms of temperature monitoring as high, while external collaboration with other actors of the supply chain is not that high.

FSP 1 does not collaborate with anyone in terms of temperature monitoring or any other issues connected with the cold supply chain. Neither they share their temperature data with other actors in the FSC.

In terms of temperature monitoring, the level of external collaboration of FSP 2 is quite low. They share the collected temperature data with their customers and technical service providers. However, all the employees dealing with these issues internally cooperate a lot (e.g., Quality Manager has an ongoing discussion with the drivers and warehouse personnel).

5. Analysis

In this chapter, the authors analyze the empirical data, collected for the current thesis, with the literature discussed in Chapter 2. As a result, a framework of enhanced utilization of TMS is proposed.

In the analysis chapter the authors discuss the current application of TMS in CCL in Sweden in terms of what is used, what are the critical points and what are the advanced TMS capabilities. Moreover, the market perception of the cutting-edge technology is presented. Thus, outlining the potential advancement that can be achieved with the help of technology.

From a managerial perspective, the authors propose an integrated approach towards the usage of TMS. This includes the implementation of advanced TMS, the alignment of CCL goals with the knowledge of the people and the TMS capabilities, and the importance of collaboration. This approach leads to the enhanced utilization of TMS and in turns to the achievement of better food quality and safety.

5.1 Current application of TMS in CCL in Sweden

An overview of the current usage of TMS in Sweden is available in Appendix 6. Overall, the research supports the idea mentioned in the literature that the implementation of advanced technology is not common and that the technology with short detection time, enabling quick response and facilitating decision-making is advancing slowly (Hoorfar et al, 2011). STMS 1 confirms that maximum 20 percent of the cold storages in Sweden have installed the advanced TMS based on the XWEB system. What is commonly used instead are data loggers in the trucks and an online alarm system in the cold storages. Moreover, in each stop or change of ownership in the distribution channel, a manual check of the temperature takes place.

As the authors learnt from the interviews, all case companies follow the temperature in the cold chain to some extent. In table 5.1, a summary of the used TMS by case is presented. As mentioned by STMS 1, the advanced TMS has the following criteria: generation of online real-time data, remote control, ability to make reports, alarm system, accessibility from all members of the chain, creation of database for analysis purposes and further decision-making.

Table. 5.1 FSC Actors and TMS usage

FSC Actor	Transport		Storage		Manual Control	Real-time, Remote Control	Analysis
	Simple TMS	Advanced TMS	Simple TMS	Advanced TMS			
Producer 1	✓	✗	✗	✓	✓	✗	✗
Producer 2	✗	✓	✗	✓	✓	✗	✗
Retailer 1	✓	✗	✗	✓	✓	✗	✗
Retailer 2	✓	✗	✗	✓	✓	✗	✗
LSP 1	✓	✗	✗	✓	✓	✗	✗
LSP 2	✓	✗	✗	✓	✓	✗	✓
FSP 1	✗	✓	✗	✓	✓	✗	✗
FSP 2	✗	✓	✗	✓	✗	✗	✗
Store 1	-	-	✓	✗	✓	✗	✗

✓ - used, ✗ - not used, - n/a

Producer 1 uses advanced TMS in their storages, but only data loggers during transportation. The check function is done manually and there is no deep analysis of temperature data.

Producer 2 has advanced TMSs in the warehouse and during the transportation. However, the database is mainly used for later review as no further analysis of the data for decision-making purposes is present.

Retailers 1 and 2 mostly outsource the transportation. Therefore, they rely on their providers, who use data loggers. The temperature is manually checked for all incoming products before the truck loading and on arrival at the distribution terminal or store. *Retailer 1* uses advanced TMS in their warehouses, but they do not manage the inventory based on shelf-life predictions, which can be made by using the temperature data. *Retailer 2* is aware of the usage of manual temperature data collection with data loggers and geographical positioning systems. No analysis is made with the help of temperature data.

LSP 1 gets the requirement for handling the TSPP from their customers. They are stated in the contract, the airway bill and the booking. The drivers are responsible to set manually the required temperature in the transport-cooling unit. Data loggers are used during the transportation, while advanced TMS in the storage. The air temperature of the truck is checked manually.

LSP 2 outsources a great deal of their transportation and they check the shipments manually with the contact thermometer at three to five points per vehicle unit. They use temperature data loggers in order to audit their subcontractors. After getting the historic temperature data they analyse it and send the graphics to their customers and contractors. In the warehouse, *LSP 2* uses advanced TMS, which generates on-line database for further basic analytics.

FSP 1 relies on advanced TMS in both transportation and distribution. However, the system lacks some extra functionality (e.g. no opportunity to analyze the data and to align it with the fleet model).

FSP 2 uses advanced TMS in both stages, but the temperature data is not subsequently analyzed. Only in the case of refrigerating equipment faults, the company reviews the temperature data.

Store 1 checks manually the products with simple thermographs or portable thermometers for the temperature control, both upon arrival and at displays. No further analysis is present, even though the shelf-life is critical for their profit performance.

Further analysis touches upon the critical points of the current cold chain in Sweden (see Appendix 6). According to the problem statement, in the context of FSCM, “if any of the links or activities in the cold chain is missing or weak, the whole system fails” (Bharti, 2014, p.33). With respect to that, two critical stages in the CCL process can be identified from both the literature and the empirical findings – storage (incl. warehousing at production facility and at distribution centers) and refrigerated transportation.

Producer 2 admits that very seldom but still disruption in the cold chain can happen due to insufficiently cooled down products before transportation or freezing the product during transportation. This problem is also mentioned by LSP 1. According to the literature, and supported by STMS 1 the reasons for breaches during transportation are mostly due to risks of power shortage, technical issues with the equipment, poor air conditioning or bad insulation (Rodrigue, 2013). However, Retailer 1 admits a human mistake is the most common reason. Furthermore, corresponding to the literature, FSP 2 and LSP 2 stress the loading and unloading process as such of high risk for inadequate exposure to ambient conditions. LSP 1 supports the idea presented by Aung et al. (2012) that the temperature management is harder in case of mixed perishable cargo. Most of the case companies do not identify any problems during the storage stage. STMS 1 points out the malfunction of the equipment and the personnel carelessness with the cold storage/display doors as the most common reason for customer complaints.

