Traceability in food supply chains Exploring governmental authority and industrial effects

Ringsberg, Henrik

2011

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

Traceability in food supply chains

Exploring governmental authority and industrial effects

Henrik Ringsberg

Department of Design Sciences
Division of Packaging Logistics
Lund University

Traceability in food supply chains

Exploring governmental authority and industrial effects

Lund University
Faculty of Engineering
Department of Design Sciences
Division of Packaging Logistics
P.O. Box 118
SE-221 00 Lund
Sweden

ISBN 978-91-7473-121-7

To my family and to my lovely wife Yan

Acknowledgements

Writing this licentiate thesis has been a process of consensus formation between a governmental authority, academia and firms in the industry regarding traceability in food supply chains.

To start with I would like to thank the Swedish Board of Fisheries, the governmental authority which has been involved in major parts of the studies conducted and has also been one of the major financers of the research. Special thanks goes to the Department of Fisheries Control and particularly Johan Löwenadler-Davidsson, Mårten Gustafsson and the staff at the Fish Control Office in Simrishamn. Also, special thanks to Maria Hellsten and Director General Axel Wenblad of the Swedish Board of Fisheries; discussions with them initiated my interest in traceability in fish supply chains.

I would also like to thank Anders Carlberg at the Region Västra Götaland, Hans Bergsten at Region Halland Region and to the staff at the European Fisheries Fund for financing the research presented in this thesis.

I am especially grateful to my two supervisors, Professor Gunilla Jönson, Division of Packaging Logistics, Lund University, and Professor Kenth Lumsden at the Division of Transport Logistics, Chalmers University of Technology. They have not only been involved as co-authors in two of the appended papers, but given me inspiration and guidance through the process of conducting research as a PhD student. I would like to send special thanks to my secondary supervisor at Lund University, Assistant Professor Daniel Hellström who has given me inspiration, constructive comments, and critique on my work. I am indebted to Eileen Deaner for reviewing the English and the contents from a third party perspective without previous knowledge about the research presented.

I want to express my gratitude to Dr. Per Olof Arnäs at the Department of Technology Management and Economics, Chalmers University of Technology. His ideas and critique of the thesis have been of utmost importance. A huge thank to my colleague and friend Vahid Mirza-Beiki at the Division of Logistics and Transportation, Chalmers University of Technology, for contributing as a co-author on one of the appended papers.

To all my colleagues and fellow doctoral students at the Division of Packaging Logistics, Lund University, thank you for all your support, for sharing knowledge and ideas, and for generating a stimulating research environment. I am also most grateful to Professor Johannes Persson at the Department of Philosophy, Lund University for contributing to the third paper. I would like to express my gratitude to my colleagues, Lennart Larsson and Mikael Magnusson, Environment and Safety Services Department, Swedish Meteorological and Hydrological Institute, for support in the context of the GIS Fish Project which was the starting point of my career as a PhD student at Lund University.

Last but not least, I am deeply indebted to my lovely family: my parents, especially my father Professor Kaj Ringsberg, my brother and his family, and to my beloved wife Yan, for your support, unlimited understanding and kindness. Love you all!

Lund, March 2011
Henrik Ringsberg

Abstract

Traceability in food supply chains has received increased attention in the last decade. The efforts of governmental authorities have also increased to regulate and control food supply chains and product characteristics related to information to ensure safety, quality, and preservation of living resources. Previous studies in the area take an industrial focus and exclude the governmental authority focus. This thesis thus focuses on exploring governmental authority and industrial effects on traceability in food supply chains. The purpose is to extend the traceability capabilities in food supply chains that are influenced by governmental authorities.

The thesis reports findings from literature reviews and case studies that investigated three research questions. The first question embraces different perspectives of food supply chain traceability in supply chain management (SCM) literature, as well as the science theoretical perspective of food supply chain traceability. The second question explores modelling techniques for mapping food supply chains based on two dimensional flows of information between a governmental authority and actors, and of the flows of physical goods in three fresh food supply chains. The third question concerns the effects on operational activities and traceability information in fresh food supply chains by implementing the RFID based smart goods concept.

The results show that food supply chain traceability is a multidisciplinary concept which is important for governmental authorities. Supply chain management techniques for mapping descriptive information flows and for capturing information in supply chains are applicable to improve traceability in fresh food supply chains. The thesis further examines the influence of traceability on operational activities in food supply chains.

The results presented contribute to the understanding of traceability in food supply chains affected by governmental regulations from a managerial point of view. This is useful for authorities and industrial firms in the food industry as well as for academia, since it shows that food supply chain traceability should be prioritised to influence future supply chain traceability setups and theoretical development of the research area.

Keywords: Traceability, supply chain management, fresh food, smart goods, information interfaces, activities, governmental authorities, scientific theory, literature study, case study.

List of appended papers

Paper 1
PERSPECTIVES OF FOOD SUPPLY CHAIN TRACEABILITY

Henrik Ringsberg and Gunilla Jönson.
Double blind reviewed and published in the Proceedings of the World Conference in Transport Research (WCTR) Annual Conference, July 2010, Lisbon, Portugal.

Ringsberg conducted the literature study. Ringsberg and Jönson performed the analysis supported by Johannes Persson (Department of Philosophy, Lund University) and wrote the paper.

Paper 2
TRACEABILITY IN THE FISH SUPPLY CHAIN – EVALUATING TWO SUPPLY CHAIN MAPPING TECHNIQUES

Henrik Ringsberg and Kenth Lumsden.

Double blind reviewed and published in the Proceedings of the Nordic Logistics Research Networks (NOFOMA) Annual Conference, pp. 695-710, June 2009, Jönköping, Sweden.

Ringsberg and Lumsden jointly collected and analysed the empirical content, and wrote the paper.

Paper 3
EFFECTS OF USING SMART GOODS ON TRACEABILITY INFORMATION AND CARRIED OUT ACTIVITIES IN SUPPLY CHAINS OF FRESH FOOD – A CROSS CASE ANALYSIS

Vahid Mirzabeiki, Henrik Ringsberg and Kenth Lumsden.

Double blind reviewed published in the reviewed Proceedings of the Nordic Logistics Research Networks (NOFOMA) Annual Conference, pp. 421-436, June 2010, Kolding, Denmark.

Ringsberg collected the empirical content. Mirzabeiki and Ringsberg performed the analysis. Lumsden, Mirzabeiki and Ringsberg jointly wrote the paper.

List of figures

List of tables

Contents

1. Introduction

This chapter describes the background of the research area, the purpose, research problem and questions, and delimitations of the thesis.

1.1 Background

Traceability is considered as a complement to governmental efforts to regulate and control product quality and characteristics, to ensure safety, and to prevent fraud in food supply chains (Popper, 2007; Furness and Osman, 2003; Coff et al., 2008). A variety of governmental guidelines, laws, and regulations exist for food supply chain traceability in different countries (Thakur and Donnelly, 2010). The European regulation (EC) 178/2002 defines and contains general rules for food supply chain traceability in the European Union. This regulation* was entered in to force on 1 January 2005 as part of the European Union's General Food Law. It is comprised of rules for the withdrawal of unsafe products from the market and provides information to consumers (Banterle and Stranieri, 2008). The incentives for these strict traceability rules in the European Union are the need for traceability due to consumer concerns about food safety (Verbeke and Viaene, 2000; Van Rijswijk et al., 2008; Furness and Osman, 2003), hygiene (Furness and Osman, 2003), ethical food production (Korthals, 2008; Beekman, 2007; Van Rijswijk et al., 2008), authenticity (Furness and Osman, 2003) and environmentally sustainable food production (Van Rijswijk et al., 2008).

The need for food supply chain traceability based on consumer concerns started at the end of the nineteenth century with the discoveries of microbes and vitamins (Popper, 2007) and has followed the development of supply chains and production methods (Thorén and Vinberg, 2000). This includes chemical progress in the form of new food additives and adulterations, and changes in packaging technology covering the acceptance of commercial canned and processed foods (Popper, 2007). This development has made food supply chains increasingly complex (Thorén and Vinberg, 2000), moving the consumer farther away from raw material sources and conventional methods of receiving, retrieving, and controlling food and ingredients (Popper, 2007), which affects consumer purchasing behaviour (Verbeke and Viaene, 2000). In addition, the interest for food supply chain traceability among producers and governmental authorities has increased in the last decade due to recall incidents, such as foot and mouth disease (FMD) in Great Britain (Bessel et al., 2010), the tomato-salmonella scare in Florida (Thakur and Hurburgh, 2009), the mince meat scandal in Sweden, and reports about the impact of food production on living resources.

According to Popper (2007), governmental, professional, and academic literature about traceability is focused on technological solutions and implementation, integration of different technical systems, impact on economic costs and on food and retail markets, market adjustments, and definitional questions (Popper, 2007). This is due to the challenges of managing traceability throughout food supply chains (Olsson and Skjöldebrand, 2008). The interest involves the physical movements of food (Kelepouris et al., 2007); an integrative approach to quality and safety through supply chains (Banterle and Stranieri, 2008); and implementing integrated information systems for communication of product quality, origin and safety (Folinas et al., 2006) through transparency (Jones and Comfort, 2004; Deblonde et al., 2007).

* A regulation must be implemented in the European Union, while a directive must not.

Communicating traceability information between the food industry and consumers will not only regain public confidence in food safety and quality (Van Rijswijk et al., 2008; Jones and Comfort, 2004), but also create better understanding of the difficulties and help in meeting consumer product requirements for firms in the food industry (Duffy et al., 2005).

The authority focus on food supply chain traceability includes governmental efforts to control food supply chains by setting up laws and regulations for the preservation of food safety, quality and living resources used in food production. This focus is visualised when looking at traceability by applying theory from logistics and supply chain management (SCM). This includes studies of flows and relations between governmental authorities and food supply chain firms, and of the effects and difficulties firms have in meeting governmental requirements on traceability and fishing control from the European Union. However, relating to the last point, general studies are lacking on the effects of and difficulties firms and organisations have in the food industry to fulfil traceability requirements from governmental authorities. This is because most studies on food supply chain traceability focus on traceability within supply chains (i.e. within a certain firm or between different firms), or within food production processes at a certain firm. One explanation for this is the different incentives (Moe, 1998; Jacquet and Pauly, 2008) and objectives (Coff et al., 2008) for implementing traceability among organisations and firms in the food industry.

1.2 Purpose and research questions

The purpose of the research presented in this thesis is to extend the capability of traceability in food supply chains that are influenced by governmental authorities. This purpose is more specifically expressed in three research questions (RQs). The first addresses the conceptual exploration of food supply chain traceability in the SCM literature:

RQ1: How can theory in supply chain management and scientific theory contribute to understand the concept of food supply chain traceability?

Food supply chain traceability borrows theories from other disciplines, such as supply chain management (Wang and Li, 2006), marketing (Popper, 2007; Coff et al, 2008), biology, or risk management (Coff et al, 2008). Conducted literature reviews shows that there is no uniform understanding of concept food supply chain traceability (Van Dorp, 2002). In addition, the science theoretical knowledge, according to theories in philosophy of science, about food supply chain traceability is currently limited, in both academia and industry, and literature dealing with the subject is scarce. Furthermore, illustrating food supply chain traceability as a concept between several disciplines will generate advances in knowledge and understanding and improves the linkage between the concept itself and the other disciplines. This has previously been illustrated for logistics (which as food supply chain traceability borrows theories from other disciplines) by Stock (1997), who points out the following three benefits of applying "borrowed" theories to logistics; 1) Learning from the experiences of others, 2) advances in knowledge and understanding, and 3) the inclusion of theories from other disciplines further enhances the linkages between logistics and those other disciplines (Stock, 1997).

Moreover, a prerequisite for achieving and understanding food supply chain traceability is to know the physical material and information flows, especially in the interfaces between supply chain actors, or between the supply chain actor and the affected governmental authority. This is because supply chains for fresh food are related to stringent requirements for monitoring processes, tracing activities, and shorter lead times (Mai et al, 2010). Because of these requirements, actors and affected governmental authorities need to understand the flow of information and physical goods in their food supply chains in order to define actions and processes that result in the establishment of traceability systems.

This leads to the second research question about the modelling and visualisation of physical goods and information flows in regulated fresh food supply chains:

RQ 2: How can regulated fresh food supply chains be modelled in order to facilitate analysis of traceability?

Another prerequisite for establishing traceability in fresh food supply chains is knowledge about effects and changes in activities due to the implementation of different technical solutions for capturing and transferring information (Frederiksen et al, 2002), such as the radio frequency (RFID) based smart goods concept. This concept is according to Holmqvist and Stefansson (2006) characterised by a higher level of sophistication than traditional solutions for goods identification. This leads to the third research question:

RQ 3: How are stakeholder activities and traceability information affected in fresh food supply chains by the implementation of the smart goods concept?

There is, however, a difference in the focus used for investigation of the research questions: The first research question has a society focus, aiming to explain food supply chain traceability for societal actors by using a general supply chain management and science theoretical approach. The second research question has a governmental authority focus, exploring food supply chain traceability according to specific regulatory requirements of resource control. The third research question has an industrial focus, looking at the effects of implementing the smart goods concept for achievement of traceability in fresh food supply chains.

Each research question is also addressed separately in the appended papers, and more comprehensively in the analysis and discussion of results (chapter 5) of the thesis. Connections exist between the three research questions: the second question about mapping material and information flows in food supply is a prerequisite to the third question. The second and third research questions are also connected to the first through the aim of expanding SCM knowledge about traceability in regulated fresh food supply chains. The answers along with the connections between the three questions are presented in the summary of appended paper (chapter 4).

Aspects of food supply chain traceability and the focuses of each of the three papers are viewed in Figure 1.

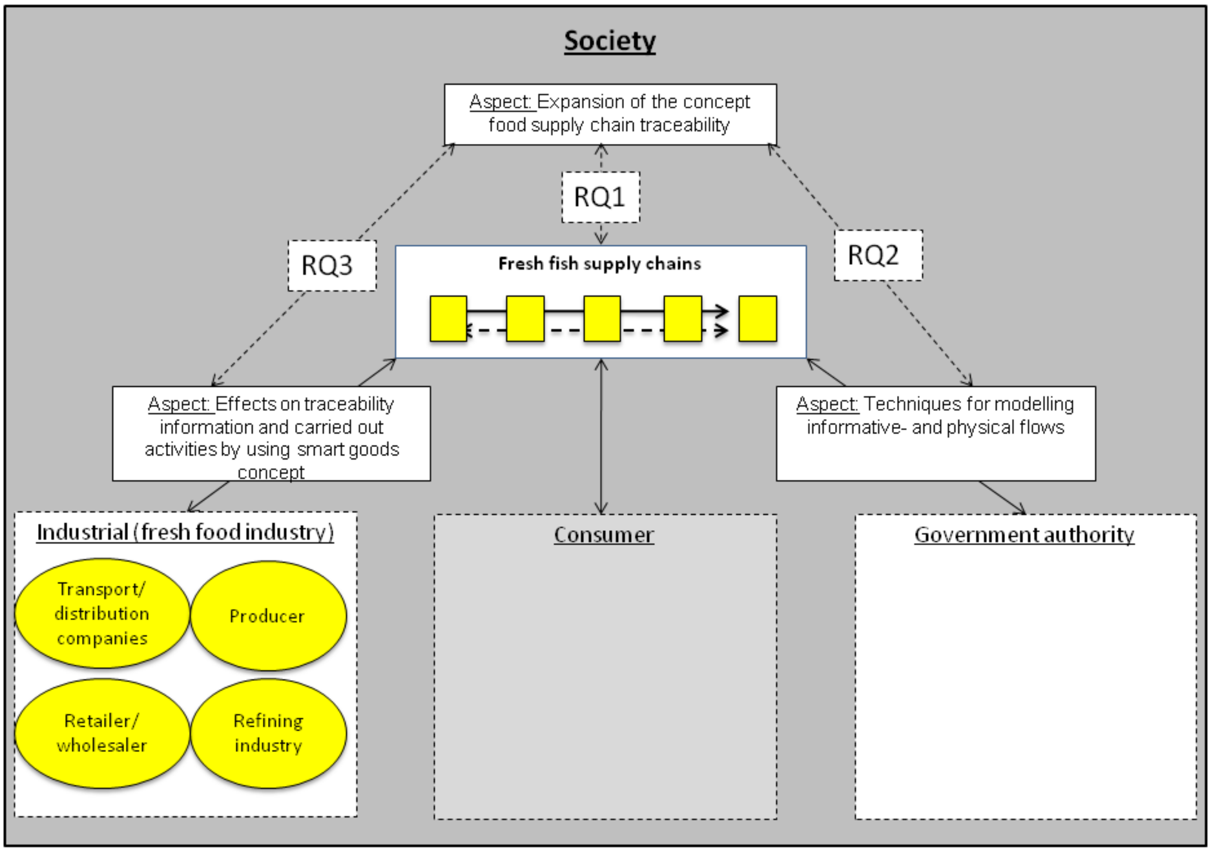

Figure 1: Relations between research questions (RQs), aspects in food supply chain traceability research and study focus (consumer not included).

1.3 Scope and delimitations

This thesis and the research described focuses on information and physical goods flows in the interfaces in fresh food supply chains, and on information flows between supply chain actors and a governmental authority. It concentrates on establishing *how* traceability should be achieved, rather than what choices should be made concerning technical information and packaging solutions or *why* traceability should be implemented; it is the material, the package as an information carrier and the information flow that are in focus and not technical solutions to meet regulations for traceability. In addition, the thesis concentrates on expanding knowledge about the food supply chain traceability concept according to scientific theory and supply chain management. This is conducted by using an industrial focus and a governmental authority focus on food supply chain traceability, excluding the consumer point of view.

The empirical investigation is limited to fresh food supply chains due to the increased societal interest in food supply chain traceability related to increased demands (Isaksson, 2004; Popper, 2007), tougher governmental regulations for preservation of food quality and environmentally sustainable food production (Van Rijswijk et al., 2008). Based on this empirical selection, in combination with a literature study, general and applicable conclusions are drawn about the effects of traceability on a governmental authority and industrial firms in fresh food supply chains.

In the SCM literature, a variety of modelling techniques are presented for mapping information and physical flows in supply chains, some of which are more accepted according to a number of publications about them than others. As a result, we chose to limit the evaluation of different process modelling techniques (paper 2) to two accepted and recognised ones: the Ishikawa diagram technique and process mapping technique.

In the evaluation of research quality the research is limited to construction of validity. Further evaluation of research quality, according internal and/ or external validity, reliability and replicability of the presented research in the thesis is a subject for further research.

The supply chains under investigation are primarily ones for fresh fish (paper 2 and paper 3), but also a fresh supply chain for meat (paper 3). These food supply chains are analysed and discussed holistically (i.e. from the stage of production until the stage of sale at a retailer). This analysis is limited to the effects on traceability information and activities performed when using information technology. The geographical limitation of the research is the Scandinavian countries in the empirical selection, and the European Union for discussions and applicable conclusions about food supply chain traceability in relation to existing regulations.

1.4 Thesis outline

The thesis has the following structure:

Chapter 1 Introduction
The chapter provides background, a description of the problem area of food supply chain traceability in previous research and the focus of interest. The research questions related to purpose, scope and delimitations are presented.

Chapter 2 Methodology
Presents and discusses methodological aspects used in the research covering research approach, research assumptions, the research process, data collection methods and research validity.

Chapter 3 Frame of reference
The chapter contains the theoretical foundation of the thesis. It constitutes the theoretical framework for exploring governmental authority and industrial effects of traceability in food supply chains according to SCM theory.

Chapter 4 Summary of appended papers
The chapter includes a presentation of each of the three appended papers according to: research questions and methods, findings and the construct validity. At the end of the chapter a summary of general paper findings in relation to the overall research questions is provided.

Chapter 5 Analysis and discussion of results
Contains an analysis and discussion of the results from the three papers according to the research questions and frame of reference.

Chapter 6 Conclusions
Summarises the results of each paper and presents conclusions as well as practical implications and theoretical contributions.

Chapter 7 Future research
Addresses future academic and industrial research possibilities.

2. Methodology

This section describes the research methodology, choice of research approach and assumptions, description of the research process, methods for collecting data, and evaluation of research validity.

2.1 Research approaches

Research according to Mentzer and Kahn is a process that has to be taken seriously and conducted in a structured manner (Mentzer and Kahn, 1995). The primary objective of carrying out scientific research is to explain and understand facts (Searcy and Mentzer, 2003), and to enrich the knowledge of subjects that are relevant to those studying and practicing the discipline (Craighead et al., 2007). A research approach is hence a process of distinct paths in scientific reasoning and has the common aim of enriching knowledge (Spens and Kovács, 2006). This process can either be quantitative, qualitative or a combination of the two approaches (Stentoft and Halldórsson, 2002).

In addition, generating knowledge is a procedure that includes the evaluation of reality, measured and observed phenomena, and the application of an analytical, actor, or systems approach. The research presented in thesis is based on a systems approach, which has its roots in systems thinking, and is described in the next section.

2.1.1 Systems approach

The systems approach is a methodological stance of systems thinking. The systems approach is "holistic" rather than fragmental (i.e. "reductionistic"); every problem is seen as being part of an environment (Churchman, 1968). Reality according to the systems approach is divided into "components", like a system with relationships (i.e. transactions, interactions inputs transmissions, and connections links) and "elements" (i.e. nodes, components, operations, vertices) (Lilienfeld, 1978). According to Checkland, it is the properties of the whole, "rather than properties of its component parts" (Checkland, p. 3, 1993) that form the reality.

Figure 2 shows that a systems approach is holistic as opposed to the reductionism because the independent elements equal the sum of all the parts (Stentoft and Halldórsson, 2002; Burrel and Morgan, 1979).

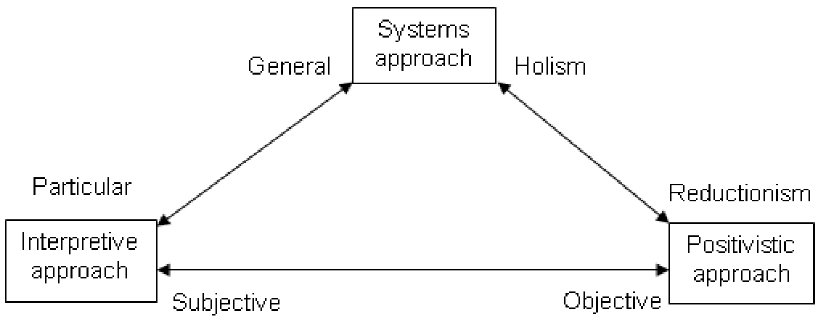

Figure 2: The systems approach (adopted and modified from Larsson, 1990, p. 317).

The systems approach is widely used in logistics (Gammelgaard, 2004; Bowersox and Closs, 1996) for co-ordination of flows of physical goods, information and services along supply chains, for solving problems and in the analysis of logistics research (Stentoft and Halldórsson, 2002; Arlbjörn and Halldórsson, 2002). However, it is to be noted that logistics ignores the notion of the existence of materialistic systems (Mears-Young and Jackson, 1997), and views the systems approach as being "desirable for full appreciation of integrated logistics" (Bowersox and Closs, p. 459, 1996).

Food supply chains can be seen as systems which include flows of both information and physical items (i.e. products and packages). Using a systems approach in the study of food supply chain traceability results in conclusions of how traceability systems can be better designed to fulfil their goals. This supports the assumption that logistics awareness can be developed using systems ideas (Mears-Young and Jackson, 1997).

Checkland (1993) defines two different thinking methodologies within the systems approach: hard and soft systems thinking;

- Hard systems thinking: focuses on solving problems using quantitative research methods such as simulation and mathematical statistics, specifying the importance of distinguishing system parts, goals to be met, and the environment in which it operates (Churchman, 1968).
- Soft systems thinking: process driven focusing on values and perceptions in which all actors involved in the system will reach at least one goal (Mears-Young and Jackson, 1997). Soft system thinking also tries to understand other systems through conceptual models (Mears-Young and Jackson, 1997).

Referring to these two extremes of the systems approach, I see soft systems thinking as an interpretive tool that can guide logistics practice in a new way in the research area of food supply chain traceability. This is because implementation of traceability in food supply chains requires the development of relationships to prevent protectionism, integrity problems and reduce conflicts. Another advantage of using soft systems thinking in the studies of food supply chain traceability is the advantage of systems theory to confirm regulations for traceability in food supply chains. Through soft systems thinking, multiple perceptions of food supply chain traceability can be considered and explored, incorporating the views of all actors in food supply chains.

Referring to the other extreme of systems approach, hard systems thinking, I see this as appropriate in traceability studies for analysing possibilities or created values of technical food traceability systems that already are up and running or are to be implemented. This is because of the ability of hard systems thinking to define resources, system boundaries, components, management and strategic goals.

2.2 Research assumptions

One aspect of knowledge creation is that it has to take "place in a real sense (and in an ethically correct manner)" for both the creator and the environment when the work is based on "conscious assumptions of the reality" and the "creator of knowledge understands what knowledge is and how it comes about" (Arbnor and Bjerke, 1997). There are two knowledge types in research: explanatory and hermeneutic. These two extremes differ in that explanatory research aims to explain a phenomenon or system, while hermeneutic research aims to understand the phenomena or system. This means that an explanatory researcher does not see any problem with viewing social contexts and events as “facts” and “objects”.

In addition to these two extremes of generating knowledge, researchers can either be subjectivistic or objectivistic in viewing the nature of science (Arlbjörn and Halldórsson, 2002). These two extremes contradict one another in that the objectivistic approach identifies reality as a measurable entity (relating to explanatory knowledge), while a subjective approach states that the reality can only be constructed by the actors who are a part of it (relating to hermeneutic knowledge), see Figure 3.

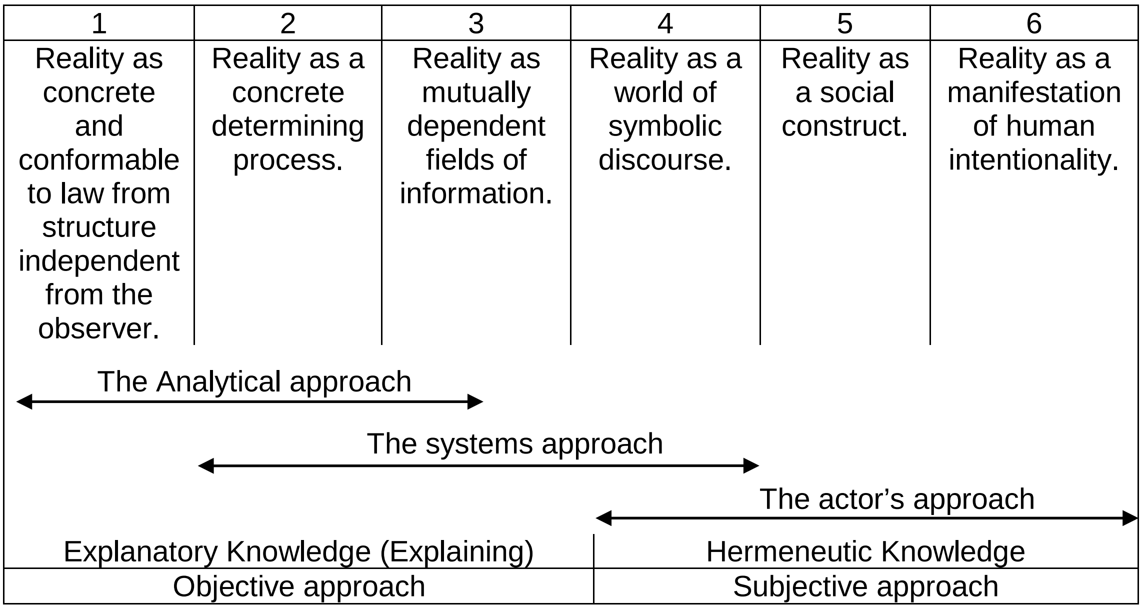

Figure 3: Methodological approaches related to knowledge types and views of reality (translated and merged from Arbnor and Bjerke, 1994, p.61-62; Lindholm, 2008, p. 30).

Logistics research is mainly objectivistic, but that social aspects also have to be considered when conducting research. This is because researchers, like all human beings, are influenced by how they view their own “nature of science” (i.e. social background and ability to create a perception of reality) when making assumptions (Arbnor and Bjerke, 1994). A researcher’s assumptions depend on his or her perception of science, concerning concepts in ontology, epistemology and human nature (which constitute the individual researcher’s fundamental assumptions of how to use and generate new theories), (Arlbjörn and Halldórsson, 2002) and of the scientific paradigm adopted by the scientific community to which he or she belongs (i.e. “opus operandi” relating to the philosophy of social science) (Mears-Young and Jackson, 1997; Burrel and Morgan, 1979).

2.2.1 Ontology

Ontology is knowledge about “what the world is made up of” (Brink and Rewitzky, 2002, p. 543) or the true form of nature. It answers questions like: What really exists? (Wallén, 1996), is “reality” “out there” or just a product of someone’s mind? (Burrel and Morgan, 1979, p.1). The two main extremes in ontology are nominalism and realism (Brink and Rewitzky, 2002). These two contradict each other in their conception of reality. For a “nominalist” reality is a projection of individual consciousness performed by a creative imagination and the world is constituted of individuals (Brink and Rewitzky, 2002).

For a “realist” reality is of an objective nature and nothing an individual can create since reality is something that exists outside an individual’s mind (Burrel and Morgan, 1979). Realists believe that the world is constituted of properties. However, a third ontological alternative exists, factualism, which states that the logical world is constructed of facts or variables of certain values (Brink and Rewitzky, 2002).

The ontological assumption of this thesis is nominalistic; it agrees that reality is a projection of the consciousness formed by individuals. In the research on governmental authority and the industrial effects on traceability in food supply chains relationships, the contracts, critical contexts and consequences of implementing traceability need to be explored. All of these are, according to my ontological standpoint, consequences of the creative imaginations formed by the individuals concerned. I also agree with the following two factuality principles: 1) “any particular thing is determined by its properties” (i.e. the Leibniz principle of the identity of indiscernibles), and 2) “any property is extensionally determined by the set of all things having that property” (i.e. the extensionality principle).

2.2.2 Epistemology

Epistemology or “the nature of knowledge” refers to the validity of knowledge and to the understanding of reality and how knowledge is communicated to others (Burrel and Morgan, 1979). Typical epistemological questions are: What is the background for producing knowledge? Can knowledge be acquired, or must it be experienced personally? (Burrel and Morgan, 1979). As with ontology, the main extremes exist within epistemology: anti-positivism (or interpretivism) and positivism (Bryman and Bell, 2007; Larsson, 1990; Burrel and Morgan, 1979). The predominant epistemological assumption used in logistics research is the positivistic one according to Mentzer and Kahn (1995) and Halldórsson and Aastrup (2003).

Pragmatism is an exception to anti-positivism and positivism. It rejects attempts to create sharp categorical differences between epistemological extremes and allows researchers to develop their research with a focus on serving human purposes, and thus the practical value or implications of the research (Freeman and Wicks, 1998). Similarities and differences between positivism, anti-positivism and pragmatism are shown in Table 1.

Table 1: Differences and similarities between positivism, anti-positivism (interpretism) and pragmatism (adopted from Freeman and Wicks, 1998, p. 129).

Epistemological stand	Differences and similarities
Positivism	• Sharp and categorical divisions across the three distinctions of making vs. finding, descriptive vs. prescriptive and science vs. nonscience. • Science as the only basis for generating knowledge. • Terms as value-neutral (stripped of moral content). • Reality as unequivocal.
Anti-positivism	• Relativises but retains the categorical distinctions of positivism. • No basis for determining which accounts are better than others. • Terms as value-neutral (stripped of moral content). • Reality as equivocal.
Pragmatism	• Rejects the categorical distinctions of positivism (no privileged status, as such, to science). • Can draw useful (pragmatic) distinctions among methods and forms of evidence in terms of what is useful (e.g. between “descriptive” and “prescriptive”, “science” and “nonscience”; better and worse metaphors). • Terms as value-laden. • Reality as equivocal, but grounded in terms of language, history, culture.

As a researcher in logistics focused on food supply chain traceability, my epistemological position is between positivism and subjectivism, but more subjective than positive in the thesis. This means that I agree with some of the basic principles of positivism: that it is the search for and study of the social world that identifies the nature of laws, regularities and causal relationships. But I also disagree with the positive principle that science is the only basis for generating knowledge. This is because I agree with the subjective principle that knowledge is partly created and understood by the individuals who are directly involved in the activities which are studied. Additionally, I agree with the basic principle of pragmatism: that reality is grounded in terms of language, history and culture.

2.2.3 Human nature

Human nature refers to how human beings interact with each other in a specific environment (Burrel and Morgan, 1979; Mears-Young and Jackson, 1997). The two extremes in human nature identified by Burrel and Morgan are voluntarism and determinism. Voluntarism depicts human actions characterised and ruled by free will, individual heredity and environmental boundaries. By contrast, determinism depicts actions as products of the situation or of the surrounding environment (Burrel and Morgan, 1979). The predominant assumption in logistics research is determinism (Mears-Young and Jackson, 1997).

However, determinism is often criticised because of the risk that an individual may be ruled by instinctual or outside forces that are beyond his or her personal control (Phemister, 2001; Morgan and Smircich, 1980). I agree with this to some degree, being not a complete logistics determinist. This is because human beings exist in interactive relationships and are influenced by the context or the environment of their world. It is also the relationships between individuals and the environment which express and describe the pattern of activities that is necessary for individual researchers (Morgan and Smircich, 1980). This is especially important in the study of traceability in food supply chains. It should also be noted that individual perceptions are extremely difficult to change (Mears-Young and Jackson, 1997). This relates to research in food supply chain traceability because of the difficulties in implementing organisational changes or information systems in food supply chains.

2.2.4 Methodological assumptions

Methodological assumptions are directly related to assumptions about ontology, epistemology and human nature (Burell and Morgan, 1979; Mears-Young and Jackson, 1997) since these last three assumptions deal with the "nature of reality" and what possible research results will be found. It is in the fusion of these three assumptions where a researcher's choice of methodology is formed. Methodology can hence be seen as the "tools" that each researcher adopts for gaining better knowledge about reality, and from that produce new theories or models for solving an indentified problem in a specific research field (Burell and Morgan, 1979). As Glaser (1992) states, "Methodology is the theory of methods" (Glaser, 1992, p. 7). As with ontology epistemology and human nature, Burrel and Morgan identify two extremes in methodology: ideographic versus nomothetic. In an ideographic approach, the only way to understand the social world is through firsthand knowledge involving an action approach, closeness to the subject under investigation, with a tendency towards qualitative research methods for collecting empirical data to generate findings. A nomothetic methodological approach is based on "systematic protocol and technique" (Burell and Morgan, 1979, p. 6) using surveys, questionnaires and personal tests. The research described in the thesis is qualitative and uses an ideographic approach. This is partly because the Swedish Board of Fisheries has been one of the partners in the research, affecting the closeness to the fish supply chains under investigation.

2.3 Processes for theory creation and testing

There are three approaches used in logistics research (De Brito and Van der Laan, 2008) in the process of testing and creating new theories and knowledge: inductive, deductive and abductive (Wallén, 1996; De Brito and Van der Laan, 2008; Spens and Kovács, 2006; Kovács and Spens, 2005). The deductive approach predominates in logistics research (Arlbjörn and Halldórsson, 2002; Mentzer and Kahn, 1995; Stentoft-Arlbjörn et al., 2008; Spens and Kovács, 2006), but its dominance is decreasing in relation to the other two (Spens and Kovács, 2006). A comparison of the three processes for testing theories are shown in Table 2

Table 2: Processes for testing theories (adopted and modified from De Brito and Van der Laan, 2008. p. 1).

Theory testing research approaches	**Research process starting point**	**Research aim**	**Drawing conclusions, development of hypotheses and propositions**
Abduction	Empirical observations (unmatched by deviating from theory).	Developing new understanding.	Suggestions for future directions, theory/paradigm/ tool.
Induction	Empirical observations (theory is absent).	Developing theory.	Generalisation/ transferability of results.
Deduction	Theoretical framework.	Evaluating theory.	Verification or falsification.

The process used for creating and testing theories in the thesis is based on the abductive approach, running from law to result to case (Kovács and Spens, 2005), or from prior theoretical knowledge to observation of certain facts to supposition of general principle to account for the facts (Fann, 1970). This process includes an iteration process of “theory matching” which practically implies that empirical data from reality (through case studies) are collected simultaneously with the processes of building theory which creates an overlapping learning loop. This property of the iteration process makes it possible for a researcher to choose the starting point of the abductive research process, which is common when applying new theory or theories from another theoretical framework to existing phenomena in the field (Spens and Kovács, 2006).

The abductive research process for testing theories applied in the thesis is presented in Figure 4, visualised by the dotted line. It is compared with the deductive and inductive research processes.

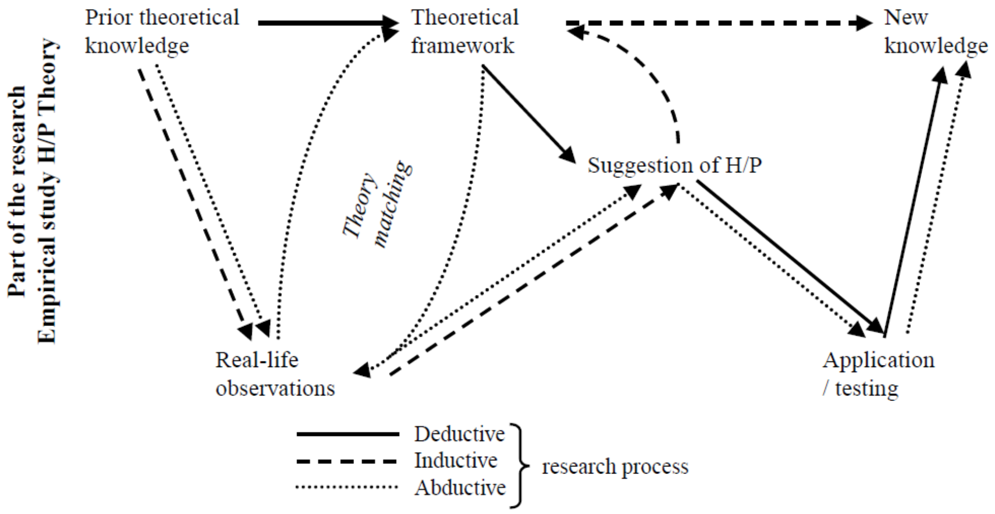

Figure 4: The abductive research process (H/P:Hypothesis/Proposition). (Adopted from Spens and Kovács, 2006 p. 376).

2.4 Research process

The research process contains both inductive and deductive elements, making it abductive (following the dotted line in Figure 4) and divisible into three phases (see Figure 5). Prior to the first phase, and used as an initial input source for the research process, were the outcomes from the GIS Fish Project that ended in September 2008.

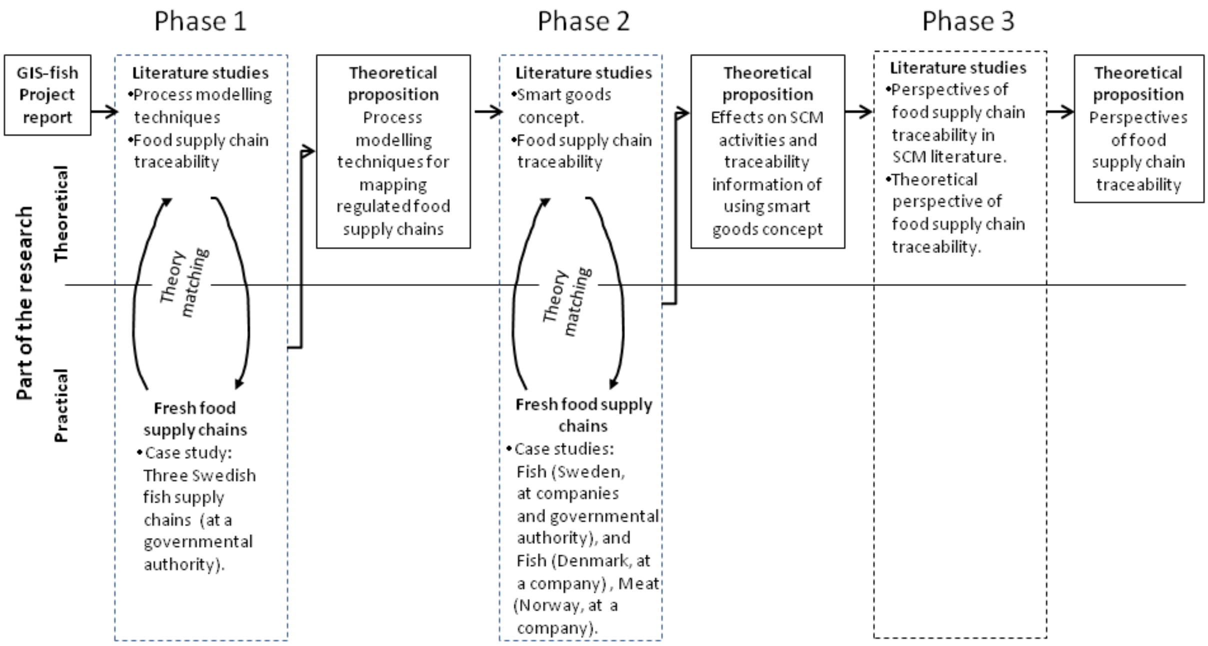

Figure 5: The three phases in the thesis research process.

Each phase contains a study that addresses one research question. This establishes a relation between the data collected and the initial research questions of the study according to Yin (2009).

2.4.1 Phase 1 Evaluation of two process modelling techniques for mapping information and physical flows in fish supply chains

The first phase started with a literature study on different process modelling techniques for mapping physical and information flows in food supply chains where time and temperature are important factors. This is because the requirements for monitoring and tracing processes in such chains need to be more stable than in non-tempered supply chains of goods. Food supply chains need to have stable temperatures and often short lead times without allowance for delays (Mai et al., 2010). An additional literature review was carried out on present projects and regulations for traceability in the fish industry.

Empirical data about the fresh supply chains for cod, herring and crayfish were used and were collected from a single case study carried out between February and September 2008 in the GIS Fish Project. The data were collected through interviews based on open ended questions and participant observations in meetings with staff and managers who on a daily basis worked with fish control issues at the Department of Fisheries Control. Internal documents were also reviewed. This data collecting strategy in case studies is in line with Yin (2009) and Eisenhardt who mention documentation/archives, interviews and observations as appropriate sources (Yin, 2009, p. 102; Eisenhardt, 1989, p. 534). Notes were taken during meetings, transcribed afterwards and sent back to the attendees to minimise the risk of misunderstandings that could affect the analysis.

Two process modelling techniques were selected and used to analyse the data about physical and information flows: process mapping diagrams (Aronsson et al., 2003), and cause-and-effect diagrams (Rydebrink, 1993). These two process modelling techniques were selected based on their academic and practical value (i.e. well published in academic papers and accepted in the industry). The supply chain mapping diagrams were sent back to the Swedish Board of Fisheries and validated through open discussions during meetings there. This is in line with Yin's (2009) framework for testing case study research.

In parallel with the analysis of physical and information flows in fresh fish supply chains, the two process modelling techniques were evaluated relative to each other to find the most suitable technique for mapping fresh fish supply chains. This in combination with the explorative purpose to achieve a general understanding of the information flow between an authority and the actors in fresh fish supply chains can be characterised as inductive, since it suggests new theoretical propositions about mapping food supply chains affected by governmental regulations based on empirical observations.

One additional outcome from the studies of information flows in the three fresh fish supply chains was that further research should be conducted concerning effects on activities and on traceability information when an automated identification and capture technique, such as the RFID based smart goods concept, is used.

2.4.2 Phase 2 Finding the effects on activities and traceability information by using the smart goods concept

Phase II was conducted to create knowledge about the effects on traceability information and activities when the smart goods concept was applied to three different fresh food supply chains. Empirical data was collected through a multiple case study of systems used for traceability in three different countries: one system in Denmark for fish traceability, one in Norway for meat traceability, and one in Sweden for fish traceability. This facilitates the formation of general conclusions because the three supply chains place the same demands on traceability information and all of them have to follow and respect the same European regulations and quality standards in the food industry. After selecting the cases, a data collection protocol was prepared including project objectives, case study subject, field procedures, case study questions and guidelines for the case study report according to Yin (2009).

The multiple case studies were conducted from a qualitative approach using semi-structured interviews, reviews of internal and external documentation and archival records, and direct observations of different operations in the supply chains. All three studies took place between September 2009 and March 2010. Fourteen interviews were conducted based on semi-structured questions and interview forms filled in by the interviewees. The study of the Swedish fish supply chain system included 12 of the interviews. It gathered data about the information flow between receivers, a filleting industry, a wholesaler, retailers, a governmental authority and eight fishing vessels (selected based on different equipment used for fishing) in Simrishamn and Gothenburg. The studies of the Danish and Norwegian information systems were based on interviews with the companies developing the traceability solutions in each country.

Results from the analysis of each interview were sent back to the interviewees for confirmation before the interview was saved in a case study database along with the oral interview recordings, notes taken, and photos from participant observations. Documentation from different actors was reviewed to enable triangulation of the data in each study (Yin, 2009).

The data collected were examined by making a cross case analysis of the three studies. According to Eisenhardt (1989) and Yin (2009), cross case conclusions can be drawn after comparing the analysed data from different supply chains. In the cross case analysis, the Swedish system, which uses stickers and delivery notes for transferring item information, was compared with the Norwegian and Danish traceability systems, both using smart goods and RFID equipped tags for carrying information in the supply chains. This cross case analysis made it possible to identify the effects of using smart goods on traceability information and on activities carried out using traceability information in fresh food supply chains.

In addition to the cross case analysis, and to create a theoretical framework for validation of general conclusions, a literature review on the smart goods concept and food supply chain traceability in fresh food supply chains was carried out. This review can be characterised as inductive since it identifies effects on activities and traceability information in relation to common knowledge about traceability and the smart goods concept.

Additionally, the outcomes from the case studies in the second phase were from the industrial focus on traceability, which initiated the subject of the third phase.

2.4.3 Phase 3 Positioning food supply chain traceability from a science theoretical and supply chain management approach.

The third phase complements the empirical findings from phases one and two because of the significance of positioning food supply chain traceability in a general science theoretical and supply chain management contexts. In the first phase, a governmental authority focus was used in the case study, while an industrial focus was used in the multiple case study in the second phase. The third phase started as a course assignment in philosophy of science, research methodology and critical thinking, held by the Faculty of Humanities and Theology, Department of Theoretical Science at Lund University.

Phase three has a theoretical and deductive approach and is based on two literature studies on food supply chain traceability focusing on the philosophy of science and SCM. The science theoretical literature study was performed as an explorative review, while the SCM study was conducted as a structured literature review. Both studies used the ELIN database (Electronic Library Information Navigator) at Lund University which integrates information from publishers, databases and electronically printed archives. The theoretical outcomes of the two literature studies were complemented with meetings, discussions and by sending the final manuscript for critical review by the Department of Theoretical Science.

The third phase applied philosophical science theory to food supply chain traceability, identifying a new concept definition and a suggestion for theoretical positioning. It further identified different perspectives of food supply chain traceability in the supply chain management literature. This is useful for practitioners as well as researchers since it addresses and aims to explain the concept of food supply chain traceability from different perspectives which could influence future supply chain traceability setups.

2.5 Methods of data collection

2.5.1 Literature reviews

There are several scientific reasons for conducting literature reviews (Hart, 1998), and the process of carrying them out runs parallel to the primary research process (Randolph, 2009), since reviews are typical in introductions or independent work that presents new primary data (Cooper, 1998). Due to this, literature reviews have several goals, perspectives coverage strategies, organisations and audiences (Randolph, 2009; Cooper, 1998). In addition, literature reviews can have multiple focuses, ranging from reviews of research outcomes, research methods, theories, applications, attempts to integrate or criticise previously conducted research, or a combination of the focuses mentioned (Cooper, 1998).

There are three different categories of literature reviews: systematic, narrative and best-evidence synthesis (Kawas, 2010):

1. *Systematic literature reviews* are characterised by a reproducible systematic and transparent scientific process (Bryman and Bell, 2007; Kawas, 2010) that identifies, evaluates and analyses all relevant research results (Kawas, 2010; Forsberg and Wengström, 2003). This process is initiated by the individual researcher, who must be interested and able to assess other researchers' work in the field (Kawas, 2010; Bryman and Bell, 2007). The systematic literature review process facilitates critical research thinking (Bryman and Bell, 2007) and is appropriate when the subject of research is focused (Kawas, 2010).

2. *Narrative literature reviews* are characterised by a summarisation and holistic interpretation process, which is based on the individual researcher's experience of theories and models to generate understanding (Bryman and Bell, 2007; Kawas, 2010). These characteristics of narrative literature reviews make them wide ranging in comparison with systematic literature reviews, and appropriate for research which is comprehensive and qualitative (Bryman and Bell, 2007; Kawas, 2010). In narrative literature reviews, techniques such as meta-ethnography and phenomenography are used to identify, evaluate and analyse specific research results (Kawas, 2010).
3. *Best evidence synthesis literature reviews* are a combination of systematic literature review methods and narrative literature review methods used to focus on finding the best evidence in a research area (Kawas, 2010). They are characterised by the use of systematic methods for selecting studies and reviews. The review procedures are comprehensive in order to generate further understanding of primary research (Kawas, 2010).

Literature reviews also have different objectives. Cooper (1989) identifies them as integrative and theoretical. Kawas (2010) goes on to add methodological, thematic, historical, state-of-the-art, and comparison of multiperspective reviews. Descriptions of the objectives and their characteristics are presented in Table 3.

Table 3: Objectives for literature reviews and their characteristics (adopted and merged from Kawas, 2010; Cooper, 1989).

Objective	Characteristics
Integrative	• Focuses on empirical studies. • Synthesises knowledge though summarisations of previous research or by reaching overall conclusions from many similar studies. • Highlights important issues so far unsolved. • Critically evaluates previously published research material. • The validity of knowledge depends on the possibility of making scientific inferences.
Theoretical	• Focuses on presentation, explanation, comparison of theories. • Reviews of existing literature highlights proposals of new theory, development of existing theories or superiority of different existing theories.
Methodological	• Focuses on descriptions of research design, methodologies, methods and procedures in educational research. • Discusses quantitative and data analytic approaches.
Thematic	• Focuses on descriptions of educational approaches or learning models. • Evaluates relevant objectives by making comparisons between different points of view about a specific subject.
Historical	• Focuses on the analysis of literature in a research field from a historical context.
State-of-the-art	• Focuses on recent research (in the last decade) of a specific subject. • Summarises current educational trends, priorities, and standardisations of interest. • Includes critical surveys of general and recently published literature and thoughts in a given field.
Comparison of multiperspectives	• Focuses on comparisons of literature about a specific subject from two or more disciplines.

Systematic searches and evaluations of documents are also important elements in the data collection plan when conducting case studies, since documents are used for evaluating evidence from other sources (Yin, 2009).

2.5.2 Case studies

This thesis presents traceability research based on studies of real-time current events in food supply chains. The preferred method for examining such real-time events when the behaviour cannot be manipulated is through case studies (Yin, 2009). The research questions consist of "how" questions, which is completely in line with Yin's theories about research questions in case studies (Yin, 2009). This is also in line with the strategy chosen for testing theories – abductive reasoning – since it stipulates that a hypothesis should be phrased as a clear question before observations are carried out to test its credibility (Kovács and Spens, 2005).

Case studies are frequently used as a method for collecting empirical data in both quantitative and qualitative research (Bryman and Bell, 2007; Näslund, 2008). They are considered by Churchman (1979) to be an ideal method in systems analysis (Gammelgaard, 2004). Ellram further elucidates the importance of the case study method in logistics research and provides insights into when the case study method is appropriate to use (Ellram, 1996). This is in line with traceability research in food supply chains, since traceability is a research field related to logistics, which sometimes may contain insufficient theories. According to Eisenhardt (1989), the most appropriate method for the creation of novel theory from insufficient theories is through case studies. On the other hand, the literature shows that there is a trend among researchers to rely more on case studies and interviews to accomplish their research objectives (Halldórsson and Aastrup, 2003), but that there is a lack of validity in the case study method if the empirical data (i.e. investigation of parlance) are based on a small sample size (Stentoft and Halldórsson, 2002).

According to Bryman and Bell (2007), a case in a case study can either be a single organisation, a single location, a person or a single event. What then is different with the case study method compared to other methods for collecting empirical data is that the researcher is concerned with clarifying unique features of the case under study (Bryman and Bell, 2007). He or she is constantly elucidating research events as long as they are selected to represent a certain system or an event that needs to be studied (Arbnor and Bjerke, 1994). These features of the case study method are completely in line with the research presented here, since an organisation, single features and the ongoing elucidation of events in fresh fish supply chains are studied, as well as fish supply chains and technical traceability solutions as single events.

2.5.3 Summary of collection methods used

Systematic literature and evaluative document reviews of integrative, methodological, state-of-the-art objectives are used in all three studies presented. However, the differences between the three appended papers are that the first is based on literature reviews, while papers two and three also include case studies for collecting data. The case designs follow two of the types proposed by Yin (2009) and differentiate in that a single case study design is used in paper 2, while a multiple case study design is used in paper 3.

Table 4 summarises the methods used for data collection in each paper and their characteristics and objectives.

Table 4: Data collection methods used and their characteristics/objectives in each paper.

Data collection method	Objective/characteristic	Paper
Case studies	Single	1
	Multiple	2
Systematic literature reviews	Integrative literature review	1,2
	Theoretical literature review	1,2,3
	Methodological literature review	1,2,3
	Comparison of multiperspectives	3

2.5 Research validity

In logistics research, as in research in general, the three criteria of validity – internal validity, external validity, construct validity – along with reliability are used to determine research quality (Halldórsson and Aastrup, 2003). Research quality in this thesis is evaluated according to the construct validity.

The concept of validity refers to the truth of conclusions generated from the research, and to the correctness and strength of a statement (Bryman and Bell, 2007). Validity reflects a researcher's ability to continually check questions and theoretically interpret findings (Kvale, 2007). Rigour is achieved by addressing the following dimensions embodied in the validity concept (Mentzer and Flint, 1997):

Internal validity concerns causality (Bryman and Bell, 2007) and seeks to establish causal relationships where confident conditions are believed to lead to genuine relationships as opposed to false ones (Yin, 2009). Considering trustworthiness, the internal validity concept is parallel to credibility (Aastrup and Halldórsson, 2003).