Several case companies express that they lack full control over the whole distribution channel (Producer 1; Retailer 2; Store 1). As described by Hsio et al. (2010), outsourcing can lead to performance measurement and behavior uncertainty as well as planning and control problems. Therefore, the outsourcing of the transportation, which is present to some extent in Producer 1, Producer 2 and LSP 2, and to a larger extent in Retailer 1, Retailer 2 and Store 1 leads to the feeling of lack of control and thus to the need of visibility and transparency in the whole chain.

Further observations of the authors are that the majority of the actors in the Swedish FSC do not share information on regular basis (Retailer 1&2; LSP 1&2; FSP 1&2). Some information is shared only by request or in case of disruption. Moreover, paper exchange of information takes place in some cases (FSP 1&2, Store 1). This, in the authors’ point of view, does not allow full control over the temperature as well as transparent and visible data exchange for all actors in the cold chain. It can lead to double work in some cases. Digital information flow is much more efficient, in terms of speed of exchange and analysis-friendliness. In relation to this, the Chillon project (2012) claims that the inability to share information along the cold chain creates a huge information gap between the actors in the cold chain and leads to weakness of the whole FSC. The Chillon project (2012) explains the gap is due to the lack of trust or proper technology. In the case of Sweden, it is more because of technology level rather than lack of trust.

As mentioned before, the checks of the TSPP after transportation are done manually and not every time. The authors believe manual work is time- and personnel-consuming. Moreover, it does not provide consistency, as randomly collected results cannot be safely extrapolated for the other consignments. The quality of TSPP can vary in one truck, depending on

where the exact box was located in the truck body - closer to the evaporator or closer to the doors (Rodrigue, 2013). LSP 1 explains this with the fact that the pallets consist of different packages and sometimes the ones in the very middle are left not well chilled.

In addition, as all case companies use manual control it is evident that the staff involvement in this process brings risk, as mistakes are always possible. Human mistakes are considered as a big risk by Retailer 1, Retailer 2 and Store 1. LSPs are more likely to use the advanced TMS, but even they have the drivers who manually control the cooling unit (LSP 1). In the authors' view, a remote control made by highly qualified operator in the control center (Shi et al., 2010), can increase the precision during transportation.

Moreover, only one case company analyzes the data with the help of advanced TMS and makes managerial decisions based on it. The authors suggest that data analysis is where the opportunity for improvement can be found. As claimed by Katsaliaki et al. (2014), managing of perishables requires competent decision-making and data-driven decision-making appear to be empowering (Tai, 2014; Major, 2012).

In the next section, taking into account the current situation and the listed critical points, the authors argue how the usage of advanced TMS can be beneficial for all stakeholders in the FSC.

5.2 Advanced TMS Capabilities

As stated in the literature, the quality and integrity control of the TSPP require efficient equipment, appropriate operating modes and proper information system (Faisal, 2011, Bharti, 2014; Hafliðason et al., 2012).

The approach for continuous temperature monitoring, which the authors propose, is based on the idea of SCCM and the framework for cold chain monitoring system (Aung & Chang, 2014; Shi et al., 2010). The process of monitoring includes data collection, data transmission and analysis. The data collection involves different devices, which are normally tagged on the product or the transportation equipment. Then, the data is transmitted, via different networks or cellular options, to a data terminal and ends up in a control server. In order to increase the efficiency in the process, some TMS providers use cloud storage instead of data terminals, using machine-to-machine technology (STMS 2). According to Hoorfar et al (2011), the combination of RFID tags on the products and WSN system for transmission allows the collection of digital real-time data and thus is very flexible and increases supply chain visibility. Moreover, this type of data collection allows single and multi point remote temperature monitoring and control, as it facilitates data linkages between the CCL vehicles and the control server. For example, the intelligent container (Lutjean et al., 2013). Finally, the data is analyzed in the control server and depending on the specific technology different reports, graphics, maps and alerts can be generated for the decision-makers.

The real-time data as well as the analysis can be accessed by all actors in the FSC through an internet portal (STMS 2). Therefore, all actors in the FSC can monitor their products in terms of temperature and traceability from fork-to-farm and are collectively responsible (STMS 1) for the monitoring of the quality of TSPP (Aung & Chang, 2014; IPI, 2012; Kim et al., 2015; Trebar, et al., 2013). Thus, all FSC actors involved in a single shipment transaction can achieve high level of information share and full cold chain visibility and control.

As mentioned in the literature, good data is a basis for good analysis and better decision-making. Therefore, as Hoorfar et al. (2011) explain the integration of advanced TMS with IT solutions can bring valuable results. The output of the analysis of temperature data can be

predictions for product quality and remaining shelf-life or risk management reports (Chillon, 2012). Thus, minimizing the wastage and increasing the company responsiveness. As deduced in the previous section only one of the case companies uses the information for the purpose of analysis. With the implementation of holistic inter-organizational CCIS, the actors in the FSC will fully grasp the benefits of a such end-to-end approach (Hoorfar et al., 2011). Apart from real-time and remote monitoring, they can leverage on excellent analytics.

Another important benefit of the systems is that, in comparison with the cheapest option for data collection that is currently in use – the data loggers (IPI, 2012), the RFID allows uninterrupted cold chain process (Kim et al., 2015). The need for manual control is absent, as the system sends real-time proactive alerts to the actors in the chain. This prevents several human handlings along the chain and thus minimizes the risk of human mistake. Therefore, the implementation of advanced TMS technology can bring cost savings and effectiveness in terms of product quality and minimization of waste (STMS 1). Producer 2 admits that they can be more efficient with the usage of better technology and are ready to embrace new technology in the name of quality. Retailer 1 also thinks that new and modern TMS could improve efficiency. Retailer 2 supports this by stressing that the real-time data is needed, because it will allow the storeowners to exclude manual control.