External validity concerns results that can be generalised beyond a specific research context (Bryman and Bell, 2007) or a specific scenario (Dunn et al., 1994). This means that a theory must be tested through a replication of findings in a different context ending up with the same results (Yin, 2009). Both time and space are major constraints when replicating the findings (Aastrup and Halldórsson, 2003). The parallel term related to the truth-value of external validity is "transferability" (Aastrup and Halldórsson, 2003).

Construct validity concerns the correct measurement of the concepts being studied (Bryman and Bell, 2007). It is thus related to identifying correct measures (Yin, 2009) and the scale of measures (Garver and Mentzer, 1999). This is because a theoretical phenomenon can only be measured and defined correctly in one explicit way and a researcher has to choose measures that are reasonable for the theoretical construct (Mentzer and Flint, 1997). Construct validity is a function of previous, current, and future research (Dunn et al., 1994).

In the thesis, the construct validity criterion is used to determine the research quality of the findings in the appended papers (chapter 4). This criterion is also present in the case studies of paper 2 and paper 3 because the case study reports have been sent in for revision by key informants.

This is in line with Yin, (2009) and Riege (2003) who both state that to ensure construct validity of multiple sources of evidence, one needs to establish a chain of evidence and/or if a case study has been conducted, let key informants review a draft of the case study report (Yin, 2009; Riege, 2003).

Kvale (2007) states that validity is a craftsmanship which is described by the following three parameters:

1) Validate is to check – That the result are continuously checked and controlled by the researcher through the research process.

2) Validate is to question – That the researcher is aware of the way in which and by what method the research is analysed in relation to different interpretations.

3) Validate is to theorise – That a method investigates what it intends to do, which involves the theoretical conception of what is investigated.

This three-parameter model of Kvale's is used in addition to the criterion of construct validity for determining the research quality in the findings from the appended papers.

3. Frame of reference

The following chapter describes the theoretical foundation of the thesis. It constitutes the theoretical framework for exploring governmental authority and industrial effects of traceability in food supply chains.

In this thesis, five central themes are used to explore the industrial and governmental effects of food supply chain traceability: 1) perspectives of packaging logistics, logistics and food traceability in supply chain management, 2) supply chain integration, 3) traceability in food supply chains, 4) packaging logistics, and 5) European governmental requirements for food supply chain traceability and fishing control. Each theme is further elaborated upon below.

3.1 Perspectives of packaging logistics, logistics and food traceability in supply chain management.

A prerequisite that provides an overall view of the industrial and governmental effects of traceability in food supply chains is knowledge about different perspectives for integrating or distinguishing packaging logistics, logistics and food traceability according to SCM.

Integrating and distinguishing logistics and supply chain management is considered to be of strategic and operational importance for supply chain professionals and researchers (Fabbe-Costes and Jahre, 2008). This is supported by the Council of Supply Chain Management Professionals which defines supply chain management as encompassing:

> "... the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes co-ordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies" (CSCMP website, accessed 16 Nov. 2010).

This CSCMP definition reflects a "unionist" perspective (Halldórsson et al., 2008) for integrating and distinguishing logistics and supply chain management, where logistics activities are treated as parts of supply chain activities. This perspective includes both strategic and tactical components for covering functional areas; the integration of key processes are important for providing service and information which add value to end customers and stakeholders (Lambert et al., 1998; Halldórsson et al., 2008).

The key processes according to the unionist perspective are:

a. Customer relationships
b. Customer service management
c. Demand management
d. Order fulfilment
e. Manufacturing flow management
f. Supplier relationship management
g. Product development and commercialisation
h. Returns management (Halldórsson et al., 2008).

In relation to the key processes, the business functional areas of the unionist perspective are marketing, sales, research and development, forecasting, production, purchasing, logistics, information systems, finance and customer service (Halldórsson et al., 2008).

These functional areas and their key processes are in line with the perspective used in previous studies of food supply chain traceability. This is because the processes cover research areas that are interesting for the food industry as well as for governmental authorities, to refute mandatory requirements on food supply chain traceability.

In addition to the unionist perspective for integrating and distinguishing logistics and supply chain management Halldórsson et al. (2008) mention three more:

- *The traditionalist perspective*, which is characterised by treating supply chain management as a part of, or a function within logistics (contradicting the unionist perspective). Supply chain management is seen as a special form of logistics.
- *The re-labelling perspective*, which is characterised by equableness between supply chain management and logistics reflecting a name change of logistics.
- *The intersectionist perspective*, which is characterised by the integration and sharing of components in logistics and supply chain management related to purchasing, logistics operations, marketing and functions (such as strategic negotiations or tactical warehousing functions) resulting in a strategic focus.

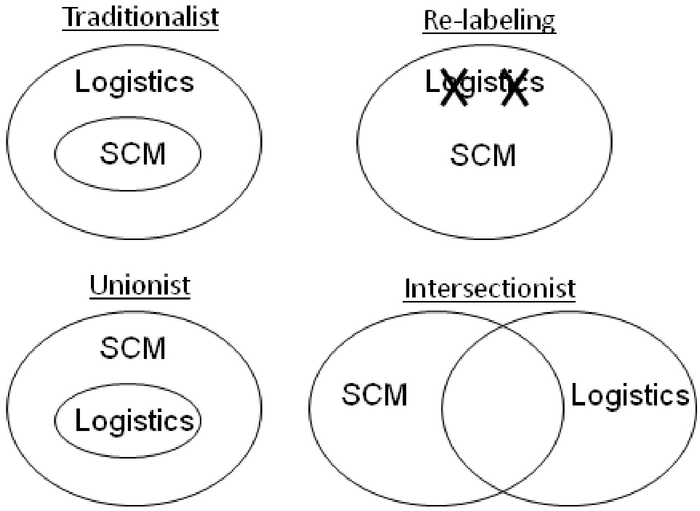

Figure 6: Different perspectives of integrating and distinguishing supply chain management from logistics (adopted and modified from Halldórsson et al., 2008, p. 130).

However, the model illustrated in Figure 6 does not include further descriptions of perspectives for integrating or distinguishing packaging logistics and food supply chain traceability in relation to supply chain management.

Different perspectives of packaging logistics and SCM have been investigated by Saghir (2002), who dealt with packaging logistics from a supply chain management perspective; by Hellström (2007), who dealt with packaging logistics from a supply chain performance perspective; and by Twede and Parsons (1997), who used a value adding perspective of logistics within SCM. What these three share in common is that packaging logistics is treated as an integrated element between, and complementary to packaging and logistics systems on an operational level. However it is to be noted that this contradicts with the traditional perspective of packaging logistics in relation to logistics, highlighted by Dominic et al. (2000), which views packaging logistics as a part of the logistical system aimed to support logistical processes and to meet customer demands (Saghir, 2004). Further research is needed on the different perspectives for integrating or distinguishing food supply chain traceability, and of the concept itself according to SCM theory.

3.2 Supply chain integration

Previous research in SCM literature presents a variety of definitions of supply chain management and logistics as concepts linked to integration (Fabbe-Costes and Jahre, 2008; Mears-Young and Jackson, 1997; Bechtel and Jayaram, 1997; Lambert et al., 1998). Mears-Young and Jackson establish that logistics is an "integrating concept" (Mears-Young and Jackson, 1997, p. 607). This is in line with the definition of logistics management given by the international research community through the Council of Supply Chain Management Professionals (CSCMP): "Logistics management is an integrating function, which co-ordinates and optimises all logistics activities, as well as integrates logistics activities with other functions including marketing, sales manufacturing, finance, and information technology," (CSCMP website, accessed 16 Nov. 2010)

Halldórsson et al. (2008) emphasise that there is a lack of a common perspective and definition of supply chain integration. This is also stressed by Fabbe-Costes and Jahre (2008) who state that "a better understanding of the concept integration, its dimensions and its implications is of managerial relevance as well as academic importance and can contribute to theory building in business logistics, operations and supply chain management" (Fabbe-Costes and Jahre, 2008, p. 131).

This need goes beyond logistics. It includes customer involvement, change of organisational structures (Mears-Young and Jackson, 1997) as well as research covering co-operative efforts/barriers between supply chain actors related to marketing, promotion, sales, information gathering, research and development, product design, and total system/value analysis (Cooper et al., 1997), highlighting integration of business operations in supply chain management (De Brito and Van der Laan, 2008). Integration of business operations between firms in food supply chains is a prerequisite to accomplishing traceability according to governmental regulations. In line with this is research about co-operative efforts/barriers between firms in food supply chains and governmental authorities, an area that needs further investigation.

Cooper et al. (1997) state that the central question is how to go about integrating supply chains. This is because it depends on different layers for integration: of material, information and financial flows (where integration of material flows needs to be viewed strategically, tactically and operationally); of flows relating to different perspectives; of processes and activities, technologies and systems; and finally of actors (i.e. of structures and organisations) (Fabbe-Costes and Jahre, 2008; Stevens, 1993). Independent of the layer considered for integration, logistics and supply chain management is looking for greater integration to attain greater efficiency and flexibility (i.e. to respond to changes) (Jahre and Fabbe-Costes, 2005).

One parameter affecting the efficiency of the supply chain is the type and frequency of updating, delivering and sharing information between the actors of the supply chain (Cooper, 1997).

Previous studies focused on food supply chain traceability within industries (i.e. internal traceability) or between different firms within a supply chain. This opens the way for further research about food supply chain traceability with a governmental authority focus. This research would be related to the interest of streamlining physical and information flows in food supply chains by using automatic identification techniques, such as the RFID based smart goods concept, to decrease costs and time for operation, and to increase accuracy of information. Studying information flows in food supply chains is related to the willingness of sharing information between different actors, including competitors and governmental authorities

The sharing of information influences how different actors recognise each other and the formation of boundaries, restrictions and relationships (or business process links) between actors in supply chains (Jahre and Fabbe-Costes, 2005). Boundaries are created due to restrictions in functional attitudes between supply chain actors, which can hinder integration along the supply chain (Mears-Young and Jackson, 1997). Restrictions, on the other hand, are created by actors who need them for making situation analyses and decisions (Jahre and Fabbe-Costes, 2005). Relationships, or business process links, in supply chains consist according to Lambert et al. (1998) either of:

- *Managed process links:* Links where the focal company integrates a process with one or more customers/ suppliers.
- *Monitored process links:* Links with other supply chain member companies, but this is less critical than managed links.
- *Not-managed process links:* Links that the focal company is not actively involved in.
- *Non-member process links:* Links between actors of the focal company's supply chain and non-actors of the supply chain that affect the performance of the company and its supply chain such as product quality.

These four types of relationships, or business process links, are illustrated in Figure 7 according different categories of supply chain actors. The figure highlights that the level of integration and management in each process link is determined by the number and level of elements connected to each link (Lambert et al., 1998).

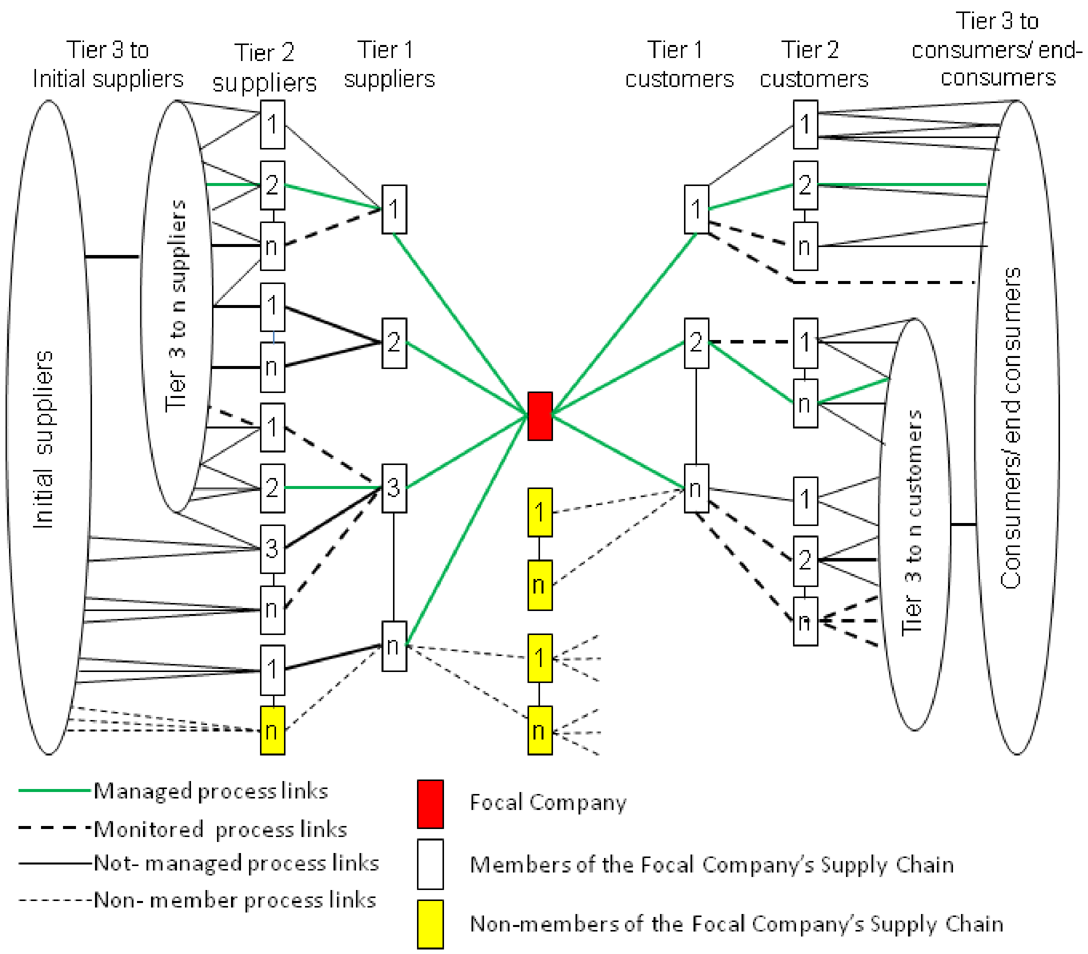

Figure 7: Business and process links between supply chain actors (adopted and modified from Lambert et al., 1998, p. 7).

Moreover, integration of supply chains is, according to the SCM literature, dependent on the level of supply chain integration and on the dimension used for analysis. External integration (i.e. with customers or suppliers) inspires internal integration within supply chain structures (Halldórsson et al., 2008). A supply chain structure is “the network of members and the links between members of the supply chain” (Lambert et al. 1998, p. 6). The members, or actors, of a supply chain network include all firms and organisations with which the supply chain member company either interacts directly or indirectly, ranging from the point of origin to end consumption. The SCM literature documents the integration between actors in supply chains from different industrial perspectives (Bowersox and Gloss, 1996; Halldórsson et al., 2008; Lambert and Cooper, 2000; Mears-Young and Jackson, 1997; Bechtel and Jayaram, 1997; Scott and Westbrook, 1991; Cooper et al., 1997; Fabbe-Costes and Jahre, 2008; Stock et al., 2010), excluding integration of information flows as well as of relations between supply chain actors and governmental authorities. This has created a deficiency in the supply chain management literature concerning flows and relations that are important for actors in the food industry to meet legal requirements for food supply chain traceability. In addition, there is a deficiency in the supply chain research and at governmental authorities in documenting physical and information flows, relationships and integration of flows in food supply chains when integrating traceability with other types of legal activities for controlling and planning, such as for the preservation of living resources.

Integration of supply chains in supply chains structures is, according to Scott and Westbrook (1991), achieved by using a three-stage model. This model starts with a modelling stage that analyses lead times and inventory levels across the supply chain, continues with a positioning stage, which identifies opportunities or limitations related to collaboration between chain actors, and ends with an action stage in which activities are selected with the aim of increasing the competiveness of the chain (Scott and Westbrook, 1991; Cooper, 1997). Reviews in SCM literature highlight that different methods for modelling food supply chains exists, but that they seldom are designed to model the chains according to parameters for time, temperature and information used for fulfilling European governmental requirements on traceability and fishing control.

Analysing supply chain integration in supply chain structures is conducted by using either one or a combination of the following approaches:

- Limited dyadic downstream: integration between the focal firm and its customers.
- Limited dyadic upstream: integration between the focal firm and its suppliers.
- Limited dyadic: integration between the focal firm and/or its customers and/or its suppliers (implies both up and downstream integration, but separately).
- Limited triadic: integration of suppliers, the focal firm, and customers, but without differentiation of upstream and downstream relationships.
- Extended: integration between more than three parties along the supply chain such as customers' customers, suppliers' suppliers or other stakeholders.
  (Fabbe-Costes and Jahre, 2008).

Managing traceability in food supply chains includes a combination of limited dyadic (both up and downstream integration) and of an extended approach to supply chain integration.

3.3 Traceability in food supply chains

A food supply chain is a directed network of actors where products are taken in the steps from raw material to consumed product (Lazzarini et al., 2001; Olsson and Skjöldebrand, 2008). Contrary to traditional supply chains of goods, food supply chains often need to have stable temperatures and short lead times without allowance for delays (Mai et al., 2010). They do not consider added values in supply chains (Olsson and Skjöldebrand, 2008).

A variety of definitions exists in the literature of the concept "traceability"" confirming the lack of a common understanding (Van Dorp, 2002). What these definitions share in common is that they are generated from different business and organisational perspectives of food supply chain traceability, excluding the science theoretical perspective in the definition. Thus the concept needs to be further defined from such a perspective. The General Food Law, which specifies the European Union's requirements for traceability, defines it in food supply chains as the "ability to trace and follow a food, feed, food producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution" (Official Journal of the European Communities, 2002).

Related to traceability are the concepts of "track-and-trace" items in supply chains (Schwägele, 2005). These also lack a uniform understanding (Stefansson and Tillanus, 2001).

Different definitions can be found in the SCM literature related to the direction from which integration should occur.

Schwägele (2005) defines "tracing" as the integration of the focal firm and its customers, and "tracking" as the integration of the focal firm and its suppliers. Jansen-Vullers et al. (2003) use both an up and downstream approach to integration when defining the two concepts in relation to traceability. The difference between "track-and-trace" and traceability is that traceability includes the ability to point out the position of an item in real time.
Two types of traceability are present in SCM literature: external (or chain) and internal (or local) traceability. External traceability (or chain traceability) refers to traceability between companies (Isaksson, 2004) and occurs when a traceable item is physically handed over from one firm or country to another in the supply chain (GS1, 2010; Olsson and Skjöldebrand, 2008). Internal traceability (or local traceability) refers to traceability within a firm or production unit; it occurs when the firm receives one or several instances of traceable items as inputs to internal processes for transportation or blending of materials before one or more instances of the traceable item are generated as output (GS1, 2010; Olsson and Skjöldebrand, 2008; Isaksson, 2004; Moe, 1998).

Several techniques can be found in the SCM literature for accomplishing traceability in food supply chains, whereof automated and radio frequency based identification techniques (RFID), such as the smart goods concept, have started to gain ground (Abad et al., 2009; Frederiksen et al., 2002; Jones et al., 2005; Kelepouris et al., 2007; Hsu et al., 2008; Hellström, 2007). However, previous research is focused on technical issues related to the implementation of such techniques for food supply chain traceability, leaving a gap in the SCM literature about the effects on operational activities and information when applying the techniques.

3.4 Packaging logistics

Packaging logistics involves the integration of packaging systems with logistics and information systems to increase supply chain efficiency by improving packaging, logistical and information technical activities and solutions. According to Saghir (2002) packaging logistics is defined as: "The process of planning, implementing and controlling the co-ordinated Packaging system of preparing goods for safe, secure, efficient and effective handling, transport, distribution, storage, retailing, consumption and recovery, reuse or disposal and related information combined with maximising consumer value, sales and hence profit" (Saghir, 2002, p. 45).

Packaging logistics is a concept that over the last two decades has gained increased industrial as well as scientific attention (Johnsson 1998; Twede 1992; Dominic et al., 2000; Twede and Parsons, 1997; Saghir, 2002; Saghir, 2004). This is because packaging has gained strategic importance due to it influences on logistics costs and performance in manufacturing and logistics processes (Twede, 1992; Chan et al., 2006; Lockamy, 1995), and on costumer value in the distribution and selling of goods (Johnsson, 1998). The package has become essential in supply chains (Chan et al., 2006; Lockamy III, 1995) because it not only functions as carrier of packed products (Olander-Roese and Nilsson, 2009), but also as a carrier of information during distribution in supply chains (Beckeman and Olsson, 2005).

In Table 5, additional functions of packages are presented along with their characteristics.

Table 5. Overview of packaging functions and their characteristics (Jönson, 2000; Chan et al., 2006).

Function category	**Functions**	**Characteristics**
Logistics (inbound logistics, operations, outbound logistics)	Protection	Protect both product and the environment from water, moisture, vapour, shock, vibration, compressive forces, etc. and damage during distribution storage and handling.
	Communication (information flow)	Provide information about conditions, locations and handling of products. There are costs related to incorrect handling of goods, such as product damage and reclamation of the secondary and tertiary packages. The use of clearly understood symbols or coding affects the efficiency of flow of goods along supply chains in international trade.
	Volume and weight efficiency	Products are contained (with the exception of large, discrete products) before they are moved from one place to another. If the volume and weight relation is not efficiently designed, there is poor utilisation of the distribution chain.
	Convenience (handle ability)	Packaging is essential for the handling process to occur in a convenient manner. If packages are deficient in convenience function (handle ability), it causes disorder and product damage.
Marketing, sales, service	Promotion	Provide features with a sales orientation. Graphic design (some packages are designed so they do not have to be unpacked by the clerk for stocking on shelves). Observe legislative demands and marketing.
	Communication	Observe customer requirements/consumer convenience for end use as well as distribution.
	Convenience (handle ability)	Provide information for correct handling of products.
	Apportionment (right amount and size)	Reducing the output from industrial production to a manageable level due to methods for apportioning the product into the desirable size and amount.
Environment		Recovery/recycling, dematerialisation, one-way vs. reusable package, toxicity.

As demonstrated in Table 5, modern packaging embraces several packaging functions which are related to integrated activities and costs in firms, such as costs for and handling of packaging material, package development, printing and labelling, filling, and disposal. In addition, there are indirect effects on logistics, production, marketing and sales, information systems and technology, and the environment of packaging. This is in line with Porter's (1985) theories on packaging logistics which stipulate that it is systematic, and that changes in packaging/the package are estimated based on effects on the values in logistics system.

Pålsson highlighted changes in packaging/the package due to demands for tracking and tracing products in supply chains and to effects on the communication and convenience functions (handle ability) of the package in logistics systems (Pålsson 2009). In addition, tracing of products affects the marketing and sales category due to functions for consumer communication and convenience (handle ability). These two functions are related in the requirements for traceability because they can provide such information to end customers as a service. However, research on the package as a carrier of information to meet regulatory requirements for traceability information in food supply chains is limited.

According to the SCM literature, there are two categories of packaging: industrial and consumer. Industrial packaging is related to physical distribution dealing with the protection of goods during shipment and storage; consumer packaging is related to product design dealing with sales, advertising, acceptance and how consumers interact with products (Chan et al., 2006). The packaging system is further classified into three levels: primary, secondary and tertiary (Jönson, 2000).

Figure 8 presents the two packaging categories in relation to levels in the packaging system, type of packaging and definitions.

Packa-ging category	Packaging system level	Packaging type	Definition
Industrial	Tertiary	Transport packaging	Used when a number of primary or secondary packages are assembled on a pallet or roll container.
		Distribution packaging	
	Second-ary	Secondary packaging is designed to contain several primary packages.	
		Group packaging	Packaging conceived to facilitate protection, display, handling and/or transport of a number of primary packages.
		Display packaging	Packaging conceived to facilitate protection and display features for handling and/or transportation of a number of primary packages.
		Retail packaging	Packaging conceived to facilitate protection and designed to fit in retail.
Consumer	Primary	Consumer packaging	Packaging which is in contact with the product. The packaging that the consumer usually takes home
		Sales packaging	
		Used packaging	Packaging/packaging material remaining after the removal of the product it contained.

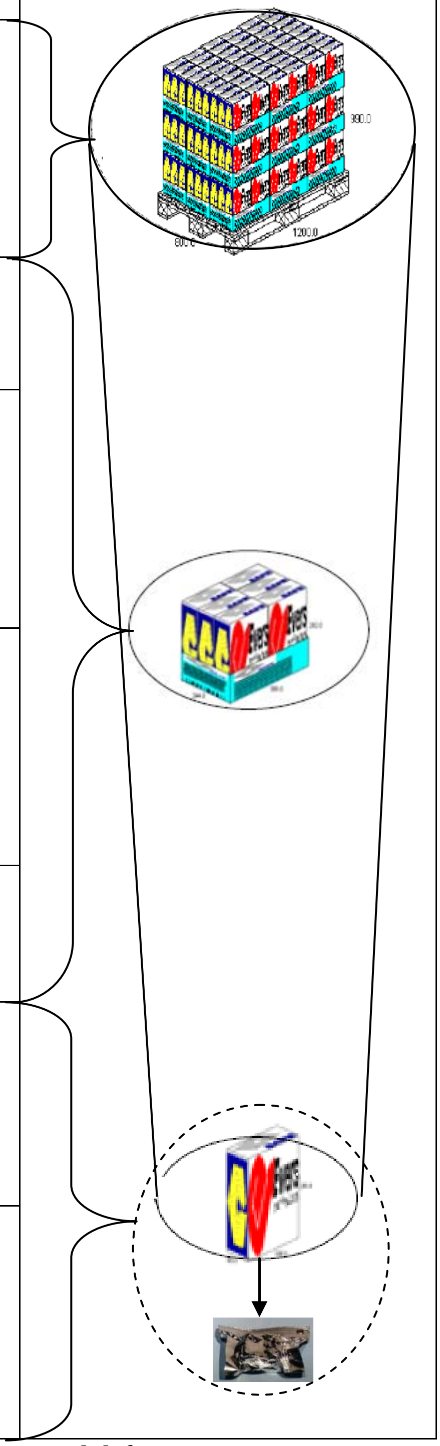

Figure 8: Packaging categories, systems levels, types and definitions (adopted and merged from Jönson, 2000; Saghir, 2004; Chan et al., 2006).

Figure 8 reflects the design and functional demands on packages to create values for different actors: primary package are designed to interact with consumers and their demands, secondary packaging is designed to serve supply chain actors at the point of sale, and tertiary packaging is designed based on demands for transport distribution and storage (Welcome, 2009). Previous research in traceability shows that the demand for it involves all three levels of the packaging system. More research should be conducted on packaging design in regards to the transfer of traceability information on packages that is required by governmental regulations. This is because all three levels of the packaging system are also important for governmental authorities to meet European regulations on traceability.