As a summary, Figure 5.1 displays the capabilities of the advanced TMS. These solutions collect online real-time data and thus monitor the temperature remotely in real-time and simultaneously log the information for compliance reports purposes. Moreover, they allow the companies to be proactive, as alerts are sent in case of temperature failure. They create a database for analysis purposes and further decision-making, the reports from which enable waste reduction, increase efficiency and responsiveness. Altogether, the risk for food quality and safety is minimized.

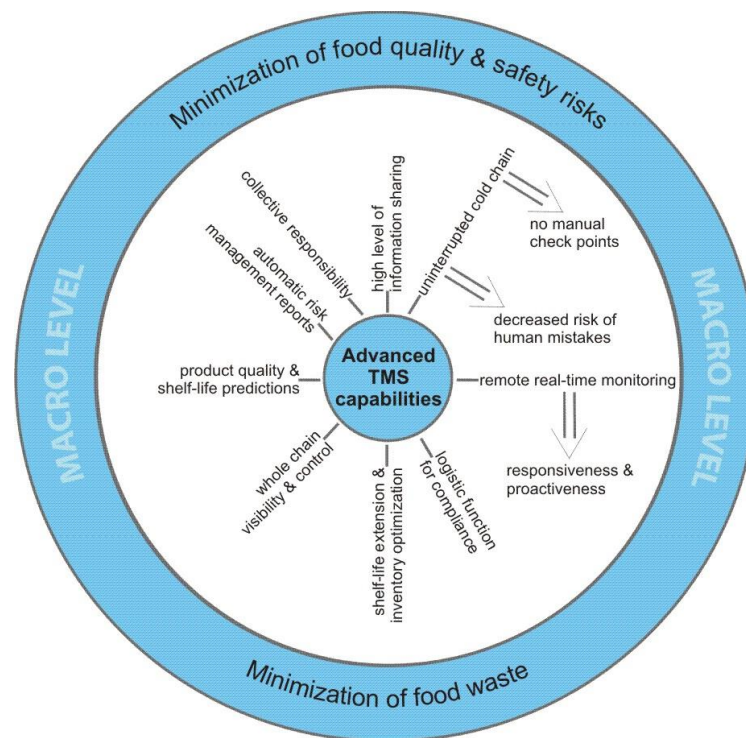


Figure 5.1 Advanced TMS Capabilities.

When it comes to the different segments of the FSC, the advanced TMS provide benefits at all stages. Effective pre-cooling management and documentation of quality for compliance purposes for the producers, real-time remote monitoring and notifications during transportation, conditions information and enabling of LSFO inventory management (Jedermann et al., 2014) for the distribution and stores, shelf-life extension, minimization of waste and view and control over the whole supply chain for the retailers and storeowners.

5.3 Advanced TMS market penetration

In the previous sections it was concluded that some actors are using advanced technologies, but not all, and mostly in their storage facilities. As emphasised by Manzini and Accorsi, (2013) and Major (2014) one of the significant barriers for implementation of cutting-edge TMS is the high cost. Moreover, integrated information system and specific knowledge are required. These ideas are expressed by many case companies (FSP 1; Retailer 1&2; Store 1; TMS 2) and followed by the need for alignment with the present system and the key processes (Producer 1). The authors admit that the price of advanced TMS is relatively high and believe that the key is in the collective business approach and macro level support. With respect to the government goals for TSPP safety and quality on a macro level and their food waste reduction plans (Livsmedelsverket, 2014) a government funds for companies implementing state of the art technologies sound reasonable. Another possible driver is the legislation (Trebilcock, 2011; TMS 2), which is expected to be more demanding and to push the usage of advanced TMS implementation. However, the best motivation for TMS implementation is the above-mentioned benefits, which lead to high level of operational excellence and efficiency.

The case companies' overall opinion about the new technology is that it might be good, but the technology-in-use is still satisfactory and cost-efficient. The need for advancements might come in the future, mostly from efficiency perspective (Producer 1&2; FSP 2; Retailer 1). Retailer 2 and LSP 2 are positive about the real-time temperature monitoring and agree that would be a good solution for replacement of the numerous manual checks. However, the current requirements to the TMS in the industry are focused solely on regulation compliance and accuracy.

As stated in the literature, approximately 90 percent of the distribution in Sweden is in the hands of the three largest retailers (Swedish Trade Chamber, 2013). Moreover, the producers deliver to wholesalers, while the wholesalers deliver to retailers, where the wholesaler and the retailer are often under the same umbrella of companies (Olsson & Skjöldebrand, 2008). This in the authors' opinion might be a good frame to explain, which actors of the FSC might have the network power dominance to raise the requirements and put pressure on the other actors of FSC.

After sorting the empirical data, it can be noticed that retailers are very likely to outsource CCL functions, while other actors have them in-house. Producer 1 owns cold terminals and fleet, 20 percent outsourced. Producer 2 has their own fleet and outsources only a small part of their outbound logistics. LSP 1 owns most of its fleet. While, Retailer 1 and Retailer 2 outsource most of their transportation. Moreover, Retailers and the store owners are mostly concerned about the control over the whole cold chain while the producers, LSPs and other actors are mostly interested in meeting their partners' requirements, therefore are more focused on the TSPP losses and cost efficiency. Thus, the retailers in Sweden are the ones who influence the other actors by introducing very strict rules and requirements.

5.4 Managerial perspective:

The literature review of the current thesis suggests that the supply chain BI, such as the SCCM and CCIS, may optimize the CCL. However, the technology itself is not enough to ensure the successful usage of advanced TMS (Major, 2014). The success factors for its adoption include matching the business goals of the CCL process with the TMS capabilities and user knowledge. Furthermore, effective communication, collaborative culture and application of system thinking is essential (Ireland, 2005).

5.4.1 Goals of the CCL and its actors' objectives

Different types of actors of the FSC were interviewed which gives a rather full overview of the issues and main goals of CCL. Figure 5.2 presents a summary of the CCL goals on macro and micro level. The authors decided to consider the government and the society role, because of the relatively high environmental and legislative pressure in Sweden (Livsmedelsverket, 2014; STMS 1).

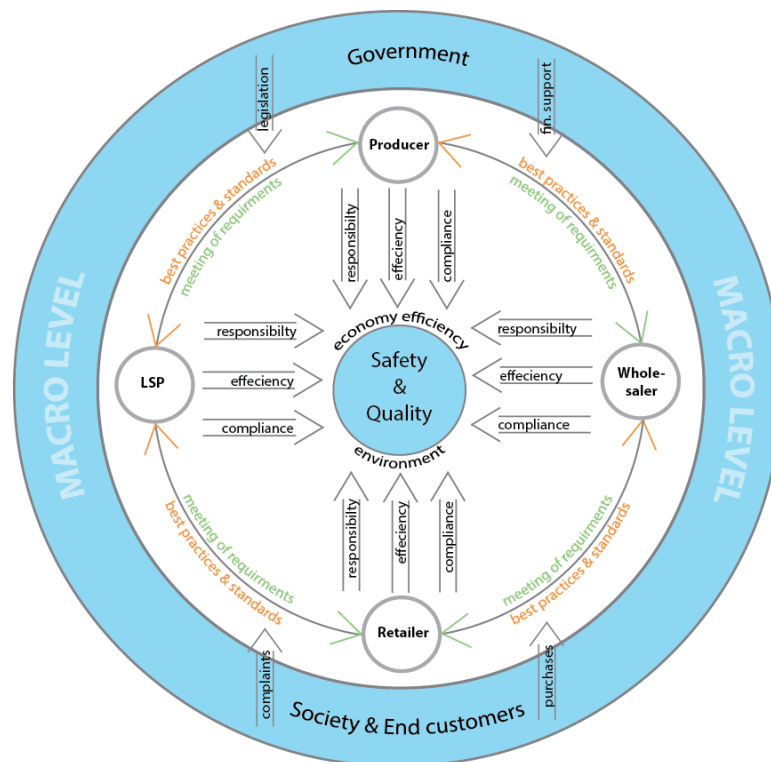


Figure 5.2 CCL Goals on macro and micro level.

As defined by Manzini and Accorsi (2013), the total quality and safety goals are the priority on macro level of the FSCM. The sustainability and economic efficiency are also important, but not with the cost of food safety. This statement is supported by the majority of the case companies.

The government is responsible for the adequacy of the legal framework, as well as the financing of innovative food waste reduction projects. Moreover, the food and safety regula-

tions in the Swedish food market are quite strict (Livsmedelsverket, 2014). All case companies confirm that they have to and do comply with the European and the local food traceability and safety regulations as well as standards for frozen and chilled food. In addition, some actors conduct internal and external audits to ensure that all the routines and regulations are in place and require standards from their suppliers and certification (Producer 1&2; Retailer 1&2). The case companies manage to comply with the law using the current technology. However, Trebilcock (2011) and STMS 1 imply the coming rise of advanced TMS usage, exactly due to the expected increase in the strictness of the governmental regulations in terms of food quality and safety.

According to Store 1, the society and end customers have a very clear perception of what the quality of the products should be. What the customers value the most is the quality and freshness of the product on the shelf. In case their demand is not met, they would complain. The trend towards organic and perishable product preference is conceivable in Sweden. Moreover, according to the Swedish Trade Chamber (2013), the social cautiousness on quality and environmental issues is rather high. Therefore, it is of the best interest of the store-owners to ensure the proper handling of the TSPP by all actors in the FSC.

Corresponding to the macro level goals and requirements, the safety and quality are the most important KPIs in the CCL (Producer 1; Retailer 1; FSP 1). The mission of the CCL is to keep the product temperature and minimize the impact on its' quality from the producer to the stores (Retailer 1). This fully matches with the suggested managerial focus for the CCL – product instead of process, quality over productivity (Silva 2010; Trebar et al., 2013). Producer 2 and Retailer 2 are more cost-oriented, but in all cases, the safety goes before the cost. Moreover, Retailer 2 and LSP 2 are developing CCL KPIs related to the temperature management and the cost-quality trade off. The CCM goal is to minimize the temperature fluctuation, by planning and control of an efficient flow and storage of TSPP (Bogataj et al., 2005; Christopher, 2011; Mattoli et al., 2010). Producer 1 and Store 1 strongly believe that CCM should be the focus of the CCL process, because of the importance of temperature management for sustaining the product integrity and freshness. LSP 1's focus is on the delivery time as from their perspective the temperature management is more an operational, rather than strategic function.

The authors would like to emphasize the social responsibility and environmental awareness of the FSC business in Sweden. The majority of actors interviewed mention that the cost is important, but only to some extent: *“cost is very important, but it can't go before product safety”* (Retailer 2). In addition, the companies pay attention to the technologies they are using from an environmental perspective. For example, Producer 1 has refrigeration units, which are environment-friendly.

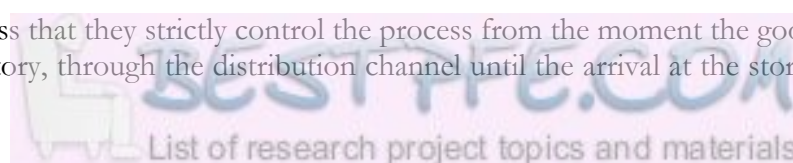
Furthermore, the authors distinguish that the regulation compliance, efficiency and responsibility are the most common objectives among all FSC actors. More reflections on each actor's objectives and the relevance of the advanced TMS follow.

(1) Producers

Producer 1 admits that they do not have the full control over the temperature in the supply chain. They aim for zero withdrawal of products and minimization of customer complaints about quality. Moreover, the producers have the legal obligation to trace their products and document the quality throughout the whole chain (Chillon, 2012).