3.5 European governmental requirements for food supply chain traceability and fishing control

Traceability is a risk management tool which enables governmental authorities to improve safety control over food supply chains (Popper, 2007; Thakur and Hurburgh, 2009; Banterle and Stranieri, 2008; Furness and Osman, 2003). This control includes not only handling of risks related to terrorism, obesity, trade development, environmental consequences such as exploitation of living resources, hygiene and authenticity, but also abilities to provide information to end consumers and to recall unsafe products (Banterle and Stranieri, 2008; Popper, 2007; Thakur and Hurburgh, 2009). In the context of safety control, a variety of regulations, policies and laws exist in the European Union for constituting legal requirements for traceability (Furness and Osman, 2003; Regattieri et al., 2006; Aarnisalo et al., 2007; Banterle and Stranieri, 2008; Thakur and Donnelly, 2009; Regattieri et al., 2006).
However, larger firms in the food industry are better able to contest regulatory tariffs, quotas and subsidies than smaller firms with limited economical margins (Popper, 2007).

The requirements of the European Union for traceability in the food sector and for further requirements at a member state level pledging traceability in the food industry are determined by Regulation (EC) 178/2002 (Folinas et al., 2006). This regulation includes general principles and requirements of the General Food Law, the establishment of the European Food Safety Agency (EFSA) and provides procedures for food safety (Schwägele, 2005). In addition, Regulation 178/2002 has a comprehensive and integrated approach concerning European food safety to ensure quality (Banterle and Stranieri, 2008; Rábade and Alfaro, 2006; Kelepouris et al., 2007), which requires traceability in all procedures and stages of production (from the producer to the end consumer) for the food and feed business (Wang and Li, 2006; Rábade and Alfaro, 2006). The requirements state that any point in the food supply chain should be traceable one step back and one step forward (Popper, 2007; Arnisaalo et al., 2007). However, Regulation (EC) 178/2002 does not specify methods to be followed by all food business operators (Folinas et al., 2006), which enables each firm in the food industry to freely choose mechanisms for product traceability, as long as they fulfil the request for information from competent authorities (Folinas et al., 2006; Aarnisalo et al., 2007).

The content of Regulation (EC) 178/2002 entered into force with the European Union's General Food Law on 1 January 2005. It includes rules for traceability concerning, for example, the withdrawal of dangerous food products from the market (Thakur and Hurburgh, 2010; Wang and Li, 2006; Folinas et al., 2006; Bechini et al., 2005; Thakur and Donnelly, 2009; Schwägele, 2005).

The General Food Law defines traceability in Articles 3 and 18 as the "ability to trace and follow a food, feed, food producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution" (Official Journal of the European Communities, 2002). This definition includes not only stages for primary production and import but also sale and supply to end consumers for whom food safety, production, manufacturing and distribution of feed is important (Folinas et al., 2006; Thompson et al., 2005). A further specification of this is given in Article 18, which includes:

- Requirements for the identification of supplier and customer channels and transactions (Thompson et al., 2005).
- Establishment of traceability systems at business operators (Senneset et al., 2007; Schwägele, 2005; Aarnisalo et al., 2007).
- Adequate labelling of food placed on the market in the Community to assure its traceability through relevant documentation or according to information containing specific relevant requirements (Schwägele, 2005, Official Journal of the European Communities, 2002).
- Provisions for applying the requirements of Article 18 in specific sectors may be adopted in accordance with the regulatory measures to be applied in accordance with Articles 7 and 8 of the Regulation (Schwägele, 2005, Official Journal of the European Communities, 2002; Aarnisalo et al., 2007).

Furthermore, Articles 19 and 20 of Regulation (EC) 178/2002 highlight responsibilities for food and feed business operators, related procedures for recalls of unsafe products and informing competent authorities thereof (Schwägele, 2005).

In addition to the European General Food Law, the European Commission has established sector specific regulations, directives (see Table 6) and guidelines and principles for the implementation of electronic chain traceability (Thakur and Donnelly, 2009).

Table 6: Summary of legal food sector requirements in the European Union (adopted and merged from Aarnisalo et al., 2007; Popper, 2007; EU-Lex, 20101213).

Food product	Regulation/ directive	Description
Meat	Regulation: 1760/2000/EU	Establishes a system for the identification and registration of bovine animals and regarding the labelling of beef and beef products. Repeals Council Regulation (EC) 820/97.
	Regulation: 1825/2000/EU	Detailed rules of Regulation 1760/2000/EU.
Fish	Regulation: (EEG) 2807/83/	Rules for recording information on catches of fish.
	Regulation: (EEG) 2847/93/ 1224/2009/EU	Establishes control system in the common fishery policies, CFP.
	Regulation: 104/2000/EU	Labelling of fishery products including commercial designation of the species, production method, catchment area.
	Regulation: 2065/2001/ EU	Detailed provisions for the application of EU Regulation 104/2000 on labelling of fresh, frozen, and smoked fish or fillets and shellfish for sale.
Gene modified components	Directive: 2001/18/EU	Deliberate release of genetically modified organisms into the environment.
	Regulation: 1829/2003/EU	Genetically modified foods and feeds.
	Regulation: 1830/2003/EU	Traceability and labelling of food products produced from genetically modified organisms.
Eggs	Regulation: 589/2008/EU	Rules for implementing Council Regulation (EC) 1234/2007 regarding marketing standards for eggs.
	Regulation: 2052/2003/EU	Trading standards for eggs.
	Regulation: 1234/2007/EU	Establishes a common organisation of agricultural markets and specific provisions for certain agricultural products.
	Regulation: 2295/2003/EU	Detailed rules for implementing marketing standards for eggs.
Organically-grown food products	Regulation: 834/2007/EU	Rules for handling and labelling organically grown food products.
Materials and articles that come into contact with food	Regulation: 1935/2004/EU	Framework for materials which come into contact with food (i.e. packages).

Along with the legal incentives from the European Union, in the shape of regulations and the European General Food Law covering traceability, some governmental authority actions have been taken in the member states. In Finland, national law states that food producers must have a system that connects information of received lots to departed lots (Aarnisalo et al., 2007).

In Great Britain, Parliament set up an independent food safety watchdog in 2000 for protection of public health and consumer interests in relation to food (Bechini et al., 2005). In Belgium, traceability is mandatory, and in Italy standards control the design and development of traceability systems (Aarnisalo et al., 2007).

Additional legislation on traceability has been adopted in France, Spain and Greece (Regattieri et al., 2006). The requirements in European countries and from the European Union for traceability in food supply chains do not include any for the establishment of integrated systems to improve safety or how to provide end consumers with information, since they are related to food quality aspects. This means the implementation of traceability systems in each country is voluntary (Regattieri et al., 2006; Aarnisalo et al., 2007; Banterle and Stranieri, 2008), highlighting this as a subject in need of further research.

Guidelines concerning protection of consumer health and preservation of food quality were previously addressed in 1999 in *The Codex Alimentarius*, the focus of which is to ensure that consumers receive products that do not pose a threat to their health (Regattieri et al., 2006). The Codex Alimentarius Commission, under the United Nations' World Health Organisation and Food and Agriculture Organisation, has started to develop international food safety standards, incorporating traceability, in co-operation with the European Committee for Standardisation, CEN (Popper et al., 2007). These standards use the definition of traceability from the International Organisation for Standardisation (ISO): ". . . the ability to trace the history, application or location of an entity by means of recorded information" (ISO 8402:1994) (Folinas et al., 2006), or the ISO: 22000 series of Quality Management Standards (Aarnisalo et al., 2007). The following standards have been established by *The Codex Alimentarius* and CEN:

- Alimentarius CAC/GL 60-2006: Covers principles for traceability/product tracing as a tool in a food inspection and certification system.
- CWA 14659:2003: Covers traceability of fishery products based on specification of information to be recorded in farmed fish distribution chains.
- CWA 14660:2003: Covers traceability of fishery products based on specification of information to be recorded in captured fish distribution chains.
- CEN/SS CEN ISO 22005: Covers general principles for traceability in the feed and food chains.
- ISO/FDIS 22005:2007: Covers general principles and basic requirements for system design and implementation of traceability systems (Aarnisalo et al., 2007).

Furthermore, the Quality Management Standards series, ISO 22000, describes traceability as a way to harmonise differences between different sets of equivalent but conflicting standards (Popper et al., 2007). Standards in the 22000 series, which include requirements for traceability systems in a food safety management system and specify what data need to be maintained, are:

- ISO 22000:2005 Food Safety Management Systems: Requirements
- ISO 22519 Traceability Systems in the Agriculture Food Chain: General principles for design and development (Folinas et al., 2006).

There are also voluntary standards for food safety from accredited national European organisations such as AFNOR in France (Association Française de Normalization), BSI in

Great Britain (British Standard Institute) and UNI in Italy (National Standards Organisation), which has established two standards for traceability:

- UNI 10939 Traceability System in Agricultural Food Chains: General principles for design and development.
- UNI 11020 Traceability Systems in Agri-food Industries: Principles and requirements for development (Banterle and Stranieri, 2008; Regattieri et al., 2006).

The various descriptions and definitions of traceability in food supply chains in European regulations and standards highlight that no common consensus exists on the concept of traceability. But a more common consensus is important in order to initiate further traceability setups, and to understand the complete potential of traceability in food supply chains. Moreover, the existence of voluntary and non-voluntary traceability standards in different European countries shows that there is also a deficiency in the legal requirements as to what information must be provided from supply chain actors and governmental authorities to achieve traceability compliance. Knowledge about different food supply chains related to the activity or process in which the information is created or used is needed to construct strict legal requirements. This knowledge is necessary for governmental authorities as well as for actors in food supply chains, but is not frequently published in the SCM literature on traceability. One explanation is that previous research on food supply chain traceability has an industrial focus. This highlights the need of exploring traceability with a government authority focus.

3.6 Research standpoint

According to the theories provided and discussed above, there are discrepancies in current SCM theory and theory about the mapping of processes in regulated food supply chains when it comes to the integration of traceability information flows and relations between supply chain actors and a governmental authority.

Furthermore, no theory discuses food supply chain traceability with a government authority focus or any other aspects of government and industrial effects that is necessary to develop traceability in food supply chains. There is also a gap in current theory about information to be transferred in food supply chains based on governmental and industrial traceability requirements. A gap exists as well in SCM theory about the effects on operational activities and traceability information related to the application of RFID based techniques for identification and data transference.

In previously published research on food supply chain traceability there is no common consensus on the food supply chain traceability concept. This illustrates that the concept needs to be positioned and defined in an SCM as well as a science theoretical context.

4. Summary of appended papers

This chapter describes, evaluates and summarises the findings of the three appended papers. This includes the research question, the analysis method and an evaluation of research validity for each paper.

Each of the three appended papers addresses a specific research question in relation to the data collection method used, to the aspect of food supply chain traceability research investigated and to one another (see Figure 9).

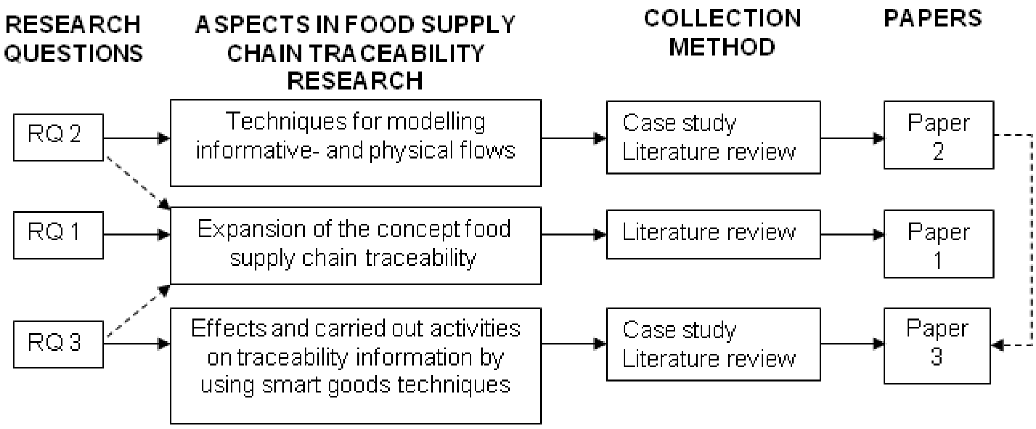

Figure 9: Relationships between research questions, collection methods, and aspects in food supply chain traceability research, and appended papers.

Paper 1 responds to the first research question on exploring the concept of food supply chain traceability from a theoretical and supply chain management perspective. This is because one of the needs highlighted from industry and academia was to position and define the concept theoretically for the creation of knowledge. The second paper responds to the second research question on finding a technique for modelling regulated fresh food supply chains according to traceability. The results expand the knowledge of food supply chain traceability and are further applied in the case study part of paper 3. The third paper explores the effects on activities carried out and on traceability information in fresh food supply chains from the usage of the RFID based smart goods technique to facilitate traceability.

4.1 Paper 1. Perspectives of food supply chain traceability

A review of previous research in SCM revealed a lack in the uniform understanding of the food supply chain traceability concept. This initiated the aim of the first paper which was to examine the theoretical position of the concept in academic scientific theory and SCM research by answering the three research questions:

- How is food supply chain traceability positioned and interpreted from a science theoretical perspective?
- What perspectives exist in food supply chain traceability?
- What are the relationships between the different perspectives found in food supply chain traceability and the objectives for improvement of traceability?

Reviews of SCM literature showed that there was no homogeneous definition of the concept food supply chain traceability, partly because of the organisational environment in which the definitions were created (Van Dorp, 2002).

Different organisations and companies have diverse objectives concerning improvement and implementation of traceability because of increase and change in demands. These objectives have been investigated in SCM literature (Furness and Osman, 2003; Golan et al., 2004; Moe, 1998; Pouliot and Sumner, 2008), and are classified into five categories according to Coff et al. (2008). The link between increased demands and the objectives is that if an objective of one actor contradicts others, this can result in further traceability demands and limitations in the whole food supply chain (Moe, 1998).

Related to the different objectives are different perspectives about important traceability needs and why the concept needs to be scientifically clarified. However, few literature reviews have been published on the subject of finding different perspectives of supply chain traceability, and those that have mainly use a business scope. This indicates that there still is a gap in research concerning different perspectives that consider the theoretical interpretation and relationships among the actors to the categorisation of objectives for improvement and implementation of traceability. The gap is also one of the reasons why the concept itself is defined in many different ways. This is because the food supply chain traceability concept depends on the scientific area of the research perspective used for investigation. Thus, it is of importance not only to investigate the concept theoretically, but also operationally.

4.1.1 Method

The research approach in the first paper is abductive, since it can be described as a learning loop between existing theories and observations in two literature reviews for finding the most suitable theory: one explorative and one structured. The explorative review looks at the scientific concepts of “paradigm”, “new paradigm business thinking”, “representational spaces”, “incommensurability” and definitions of the paradigm concept found in relevant scientific articles and books. The structured literature review examines perspectives and definitions of the concept “food supply chain traceability” depicting the current state-of-the art.

Both literature reviews were conducted using the ELIN database platform (Electronic Library Information Navigator) at Lund University which integrates information from publishers, databases and electronically printed archives. Terms and combinations of terms used for the literature search were: “food supply chain traceability*”, “traceability*”, “perspectives*”, “paradigm*”, “new paradigm thinking*”, “paradigm definitions*”, and “representational spaces*”. Two literature reviews indicated that the validity in the research was twofold: first, it stems from a comprehensive review of different definitions of food supply chain traceability and their analyses in terms of incommensurability; second, it stems from an analysis of different perspectives of food supply chain traceability found in the literature.

4.1.2 Findings

The literature reviews on food supply chain traceability confirmed that the research area is multidisciplinary between different paradigms, contains several perspectives and objectives, and that different definitions of the concept exist. This verified that the concept sometimes is difficult to understand and to use, and thus needs to be further analysed from a theoretical perspective.

Analysing food supply chain traceability from a scientific theoretical perspective revealed that the research area should be interpreted as a physical “representational space”, rather than a new paradigm in “new paradigm thinking in business” in science. The similarities between the characteristics of physical representational spaces and food supply chain traceability are: a) that both are seen as a set of related possibilities for an explanation of reality and activities, and b) that both are formed when the properties and the interrelationships between actors are interpreted in terms of the properties and relationships between actors of a food supply chain system. In addition, theories about new paradigm business thinking do not meet the Kuhn’s criterion that there is no need to repeatedly clarify and justify basic principles and assumptions of one paradigm, since these are simply taken for granted by anyone who supports the paradigm (Kuhn, 1970, p. 19).

The motivation for using new paradigm thinking varies significantly among business leaders, in terms of consistency of application as well as loyalty to new paradigm values and thinking. For example, new paradigm Darwinist and pragmatic business leaders are more focused on profit and efficiency, which make them less loyal to issues that are not profitable. This contradicts the objectives found for improvement of traceability by Coff et al. (2008): risk management and food safety, control and verification, supply chain management and efficiency, provenance and quality assurance of products, information and communication to the customer**.**

The paper presents eight different perspectives of food supply chain traceability related to the five previous stated objectives. These include perspectives of governmental control of food safety and quality, logistics, information technology, ethical, environmental and business. In addition, the paper shows that most articles are published from an information technical perspective, that they cover several perspectives and that the least explored perspectives are the environmental and ethics, leaving this as a suggestions for further research. The findings reveal that food supply chain traceability is a multidisciplinary research area which is related to and uses terms from several other scientific disciplines and paradigms.

The paper shows that the terms used in definitions of food supply chain traceability are commensurable, highlighting a gap in incommensurability between the concept and other existing and related paradigms. This supports the previous conclusion that food supply chain traceability should not be treated as a new paradigm in business, since incommensurability between paradigms is essential when treating a science as a paradigm. In addition, the paper offers a new definition of the food supply chain traceability concept: “ . . . the ability to trace the history of application, information or location of a product or group of products through all stages of production processes and distribution”.

4.1.3 Construct validity

What the structured and explorative reviews share in common are that the concepts being used are clearly identified, which affects the scale of the two reviews’ construct validity. In addition, validity is constructed in the paper through a continuous check of results by using multiple sources of evidence (Yin, 2009) and by analysing different interpretations (Kvale, 2007).

4.2 Paper 2. Traceability in the fish supply chain

The aim was to investigate different supply chain modelling techniques to answer the research question about finding a suitable technique for mapping information and physical flows in regulated fresh food supply chains due to traceability requirements.

Traceability in fresh food chains is important not only to ensure food safety and quality for consumers, but is also related to governmental regulations to ensure environmental and sustainable food production. Several studies in traceability point out that there are shortcomings and unresolved problems due to different methods for capturing and transferring information. This creates problems in the communicative interfaces between actors in food supply chains and leads to the risk of losing crucial information for the achievement of good traceability.

Supply chains can be seen as a set of processes made up of several interlinked sub-processes with critical contexts in the interfaces between the supply chain actors. Communication interfaces in food supply chains can be investigated through logistical surveys of the situation and by using process mapping techniques (Pojasek, 2005; Keller and Jacka, 1999; Matsumoto et al., 2005; Anjard, 1996). However, research shows that fresh food supply chains differ from traditional supply chains of goods (Mai et al., 2010), which means that the techniques for modelling supply chains need to be adapted to the supply chain under investigation. This is because the requirements of monitoring processes and tracing products in fresh food supply chains are higher due to the demands for low temperature, which entails short lead times without delays.

The fish industry is controlled by governmental regulations and is an industry in which food supply traceability has become of interest in the last decade. Analysing different modelling techniques that show the flow of physical goods, information, load carriers used, ownership and critical contexts between supply chain actors increases the feasibility of implementing and exploring the concept of food supply chain traceability. The results of the study contribute to research about fish supply chains and concern techniques for modelling supply chains affected by governmental regulations.

4.2.1 Method

An abductive approach consisting of a literature review and a single case study was used for the creation of theory and conclusions in the paper. The literature review comprised previous traceability initiatives and European governmental regulations related to the fish industry, and research about different techniques for process modelling.

The case studied involved the supply chains for cod, herring and crayfish because traceability has become of great importance for a selected governmental authority. The three supply chains were selected in respect to media value, potential supply chain differences or similarities, choice of primary package, and temperature.

The purpose of this part of the study was to describe the current situation in three fresh fish supply chains for further analysis of information flow, communicative interfaces and techniques for mapping supply chains affected by governmental regulations.

The results from the case study were refined through meetings with supply chain management and logistics researchers as well as with governmental professionals in the fish industry.

In these meetings, alternative modelling techniques, food supply chain traceability and flow of information were discussed in order to achieve completeness and validity of the results.

4.2.2 Findings

The literature review confirms that fish supply chains are regulated by governmental authorities and that several efforts have previously been conducted to establish traceability. What is common with these efforts is the lack of an authority focus on traceability. The paper evaluates two process modelling techniques for mapping supply chains due to legal requirements on traceability and fishing control: process mapping diagram technique, and the cause-and-effect diagram (Ishikawa diagram) technique.

The evaluations show that fresh fish food supply chains are complex due to informational interfaces between the governmental authority and the actors of the supply chain. These interfaces contain information for fulfilling the legal requirements of traceability and are hence continuously controlled by the governmental authority. The application of two different process modelling techniques for mapping the three fresh fish supply chains reveals differences and similarities between them, and that fish products are handled differently in Sweden and Denmark.

A comparison of the two process modelling techniques in the evaluation illustrates when each technique is most appropriate to use and differences between them. The cause-and-effect diagram technique is most appropriate when analysing time differences, while the process mapping diagram technique is most appropriate for analysing the physical material flow due to temperature demands in fresh supply chains. Since both time and temperature demands on material flows are important parameters for fulfilling requirements for traceability in fresh food supply chains, the paper indicates that a combination of the two modelling techniques should be used.

4.2.3 Construct validity

The concept measured in the second paper is the information flow between an authority and the actors of three fresh food supply chains for fish. This was conducted through an analysis and usage of two well-known process modelling techniques suitable for mapping supply chain flows of information and physical goods. This approach supports the third step in Kvale's craftsmanship model, "validate is to theorise" (Kvale, 2007), since the method of analysis is chosen in addition to what is investigated. The two process modelling techniques were evaluated in relation to each other and according to existing literature. The conclusion was that a combination of the two methods is the most suitable for mapping fresh food supply chains. From a construct validity perspective, this part of the paper demonstrates that the second step of Kvale's craftsmanship model, "validate is to question" (Kvale, 2007), has been considered since the different process modelling techniques were analysed in relation to different interpretations.

Finally, the first step of Kvale's three step craftsmanship model (Kvale, 2007) is achieved: that the results are continuously checked and controlled through the entire research process. This was accomplished by letting key informants review a draft of the paper and by checking the results against existing literature as multiple sources of evidence, both supporting Yin's opinion on construct validity.

4.3 Paper 3. Effects of using smart goods on traceability information and activities carried out in supply chains of fresh food

The primary aim of the paper was to investigate the effects of using the RFID based smart goods concept on traceability information and activities carried out by different actors in fresh food supply chains by answering the three research questions:

- What types of information related to the goods are valuable for achieving traceability in supply chains of fresh food?
- What type of activities do different actors of the fresh food supply chains carry out by using the traceability information?
- What are the advantages and disadvantages of traditional and smart goods based traceability systems for the supply chains of fresh food?

The capacity of smart tags on smart products to communicate with their environment in supply chains have previously been introduced and investigated from different angles in the literature (Meyer et al., 2009; Wong et al., 2002; Lumsden and Stefansson, 2007; Holmqvist and Stefansson 2006; Stefansson and Lumsden, 2009). The literature shows that most applications of smart goods techniques are conducted to increase traceability in the supply chains, and that there are advantages and disadvantages as well as willingness among supply chains actors to apply smart goods techniques in the future (Johansson and Pålsson, 2009). Reviews of SCM literature show that there is still a gap in the research on the effects of using smart goods on activities for transport goods, from upstream to downstream, in fresh food supply chains considering the special supply chain features.

One industry in which traceability has increased in importance is the fresh food industry. This is because of the inability to meet food quality demands and regulations (causing consumer health problems and economic losses for society). The undermining of eco-campaigns and liberalisation of trade are some of the consequences related to lack of appropriate traceability in fresh food supply chains.

4.3.1 Method

An abductive approach was taken in the third paper. It contains two key elements: a literature review of books, journal and conference proceeding papers, and of organisations' websites and a cross case study of three fresh food supply chains: one Swedish fish supply chain, one Danish fish supply chain and one Norwegian meat supply chain. The literature review was used in the paper as a theoretical framework of smart goods and fresh food traceability for the creation and verification of findings and results. The cases were selected because the Nordic countries are major fresh fish producers, making it easier to generalise the results, and because they use almost the same type of information for the realisation of traceability, which allows comparisons between them.

The three supply chains were also selected because they have to follow the same European regulations and respect existing food quality standards in the fresh food industry. Techniques used for transferring and the information transferred between actors in three supply chains for fresh foods were studied.

After selecting the cases, a data collection protocol was prepared and followed according to Yin (2003). This protocol included an overview of the project's objectives, field procedures, case study questions and guidelines for the case study reports.

In reference to Yin (2003), there are six sources of evidence when conducting case studies: documentation, archival records, interviews, direct observations, participant observations, and physical artefacts. In the case studies, 14 interviews were conducted in the form of oral and written responses to semi-structured questions and by using a written interview form that was filled in by the interviewees.

All verbal responses during the interviews were recorded and saved along with the written interview forms in a case study database. Interviews conducted with representatives from the three supply chains actors were considered to be a significant source of empirical data. The results from the analysis of the interviews were returned for confirmation to the interviewees.
In addition, information from documentation and archival records were collected from different actors, as well as from direct observations of supply chain operations. This information was used as additional sources of data triangulation, according to Yin (2003), resulting in cross case conclusions from the comparison of the three supply chains.

4.3.2 Findings

The empirical study of three fresh food supply chains revealed not only differences among characteristics in information systems used for traceability, but also that traceability information is valued differently by the actors. The paper presents advantages and disadvantages of a traditional information system compared with two information system based on smart goods. This comparison illustrates that the application of the smart goods concept with the capability of auto-identification has positive effects on activities conducted by different actors in fresh foods supply chains. These include activities for logistics operations, activities related to quality control of fresh food, management activities of units and resources used for transportation, and buying and selling activities. The main adverse effects found in using smart goods to achieve traceability was the high implementation costs for some of the actors.

The paper identified three categories for the classification of valuable traceability information in fresh food supply chains: product information, transportation information and item information. These categories differ in that product information is related to the impact on willingness among customers to pay for the product, transportation information contains information which is important from a shipping and material handling perspective, and item information is related to information about quality attributes for customers which is considered as a pricing factor.

4.3.3 Construct validity

The third paper is based on a cross case study where triangulation of information from documents, direct observations and written and recorded interviews were used as sources. This supports the idea that validity is constructed through the usage of multiple sources (Yin, 2009) and that results have to be continuously checked and controlled by the researcher (Kvale, 2007).

In the analysis of the interviews, the results were returned to the interviewees for confirmation, which supports that validity can be constructed if the researcher lets key informants review a draft of the paper (Yin, 2009). In addition, validity is constructed within the case study by checking the achieved results and conclusions against theories from the literature, which is completely in line with the first and third steps in Kvale's validity model (Kvale, 2007).

4.4 Summary of paper findings

A summary of the findings from the papers are presented in Table 7 in relation to each paper's research question.

Table 7: Summary of paper findings related to the research question addressed.