(2) Retailers

Retailers express that they strictly control the process from the moment the goods leave the producers' factory, through the distribution channel until the arrival at the store. There is a



growing demand from retailers and stores to have track record of the temperature in the trailer during the whole journey. They request explanation from their LSPs in case a temperature deviation occurs. In addition, retailers have very high standards for supplier selection: the transporters should have all the certificates and the drivers should be trained in handling TSPP. Both Retailer 1 and 2 feel that the biggest risk for them is during transportation, when they subcontract it and therefore do not have the full control over it.

(3) LSPs

LSPs basic need in terms of temperature monitoring is to show that the cool cargo is of the right quality and follow the right temperature in order to fulfill the contract terms and stay in the business (Retailer 2; LSP 1). In addition, considering the critical points in the transportation and distribution, they have a need for signalization in case of breaches. An on-line remote control and proactive alerts enable the operator to take immediate actions. With the advanced TMS such functions as remote control and precool of the trailer ensure sustainability, give extra flexibility and save operational costs (STMS 2). LSPs are not only interested in recoding the temperature but also controlling the refrigeration unit, following the trailer location in terms of routing and strict control if the trailer reaches its' destination at the right time (STMS 2; LSP 1; LSP 2). LSP 2 does invest in good technology and is ready to pay in order to be the preferred provider for their customers.

(4) FSPs

FSP 1 states that in order to meet their customer requirements the focus of the CCL process is on sustaining quality, safety and traceability of all food products. They believe these goals are particularly important in the case of perishables. That is why the company has a chain of control measures of the entire flow of goods from receipt to delivery to the customer.

(5) Stores

According to Retailer 2 in the present situation, the stores have to trust retailers with ensuring the proper handling and delivery of the products. If the stores have the option for real-time monitoring of the temperature, then they will not need the manual checks of the quality. Moreover, they want to minimize the customer complaints about the quality of the products and meet their demands.

5.4.2 User knowledge

The majority of case companies focus on training and allocate funds for it, as they consider education vital in terms of foodstuffs, temperature control requirements and advanced TMS operation. Most companies use the materials provided by the TMS suppliers as guidance for the development of their own trainings, adding their own resources and experiences (Retailer 1; LSP 2; FSP 1). Some rely solely on TMS suppliers to provide such education for their employees (LSP 1; Producer 2). The biggest LSPs even have their own education systems. Apart from the internal trainings, some organizations insist on training the personnel (drivers etc.) of their suppliers and monitor their performance through regular audits (Retailer 2).

In most cases, there are manuals and written instructions for transportation and storage of perishable products. The authors consider that the trainings can be divided into the following categories (see Figure 5.3):

1. *Strategic*: Importance of food quality and safety at all stages (Producer 1), Temperature monitoring regulations;
2. *Tactical*: Crucial knowledge about the KPIs of the CCL process (Retailer 1; FSP 2; Store 1), Saving losses for the company (Producer 2; Retailer 2);

3. *Operational*: Competence in the temperature control of perishables, TMS expertise – benefits and risks of improper usage; Calibration (LSP 2);

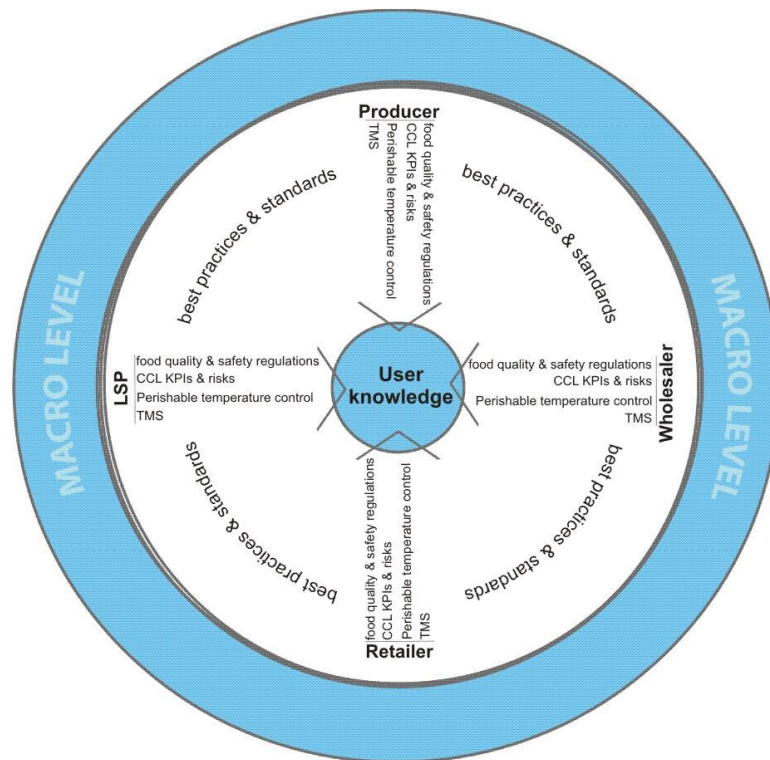


Figure 5.3 User Knowledge.

In addition, FFKM develops industry guidelines and standards, such as ‘Industry guidelines for temperature management in the handling of chilled and frozen food’ (Retailer 2; LSP 1; FFKM, 2007). As some of the case companies (FSP 2; Retailer 1&2; LSP 1) are members of this organization they follow it as well. The guidelines cover the conditions and operations related to the temperature management during all FSC stages. FFKM is a good example of fruitful collaboration, which is present in the Swedish FSC. A discussion about the benefits of collaboration follows.

5.4.3 Collaboration and alignment within the supply chain

Manzini and Accorsi (2013) and Xiaoqiang and Yongbo (2013) perceive the collaborative relationships as a successful competitive strategy in the FSCs. Kumar and Nigmatullin (2011) believe the involvement of all actors is crucial for the achievement of total quality control in the farm-to-fork process. That is confirmed by the case companies. Retailer 1 considers collaboration as the best way to solve common industry problems and develop best practices and standards. Moreover, the actors of the Swedish FSC are expecting collaboration to be more widespread in the future and as a result, the industry is to become more integrated (Retailer 1&2). As a key driver, Retailer 1 points out the efficiency goal. Retailer 2 and LSP 1 mention their membership in FFKM, where they collaborate with other producers, retailers, FSPs and manufacturers of TMS. The goal of FFKM is to achieve an unbroken cold chain and thus ensure the total food quality and safety as well as minimization of waste (Retailer 2). All FSC actors discuss together the industry problems and try to achieve efficient flow of

food that reaches the customer in the best possible quality. In addition, LSP 1 cooperates with the Swedish Institute for Food and Biotechnology.

Considering the presence of branch and industry associations, such as FFKM, it can be concluded that the level of cooperation and trust among the major player of the Swedish food industry is high. Coopetition is present and enables the FSC actors to achieve synergy (Lacoste, 2012; Madhavan Nair et al., 2013). However, it can be inferred the actors still do not collaborate in terms of temperature data management and control (Retailer 1&2; LSP 1&2; FSP 1&2). As discussed previously they share the data only in case of disruptions and deviations. In relation to this, Olsson and Skjöldebrand (2008) suggest accurate data and high level of information transfer as good practice for the food quality risk management. Moreover, with collaborative investment in advanced TMS, the Swedish FSC can easily achieve the desired operational excellence and the total food quality and safety goals (Madhavan Nair et al., 2013; TMS 1).

5.5 Enhanced utilization of TMS through an integrated approach

The literature frames that the superior performance of CCL relies on the alignment of processes, technology and people. It is essential that the business goals, user knowledge and the technology capabilities are aligned (Major, 2014). The case companies agree with this statement. They do underline the positive effect of the full alignment between the technology itself and the key processes inside and outside the organization on the company performance (Producer 1; Retailer 1). Moreover, collaboration practices are considered critical for the usage of advanced TMS.

As stated by Ireland (2005), only when a company aligns the people and processes with the technology, a class A performance can be achieved. With respect to this, and as a summary of the presented information in the analysis (See Figure 5.1-3), the authors propose the following framework for enhanced utilization of TMS (Figure 5.4).

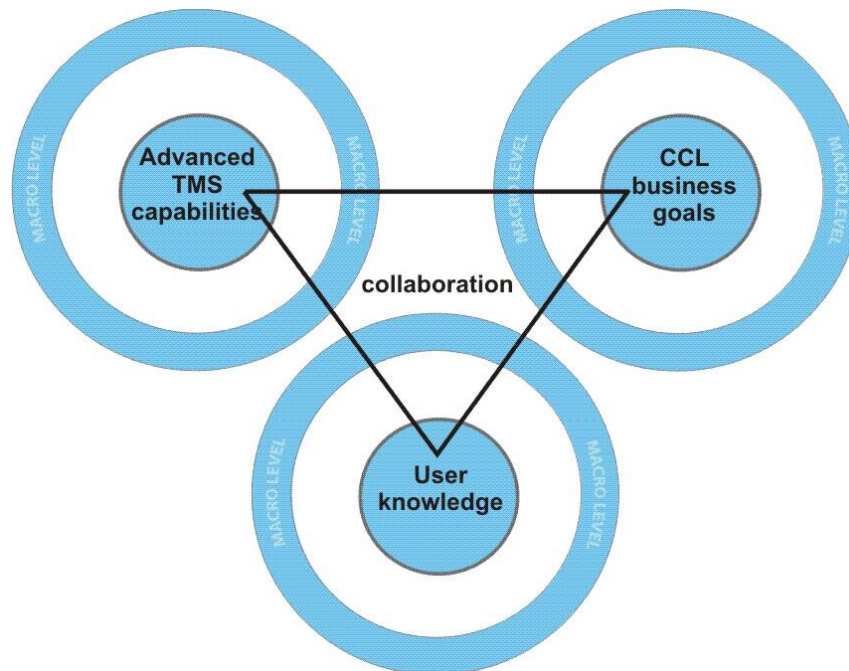


Figure 5.4 Framework for enhanced utilization of TMS.

The framework has three main pillars: CCL business goals, advanced TMS capabilities and user knowledge. As deduced before, the CCL business goals are compliance, efficiency and responsibility. In line with this, the advanced TMS capabilities facilitate compliance, responsiveness, flexibility and efficiency. The user knowledge that has been identified as critical in terms of achieving the CCL business goals is related to the regulations, the KPIs and goals themselves, the temperature control of perishables and technological expertise on the TMS. In addition, as mentioned by Major (2012), training on KPI development and data-driven decision-making is advisable with the use of advanced technology.

All three pillars should be aligned and working as a system. With this respect, the high level of collaboration is a prerequisite for the effective relationships between the actors in the FSC and a connecting link between the pillars.

6. Conclusion

The conclusion chapter highlights the results of the analysis and mirrors the research questions. Finally, recommendations for future research are expressed in the discussion section.

The thesis focuses on the CCM in the food industry of Sweden and explores how the FSC actors handle the temperature monitoring of perishable products and how an integrated approach towards it can contribute to the achievement of the quality and safety goals of the perishable FSCs.

RQ1. What is the current application of temperature monitoring solutions in cold chain management in Sweden?

The TMS used in the CCM of Sweden are predominantly data loggers in the trucks and online alarm systems in the cold storages. None of the companies has or considers implementing real-time remote temperature monitoring. The temperature data is shared only in case of disruptions. Only one case company analyzes the temperature data. Most of the critical points in the CCL process occur at the stages of distribution and transportation. There are many handoffs and points of change of ownership, which leads to many manual checks of the temperature and in turns to high risk of human mistakes.

The case companies are satisfied with the current technology and regard it as cost-effective. They perceive the advanced TMS as an opportunity for an increase in efficiency. However, what is important for them at present is to log the temperature for regulation compliance and contract accountability purposes. In addition, some of the case companies point out the lack of full control over the whole FSC in the case of outsourcing as disturbing and admit that solutions enabling end-to-end supply chain visibility and transparency are likely to be beneficial.