Paper		Research question/ paper findings
Paper 1	RQ 1	How can theory in supply chain management and scientific theory contribute to understand the concept of food supply chain traceability?
	Findings	• Food supply chain traceability is a multidisciplinary concept between paradigms with several objectives, perspectives and definitions. • Food supply chain traceability is positioned as a physical representational space, rather than paradigm according to new paradigm business thinking. • Food supply chain traceability has relations to, and borrows ideas from other paradigms and scientific disciplines. • A new definition of the concept of food supply chain traceability is proposed based on meaning incommensurability. • Supply chain literature contains eight different perspectives of food supply chain traceability, which are related to objectives previously stated in SCM literature.
Paper 2	RQ 2	How can regulated fresh food supply chains be modelled in order to facilitate analysis of traceability?
	Findings	• Fish supply chains are regulated by governmental authorities. • A cause-and-effect diagram technique is appropriate for mapping fish supply chains related to time differences. • A process mapping technique is appropriate for mapping fish supply chains related to physical material flows. • A combination of process and cause-and-effect diagram techniques should be used for mapping fish supply chains. • Differences and similarities exist between fish supply chains. • External interfaces between governmental authorities and supply chain actors exist that contain traceability information. • Fish is handled differently in Swedish and Danish fish supply chains.
Paper 3	RQ 3	How are stakeholder activities and traceability information affected in fresh food supply chains by the implementation of the smart goods concept?
	Findings	• Differences between systems for handling traceability exist in the Nordic countries. • Advantages and disadvantages exist for using traditional information systems compared with those based on smart goods. • Application of smart goods has positive effects on activities in fresh food supply chains. • Traceability activities affected in fresh food supply chains involve logistics operations, quality control, management of units and resources, and buying and selling. • Traceability information is categorised into product information, transport information and item information.

5. Analysis and discussion of results

This chapter presents an analysis and discussion of results from the papers according to the research questions and frame of reference in the thesis.

5.1 Framework of analysis

The results and analysis from each paper are further discussed according to the research questions and the frame of reference, which is presented in chapter 3. Table 8 shows the relation between research questions and sections in the frame of reference chapter.

Table 8: The relation between research questions and sections in frame of reference chapter.

Research question	Research covered	Section in chapter 3, Frame of reference
RQ 1	Food supply chain traceability definition and positioning of the concept	3.1, 3.3, 3.5
RQ 2	Exploring information flows in regulated food supply chains	3.2, 3.3, 3,5
RQ 3	Effects on activities and traceability information from using the smart goods concept	3.2, 3.4, 3.5

5.2 Food supply chain traceability definition and positioning of the concept

The legal regulatory situation regarding food supply chain traceability highlights that it is a research area that contains several firm objectives (Coff et al., 2008), perspectives and definitions. An additional literature review of the research area show that it is multidisciplinary in SCM, which relates to and borrows ideas from other scientific disciplines and paradigms; the concept of food supply chain traceability needs to be further explored according to the literature in SCM and scientific theory. This addresses the first research question:

RQ1: How can theory in supply chain management and scientific theory contribute to understand the concept of food supply chain traceability?

First, the concept of food supply chain traceability needs to be analysed, defined and positioned based on scientific theory. In this research, this covers new paradigm business thinking, representational spaces, a review of the paradigm concept and a definition analysis of the food supply chain traceability concept in accordance with meaning incommensurability. The results, using a science theoretical perspective, show that food supply chain traceability is a physical representational space rather than a new paradigm according to theories about new paradigm business thinking. The results also show that the food supply chain traceability concept has many definitions but that none are based on the philosophy of science.

Defining food supply chain traceability according to scientific theory, and by analysing different definitions based on meaning incommensurability results in the following definition. Food supply chain traceability is:

"*The ability to trace the history of application, information or location of a product or group of products through all stages of distribution and processes for production*". **

This definition is similar to that of the European Union: "Traceability means the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution" (REGULATION [EC] 178/2002 Article 3 §15). It highlights the process approach and that food supply chain traceability is a concept in SCM.

The process approach to traceability in SCM is supported by previous research which shows that food supply chain traceability is an integrating concept in SCM, covering several industrial objectives (Coff et al., 2008) and business perspectives (Van Dorp, 2002). However, such considerations raise questions concerning the existence of and relations between different objectives and additional perspectives of food supply chain traceability in the SCM literature.

One way of answering these questions is the unionist perspective for integrating and distinguishing SCM and logistics, the key processes of which have similarities with the processes for food supply chain traceability. These processes are related to layers for integrating supply chains, material, financial and information flows, processes and activities, technologies and systems, actors and organisations (Fabbe-Costes and Jahre, 2008). A unionist perspective confirms the position of food supply chain traceability as a concept within SCM that interacts with packaging logistics and logistics (Figure 10).

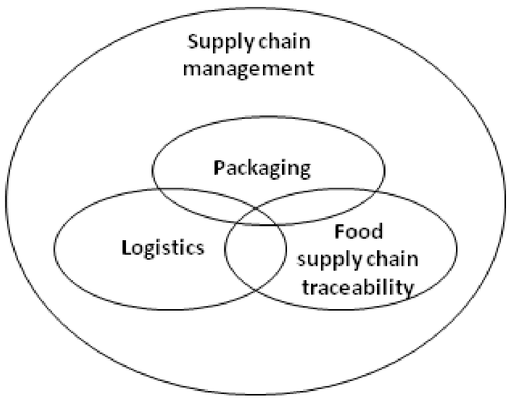

Figure 10: Food supply chain traceability as a concept within supply chain management and interactions with packaging logistics and logistics.

This is because the key processes to accomplishing traceability in food supply chains in order to meet legal requirements are similar to the key processes in the unionist perspective. Reviewing SCM literature from a unionist perspective and according to the objectives highlighted by Coff et al. (2008) shows that eight perspectives exist for the food supply chain traceability concept. These are: safety, quality, information technical, governmental, logistics, environmental, business and ethical.

** The definition slightly differs from the definition presented in paper 1 in the sence of that order among the including terms in the end of the definition has been changed.

Furthermore, analysing traceability according to the concepts of "track-and-trace" and different ways of analysing supply chain integration reveals that different approaches are used. Schwägele (2005) uses a dyadic downstream approach of the tracing concept and a dyadic upstream approach on the tracking concept; Jansen-Vullers et al. (2003) uses a dyadic approach when defining the two concepts according to traceability. The supply chain integration approach to the analysis of food supply chain traceability is dyadic, since it includes the ability to point out the position of an item in real time (i.e. tracking).

5.3 Exploring information flows in regulated food supply chains

Governmental authorities' requirements for food supply chain traceability in the European Union have emerged according to the expectations of mandatory rules. These requirements, (which went into force on 1 January 2005 through the ratification of the European General Food Law) have not only increased labelling requirements on food quality, safety and production methods, but have also given rise to the development of local governmental legislation and integrated systems for minimising business risks by improvements in control and traceability. Although many EU member states have to adopt their own legislative measures for development of traceability in fresh food supply chains, little effort has been dedicated to examining flows of information and relations between governmental authorities and different actors in regulated fresh food supply chains. According to SCM literature, various techniques exist for modelling supply chains and the choice depends on the purpose and perspective of the modelling. This is of specific relevance when modelling food supply chains, since they not only are regulated by governmental authorities but also need to have stable temperatures and often short lead times. This triggered the investigating of different process modelling techniques suitable for mapping flows of information and of physical goods, and for visualising relations, leading up to the second research question:

RQ 2: How can regulated fresh food supply chains be modelled in order to facilitate analysis of traceability?

This question was investigated by conducting a single cross case analysis of three regulated fresh supply chains for fish using two different process modelling techniques: the cause-and-effect diagram and the process mapping technique. These techniques were evaluated according to legal requirements for traceability and revealed the following:

- That the cause-and-effect diagram technique is appropriate for mapping fresh fish supply chains related to time differences.
- That the process mapping technique is appropriate for mapping fresh fish supply chains related to physical material flows.
- That both techniques are appropriate for mapping fresh fish supply chains related to requirements of control and information flows.

The model used for analysis of traceability in the three fish supply chains is illustrated in Figure 11.

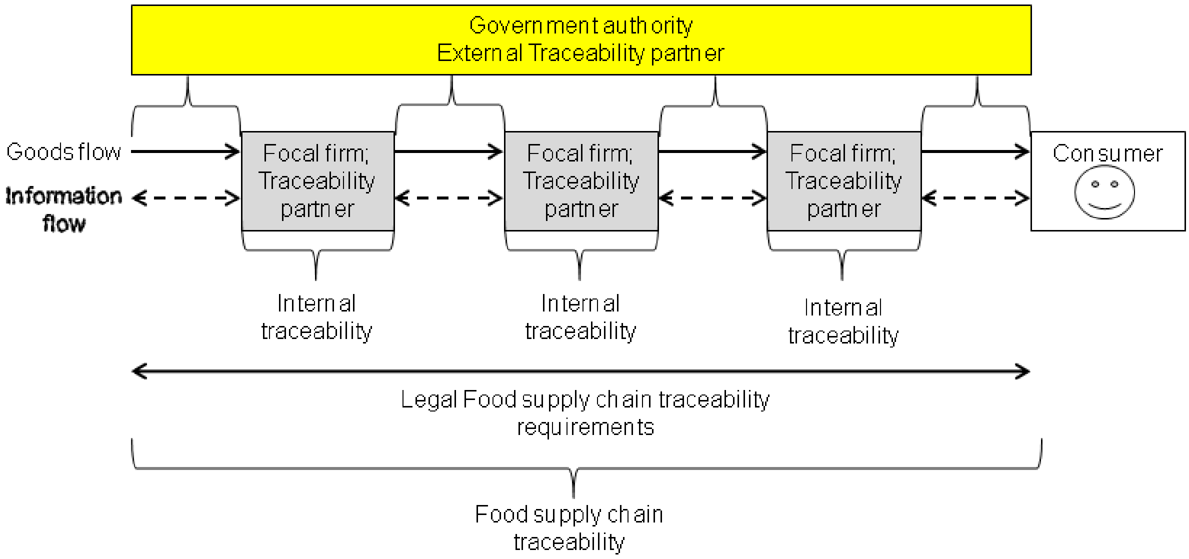

Figure 11: External and internal traceability according to demands for traceability in governmental laws and regulations (*adopted and modified from GS1, 2010, p.17).*

This model highlights that the three fish supply chains are modelled according to legal requirements for external traceability.

In addition to the results of evaluating two different supply chain modelling techniques, the empirical studies showed that similarities and differences exist between fish supply chains, and that regulated fresh fish supply chains are complex due to external information interfaces and information flows between the governmental authorities and actors of the supply chain.
The analysis of the information flows according to legal requirements for traceability, and theories about integrating information in supply chains (Fabbe-Costes and Jahre, 2008), revealed a combination of a dyadic and an extended approach. This is because the EU legal requirements definition of traceability specifies that food, feed, food producing animal or substance should be traceable through all stages of production, processing and distribution. This requires that that a product can be traced both up and downstream in information and physical flows between all actors that in one way or another are linked to the food supply chain. This includes the focal firm, focal firm customers and suppliers, and third party firms such as the customers' customers, suppliers' supplier.

A further analysis of the information flows and information interfaces showed that these contain legally required and valuable traceability information that is continuously controlled by the governmental authority throughout the entire supply chain. Valuable traceability information in fresh food supply chains was categorised (according to the results in the third paper) as production information, transport information and item information (each category includes sub-categories of information). The most valuable traceability information in the three information categories was also identified by the industry for a fresh fish food supply chain of cod (Table 9).

Table 9: Information types and valuable traceability information in a Swedish fresh fish supply chain.

Information categories	Information types related to each category	Valuable traceability information from industry
Production information	Vessel name, vessel external marketing, captain's name, fishing tackle/method, date/time (departure), date/time (arrival), date/time (landing), date of transhipment, name of receiving vessel (transhipment), nationality of receiving vessel (transhipment), identification number (logbook), productions date, packing date, best before date, landing quantity (kg), landing quantity (units), transhipment quantity (kg), transhipment quantity (units)	Vessel name Vessel external marketing Best before date Name receiver
Transportation information	Net weight (kg), batch number, lot number, name receiver, name seller, name buyer, buy off date, selling date	Name seller Name buyer
Item information	Specie denotation (English), specie denotation (Swedish), specie code, processing degree/class, size-class, freshness class, date (fishing activity), identification number, deductive bill, selling price information, temperature	Specie denotation (Swedish) Size-class Selling date

However, reviewing the European legislation and regulations on traceability information highlights that the regulations do not include specific requirements on standards to be followed for labelling and handling products, and for establishing traceability systems in food supply chains. In addition, regulatory requirements for traceability fortify relationships between larger food firms, or between firms which easily can adapt the regulations. This is because regulatory requirements for food supply chain traceability have a positive impact on larger firms, than smaller ones that do not already comply with the requirements of traceability (Popper, 2007; Schwägele, 2005).

5.4 Effects on activities and traceability information by using the smart goods concept

The identification of relations, information interfaces and flows, and physical goods flows in three fresh fish supply chains affected by European requirements for food supply chain traceability, triggered the need of further knowledge. The next step was to examine the effects on operational activities and traceability information in fresh food supply chains by using the RFID based smart goods concept. The smart goods concept, according to the literature, is gaining ground in supply chains for goods, including those for fresh food, compared to other traditional techniques, such as those based on barcode or manual paper. This led to the third research question:

RQ 3: How are stakeholder activities and traceability information affected in fresh food supply chains by the implementation of the smart goods concept?
The following model was created to identify the activities affected in fresh food supply chains due to the application of the smart goods technique (Figure 12). The model is based on literature reviews of the smart goods concept as an element in freight ITS or STM systems, and of published papers about the effects of using RFID techniques for traceability in fresh food supply chains.

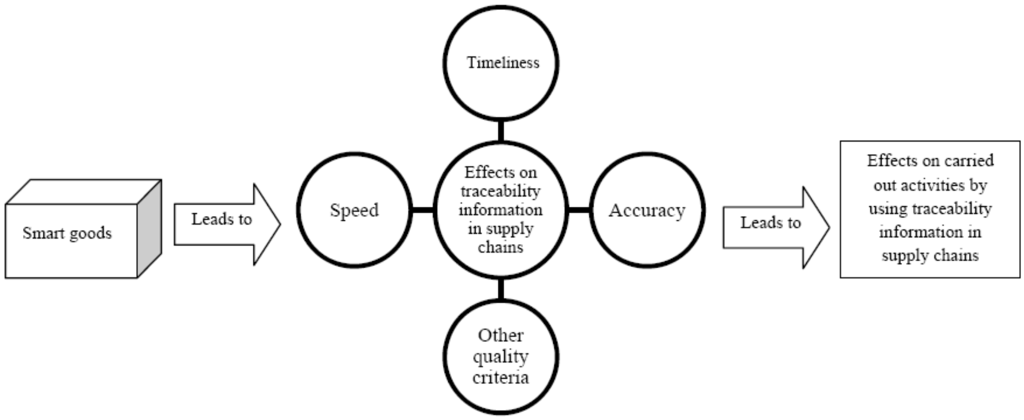

Figure 12: Analysis model to identify the effects on activities carried out using the smart goods concept to accomplish traceability in fresh food supply chains.

In the model an evaluation of the effects of smart goods concept is presented based on accuracy, timeliness and speed for exchanging traceability information.

An analysis of the empirical data collected on the external traceability of three fresh food supply chains that used two identification techniques for traceability (one meat and one fish supply chain using RFID technique, and one fish supply chain using a manual identification technique) provided a categorisation of activities affected by the smart goods concept into three groups:

- Logistics related activities: activities for logistical operations in food supply chains (i.e. tagging of goods, storage, identification and management of resources).
- Control activities: activities for asset management such as reducing missed items, and activities for control of consumer products due to governmental regulations for quality control (i.e. tracing of products related to control of safety and quality of products and reporting to governmental authorities).
- Buying-selling activities: activities related to the effects on costs for implementation of the smart goods and RFID techniques in different management and logistics operations in food supply chains for traceability (i.e. costs for using smart goods/ RFID on products, where the negative effects are related to costs for implementing traceability systems and costs for RFID tags).

The three supply chains covered were analysed according to the dyadic approach to supply chain integration. The secondary package (group package) was tagged with RFID tags and used as a traceable resource unit in the analysis. This revealed that the activities affected are related to three categories (including sub-categories) of valuable traceability information:

production information, transport information and item information. This supports previous theories about the package as a carrier of information between actors of a supply chain.

Table 10 summarises the effects on traceability information and on activities carried out when the smart goods concept is applied to traceability in two fresh food supply chains (one Norwegian meat supply chain and one Danish fish supply chain). In the table, positive or advantageous effects are marked “+” and negative or disadvantageous effects are marked “-”.

Table 10: Effects of using RFID based smart goods concept on traceability information, cost operations and activities for control and logistics in two food supply chains.

Applica-tion of smart goods concept	**Comparison of using smart goods concept in two different food supply chains**				
	Danish		Norwegian		
Supply chain actors	Producer Fishing companies	Distributor Auction, wholesaler, collecting, washing, and retailer companies	Producer Slaughtering and cutting companies	Distributor Transport companies	Customer
Affected information types	*Production, transportation, item*	*Production, transportation, item*	*Production, transportation, item*	*Production, transportation, item*	*Production, transportation, item*
Affected logistics activities	+ Easier tagging + Quicker tagging + Quicker storage + Identification of crates	+ Easier tagging + Quicker tagging + Quicker storage + Identification of crates	+ Easier tagging + Quicker tagging + Identification of crates + Less paper work and manual data acquisition	+ Easier tagging + Quicker tagging + Quicker storage + Identification of crates + Less paper work and manual data acquisition	
Affected control activities	+ Control of crates + Product quality control	+ Control of crates + Product quality control	+ Better control of crates + More secure readings + Traceability of products	+ Better control of crates + More secure readings + Traceability of products	+ Traceability of products + Preservation of product quality
Affected buying-selling activities	+ Cost reduction for tagging/ labelling + Cost reduction for crate management + Cost reduction of crates - Traceability system costs	+ Cost reduction for tagging/ labelling + Cost reduction for crate management + Cost reduction of crates - Traceability system costs	+ Cost reduction for tagging/ labelling + Cost reduction for crate management	+ Cost reduction for tagging/labelling + Cost reduction for crate management + Cost reduction of crates	

As Table 10 shows, the smart goods concept improves (i.e. has positive effects on) the supply chain actors' abilities to control and trace movements of crates to ensure product quality for end customers through received information. The table also illustrates that applying the smart goods concept to fresh food supply chains has positive effects on logistics related operations, but negative effects on buying-selling activities. These negative effects are caused by costs for implementation of traceability systems, and expenses related to the application of smart goods technique, such as costs for tags and readers.

Table 11 presents a summary of the supply chain activities affected by the application of the smart goods technique (as opposed to paper and barcode based techniques) for traceability in a Swedish regulated fresh fish supply chain for cod.

Table 11: Affected activities and traceability information at different actors in a Swedish fresh fish food supply chain based on the application of the smart goods concept.

Information Category	**Actors**				
	Producer	**1st hand receiver**	**Distributor**	**2nd hand receiver**	**Customer**
Production information	- Producing (fishing) - Landing - Goods manage-ment - Reporting to authorities	- Goods manage-ment - Reporting to authorities	- Goods manag-ment - Reporting to authorities	- Goods manag-ment	- Selection of specific producer - Creation of added values
Transport Inmforma-tion	- Labelling - Selling	- Storing - Labelling - Selling	- Labelling - Selling - Storing - Product recall	- Labelling - Selling - Storing - Product recall	
Item information	- Identify items - Cost reduction - Prove quality	- Identify items - Buying	- Identify Items - Buying - Prove quality	- Identify items - Buying - Prove quality - Creation of safer food - Creation of added values	- Quality preserva tion - Safety preserva-tion - Buying - Proving quality

Buying, selling and labelling of goods are among the affected activities presented in Table 11. The effects on these activities are related to costs for stickers used in labelling goods, which is high in a traditional paper based system compared to a smart goods RFID based system. Other identified disadvantages with the stickers are printer problems, glue residues problems from previous stickers on goods, and temperature and water problems related to goods tagging. However, among the advantages with the paper based traceability system are better usability and visibility of information. This is because a RFID based traceability system has to be combined with techniques which visualise information in an understandable way. However, among the advantages with a RFID based traceability system are more effective activities for goods management, identification, selection of a specific producer, and creation of added values.

Moreover, the results from the cross case analysis of three information systems for food supply chain traceability in two fresh food supply chains, show a structural difference between information systems in the Nordic countries. In Sweden and Norway, decentralised information systems are used (consisting of several databases at each actor that contain traceability information), while in Denmark a centralised information system is used (consisting of one central database for storing traceability information). Another result to be noted is that the information system in the Norwegian fresh food supply chain is based on the voluntary information standard, EPCIS (EPC Information Services). This enables individual actors in supply chains to determine what information and to whom they have to deliver information, preserving the individual firm's integrity. The standard also provides means for smaller or medium sized firms to deliver information at limited costs. This is important for the implementation of traceability in extended supply chain networks, like the Swedish fish industry which consists of smaller firms with limited financial margins that means they risk being marginalised as a consequence of stricter governmental regulations (Popper, 2007).

5.5 Summary of analysis

The results from the appended papers have been discussed and further analysed in reference to the literature in order to generate new knowledge. This has been conducted as follows:

Exploring information flows in regulated food supply chains. This has been analysed according to SCM literature on supply chain integration, traceability in food supply chains and literature about European governmental requirements for food supply chain traceability. Based on this, new knowledge has been generated on techniques for mapping processes in food supply chains that meet the European governmental requirements. Further knowledge has been generated about categories of traceability information, complexity in external information interfaces between a governmental authority and actors, and about differences between supply chains for fresh fish. The analysis of the traceability information flows, based on theories about supply chain integration in supply chain structures, shows that a combination of the dyadic and extended approaches for analysing integration in supply chain networks to meet legal requirements for food supply chain traceability should be used.

Effects on activities and traceability information by using the smart goods concept: This has been analysed according to accuracy, timeliness and speed for exchanging traceability information in fresh food supply chains by using the RFID based smart goods concept. New knowledge has been generated about the effects on operational activities and traceability information related to the application of RFID based techniques to accomplish traceability according to legal requirements in fresh food supply chains. Knowledge is also highlighted about centralised and decentralised systems for traceability and the effects of applying the EPCIS standards to food supply chain networks.

Food supply chain traceability definition and positioning of the concept. This has been analysed according to theories in SCM literature about different perspectives for integrating or distinguishing logistics from supply chain management. In addition, the traceability concept has been further analysed based on the concepts of “track-and-trace” in relation to different approaches for analysing supply chain integration networks. These two analyses of the food supply chain traceability concept combined with the science theoretical analysis of the concept (paper 1) have generated knowledge about how to define and position the food supply chain traceability concept according to an SCM and science theoretical approach.

6. Conclusions

The main conclusions of the thesis and appended papers are presented in this chapter. Practical implications and theoretical contributions of the research are also addressed.

The thesis explains industrial effects of food supply chain traceability for a governmental authority, according to theories of supply chain management, and governmental effects of food supply chain traceability for an industrial audience. The food supply chain traceability concept is also explained according to scientific theory.

The research results presented have a governmental and industrial focus on governmental requirements for food supply chain traceability and fishing control in the European Union. These requirements affect the structure of fresh food supply chains, making them complex as a consequence of food traceability demands on information in the interactive interfaces between a governmental authority and different supply chain actors. The structure of regulated fresh food supply chains can be analysed by applying different process modelling techniques for mapping information and physical flows. Evaluating two process modelling techniques show that the techniques often must be adapted to the food supply chain to be studied and that parameters for time and temperature have to be considered when modelling food supply chains in order to facilitate traceability according to legal requirements.

Valuable information for the traceability of products in the interfaces in fresh food supply chains is related to three categories: product information, transport information and item information. Product information affects activities for reporting information to governmental authorities and customer willingness to pay for the products. Transport information affects activities for handling and managing goods in food supply chains. Item information contains information for the identification and preservation of food quality and safety.

The challenge facing food traceability according to an SCM approach is to reconcile theories from supply chain management research with requirements for achieving food supply chain traceability in regulations from European governmental authorities. Dealing with this challenge requires a unionist perspective on integration and distinguishing logistics from supply chain management, whose key processes share similarities with the processes required for traceability in regulations and laws from European governmental authorities. These laws and regulations require integration according to the four layers of supply chain integration: integration of flows, integration of processes and activities, integration of technologies and integration relationships between actors.

The empirical studies highlight the RFID based smart goods concept for capturing and transferring traceability information. This concept has positive effects on activities for product quality and safety control and on logistics operations such as asset management and transportation in food supply chains. Negative effects of using smart goods concept are related to costs for implementation (purchasing costs and system development costs), while activities for buying and selling are equally affected. Knowledge on centralised and decentralised information systems and the effects of using the EPCIS standard in food supply chains are also highlighted.

Positioning the food supply chain traceability concept according to scientific theory shows that the concept is a physical representational space, rather than a paradigm according to theories about new paradigm business thinking.

A philosophical interpretation of the concept based on meaning incommensurability defines food supply chain traceability as:

"*The ability to trace the history of application, information or location of a product or group of products through all stages of distribution and processes for production*".

Moreover, the studies of food supply chain traceability according to an SCM approach show that eight different perspectives exists (logistical, safety and risk management, quality, information technology, governmental, business, environmental, and ethical) according to previous highlighted organisational objectives in SCM literature.

6.1 Practical implications

The research has a number of practical implications. The thesis provides guidance concerning modelling of regulated food supply chains and on the usage of the smart goods concept for traceability in food supply chains. This can be useful for governmental authorities as well as for supply chain actors to have a better image of implementing traceability in their supply chains. A presentation of the advantages and disadvantages of using traditionally paper based techniques compared with the RFID based smart goods concept for traceability can be used by managers at governmental authorities and in food supply chains as decision support in control activities and supply chain operations.

The review of literature on the legal requirements for traceability of different foods provides information about the legislation that must be considered when implementing traceability and about available voluntary guidelines to be followed by governmental authorities and companies in different food supply chains.

Studying different definitions of the food supply chain traceability concept from a science theoretical perspective provides a neutral definition of the concept. This definition can be used by industrial practitioners and academic researchers, which can affect future traceability setups in food supply chains.

6.2 Theoretical contribution

Creation of knowledge about structures in food supply chains is a basic for the implementation of traceability**.** Different techniques and methods exists in supply chain literature for illustrating and finding flows (physical, information, financial), processes and activities and technologies and systems in food supply chains. Food supply chains differs not only from each other but from traditional supply chains of ordinary goods due to strict requirements of monitoring processes, activities, temperature, and short lead times. The techniques for modelling food supply chains must, because of this, often be adapted to the food supply chain to be studied. Studying the interactive interfaces and information flows through an evaluation of two different process mapping techniques has created further knowledge methods for mapping processes due to governmental requirements on food supply chain traceability.

In addition, illustrating relationships, external information interfaces and flows between a governmental authority and actors in fresh food supply chains highlights the fact that governmental authorities are important actors in studies of food supply chain traceability.
An SCM approach on such studies expands the theoretical knowledge about integration of food supply chains according to legal requirements for food supply chain traceability, showing that a combination of a dyadic and extended approach on supply chain integration in supply chain networks should be used.