RQ2. How can an integrated approach towards the use of temperature monitoring solutions contribute to the enhanced utilization of these solutions and to the achievement of the quality and safety goals of the perishable food supply chain?

The integrated approach comprises the implementation of advanced TMS, the alignment of CCL goals with the knowledge of the people and the TMS capabilities, and high level of collaboration. Considering the benefits of the advanced TMS, it can be concluded that their usage leads not only to the minimization of the food safety and quality risks, but also to food waste minimization and high operational efficiency for all FSC actors. Moreover, their capabilities are fully aligned with the FSCM goals on macro and micro level as they ensure compliance, efficiency and sustainability. In addition, the macro pressure for their implementation is very high as the expected rise in the already high customers' and regulations requirements in the sector is evident. Therefore, it is highly probable that the advanced technology, which enables better monitoring and analytics of the temperature in a real-time will play a main role in many CCL networks. A major finding is that in contrast to the research of Olsson and Aronsson (2004), which concludes that the Swedish food cold chain calls for knowledge and shared responsibility and might lack temperature control, the present paper concludes that the industry knowledge has been upgraded and most of the companies pay attention to the education of their personnel. However, despite the presence of deep collaboration on branch and industry level, the Swedish FSCs still lack shared responsibility and do not collaborate in terms of temperature data management and control. With respect to this the implementation of the integrated approach towards the advanced TMS usage appears to be reasonable. Based on the literature and the empirical findings, a framework for enhanced utilization of TMS has been developed.

7. Discussions

7.1 Managerial Implications

According to many scholars, the continuous control and monitoring of the temperature is the hardest management task in the cold chain (Aung & Chang, 2014; Bruckner et al., 2012; Hafliðason et al, 2012; Kuo & Chen, 2009; Montanari, 2008; Raab et al., 2011).

In the food industry, there is an expected increase in the society and government pressure on manufacturers and logistics providers to show that regulatory compliance and food quality and safety are not compromised. There are both monitoring and reporting requirements in the cold chain. At present, this reporting is mainly provided on a historical basis, but there is a growing trend for real-time monitoring.

Considering the latest European initiatives in the field, e.g. Chillon project (2012), RFID from Farm-to-Fork (European Commission, 2012), FRISBEE (2011), the authors of the current paper explored the benefits of the implementation of such technology and proposed an integrated approach for their enhanced utilization.

Some trends that might define the future of temperature monitoring in the food industry will be discussed. As mentioned by professionals, the technical characteristics of the TMS are to be overtaken by the power of information and the ability to capture and process large amount of data. In support to that statement, the ability to be easily integrated in the already existing information systems such as BI, ERP, SAP and to stay flexible and open for the emerging technologies are emphasized (Tai, 2014). All highly valuable requisites in the today's uncertain and ever-changing environment. Furthermore, the new technology seems costly. However, when the less amount of food waste, the less man-hours and the improved inventory management are taken into account, the total cost of ownership appear to be lowered.

7.2 Future research

The present research addresses the quality and safety goals of the integrated FSCM supported by the CCM and, in particular, by technologies used for temperature monitoring. However, there are two more goals to be addressed, namely efficiency and sustainability (Manzini & Accorsi, 2013). The sustainable (green) pattern (Vitterso & Tangeland, 2014) or eco-efficiency trend (Manzini & Accorsi, 2013) is reshaping the food industry and all related areas. The concept of sustainability makes it possible to diminish the environmental impact of the entire food chains on the ecosystems, achieve social prosperity and reach the economic stability. The most important indicators of sustainability in the food logistics are energy consumption and emissions, material consumption, employment, revenues, waste production and percentage of food lost, and environmental monitoring systems (Bloemhof, Van der Vorst, Bastl & Allaoui, 2015). Thus, it is of a particular interest to investigate how the advanced TMS used in the cold management of the food industry are able to support these indicators, especially in relation to waste management, revenues and energy consumption. With respect to this, the shelf-life management based on the TMS might serve as an interesting idea for the future research.

Since the present research has a number of delimitations, a future research could have a broader perspective on the entire FSC and include farmers (fisheries), final customers and governmental policy makers in the framework. The consumer, who is one of the weakest points in the cold chain (Schmidt, Lettmann & Stamminger, 2010), is often not integrated in the concept of the continuous improvement of food quality and safety and is not concerned

by any regulations (Geppert, Rege, Bichler & Stamminger, 2010; Raab et al, 2011). Moreover, such logistics functions as production, distribution, consumption and waste management may be added for the analysis.

As all the food companies used for the empirical part are located in Sweden, it could be of interest to conduct the same type of research in a different setting: to choose geographical location outside the Nordic region and compare it with the findings of the present thesis. In addition, the advanced use of TMS may be analyzed in the context of pharmaceutical industry that relies even more on the cold chain industry (STMS 1; LSP 2).

The authors of this thesis hope that this research will encourage future investigators to pay attention to the field of CCM and thus contribute to the theoretical and practical richness of the CCM field.

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Appendix I – Key Definitions

Term	Definition
HoReCa	Abbreviation that stands for hotels, restaurants and café. Commonly used for food industry commercial and non-commercial sectors.
From farm-to-fork	The definition that includes the following stages of the food supply chain: harvesting, storage, processing and manufacturing, packaging, distribution and sales, final consumption.
Cold Chain	A cold chain is a supply chain that ensures the integrity and quality of the product through temperature and humidity control (Faisal, 2011; Bharti, 2014; Arduino, Murillo & Parola, 2013).
Cold Chain Management (CCM)	CCM refers to the proper temperature control throughout all stages of the cold chain. The ultimate goal of CCM is to minimize the temperature fluctuations of the products in transit and thus preserve their freshness, wholeness and quality (Bharti, 2014; Kuo & Chen, 2009; Salin & Nayga, 2003).
Cold Chain Logistics	CCL encompasses all the processes and equipment needed to ensure the proper temperature-controlled environment. It includes all activities related to temperature control logistics services within the production, processing, packaging, storage, transportation, distribution, retail display and household refrigeration of TSP (Casper, 2007; Aung & Chang, 2014).
Temperature monitoring solutions (TMS)	Type of equipment with guaranteed thermal characteristics, appropriate operating modes and proper information system (Faisal, 2011, Bharti, 2014; Hafliðason et al., 2012).