Ensuring safety and quality in fresh food supply chains is not only an important factor for costumers, companies and stakeholders in food supply chains, but also for governmental authorities and environmental organisations. Through the constitution of legal requirements and regulations, government authorities have opportunities to control supply chain operations in terms of traceability for quality and safety preservation, and the impact on living resources as a consequence of food production. The RFID based smart goods concept can be a tool to control supply chain operations due to legal and customer requirements for traceability, as well as a tool to control the effects of food production on living resources and transport operations. An additional theoretical implication is thus the application of the smart goods concept as a support in fresh food supply chain operations to achieve traceability.

Finally, the theoretical implication of a theoretical analysis, according to theories in the philosophy of science and in identifying different perspectives in the supply chain management literature, is the suggestion of further knowledge about the food supply chain traceability concept that could affect future food supply chain traceability research.

7. Further research

This final chapter suggests further research possibilities based on the results and conclusions of the research presented.

Three focus areas for future research are highlighted and described in addition to the results and conclusion about the governmental and industrial effects of legal requirements for food supply chain traceability and fishing control already presented.

1. *Focus on integrating traceability in information flows and systems*

Include research on:

- Visualisation of traceability information for end consumers and for actors in food supply chains.
- Implementation of open information standards such as the EPCIS standard, which allows all firms and organisations to meet legal requirements on food supply chain traceability, regardless of financial abilities.
- Information quality (i.e. reading and transference of errors) based on cross analysis between different information techniques.
- Smart goods concept which incorporates higher levels of functionality, such as temperature sensors and GPRS.
- Integrity due to sharing, visualisation and storing of information in food supply chains that are set by European governmental regulation on traceability.
- Tracking or tracing information within existing electronic traces in information flows and systems in food supply chains and logistical networks.
- Decisions about and needs of traceability information at levels in industrial production processes, and of customer needs of traceability information. For example, a single fish burger can contain fish from over 50 boats, which is mixed with other ingredients such as spices in the production process. On what level is it necessary and possible to secure traceability? On the finished fish burger level covering traceability information from production processes at all fishing vessels, suppliers, producers and retailers of ingredients, etc.? On the firm level? How much and what kind of quality and safety information based on legal requirements is the end customer interested in or willing to accept?
- Effects at different food supply chain actors of using traceability information to meet governmental requirements.

2. *Focus on evaluation of traceability in food supply chains*

Include research on:

- Methods, techniques and models for the evaluation of values and of created added values in food supply chains as a consequence of implementing traceability. The inescapable question here is: How do you measure quality and safety, according to legal requirements for traceability, at supply chain actors, governmental authorities and end customers?

3. *Focus on traceability in food supply chains*

Includes research on:

- Cargo theft in food supply chains due to the implementation of traceability systems.

- Effects and changes on organisational structures and routines in firms, governmental authorities and organisations as a consequence of implementing traceability in supply chains.

References

Aarnisalo, K., Heiskanen, S., Jaakkola, K., Landor, E., and Raaska, L. (2007),“Traceability of foods and foodborne hazards”, *VTT Tiedotteita – Valtion Teknillinen Tutkimusleskus no. 2395*, pp. 1-46.

Abad, E., Palacio, F., Nuin, M., Gonzalez de Zarate, A., Juarros, A., Gomez, J.M., Marco, S., (2009), “RFID smart tag for traceability and cold chain monitoring of foods: Demonstration in an intercontinental fresh fish logistic chain”, *Journal of Food Engineering*, No. 93, pp. 394-399.

Arbnor, I. and Bjerke, B. (1994), *Företagsekonomisk metodlära*, 2:a upplagan, Studentlitteratur, Lund.

Arbnor, I. and Bjerke, B. (1997), *Företagsekonomisk metodlära*, 2:a upplagan, Studentlitteratur, Lund.

Arlbjörn, J.S. and Halldórsson, A. (2002), “Logistics knowledge creation reflections on content, context and processes”, *International Journal of Physical Distribution and Logistics Management*, Vol. 32, No. 1, pp.22-40.

Aronsson, H., Ekdahl, B. and Oskarsson, B. (2003), *Modern Logistik – för ökad lönsamhet*, Liber förlag, Malmö, pp. 173-177.

Banterle, A. and Stranieri, S. (2008), ”The consequences of voluntary traceability system for supply chain relationships. An application of transaction cost economics”, *Journal of Food Policy*, No. 33, pp. 560-569.

Bechini, A., Cimino M.G.C.A., Lazzerini, B., Marcelloni, F. and Tomasi, A. (2005), “A general framework for Food Traceability”. In: Proceedings of the 2005 Symposium on Applications and the Internet Workshops (SAINT-W´05). IEEE 2005.

Bechtel, C. and Jayaram, J. (1997), “Supply chain management a strategic perspective”, *International Journal of Logistics Management*, Vol. 8, No. 1, pp.15-34.

Beekman, V. (2008), “Consumer Rights to Informed Choice on the Food Market”, *Journal of Ethic Theory Moral Practice*, Vol. 11, pp. 61–72.

Beckeman, M. And Olsson, A. (2005), “driving forces for food packaging development in Sweden – a historical perspective”, *International Journal of Food Science and technology*, Wold of Food Science.

Bessell, P.R., Shaw, D.J., Savill N. J. and Woolhouse , M.E.J.(2010), “Statistical modeling of holding level susceptibility to infection during the 2001 foot and mouth disease epidemic in Great Britain”, *International Journal of Infectious Diseases*, No. 14, pp. 210-215.

Bowersox, D.J. and Gloss, D.J. (1996), *Logistical Management: The Integrated Supply chain process*, Irwing Mcgraw-Hill, New York.

Brink, C. and Rewitzky, I. (2002), “Three dual ontologies”, *Journal of Philosophical Logic*, Vol. 31, pp. 543-568.

Burrel, G. and Morgan, G. (1979), *Sociological Paradigms and Organizational Analysis; Elements of the Sociology of Corporate Life*, 1st Edn., Heinemann Educational Books, London.

Bryman, A. and Bell, E. (2007), *Business Research Methods*, Oxford University Press, Oxford.

Chan, F.T.S., Chan, H.K. and Choy, K.L. (2006), "A systematic approach to manufacturing packaging logistics“, International Journal of Advanced Manufacturing Technology Vol. 29, No. 9-10 pp.1088–1101

Checkland, P. (1993), *Systems thinking, Systems in practice*, John Wiley & Sons, Chichester.

Churchman, C. (1968), *The systems approach*, A Delta Book, Dell publishing Co., New York.

Coff, C., Korthals, M. and Barling, D. (2008), “Ethical traceability and informed food choice”. In: Coff, C., Korthals, M., Barling, D. and Nielsen, T. (Eds.), Ethical Traceability and Communicating Food: The International Library of Environmental, Agricultural and Food Ethics, Vol. 15, Springer, Berlin, pp. 1-22.

Cooper, H. (1998), *Synthesizing research*, Vol. 2. 3rd Edn., SAGE Publications, London.

Cooper, M., Lambert, D.M. and Pagh, J.D. (1997), “Supply chain management: more than a new name for logistics”, *International Journal of Logistics Management*, Vol. 8, No. 1, pp. 1-14.

Craighead, C.W., Hanna, J.B., Gibson, B.J. and Meredith, J.R. (2003), “Research approaches in logistics trends and alternative future directions”, *The International Journal of Logistics Management*, Vol. 18, No. 1, pp. 22-40.

CSCMP – homepage http://cscmp.org/Default.asp, uploaded 2010116.

De Brito, M.P. and Van der Laan, E.A. (2008), “Supply chain management and sustainability: Procrastinating a holistic integration”, pp.1-4, Engineering Management Conference, 2008. IEMC Europe 2008. IEEE International.

Deblonde, M., De Graaff, R., and Brom, F. (2007), "An ethical toolkit for good companies: reflections on its issue", *Journal of Agricultural and Environmental Ethics*, Vol. 20, pp. 99-118.

Dominic, C., Johansson K., Lorentzon A., Olsmats C., Tiliander L., and Weström P. (2000), Förpackningslogistik, 2nd edn. PACKFORSK, Kista, Sweden

Dubois, A. and Gadde, L.E. (2002), "Systematic combining: an abductive approach to case research", *Journal of Business Research*, Vol. 55, No. 7, pp. 553-560.

Duffy, R., Fearne, A. and Healing, V. (2005), "Reconnection in the UK food chain Bridging the communication gap between food producers and consumers", *British Food Journal*, Vol. 107, No. 1, 2005, pp. 17-33.

Dunn, S.C., Seaker, R.F. and Waller, M.A. (1994), "Latent variables in business logistics research: scale development and validation", *Journal of Business Logistics*, Vol. 15, No. 2, pp. 145-73.

Eisenhardt, K.M. (1989), "Building Theories from Case study Research", *The Academy of Management Review*, Vol. 14, No. 4, pp. 532-550.

Ellram, L. (1996), "The use of the case study method in logistics research", *Journal of Business Logistics*, Vol. 17, No. 2, pp. 93-138.

EU-Lex Ingång till EU rätten available on http://eur-lex.europa.eu/sv/index.htm, uploaded 20101213.

Fabbe-Costes, N. and Jahre, M. (2008), "Supply chain integration and performance: a review of evidence", *The International Journal of Logistics management*, Vol. 19, No. 2, pp. 130-154.

Fann, K.T, "Peirce's theory of abduction" (1970), The Hague: Martinus Nijhoff Edn., Cambridge University Press.

Frederiksen, M., Osterberg, C., Silberg, S., Larsen, E. and Bremner, A. (2002), "Info-Fisk. Development and validation of an internet based traceability system in a Danish domestic fish chain", *Journal of Aquatic Food Product Technology*, Vol. 11 No. 2, pp.13-34.

Freeman, R.E. and Wicks, A.C. (1998), "Organization studies and the new pragmatism: positivism, anti-positivism, and the search for ethics", *Journal of Organizations Science*, Vol. 9, No. 2, pp. 123-140.

Forsberg, C. and Wengström, Y. (2003), *Att göra systematiska litteraturstudier – värdering analys och presentation av omvårdnadsforskning*, Första upplagan, Natur och Kultur förlag, Stockholm.

Folinas, D., Manikas, I. and Manos B. (2006),”Traceability data management for food chains”, *British food Journal*, Vol. 108, No. 8, pp. 622-633.

Furness, A. and Osman, K.A. (2003), “Developing traceability systems across the supply chain”. In: Food authenticity and traceability (M. Leeds ed.), pp. 473-495, Woodhead Publishing Limited, Cambridge.

Gammelgaard, B. (2004), “Schools in logistics research? A methodological framework for analysis of the discipline”, *International Journal of Physical Distribution and Logistics Management*, Vol. 34, No. 6, pp. 479-491.

Garver, M.S. and Mentzer, J.T. (1999), “Logistics research methods: employing structural equation modeling to test for construct validity”, *Journal of Business Logistics*, Vol. 20, No. 1, pp. 33-57.

Glaser, B.G. (1992), *Basics of Grounded theory analysis*, Sociology Press, Mill Valley, CA.

Goles, T. and Hirshheim, R. (2000), “The paradigm is dead, the paradigm is dead. . .long live the paradigm: the legacy of Burrell and Morgan”, *Omega*, Vol. 28, pp. 249-268.

GS1(2010), “GS1 Global Traceability Standard. Business Process and System Requirements for Full Supply Chain Traceability”, GS1 Global Office, Brussels Belgium.

Halldórsson, A. and Aastrup, J. (2003), “Quality criteria for qualitative inquiries in logistics”, *European Journal of Operational Research*, Vol. 144, No. 2, pp. 321-332.

Halldórsson, A., Larson P.D. and Poist, R.F. (2008), “Supply chain management a comparison of Scandinavian and American perspectives”, *International Journal of Physical Distribution and Logistics Management*, Vol. 38, No. 2, pp.126-142.

Hart, C. (1998), “Doing a literature review: Releasing the social science research imagination”, SAGE Publications, London.

Hellström, D. (2007), “On interactions between packaging and logistics – exploring implications of technological developments”, Doctoral Dissertation, Packaging Logistics, Design Sciences, Lund University, Sweden.

Holmqvist, M. And Stefansson, G. (2006), “Smart Goods and Mobile RFID-A Case With Innovation From Volvo”, Journal of Business Logistics, Vol. 27, No. 2, pp 251-272.

Hsu, Y.C.; Chen, A.P. and Wang C.H. (2008). A RFID-Enabled Traceability System for the Supply Chain of Live Fish, 2008 IEEE International Conference on Automation and Logistics, Qingdao, China, pp. 81-86

Isaksson, A. (2004), “Spårbarhet i Livsmedelskedjan”, SLI-SKRIFT 2004:3, Livsmedelsekonomiska institutet.

Jacquet, J. L. and Pauly, D. (2008), “Trade secrets: Renaming and mislabeling of seafood”, *Marine Policy*, Vol. 32, pp. 309-318.

Jahre, M. and Fabbe-Costes, N. (2005), “Adaptation and adaptability in logistics networks”, International *Journal of Logistics research and applications*, Vol. 8, No. 2, pp. 143-157.

Jansen-Vullers, M.H., Van Dorp, C.A., and Beulens, A.J.M. (2003),”Managing traceability information in manufacture”, International Journal of Information Management, Vol. 23, No. 5, pp. 395-413.

Johnsson, M. (1998), Packaging Logistics,- “A value added approach”, Doctoral thesis, Department of Engineering Logistics, Lund Institute of Technology, Lund University, Lund Sweden.

Jones, P.; Clarke-Hill, C.; Comfort, D.; Hillier, D. and Shears, P. (2005). Radio frequency identification and food retailing in the UK. In: British Food Journal, Vol. 107, No. 6, pp. 356-360.

Jones, P. and Comfort, D. (2004), “A case study of local food and its routes to the market in the UK”, *British Food Journal*, Vol. 106, No. 4, pp. 328-335.

Jönson, G., (2000). Packaging Technology for the Logistician, 2nd Edn, Lund University.

Kawas, R. (2010), “An authors guide to writing articles and reviews for educational purpose”, Elsevier, South San Francisco, CA.

Kelepouris, T., Pramatari, K. and Doukidis G. (2007), “RFID-enabled traceability in the food supply chain”, *Industrial Management and Data Systems*, Vol. 107, No. 2, pp. 183-200.

Korthals, M. (2008), “Ethical rooms for manoeuvre their prospects vis-á-vis the current ethical food policies in Europe” *Journal of Agricultural and Environmental Ethics*, Vol. 21, pp. 249-273.

Kovács, G. and Spens, K.M. (2005), “Abductive reasoning in logistics research”, International *Journal of Physical Distribution and Logistic Management*, Vol. 35, No. 2, pp. 132-144.

Kvale, S. (2007), *Doing interviews*, SAGE publications, London.

Lambert, D.M., Cooper, M.C. and Pagh, J.D. (1998), “Supply chain implementation issues and research opportunities”, *Journal of Logistics Management*, Vol. 9, No. 2, pp. 1-19.

Larsson, R. (1990) “Coordination of action in mergers and acquisitions. Interpretive and systems approaches towards synergy”, Dissertation, The institute of Economic Research, Lund Sweden, 12th Dec. 1990.

Lazzarini, S.G., Chaddad, F.R. and Cook, M.L. (2001), "Integrating supply chain and network analyses: the study of netchains", Journal on Chain and Network Science, Vol. 1, No. 1, pp.7-22.

Lilienfeld, R. (1978), *The rise of systems Theory: An ideological Analysis*, John Wiley & sons, New York.

Lindholm, M. (2008), "A sustainable perspective on urban freight transport - Factors and incentives affecting local authorities in the planning procedure", Licentiate thesis dissertation, Chalmers University of Technology, Gothenburg. Report L2008:027.

Lockamy, A., (1995), "A Conceptual Framework For Assessing Strategic Packaging Decisions", *The International Journal of Logistics Management*, Vol.6, Issue 1, pp 51-60.

Mai, N., Margeirsson, B. and Stefansson, G. (2010), "Temperature controlled transportation alternatives for fresh fish – air or sea?" In: NOFOMA proceedings of the NOFOMA-conference in Kolding, Denmark, 2010, University of Southern Denmark, Kolding, pp. 147-162.

Mears-Young, B. and Jackson M.C. (1997), "Integrated logistics – call in the revolutionaries!", *International Journal of management Science*, Vol. 25, No. 6, pp. 605-618.

Mentzer, J.T. and Flint, D.J. (1997), "Validity in logistics research", *Journal of Business Logistics*, Vol. 18, No. 2, pp. 199-216.

Mentzer, J.T. and Kahn, K. (1995), "A framework for logistics research", *Journal of Business Logistics*, Vol. 16, No. 1, pp. 231-250.

Moe, T. (1998), "Perspectives on traceability in food manufacture", *Trends in Food Science and Technology*, Vol. 9, No. 5, pp. 211-214.

Morgan, G. and Smircich, L. (1980), "The case for qualitative research", *Journal of Academy of Management Review*, Vol. 9, No. 5, pp. 211-214.

Näslund, D. (2008), "Action research: Rigorous research approach or Scandinavian excuse for consulting?", in Northern Lights in Logistics & supply chain management, J. Stentoft Arlbjörn et al. Edn., Copenhagen Business Press, pp. 99-116.

Official Journal of the European Communities, (2002), Regulation (EC) No. 178/2002 of the European Parliament and the Council of 28 January 2002.

Olander-Roese, M. and Nilsson, F. (2009), "Competitive advantage through packaging design –propositions for supply chain effectiveness and efficiency", Proceedings of the international conference of engineering design, ICED'09, Stanford, CA, U.S.A.

Olsson, A. and Skjöldebrand, C. (2008), "Risk management and quality assurance through the food supply chain – case studies in the Swedish food industry" *The open food science journal*, Vol. 2, pp. 49-59.

Phemister, A.A. (2007), "Revisiting the Principles of Free Will and Determinism: Exploring Conceptions of Disability and Counseling Theory", *Journal of rehabilitation*, Vol. 67, No. 3, pp-5-13.

Popper, D.E. (2007), "Traceability: Tracking and privacy in the food system", *Journal of Geographical Review*, Vol. 97, No.3, pp. 365-389.

Pålsson, H. (2009), "Logistics value of using data from uniquely labeled goods", Doctoral Dissertation, Packaging Logistics, Design Sciences, Lund University, Sweden.

Rábade, L.A. and Alfaro, J.A. (2006), "Buyer-supplier relationship's on traceability implementation in the vegetable industry", *Journal of Purchasing & Supply Chain Management*, No.12, pp. 39-50.

Randolph, J.J. (2009), "A guide to writing the Dissertation Literature review", Journal of Practical Assessment Research & evaluation, Vol. 14, No. 13, pp. 1-13.

Regattieri, A., Gamberi, M. and Manzini, R. (2006), "Traceability of food products: A general framework and experimental evidence", *Journal of Food Engineering*, No. 81, pp. 347-356.

Riege, A.M. (2003), "Validity and reliability tests in case study research: a literature review with "hands-on" applications for each research phase", *Qualitative Market Research: An International Journal*, Vol. 6, No. 2, pp. 75-86.

Rydebrink, P. (1993), *Verktygslådan – En sammanställning av 21 verktyg för kvalitetsarbete*, IVF-skrift 93816, Institutet för Verkstadsteknisk Forskning (IVF), Mölndal, Sweden, pp. 26-27.

Saghir, M. (2002), Packaging Logistics Evaluation in the Swedish Retail Supply Chain, Licentiate thesis dissertation, Lund University, Lund.

Saghir, M. (2004), "The concept of packaging logistics", In: Proceedings of the 15th annual POM-conference.

Searcy, D.L. and Mentzer, J.T. (2003), "A Framework for conducting and evaluating research", *Journal of Accounting Literature*, Vol. 22, No. 1, pp. 130-67.

Schwägele, F. (2005), "Traceability from a European perspective", *Journal of meat science*, No. 71, pp.164-173.

Scott, C. and Westbrook, R. (1991), "New strategic tools for supply chain management", International Journal of physical distribution and logistics management, Vol. 21, No. 1, pp. 23-33.

Senneset, G., Forås, E. and Fremme K.M. (2007), "Challenges regarding implementation of electronic chain traceability", *British Food Journal*, Vol. 109, No. 10, pp. 805-818.

Spens, K.M. and Kovács, G. (2006), "A content analysis of research approaches in logistics research", *International Journal of Physical Distribution and Logistic. Management*, Vol. 36, No. 5, pp. 375-390.

Stefansson, G. and Tilanus, B. (2001), "Tracking and tracing: principles and practice", International Journal of Services Technology and Management, Vol.2, No. 3-4, pp. 187-206.

Stentoft-Arlbjörn, J., Halldórsson, A., Jahre, M. and Spens, K. (2008), Northern lights in logistics and supply chain management (1st Edn.), pp. 99-115, Copenhagen business school press, Copenhagen, Denmark.

Stentoft, J. and Halldórsson A. (2002), "Logistics knowledge creation: reflections on the content, context and processes", *International Journal of Physical Distribution and Logistics management*, Vol. 32, No. 1, pp. 22-40.

Stevens, G.C. (1993), "Integrating the Supply Chain", *International Journal of Physical Distribution & Logistics Management*, Vol. 19, No. 8, pp. 3-8.

Stock, J.R. (1997), "Applying theories from other disciplines to logistics", *International Journal of Physical Distribution and Logistics Management*, Vol. 27, No. 9, pp.515-539.

Stock, J.R, Boyer, S.L, and Harmon, T.J. (2010), "Research opportunities in supply chain management", *Journal of the Academic Marketing Science*, Vol. 38, pp. 32-41.

Thakur, M. and Hurburgh, C.R, (2009), "Framework for implementing traceability system in the bulk grain supply chain", *Journal of Food Engineering*, Vol. 95, pp 617-626.

Thakur, M. and Donnelly, K.A.M. (2010), "Modeling traceability information in soybean value chains", *Journal of food Engineering*, Vol. 99, pp. 98-105.

Thompson, M. and Sylvia, G. (2005), "Seafood traceability in the United States: Current trends, system design and potential application", *Comprehensive Reviews Food Science and Food Safety*, Vol. 1, pp. 1-7.

Thorén, A. and Vinberg, B. (2000), *Pocket book of packaging*, Packforsk, Kista, Sweden.

Twede, D. and Parsons B. (1997), Distribution Packaging for Logistical Systems: A Literature Review. Pira, UK.

Twede, D. (1992), "The process of logistical packaging innovation" Journal of Business Logistics, Vol. 13, No- 1, pp.69-95.

Van Rijswijk, W., Frewer, L.J., Menozzi, D. and Faioli, D. “Consumer perceptions of traceability: A cross-national comparison of the associated benefits”, *Journal of Food Quality and Preference*, Vol. 19, pp. 452-464.

Verbeke, W.A.J., and Viaene, J. (2000), “Ethical challenges for livestock production: meeting consumer concerns about meat safety and animal welfare”, *Journal of Agricultural and Environmental Ethics*, Vol. 12, pp. 141-151.

Wallén, G. (1996), *Vetenskapsteori och forskningsmetodik*, andra upplagan, Studentlitteratur, Lund.

Wang, X. and Li, D. (2006), “Value Added on Food Traceability: a Supply Chain Management Approach”. In: Proceedings of the International Conference on Service Operations and Logistics, and Informatics. IEEE 2006, pp. 493-498.

Yin, R. K. (2009), Case Study Research – Design and Methods, (4^{th} ed.), SAGE Publications, Thousand Oaks, US.

Appendix 1 List of abbreviations

- ITS: Intelligent Transport systems and Services.
- RFID: Radio Frequency Identification.
- SCM: Supply Chain Management.
- Smart goods concept: combination of technologies such as RFID, GSM/GRPS, sensor for temperature and web technology.
- STM: Software transactional memory.

APPENDIX PAPER 1

PERSPECTIVES OF FOOD SUPPLY CHAIN TRACEABILITY

Henrik Ringsberg and Gunilla Jönson

Published in the reviewed proceedings of the World Conference in Transport Research (WCTR) annual conference, July 2010, Lisbon, Portugal

PERSPECTIVES OF FOOD SUPPLY CHAIN TRACEABUILITY

Henrik Ringsberg: Department of Design Sciences, Packaging Logistics, Lund University, SE-221 00 Lund, Sweden, E-mail: henrik.ringsberg@plog.lth.se, phone: +46 46 222 4042; Fax: +46 46 222 8060

Gunilla Jönson: Department of Design Sciences, Packaging Logistics, Lund University, SE-221 00 Lund, Sweden, E-mail: gunilla.jonson@plog.lth.se, phone: +46 46 222 3302; Fax: +46 46 222 8060

ABSTRACT

Purpose of this paper

Several different perspectives exist on the importance of food supply chain traceability and why it is scientifically investigated. These include the assessment of food security and quality preservation, economic, logistic, supply chain management, and information technical. Because of this, the concept of food supply chain traceability is defined in many different ways, depending on the scientific area of the research perspective used for investigation. This makes the concept and the scientific value of food supply chain traceability sometimes hard to understand theoretically. Thus, it is of great importance to position the concept theoretically and in relation to other scientific research areas. The purpose of this paper is to examine how food supply chain traceability can be theoretically positioned in academic supply chain research.

Design/methodology/approach:

The paper is based on a literature review of definitions and perspectives of food supply traceability, and of the concepts and definitions used within the paradigm thinking found in relevant scientific articles and books.

Findings:

The results show that food supply chain traceability is pre-paradigm research and further suggests that it should be treated as a "physical representational space" in scientific theory. The results also verify that food supply chain traceability is a complex research field, which is studied by using several perspectives in different research areas, especially logistics. It is

important to clarify the perspective that has been applied when making suggestions concerning logistics development.

Research limitations/implications: The literature review only includes definitions and methods for positioning food supply chain traceability from a scientific theoretical perspective. The study excludes the concepts “track-and-trace”, “internal traceability” and “external traceability”, which are used in food supply chain management.

Practical implications:
The results of this paper are useful for practitioners as well as researchers since it addresses and aims to explain the concept of food supply chain traceability from a scientific perspective. This should influence future supply chain traceability setups.

What is original/value of paper:
The paper provides an extended understanding of food supply chain traceability in relation to scientific theory in a new unique way that can influence future research in and development of the area, particularly concerning societal perspectives.

Keywords: Food supply chain traceability, scientific theory, literature study

1. INTRODUCTION

1.1 Background

Different objectives of supply chain traceability for actors in the food industry have been introduced and investigated in recent literature (Furness and Osman, 2003; Golan et al., 2004; Lindh, 2009; Moe, 1998; Pouliot and Sumner, 2008). These can be categorised into objectives for: 1) risk management and food safety, 2) control and verification, 3) supply chain management and efficiency, 4) provenance and quality assurance of products, and 5) information and communication to customers (Coff et al., 2008).

These different objectives are used to improve traceability due to increased and changed demands on food supply chains, which range from the ability to transport a diversity of food products further distances at low costs (Stadig et al., 2002), to increased customer demands about cost, quality, safety, ethical and environmental sustainability during all stages of production, packaging and transportation. : If an objective of one actor contradicts that of others, this can result in further traceability demands and limitation on the whole food supply chain (Moe, 1998).

Related to the objectives of the actors to improve traceability are different perspectives of food supply chain traceability. These include perspectives of governmental control of food safety and quality, logistics, information technology, ethical, environmental and business. An interesting area to investigate is the concept and definitions of food supply chain traceability from a scientific theoretical perspective, relating it to concepts such as paradigm, new paradigm business thinking, representational spaces and incommensurability used in scientific theory. This is because food industry companies and organisations have to face, understand and know how to use the term and concept of food supply chain when addressing traceability. The literature, however, reveals that there is no homogeneous understanding of traceability related to food in food supply chains, and that there is a gap in how the definitions of food supply traceability should be interpreted and practically used. One explanation for this is that existing definitions of food supply chain traceability are dependent on the organisational environment in which they are created (Dorp, 2002). Reviewing related literature on food supply chain traceability indicates that there still is a lack of research on different perspectives that consider the relationship among the actors to the categorisation of objectives for improvement of traceability.

The purpose of this paper is to investigate the concept and definitions of food supply chain traceability from a scientific theoretical perspective. This is achieved through a study of the literature on definitions and concepts used in scientific theory and food supply chain traceability, and of the perspectives used in food supply chain traceability. The following research questions were formulated so that the answers would achieve the purpose of the paper:

RQ1: How is food supply chain traceability positioned and interpreted from a science theoretical perspective?

RQ2: What different perspectives exist in food supply chain traceability?

RQ3: What are the relationships between the different perspectives found in food supply chain traceability and the objectives for improvement of traceability?

With the exception of the scientific theoretical perspective of food supply chain traceability already mentioned, the paper has an operational perspective on the application of an incommensurability analysis of definitions which further suggests how food supply chain traceability can be defined using scientific theory. These results can be useful for actors in the food industry as well as for other researchers in academia.

1.2 Aim

The paper has two aims: to examine the concept of traceability from a scientific theoretical perspective; and to identify and verify different perspectives of food supply chain traceability.

1.3 Limitations

The study examines the concept “traceability” in food supply chains from a theoretical perspective in science. It analyses existing definitions of food supply chain traceability in relation to the concepts of “paradigm” and “incommensurability”. It further examines perspectives for fulfilment and understanding of the concept “food supply chain traceability” and positions it in relation to the concepts “new paradigm business thinking” and “representational spaces”. Other perspectives for examining traceability in supply chains and of related terms to traceability are excluded.

2. RESEARCH METHOD

According to Yin, a research strategy can be defined as a logic sequence that links collected information to the initial research questions of the study (Yin, 2003). This means that the selection of research methodology depends on the research questions which are to be investigated (Yin, 2003; Saunders et al., 2007). This paper is theoretical and conceptual and is based on material collected from an explorative literature review of paradigm, paradigm business thinking, representational spaces, incommensurability and of different definitions of the paradigm concept.

This explorative review is complemented by a structured literature review on perspectives and definitions of food supply chain traceability depicting the current state-of-the art. The literature reviews were conducted by using the ELIN database platform (Electronic Library Information Navigator) at Lund University which integrates information from publishers, databases and electronically printed archives. Terms and combinations of the terms used for the literature search were "food supply chain traceability*", "traceability*", "perspectives*", "paradigm*", "new paradigm thinking*", "paradigm definitions*", and "representational spaces*". The validity in the research is twofold: first it stems from a comprehensive review of different definitions of food supply chain traceability and their analysis in terms of incommensurability; secondly it stems from an analysis of different perspectives of food supply chain traceability found in the literature.

However, researchers, like all human beings, are influenced by their own "nature of science" (i.e. their social background and ability to create a perception of reality when making assumptions) (Arbnor and Bjerke, 1994). One characteristic of the research approach in Nordic logistics is that researchers take highly uncertain technical and strategic tasks into consideration (Vafidis, 2007). The research approach used in this paper is abductive since it can be described as a learning loop between existing theories and empirical literature studies where inductive research processes are used for the creation of understanding, and deductive research processes are used for the creation of well-defined hypotheses and research questions for finding the most suitable theory (Kovács and Spens, 2004).

The practical processes of abductive reasoning are further investigated by Gooding and Addis (Addis et al., 2008) emphasising that hypotheses in abductive reasoning are context dependent which is in line with the chosen research method of this study.

3. FRAME OF REFERENCE

3.1 Description of the paradigm concept

Thomas Kuhn's description of paradigm is a part of his concept structure of scientific revolutions described in his book, *The Structure of Scientific Revolutions (*1962). This revolution structure model can be broken down into six chronically different phases: "pre-science", "paradigm", "normal science", "anomalies", "crisis" and ending with the "revolutionary" phase. However, before an in-depth description of the model is given, it is necessary to state what Kuhn actually meant by revolution: that every prevailing paradigm sooner or later will be replaced by a new one through a "paradigm shift".

The shift is based on a deep discontinuity (or gap) between thought and concept which is masked by language before and after the revolution (Quinn, 2001). The word "revolution" in Kuhn's model thus refers to the concept that a theoretical structure in science is abandoned and replaced by another that is incompatible with the first.

The first phase, pre-science, in Kuhn's revolutionary science model highlights the consensus if any particular theory related to the research being carried out can be considered scientific in nature. Another characteristic of the first phase is that it includes several incompatible and incomplete theories to which a researcher eventually in a widespread consensus is attracted to. This concerns the choice of methods, terminology and type of experiment for the creation of increased insight in the research field being studied. The second phase, paradigm, is then characterised by the general theoretical assumptions, laws and techniques introduced by a specific scientific community and which the researcher decides to adopt. This phase is characterised by its regulation of the standards for valid work and methods of the science which it encompasses. The paradigm phase includes the metaphysical principles that guide the work within a given paradigm (Hacking, 1983). One implication of this is that a mature science only is regulated and supported by one paradigm (Kuhn, 1996). The terms of paradigm theory and the terms of successor replacement theory do not have the same implication. On the contrary, it is important to note that Kuhn also points out that a definition of a problem in the second phase can shift between different paradigms as well as the most appropriate methods for solving problems (Kuhn, 1996). This is explained by every paradigm also viewing the world as a combination of things.

Researchers within a specific paradigm then form the third phase, normal science, in Kuhn's model. This phase illustrates the fact that as long as there is a general consensus within the chosen discipline from the second paradigm phase, the procedure of normal science will continue. According to Kuhn, it is also the existence of a paradigm that supports a tradition within normal science that differentiates science from non-science (Hacking, 1983).
Because of this, normal scientists are uncritical of the paradigm in which they work since it provides them with well-defined problems and methods. A typical normal scientist will learn the methods, standards and techniques of a certain paradigm from a senior scientist or researcher who already is experienced in the paradigm and by conducting experiments. This

means that normal scientists are unaware of the condition of the paradigm in which they are working (Hacking, 1983). On the contrary, if normal scientists would begin to accuse the paradigm of incapability when solving a specific problem, this would mean that they were simultaneously criticising themselves in the same way as a carpenter criticises his tools (Kuhn, 1996), or quoting Kuhn:

> "But only his personal conjecture is tested. If it fails the test, only his own ability not the corpus of current science is impugned. In short, though tests occur frequently in normal science, these tests are of a peculiar sort, for in the final analysis it is the individual scientist rather than the theory which is tested" (Kuhn, 1996, p.5).

This does not mean, however, that a paradigm will not have unsolved questions and difficulties, but that these will depend on the capability of the scientist to solve them. Instead, according to Kuhn, unsolved questions and difficulties within a paradigm create the fourth phase, anomalies. Some of these anomalies will always exist since when the "anomalies that signal a new paradigm arise they may be invisible to the majority of normal science adherents. And when they are encountered they may be ignored, suppressed or discredited" (Swayne, 2008, p. 91). Under certain conditions confidence in the paradigm is undermined leading into the crisis (fifth) phase of the paradigm (Kuhn, 1996).

Examples of these conditions are: a) if the anomaly attacks the foundations of the paradigm and continuously resists all elimination efforts by the normal scientists within the paradigm, b) if the paradigm is important for an urgent society need, c) in times of resistance and the trials for removing it, and d) the number of difficult anomalies existing within the paradigm. The severe test of challenging an existing paradigm is that a new conceptual framework that includes the anomalies will be needed and has to be taken seriously by other scientists (Swayne, 2008, p. 91). Forming such a conceptual framework is difficult, according to Swayne (2008), since it questions the nature of scientific authority, and considers itself "self-evident and true" without need for justification from the first principles of the paradigm being questioned (Swayne, 2008).

Another difficulty, mentioned by Kuhn in challenging a prevailing paradigm, is that psychological and historical competence is needed to identify the crisis phase within science. A state of "enounced professional insecurity" will occur when the anomalies become serious problems, characterised by increasingly radical solution efforts from the normal scientists of the paradigm. These efforts result in the rules for solving problems within the paradigm becoming vaguer and deepen the state of crisis, ending in the appearance of a competitive and alternative paradigm. It is completely different and inconsistent with the previous one in the context that all the unsolved questions from the previous paradigm are perceived as legitimate or meaningful. In the stage of competition between two paradigms there is no logical binding argument for a researcher to abandon one paradigm for another. As the crisis in a paradigm deepens due to the existence of a competitive paradigm, the final revolutionary phase of Kuhn's structure model begins.

This revolutionary phase is characterised by a crisis period of a certain duration during which an anomaly or several anomalies in research reveal weaknesses or incompatibilities in the research paradigm. This period of crisis may go on repeatedly even though it is not always good for a science to shift often or easily within paradigms (Kuhn, 1996; Chalmers, 1999). However, scientific revolutions do occur and succeed. Kuhn compares scientific revolutions with gestalt physiological transitions, religious conversions and political revolutions, and suggests that different people's ideas will be approved (Kuhn, 1996; Chalmers, 1999, Swayne, 2008). This is a also one of the difficulties with paradigm shifts, since shifting between paradigms is not just intellectual but also involves changing hearts and minds at the same time.

Paradigm theories are not only general and global by nature, a characteristic highlighted by Feyerabend who describes them as non-instantial (Feyerabend, 1977), by Laudan who describes them as maxi and global (Laudan, 1977), and by Hung who classifies them as "generic" (Hung, 1997; 2001), but they are also criticised. One reason for the criticism of Kuhn's paradigm concept is that his theories have always been contentious and perplexing. Among the critics are Sharpere and Masterman (Hung, 2001), and especially Popper, who favours a more open approach than Kuhn (Swayne, 2008). Moreover, compared with Kuhn's theories of scientific paradigms, Popper claims that "a genuine commitment to the truth gives scientists the courage to challenge the truth of particular theories, including the ones associated with a scientific paradigm" (Popper, 2002). According to Popper, scientists should do this by putting their theories to test in experiments in a similar way as politicians put their policies to test during elections, meaning that scientists must challenge and change their minds concerning scientific principles when the evidence requires it. This means that a scientific hypothesis has to be stated in a manner so it can be falsified by an experiment. For testing any type of scientific theory, Popper introduced the concept of "falsifiability" (Popper, 2002). However, both Popper and Kuhn agree that certain scientific theories can be falsified while generic theories such as Einstein's, Newton's and Aristotle's cannot, according to Kuhn (Hung, 2001).

Additionally, Kuhn's and Popper's theories are commented on by the philosopher Fueller, who states that scientist are not mentally flexible and scientific revolutions arise because "argumentation in science does more to sway uncommitted spectators...than to change the minds of the scientific principles themselves" (Swayne, 2008). Popper's theory that scientists should put their theories to experimental test is commented on by Fueller as being something that marks the distance between normal science and actual scientific practice (Fueller, 2004). Kuhn's theories of paradigm and paradigm shifts are also commented on by Hacking who points out that Kuhn has two definitions of a paradigm: 1) paradigm-as-achievement and 2) paradigm-as-set-of-shared-values. These are evaluated by Hacking, according to scientific rationality, indicating that there is nothing in Kuhn's paradigm idea that speaks against scientific rationality. Hacking further comments that it is Kuhn's concepts about shifts in paradigms that threaten scientific rationality because the gestalt switches in the concepts do not include any necessary reasoning (Hacking, 1983).

In response to the later criticism of his scientific structure model, Kuhn explained that the paradigm term represented two different concepts – "exemplar" and "disciplinary matrix" – in which the core of paradigm theory lies in the former.

In responding to criticism, Kuhn also comments that normal science and revolutions are necessary functions, among similar ones, which are used for the description of functions within scientific components. Other similar functions mentioned by Kuhn are: a) periods of normal science during which the researchers have the opportunity to develop the esoteric details in their own theories, b) when the credence of their own paradigm generates energy to solve intricate questions in the paradigm instead of discussing methods and assumptions among researchers, and c) when science is a tool in the revolutionary function of leaving one paradigm for another (Kuhn, 1996).

3.2 Definitions of paradigm

Concepts are dependent on the structure of the theory in which they exist and can be made believable if the limitations in other alternatives in which a concept is perceived are highlighted. One such alternative is that concepts acquire a purpose by means of a definition (Chalmers, 1999). Additionally, a concept is created from an initial vague thought which is gradually clarified as the concept's theory develops.

The word "paradigm" comes from ancient Greek and thanks to the scientist Thomas Kuhn has become a vogue word that is not easily defined. Vafidis (2007) mentions that there are more than 50 definitions that are related to the original source. This is also supported by Hacking in the book, Representing and Intervening – Introductory Topics in the Philosophy of Natural Science, where he states that Kuhn uses the term "paradigm" in no more than 22 different ways in his book, The Structure of Scientific Revolutions (Hacking, 1983). This criticism of Kuhn's interpretation of the paradigm concept is also confirmed by Chalmers who states that Kuhn does not provide an exact definition of the concept (Chalmers, 1999).

However, one explanation for this is that Kuhn, when using the paradigm term, was rather unclear about what components a paradigm should consist of, and how the definition should be used when interpreting the scientific process of knowledge (Arbnor and Bjerke, 1994).

Another explanation is that Kuhn saw difficulties in the processes of creating a new paradigm, if it was created for the explanation of a phenomenon. Quoting Kuhn:

> "The man who embraces a new paradigm at an early stage must often do so in defiance of the evidence provided by problem solving" (Natoli and Hutcheon, 1993, p. 386).

Examining other definitions of paradigms will not only show that different definitions of the word exist, but also the difficulties of grasping the concept of paradigms. Burrel and Morgan (1979) define paradigms as:

> "…very basic meta-theoretical assumptions which underwrite the frame of reference, mode of theorising and modus operandi of social theorists who operate within them" (Burrell and Morgan, 1979, pp. 23-24).

While Vafidis (2007), whose definition is strongly linked to Thomas Kuhn's ideas, provides the following definition:

> "In the principle, paradigms mean fundamentally different approaches to research, making it possible to communicate research results to representatives of competing paradigms. Paradigms are characteristics of a mature discipline, in which one paradigm is seen as a superior approach to the discipline and becomes dominant" (Vafidis, 2007, p.25).

Vafidis' definition is completely in line with Hacking's opinion that, "We might like to compare the merits of an old paradigm with those of a successor" (Hacking, 1983, p.12). On the contrary, Vafidis' definition contradicts Hacking's opinion of paradigms. This is because there are no logical arguments that show why one paradigm is superior to another, which would force a scientist to shift paradigms because: 1) it would be impossible for a scientist to evaluate all the benefit factors of a scientific theory; 2) scientists of competing paradigms use different norms and metaphysical principles. This means that scientists of competing paradigms see the world differently and describe it using different languages.

Finally Arbnor and Bjerke (1997) see paradigms as:

> ". . . the bridge between the starting points of ultimate presumptions and of methodological approaches" (Abnor and Bjerke, 1997, p. 12)

This above definition is based on the scientific theorist Törnblom's (1974) evolutionary view model when defining the components (i.e. conception of reality, conception of science, scientific ideas, ethical/ aesthetical aspects) (Arbnor and Bjerke, 1997). However, the definition is mainly applicable in a practical deductive research perspective, but is difficult to apply to a hypothetical deductive one. Thus the definition supports Hacking's perceptions of science, since according to him, science "is not hypothetico-deductive" (Hacking, 1983).

Arbnor and Bjerke also suggest the consistence of an operative paradigm, defined as:
" …methodological approach to a specific area of study" … which should consist of "two important parts: methodological procedure and methodic" (Abnor and Bjerke, 1997 p.16).
Other definitions of paradigms which ought to be mentioned are "a paradigm acts like a cultural grid or filter" (Burke, 2008, p. 244), "...paradigm which is defined as standard case, archetypal pattern, or central reference configuration" (Quinn, 2001, p. 31) and "... a mindset that determines, and restricts, the direction in which scientific thinking and investigation are allowed to progress" (Swayne, 2008, p. 90). What is common with these definitions is that they all describe the paradigm concept from a commensurable view (i.e. "a

grid", "a pattern", or a "mindset" are all words describing a paradigm as a "unity" within science). The many definitions of the term "paradigm" show, however, that the term is difficult to interpret in relation to incommensurability, a concept which was important for Kuhn since it concerns scientific methods and concepts (Hoyningen-Huene, 1990).

3.3 New paradigm business thinking

A concept which has caused a great deal of discussion and which is still in its early stages in business is "new paradigm business thinking" (Giacalone and Eylon, 2000). This is characterised by scientific theories and approaches that are formulated according to terms which previously were considered as unscientific and were rejected.

New paradigm thinking is characterised by a combination of ideas from different scientific disciplines: religion, biology, psychology, ecological studies, futurism, physics, and systems theory (Giacalone and Eylon, 2000). This brings different modes of knowing such as cognitive thought, emotional understanding, and intuitive recognition together with thoughts of understanding (i.e. sum of all parts vs. parts), which creates a more uniform and holistic view of reality using a collaborative, integrative, system view (Senge, 1990). Furthermore, new paradigm thinking includes a critical approach to previously accepted methodological and philosophical assumptions, and has a clear rejection of materialistic values. It tries to identify enough views of exploration for creation of understanding, building on the contributions, learning and methods from a variety of sources.

Giacalone and Eylon (2000) grouped the transforming assumptions of new paradigm thinking into three categories:

1. Individual transformation: Changes in individual assumptions among theorists who are striving to balance individual and community needs (which according to Kuhn can undermine an existing paradigm). These changes reflect shifts in how individuals interact and react to their environment when preparing for the future. The changes are also characterised by an acceptance of qualitative data, spiritual/ intuitive data and holistic approaches.

2. Social-ecological transformation: Changes in social and/ or ecological domain including societal expectations of change (opposite stability), need for learning (instead of blaming), seeking co-operation and win-win outcomes, an apparent timeline and efforts in changing others' views into a view of unity and inclusion. Social – ecological transformation is also characterised by the attempt from society to live in harmony with the environment due to a new perspective on resource usage.

3. Business transformation: Changes in how business function is valued in relation to social changes. These changes include economic balance, work life quality, social responsibility, and a change in gains from an individual to a group perspective.

The driving forces of new paradigm thinking in business are either profit or moral beliefs.

Based on these, Giacalone and Eylon mention four different types of new paradigm leaders; New Paradigm Darwinists, New Paradigm Pragmatists, New Paradigm Missionaries, and New Paradigm Humanitarians, see Figure 1.

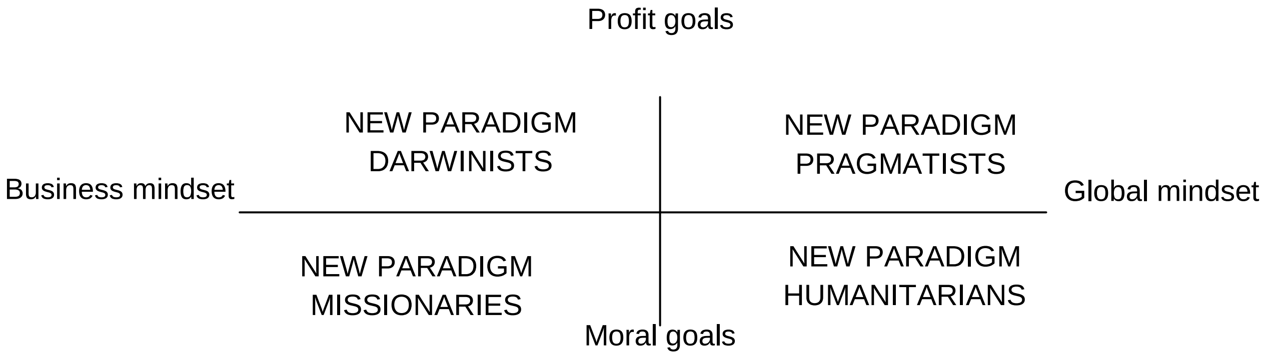

Figure 1 – Driving forces in new paradigm thinking (Giacalone and Eylon, 2000, p. 1223).

New Paradigm Darwinists are driven by profit and efficiency for organisation expansion and sees new paradigm theories as operational changes to increase organisational profit and efficiency. New Paradigm Pragmatists are driven by profit and efficiency using a global focus on resources and recognizing the interconnections between issues in social and ecological business. New paradigm theories are for understanding the interconnectedness and interdependence in the world. New Paradigm Missionaries, however, are driven by the effort to improve the quality of work life and to educate others about organisational environmental responsibility. New Paradigm Humanitarians are driven by a moral desire to improve the world from a larger perspective (building a better world vs. building better business). New Paradigm Humanitarians use new paradigm theories in relation to global uniformity despite differences and borders (cultural, national, economical, ethnic and religious) which separate people (Giacalone and Eylon, 2000).

3.4 Representational spaces

Theories in science can either be scientific or general; a theoretical scientist's aim is to correct the representation of reality. This representation takes place in two steps: 1) the construction of a generic theory or a representational space, and 2) the modelling of reality aspects by construction of theories in the representational space. A representational space is formed if the properties and interrelationships between members are interpreted in terms of the properties and relationships between the members of a system (Hung, 2001).

In scientific theory, representational spaces are interpreted as structures that provide a set of related possibilities or instruments of the mind for the explanation of reality and activities. According to Hung (2001), there are two main categories of representational spaces: a) physical representational spaces, which are characterised by the structure of the physical object, and b) symbolic representational spaces, which consist of axiomatic representational spaces (including axiomatically defined structures) and generated representational spaces (with no need of axiomatic presentation).

Furthermore, changes between different representational spaces are either theoretic developments (depending on reduction and expansion of theories) or theoretic innovations, (depending on replacement or reorganisation of theories) (Hung, 2001). Representational spaces can hence be used for:

1. Explanation of anomalies, because a representational space is neither a uniform, nor a systematic set of possibilities.

2. Explanation of regularities, because a representational space allows exceptions in explaining the replacement of one representational space with another one, viewing the regularities from the former in terms of necessities for the latter. Because of this, representational spaces are laws of nature in a similar way as laws of nature are logical consequences of representational spaces.

3. Explanation of irregularities, because irregularities in data in one representational space are seen as projection images of events of an occurring new representational space.

The theory of representational spaces is also regulated by the following three laws: 1) law-like statements that are logic statements deduced from a given representational space, 2) potential laws that are law-like statements with an empirically sufficient base, and 3) laws that are potential laws based on a representation of a real representational space.

3.5 Incommensurability

"Incommensurability" means that terms or statements of one paradigm cannot be translated into terms and statements of another. Kuhn points out that incommensurability is partial or local in his last explanation of the term, and that only specific terms and statements can be transferred between paradigms. Quoting Kuhn:

> "My claim has been that key statements of an older science, including some that would ordinarily be considered merely descriptive, cannot be rendered in the language of a later science and vice versa. By the language of a science I here mean not only the parts of that language in actual use but also all extensions that can be incorporated in that language without altering components already in place" (Kuhn, 2000, p. 55).

The terms of a paradigm do not only, according to Kuhn, form a multidimensional lexical network (Kuhn, 2000, p. 55), but also depend on their position within the network (in addition to their relationship to experience and the world). The translation of terms within the lexical framework must be homogenous with the network that formed the original terms, implying that any faithful translation of a term will maintain the structure of the multidimensional lexical network. Terms such as "mass" and "force" in Newtonian mechanics, for instance, cannot be translated into terms used in relativity since these terms are members of the lexical network of Newton's Second Law of Motion which is not applicable to the Theory of Relativity (Hung, 2001). This thought is supported by Hacking who states that "We can pass from one world or language to another by a gestalt-switch, but not by any process of understanding" (Hacking, 1983, p. 66). Hacking also classifies the word "incommensurable" into the following three categories:

1. Topic incommensurability: a successor theory may simply have forgotten successes from an older theory at the same time as it attacks different problems, uses new concepts and applications.

2. Dissociation: shifts in theory may make an older theory unintelligible to a later audience or to anyone who is willing to spend time leaning it.

3. Meaning incommensurability: philosophical meaning of terms for description of theoretical unobservable units (i.e. how theoretical units and processes get their meaning). (Hacking, 1983, pp. 67-74).

Kuhn's objective to incommensurability partly supports Wittgenstein's theories of the usage of language and paradigm (Kuhn, 1979). For Wittgenstein the meaning of a word is defined by its use in language (Wittgenstein, 1921, p. 43), which is full of mysterious concepts that cannot be bound by logical statements depending on referential objects.

4. EMPIRICAL FINDINGS

4.1 Definitions of Food supply chain traceability

Efforts in analysing the term "traceability" have previously been performed, resulting in the conclusion that there is a lack of common understanding of the term (Dorp, 2002; Lindh, 2009). What these efforts share in common is that the traceability concept has been examined though the analyses of the terms "track" and "trace", which in the literature also are considered to be the main functions in supply chain traceability (Schwägele, 2005). Table 1 lists some existing definitions of the term "traceability" used in food supply chains.

Table 1 – Definitions of food supply chain traceability.

Number	Author/ organisation	Definition
1	European Union (1998), REGULATION (EC) No. 178/2002 Article 3 §15.	"'Traceability' means the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution".
2	Liu and Ólafsdóttir, (2002).	"Traceability concerns only the ability to trace things, which means that the necessary information must be available when required" (Liu and Ólafsdóttir, 2002, p.11).
3	International Standards Organisation (ISO) (1994) ISO Quality Standards 8402:1994.	"The ability to trace the history, application or location of an entity by means of recorded information" (Folinas, 2006, p. 623).
4	International Standards Organisation (ISO) (2007) ISO Farm to Fork Traceability-ISO 22000.	"The ability to trace the history, application or location of that which is under consideration", and "When considering a product, traceability can relate to the origin of materials and parts, the processing history, and the distribution and location of the product after delivery" (Srinivasan, 2007).
5	International Standards Organisation (ISO) (2000), ISO 9001:2000, clause 3.5.4.	"The ability to trace the history, application or location of that which is under consideration" (Thompson, Sylvia, and Morrissey, 2005. p.1).
6	United Nations, Joint FAO/WHO Food Standards Programme (2007). Codex Alimentarius - Food Import and Export Inspection and Certification Systems.	"The ability to follow the movement of a food through specified stage(s) of production, processing and distribution" (World Health Organisation and Food and Agriculture Organisation of the United Nations, 2007. p.79).
7	Moe (1998).	"Traceability is the ability to track a product batch and its history through the whole, or part, of a production chain from harvest through transport, storage, processing, distribution and sales (hereafter called chain traceability) or internally in one of the steps in the chain for example the production step (hereafter called internal traceability)" (Moe, 1998. p. 211).
8	Wilson and Clarke (1998).	"Food traceability can be defined as that information necessary to describe the production history of a food crop, and any subsequent transformations or processes that the crop might be subject to on its journey from the grower to the consumer's plate" (Wilson and Clarke, 1998. p. 128).
9	Lindh (2009).	"The ability to identify history, origin, location or attributes, of an item or group of items through records held".