Appendix 2 - Certification Bodies in Sweden European Commission (European Commission, 2005, p. 41)

Certification body	Organization	Schemes
SWEDAC	Public authority	Accreditation of certification bodies
Swedish Standards Institute	Memberbased organization	ISO9000 and ISO14000
Det Norske Veritas Sverige	Private company	ISO9001-2000, DS 3027-2002 (HACCP), BRC Food, BRC – IoP and DPV
LRQA Integria	Private company	ISO 9001, ISO14001 and BRC Food, HACCP and BRC IoP
BVQI Sverige AB	Private company	ISO9001, ISO14001 and BRC Food
SEMKO-DEKRA Certification AB	Private company	ISO9000 series, ISO14001 and BRC Food (Swedish Seal, Danisco Sugar and HACCP)
SFK Certifiering AB	Association	ISO9001 and ISO14001
SP Certifiering	Company owned by the government	ISO9001, ISO14001, HACCP, in cooperation with EFSIS Scandinavia EFSIS/BRC
KRAV Ekonomisk Förening	Cooperative organization	KRAV (organic certification)
FLO Fair Trade Label Organization	Association	Rättvis märkt (fair trade label)
Odling I Balans	Organization, part of international alliance	Odling I Balans
Svensk Lantmat	Organization	Svensk Lantmat
LRF (Swedish Farmers Federation)	Federation	Kaprifol meat, Svenskt Sigill
Regional Culinary Heritage	European Network	Culinary Heritage
National Food Administration	Public authority	Key Hole

Appendix 3 - Differences between a normal supply chain and a cold supply chain (Faisal, 2011, p.259)

Normal Supply Chain	Cold Supply Chain
Products are temperature insensitive	Deals with temperature-sensitive products Maintenance of a particular range is very critical
Transaction and Location are important	Condition and Time are crucial factors for the quality of the product
Transportation costs incurred are low because normal trucks can be employed	Transportation costs are very high as refrigerated vehicles are employed
Can easily utilise product assortment	Product assortment is difficult as different products require different ranges of temperatures
Delays might affect sales but have no impact on the quality of the product	Delays in transit can affect integrity and quality of the product
No degradation in value during transport	Continuous degradation in value during transit
Product can easily be inventoried at various stages and thus it's easier to manage demand fluctuations	Product very difficult to be inventoried and so demand fluctuations difficult to manage
Practices like 'postponement' can be employed to match demand	Cannot adopt postponement as product has limited shelf-life
Product markdowns can be delayed	Product markdowns cannot be delayed as the shelf-life of the product is limited
Risk pooling practices can easily be employed	Difficult to practice risk pooling because of the limited availability of refrigerated vehicles

Appendix 4 - Interview Outline: FSC Actors

I. Cold Chain Management (CCM):

1. How does your company ensure the quality of temperature-sensitive products in the end-to-end supply chain?
2. What are the KPIs in the CCL process?
3. How does your company comply with the European regulations for food safety and quality? Who is responsible for this function in the company?

II. Temperature monitoring solutions as a part of CCM – technological perspective:

1. What technologies does your company use to capture temperature data during the stages of transportation, storage and at point of sale?
2. What data is generated by the technology? Is it a real-time data or historic data?
3. How do you analyze the generated data?
4. What are the requirements for these technologies?
5. Does your company measure the performance of these technologies? If yes – How?
6. Does your company use the latest temperature monitoring technology? If no – what are the reasons?
7. Does your company experience challenges in the usage of TMSs?
8. What were the reasons to implement temperature monitoring technologies?
9. Do you think that these technologies meet the business goals of the CCL process you mentioned? Do you see any opportunities for the improvement?

III. Temperature monitoring solutions as a part of CCM – managerial perspective

According to the experts in the field, technology is only a part of the final solution. They state that temperature monitoring solutions should be aligned with people and processes.

People:

1. Which kind of managerial practices can contribute to a better utilization of these technologies? (training, education)
2. How does your company ensure that end users of these technologies are knowledgeable enough?

Processes:

1. How does your company integrate temperature monitoring solutions with the key activities within the Cold Chain?

Collaboration:

1. Do you have collaborative relations with other member (incl. customers) of the cold chain in terms of temperature monitoring? If yes – what kind is it?
2. Do you share the temperature information with other members of the cold chain?

Appendix 5 - Interview Outline – Suppliers of TMS

I. Temperature monitoring solutions as a part of CCM – technological perspective:

1. What makes companies buy and install TMS?
2. Which solutions in TMS are the most frequently used & why?
3. What do you consider as advanced TMS?
4. What problems do companies face when they start to launch TMS in their fleet?
5. Any examples of how TMS helped to solve any problems existed in the company before?
6. Will the TMS be used more in future and why?
7. What can enhance the benefits that TMS brings to the supply chain?
8. What is your opinion about giving access to the TMS to LSPs not only the owner of the fleet: like trailer service companies, retailers or other clients of the transport companies, government institutions or professional unions?
9. Which solutions do you provide for different segments: producers, in-transit transport, distribution centers, last-mile transportation, and retailers?
10. What requirements do customers have?

II. Temperature monitoring solutions as a part of CCM – managerial perspective

According to the experts in the field, technology is only a part of the final solution. They state that temperature monitoring solutions should be aligned with people and processes.

1. Which kind of managerial practices can contribute to a better utilization of these technologies?
2. What customer service do you provide to your clients (guidelines, education for end users) and do you provide customized solutions based on the processes of the company?

Appendix 6 - Overview of the usage of TMS in Sweden