An examination of the above definitions of traceability in food supply chains in terms of incommensurability reveals that almost all definitions are commensurable since they include the word “ability” (except number 8), six include the word “history” (numbers 3, 4, 5, 7, 8 and 9), and definitions 1-5 use the word “trace”. This indicates that there is a uniform lexical framework for the paradigm in which food supply chain traceability exists. However, examining the definitions using topic incommensurability highlights that traceability is a multidisciplinary concept related to other disciplines such as supply chain management, production (due to the terms “production”, “product”, “distribution”, “process” in definitions 1, 4, 7, 8 and 6) and information technology (due to the terms “information” in definitions 2, 3 and 8 and “record” in 9).

Food supply chain traceability can hence be defined as “the ability to trace the history of application, information or location of a product or group of products through all stages of production, processes and distribution”. This definition also supports the conclusion that food supply chain traceability includes different objectives and perspectives, ranging from supply chain management, business, logistics to communication.

4.2 Perspectives of food supply chain traceability

Food supply chain traceability is now a matter of concern for suppliers, producers, customers and authorities. Recent outbreaks of diseases such as the bovine spongiform encephalitis (BSE) and food-and-mouth disease (Regattieri et al., 2006; Folinas et al., 2006), and discussions concerning gene-manipulated food (GMO) (Opara, 2003), the utilisation of living resources, food scandals and the increase in demands for product recalls (Senneset et al., 2007) have forced the commercial and industrial markets to build up food infrastructures for production, processing and delivering of food in which the information is traceable and controllable at each link (Furness and Osman, 2003). This resource of information has according to Coff et al. (2008) five objectives: 1) risk management and food safety, 2) control and verification, 3) supply chain management and efficiency, 4) provenance and quality assurance of products, and 5) information and communication to customers (Coff et al., 2008). Related to these five objectives of food supply chain traceability are the different perspectives that each company or organisation has to take to achieve traceability. Different perspectives on traceability in supply chains have been studied by Van Dorp (2002) by using a business scope on tracking and tracing and proposing the following four perspectives:

- The enterprise perspective: views tracking and tracing of products due to manufacturing.
- The multi-site perspective: views tracking and tracing issues for companies with several plants or manufacturers.

- The supply chain perspective: views tracking and tracing issues due to a holistic and integrative supply chain approach, which includes planning and control of materials, and efficient information flow through the complete supply chain.

- The external environment perspective: views issues for tracking and tracing of products due to existing regulations for traceability that authorities, organisations, and companies have to follow.

However, analysing different perspectives on food supply chain traceability in relation to the objectives and concerning fulfilment of food supply chain traceability reveals that the perspectives are to be extended into the following eight categories.

- Safety and risk management
- Quality
- Information technology
- Governmental
- Business
- Logistics
- Environmental
- Ethical

Table 2 shows the objectives and the different aspects in each perspective of food supply traceability found in the literature reviews.

Table 2 – Objectives, perspectives and aspects of food supply chain traceability.

OBJECTIVE according to Coff et al. (2008)	**PERSPECTIVE**		**LITERATURE**
	Perspective	**Aspect**	
Risk manage-ment and food safety	Safety	Health risks measurement and control	Trade secrets: remaining and mislabeling of seafood (Jacquet and Pauly, 2007), Traceability in agriculture and food supply chain: a review of basic concepts, technological implications and future prospects (Opara, 2002). Traceability system in a Danish domestic fresh fish chain (Frederiksen et al., 2002). Perspectives on traceability and BSE testing in U.S beef industry (Bailey et al., 2005). Traceability from a European perspective (Schwägele, 2005). One ingredient in a safe and efficient food supply (Golan et al., 2004). Traceability of foods and foodborne hazards (Aarnisalo et al., 2007). Traceability as a key instrument towards supply chain and quality management in the Belgian poultry meat chain (Viaene and Verbeke, 1998). Fuzzy traceability: a process simulation derived extension of the traceability concept in continuous food processing (Skoglund and Dejmel, 2007).
	Quality	Control	Value added on food traceability: a supply management approach (Wang and Li, 2006). One ingredient in a safe and efficient food supply (Golan et al., 2004). Traceability as a key instrument towards supply chain and quality management in the Belgian poultry meat chain (Viaene and Verbeke, 1998). Risk management and quality assurance through the Food supply chain – case studies in the Swedish food industry (Olsson and Skjöldebrand, 2008).
Control and verification	Information technical	Data capture	Traceability data management for food chains (Folinas et al., 2006). Developing traceability systems across the supply chain (Furness and Osman, 2003). Traceability system in a Danish domestic fresh fish Chain (Frederiksen et al., 2002). Traceability from a European perspective (Schwägele, 2005).
		Labelling	A RFID-enabled traceability system for the supply chain of live fish (Hsu et al., 2008). Trade secrets: remaining and mislabeling of seafood (Jacquet and Pauly, 2007). Challenges regarding implementation of electronic chain traceability (Senneset et al., 2007). Developing traceability systems across the supply chain (Furness and Osman, 2003). Traceability system in a Danish domestic fresh fish Chain (Frederiksen et al., 2002). Traceability of foods and foodborne hazards (Aarnisalo et al., 2007). Radio frequency identification and food retailing in the UK (Jones et al., 2005). RFID-enabled traceability in food supply chain (Kelepouris et al., 2007).

Control and verification	Information technical	Connectivity/ integration	Food product traceability and supply network integration (Engelseth, 2009), A RFID-enabled traceability system for the supply chain of live fish (Hsu et al., 2008). Seafood traceability in the United States: current trends, system design and potential applications (Thompson et al., 2005). Traceability data management for food chains (Folinas et al., 2006). Traceability in agriculture and food supply chain: a review of basic concepts, technological implications and future prospects (Opara, 2002). Developing traceability systems across the supply chain (Furness and Osman, 2003). Traceability of food products: general framework and experimental evidence (Regattieri et al., 2007). Traceability system in a Danish domestic fresh fish chain (Frederiksen et al., 2002). Improving information exchange in the chicken processing sector using standardised data lists (Donelly et al., 2009). Tracking and tracing: principles and practice (Stefansson and Tilanus, 1998). A general framework for food traceability (Bechini et al., 2005). The consequences of voluntary traceability system for supply chain relationships. An application of transaction cost economics (Banterle and Stranieri, 2008).
	Govern-mental	Legislative and regulatory	Seafood traceability in the United States: current trends, system design and potential applications (Thompson et al., 2005). Trade secrets: remaining and mislabeling of seafood (Jacquet and Pauly, 2007). Challenges regarding implementation of electronic chain traceability (Senneset et al., 2007). Developing traceability systems across the supply chain (Furness and Osman, 2003). Traceability of food products: general framework and experimental evidence (Regattieri et al., 2007). Tracking and tracing a structure for development and contemporary practices (Dorp, 2002). Traceability from a European perspective (Schwägele, 2005). Traceability of foods and foodborne hazards (Aarnisalo et al., 2007).
Supply chain manageme nt and efficiency	Business	Economic	Trade secrets: remaining and mislabeling of seafood (Jacquet and Pauly, 2007). Perspectives on traceability and BSE testing in U.S beef industry (Bailey et al., 2005). A transaction cost analysis of quality, traceability and animal welfare issues in UK beef retailing (Hobbs, 1996). The consequences of voluntary traceability system for supply chain relationships. An application of transaction cost economics (Banterle and Stranieri, 2008).
		Enterprise	Tracking and tracing a structure for development and contemporary practices (Dorp, 2002). Buyer-supplier relationship's influence on traceability implementation in the vegetable industry (Alfaro and Rábade, 2006).
		Multisite	Tracking and tracing a structure for development and contemporary practices (Dorp, 2002). Buyer-supplier relationship's influence on traceability implementation in the vegetable industry (Alfaro and Rábade, 2006).

Supply chain manage-ment and efficiency	Business	Legislative and regulatory	Seafood traceability in the United States: current trends, system design and potential applications (Thompson et al., 2005). Challenges regarding implementation of electronic chain traceability (Senneset et al., 2007). Developing traceability systems across the supply chain (Furness and Osman, 2003). Traceability of food products: general framework and experimental evidence (Regattieri et al., 2007). Tracking and tracing a structure for development and contemporary practices (Dorp, 2002). Traceability from a European perspective (Schwägele, 2005). Traceability of foods and foodborne hazards (Aarnisalo et al., 2007).
	Logistics	Efficiency	Tracking and tracing a structure for development and contemporary practices (Dorp, 2002). Value added on food traceability: a supply management approach (Wang and Li, 2006). Perspectives on traceability in food manufacture (Moe, 1998). One ingredient in a safe and efficient food supply (Golan et al., 2004), Traceability in the fish supply chain – evaluating two supply chain mapping techniques (Ringsberg and Lumsden, 2009). Tracking and tracing: principles and practice (Stefansson and Tilanus, 1998). Buyer-supplier relationship's influence on traceability implementation in the vegetable industry (Alfaro and Rábade, 2006). RFID-enabled traceability in food supply chain (Kelepouris et al., 2007). Fuzzy traceability: a process simulation derived extension of the traceability concept in continuous food processing (Skoglund and Dejmel, 2007). Risk management and quality assurance through the food supply chain – case studies in the Swedish food industry (Olsson and Skjöldebrand, 2008).
		Benefits	Value added on food traceability: a supply management approach (Wang and Li, 2006). Perspectives on traceability in food manufacture (Moe, 1998).Traceability of foods and foodborne hazards (Aarnisalo et al., 2007).
Supply chain manageme nt and efficiency	Information technical	Connectivity/ integration	Food product traceability and supply network integration (Engelseth, 2009).). Traceability data management for food chains (Folinas et al., 2006). Seafood traceability in the United States: current trends, system design and potential applications (Thompson et al., 2005). A RFID-enabled traceability system for the supply chain of live fish (Hsu et al., 2008). Challenges regarding implementation of electronic chain traceability (Senneset et al., 2007). Developing traceability systems across the supply chain (Furness and Osman, 2003). Traceability of food products: General framework and experimental evidence (Regattieri et al., 2007). Value added on food traceability: a supply management approach (Wang and Li, 2006). Traceability from a European perspective (Schwägele, 2005). Improving Information exchange in the chicken processing sector using standardised Data Lists (Donelly et al., 2009).). Value Added on Food Traceability: a supply management approach (Wang and Li, 2006). Traceability in the fish supply chain – evaluating two supply chain mapping techniques (Ringsberg and Lumsden, 2009). A general framework for food traceability (Bechini et al., 2005). RFID-enabled traceability in food supply chain (Kelepouris et al., 2007).
Provenance and quality assurance Of products	Environ-mental	Resource loss	Trade secrets: remaining and mislabeling of seafood (Jacquet and Pauly, 2007).
		Legal and regulatory	Tracking and tracing a structure for development and contemporary practices (Dorp, 2002). Ethical rooms for maneuvre and their prospects vis-á-vis the current ethical food policies in Europe (Korthals, 2008).

Information and communication to the customer	Environ-mental	Costumer trust	Trade secrets: remaining and mislabeling of seafood (Jacquet and Pauly, 2007).
	Ethical	Costumer trust	Food product traceability and supply network integration (Engelseth, 2009).). Ethical traceability and informed food choice (Coff et al., 2008). A transaction cost analysis of quality, traceability and animal welfare issues in UK beef retailing (Hobbs, 1996). Ethical rooms for maneuvre and their prospects vis-á-vis the current ethical food policies in Europe (Korthals, 2008). Risk management and quality assurance through the food supply chain – case studies in the Swedish food industry (Olsson and Skjöldebrand, 2008). Ethical challenges for livestock production: meeting consumer concerns about meta safety and animal welfare (Verbeke and Viaene, 2000).

Analysing food supply chain traceability from different perspectives shows that most of the articles published have an information technical perspective and that most of them also cover several different perspectives. The analysis further shows that the perspectives least yet explored are the environmental and the ethical ones in the objectives for “Provenance and quality assurance of products” and “Information and communication to the customer”.

One additional finding of the literature review on perspectives of food supply chain traceability is that the concept needs to be analysed from a theoretical perspective. This is because food supply chain traceability is multidisciplinary between several scientific paradigms, which sometimes make the concept difficult to understand and use.

Analysing food supply chain traceability from a scientific theoretical perspective also shows the ability to classify traceability as new paradigm according to new paradigm thinking in business. Some similarities are: a) traceability, as in new paradigm thinking characterised by a combination of different ideas from different scientific disciplines, b) traceability based on a uniform and holistic view of reality using a collaborative, integrative, system view, c) the incentives behind food supply chain traceability are either profit, moral but also a combination of values, and d) the traceability concept has similarities with several of the categories of new paradigm business thinking (traceability researchers strives to balance community needs, seeking co-operation and win-win solutions, live in harmony with the environment, economical balance). However, it should be noted that it is important to identify if the primary motivation is profit or moral values when determining if new paradigm concepts should be considered for food supply chain traceability. An additional, but more general, similarity between new paradigm thinking and traceability is that traceability as thought in new paradigm business thinking is a relatively young and immature concept which is difficult to define. Kuhn’s paradigm theories are because of this much better to understand as schematic theories for structuring subjects in science ranging from atoms, laws of mass and force, and even including supply chain management.

However, the motivation for using new paradigm thinking varies also significantly among business leaders, in terms of consistency of application as well as loyalty to new paradigm values and thinking. For example, New Paradigm Darwinists and Pragmatists are more focused on profit and efficiency which make them less loyal to issues which are not profitable. This shows an inconsistency within new paradigm thinking which should not be accepted by Kuhn due to his definition of a normal scientist. New paradigm thinking in business does not meet Kuhn's criterion that there is no need to repeatedly clarify and justify basic principles and assumptions of one paradigm since these are simply taken for granted by anyone who supports the paradigm (Kuhn, 1970 p.19). This is because new paradigm thinking in business formulates scientific theories and approaches in terms which previously have been considered as unscientific and or rejected.

Finally, since the terms used in definitions of food supply chain traceability are commensurable, viewing the lack in incommensurability between food supply traceability and other existing and related paradigms, food supply chain traceability should not be treated as a new paradigm in business. This since incommensurability between paradigms is an essential concept when treating a science as a paradigm. One suggestion is instead that it should be treated as a physical representational space; a) food supply chain traceability be seen as a set of related possibilities for an explanation of reality and activities, and, b) is formed when the properties and the interrelationships between members are interpreted in terms of the properties and relationships between members of a bigger food supply chain system. Treating food supply chain traceability as a representational space in scientific theory would also help scientists to explain and resist anomalies from other sciences which attack the theoretical foundations.

5. CONCLUSIONS AND SUGGESTINS FOR FURTHER RESEARCH

This paper explores different perspectives of food supply chain traceability. It examines the concept from a scientific theoretical perspective by analysing different definitions of food supply chain traceability in relation to incommensurability. This concept is especially essential in scientific theory when definitions are analysed, since every paradigm consists of its own lexical multidimensional lexical network (Kuhn, 2000 p. 55). Based on the analysis of food supply chain traceability due to incommensurability, a new definition was formed defining food supply chain traceability as:

> The ability to trace the history of application, information or location of a product or group of products through all stages of production, processes and distribution.

Secondly, the paper further positions food supply chain traceability theoretically by showing that the concept should be interpreted as a "representational space", rather than a new paradigm within "new paradigm thinking in business" within science. This is because food supply chain traceability is a multidisciplinary discipline between several paradigms with relations and terms from several other scientific disciplines and or paradigms. However, one additional finding related to the scientific analysis is that food supply chain traceability sometimes, as the paradigm concept, is difficult to understand, define, explain and use.

Finally, the paper identifies eight different perspectives of food supply chain traceability (except from the theoretical science perspective above) related to the different objectives found for improvement of traceability by Coff (Coff et al., 2008): safety, quality, information technical, governmental, business, logistics, environmental and ethical. This analysis also includes the conclusion that the perspectives in food supply chain traceability least explored are the environmental and ethical in the objectives “Provenance and quality assurance of products” and “Information and communication to the customer”, leaving these objectives as a suggestions for further research.

The results of this paper are useful for practitioners’ as well as supply chain researchers since they explain and position the concept of food supply chain traceability from a scientific perspective in a new unique way, and identify different perspectives in relation to the objectives found. The paper provides an extended understanding of the concept and of different perspectives which should influence the development of future supply chain traceability setups especially from societal perspectives.

6. ACKKNOWLEDGEMENTS

The authors wish to thanks associate professor Johannes Persson (Department of Philosophy, Lund University) for successful discussions and critical reading of the manuscript.

REFERENCES

Aanisalo, K.; Heiskanen, S.; Jaakkola, K.; Landor, E. and Raaska, L. (2007). Traceability of foods and foodborne hazards. In: VTT Tiedotteita Research notes, No. 2395. Julkaisija, Finland.

Addis, T.; Gooding D.; Visscher B.F.and Billinge D. (2008). The Abductive loop: Tracking Irrational sets, In: Springer Science Business Media, Vol. 13, pp. 5-16.

Arbnor I. and Bjerke, B. (1994). Företagsekonomisk metodlära, Andra upplagan,. Studentlitteratur, Lund.

Arbnor I. and Bjerke B. (1997), Methodology for creating Business Knowledge (2nd ed.), Sage Publications, Thousand Oaks, CA.

Bailey D.; Robb, J. and Checketts, L. (2005). Perspectives on Traceability and BSE Testing in the U.S. Beef Industry, In: Choices – The magazine of food, farm, and resource issues, No. 4, American Agriculture Economics Association, pp.493-497.

Banterle, A. and Stranieri S. (2008). The consequences of voluntary traceability system for supply chain relationships. An application of transaction cost economics. In: Journal of Food Policy, Vol. 33, pp. 560-569.

Bechini, A.; Cimino M.G.C.A.; Lazzerini, B.; Marcelloni, F. and Tomasi, A. A general framework for Food Traceability. In: Proceedings of the 2005 Symposium on Applications and the Internet Workshops (SAINT-W´05). IEEE 2005.

Burrel, G. and Morgan G. (1979). Sociological Paradigms and Organizational Analysis; Elements of the Sociology of Corporate Life (1st ed.), Heinemann Educational Books, London.

Burke, P. (2008). Paradigms lost, In: Journal of Common Knowledge, Vol. 14, No. 2. Duke University Press.

Chalmers, A.F. (1999). Vad är vetenskap egentligen (3rd ed.), pp.103-124. University of Queensland Press.

Coff, C.; Korthals, M.and Barling, D. (2008). Ethical traceability and informed food choice. In: Coff, C.; Korthals, M.; Barling, D. and Nielsen, T. (Eds.), Ethical Traceability and Communicating Food: The International Library of Environmental, Agricultural and Food Ethics, Vol. 15, Springer, Berlin, pp. 1-22.

Donelly, K.A.M.; Van der Roest, J.; Höskuldsson, S.T.; Olsen, P. and Karlsen, K.M. (2009). Improving Information Exchange in the Chicken Processing Sector Using Standard Data Lists. In: Sartori, F.; Sicilia M.Á. and Manouselis N. (Eds.), MTSR 2009, Springer, Berlin, pp.312.321.

Dorp, van K.J. (2002). Tracking and tracing: a structure for development and contemporary Practices, In: Logistics Information Management, Vol. 15, No. 1, pp. 24-33.

Engelseth, P. (2009). Food product traceability and supply network integration, In Journal of business and Industrial Marketing, Vol. 25, No. 5, pp. 421-430, Emerald Publ.

Folinas, D.; Manikas I. and Manos B. (2006), Traceability data management for food chains, In: British Food Journal, Vol. 108 No. 8 pp. 622-633.

Feyerabend, P.K. (1977). Review Articles – changing patterns of reconstruction. In: British Journal for the Philosophy of Science, Vol. 28, No. 4, pp. 351- 369.

Frederiksen, M.; Osterberg, C.; Silberg, S.; Larsen, E. and Bremmer, A. (2002). Info-Fisk. Development and Validation of an Internet Based Traceability System in a Danish Domestic Fresh Fish Chain, In: Journal of Aquatic Food Product Technology, Vol. 11, No. 2, pp. 13-34. Taylor and Francis Publ., UK.

Fueller, S. (2004). Kuhn vs. Popper: The Struggle for the Soul of Science. Columbia The Struggle for the Soul of ScienceUniversity Press.US.

Furness, A. and Osman, K.A. (2003). Developing traceability systems across the supply chain. In: Food authenticity and traceability (M. Leeds ed.), pp. 473-495. Woodhead Publishing Limited, Cambridge.

Giacalone, R.A. and Eylon, D. (2000). The Development of New Paradigm Values, Thinkers, and Business: Initial Frameworks for Changing Business Worldview, In American Behavioral Scientist, Vol. 43 No. 1217, pp. 1217 -1230.

Golan, E.; Krissoff, B. and Kuchler, F. (2004). Food Traceability: One ingredient in a Safe and Efficient Food Supply. In: Amber Waves, Vol. 2 No. 2, pp. 14-21.

Hacking I. (1983). Representing and intervening – Introductory Topics in the Philosophy of Natural Science, Cambridge University Press.

Hobbs, J.E. (1996). A transaction cost analysis of quality, traceability and animal welfare issues in UK beef retailing. In: British Food Journal, Vol. 98, No. 6, pp. 16-26.

Hoyningen-Huene, P. (1990). Kuhn's conception of incommensurability, In: Studies of Historical Philosophical Science, Vol. 21, No. 3, pp. 481-492. Pergamon Press. Great Britain.

Hung, E. H-C. (1997). The nature of science: Problems and Perspectives. Belmont, CA

Hung, E. H-C. (2001). Kuhnian paradigms as representational spaces: new perspectives on problems in incommensurability, scientific explanation, physical necessity. In: International Studies in Philosophy of Science, Vol. 15, No. 3, pp. 275-290.

Hsu, Y.C.; Chen, A.P. and Wang C.H. (2008). A RFID-Enabled Traceability System for the Supply Chain of Live Fish, 2008 IEEE International Conference on Automation and Logistics, Qingdao, China, pp. 81-86.

Jacquet, J. L. and Pauly, D. (2008). Trade secrets: Renaming and mislabeling of seafood, In: Marine Policy, Vol. 32, pp. 309–318.

Jones, P.; Clarke-Hill, C.; Comfort, D.; Hillier, D. and Shears, P. (2005). Radio frequency identification and food retailing in the UK. In: British Food Journal, Vol. 107, No. 6, pp. 356-360.

Kelepouris, T.; Pramatari, K. and Doukidis G. (2007). RFID-enabled traceability in the food supply chain. In: Industrial Management and Data Systems, Vol. 107, No. 2, pp. 183-200.

Korthals, M. (2008). Ethical rooms for maneuver their prospects vis-á-vis the current ethical food policies in Europe, In: Journal of Agricultural and Environmental Ethics. Vol. 21, pp. 249-273.

Kovács, G. and Spens K.M. (2004). Abductive reasoning in Logistics research, In: International Journal of Physical Distribution and Logistics Management, Vol. 35 No. 2, pp.132-3144.

Kuhn, T. (1996). The Structure of Scientific Revolutions (3 rd Ed.), The University of Chicago Press.

Kuhn, T. Conant J. and Haugeland J. (2000). The road since structure: philosophical essays, 1970-1993, with an autobiographical interview, The University of Chicago Press. London.

Kuhn, T. (1977). The essential tension: Selected studies in scientific tradition and change. The University of Chicago Press. London.

Laudan, L. (1977). Progress and its Problems: Towards a Theory of Scientific Growth. In: Springer 1980 Vol. 15 No. 1. Berkeley: University of California Press.

Lindh, H. (2009). Traceability in food supply chains – beyond food safety. Licentiate thesis, Lund University, Lund.

Liu, J. and Ólafsdóttir, G. (2002). Final project report: Investigation on traceability of fish products in Iceland - a traceability study for processing industry in China. Dalian Fisheries University, China.

Moe, T. (1998). Perspectives on traceability in food manufacture, In: Trends in Food Science and Technology, Vol. 9, No. 5, pp. 211-214.

Natoli, J. and Hutcheon L. (1993). A Postmodern Reader. State of New York Press, Albany

Olsson, A. and Skjöldebrand C. (2008). Risk management and Quality Assurance Through the Food Supply Chain – Case Studies in them Swedish Food Industry, In: The Open Food Science Journal, Vol. 2, pp. 49-56.

Opara, L.U. (2003). Traceability in agriculture and food supply chain: a review of basic concepts, technological implications, and future prospects, In: Journal of Food, Agriculture and Environment, Vol. 1, No. 1.

Popper, K. (2002). The logic of scientific discovery. Taylor and Francis. London.

Pouliot, S. and Sumner, D.A. (2008). Traceability, Liability and Incentives for Food safety and Quality. In: American Journal of Agricultural Economics. Vol. 90, No. 3, pp 15-27.

Rábade, L.U. and Alfaro, J.A. (2006). Buyer-supplier relationship's influence on traceability implementation in teh vegetable industry. In: Journal of Purchasing and Supply Management, Vol. 12, pp. 39-50.

Regattieri, A.; Gamberi, M. and Manzini, R. (2007). Traceability of food products: General framework and experimental evidence. In: Journal of Food Engineering, Vol. 81, pp. 347-356.

Ringsberg, H. and Lumsden, K. (2009). Traceability in the fish supply chain – evaluating two supply chain mapping techniques. In: NOFOMA proceedings of the NOFOMA-conference in Jönköping, Sweden, 2009, Jönköping international business school Jönköping University, Jönköping, pp. 695-711.

Schwägele, F. (2005). Traceability from a European perspective, In: Meat Science, Vol. 71, No.1, pp. 164-173.

Saunders, M.; Lewis P. and Thornhill A. (2007), Research Methods for Business students, (4th Ed.) Prentice Hall, Harlow.

Senge, P. (1990). The Fifth Discipline, New York: Doubleday/ Currency

Senneset, G.; Forås, E. and Fremme, K.M. (2007). Challenges regarding implementation electronic chain traceability. In: British food journal, Vol. 109, No. 10, pp.805-818.

Skoglund, T. and Dejmek P. (2007). Fuzzy traceability: A process simulation derived extension of the traceability concept in continuous food processing, In: Journal of Food and Bioproducts Processing, Vol. 85, pp.354-359.

Srinivasan, S. (2007). Farm to Fork Traceability – ISO22000. In: Frost and Sullivan Market Insight.

Stadig, M.; Berg, B.; Bergström, B.; Janson, C-G.; Karlsson, R.; Wiik, L. and Johnsson M. (2002). Spårbarhet i Livsmedelskedjan. SIK, SIK document No. 161.

Stefansson, G. and Bernhard, T. (1998). Tracking and tracing: principles and practice, In: International Journal of Technology Management. Vol. 20, No. 3-4, pp. 252-271.

Swayne, J. (2008). Truth, proof and evidence Homeopathy and the medical paradigm, In: Journal of the Faculty of Homeopathy, Vol. 97, No. 2, pp. 89-95.

Thompson, M.; Sylvia, G. and Morrissey, M. T. (2005). Seafood traceability in the United States: Current trends, system design, and potential applications, Comprehensive Reviews in Food Science and Food Safety, Vol. 1, pp. 1-7.

Wang, X. and Li, D. (2006). Value Added on Food Traceability: a Supply Chain Management Approach. In: Proceedings of the International Conference on Service Operations and Logistics, and Informatics. IEEE 2006, pp. 493-498.

World Health Organisation; Food and agriculture organisation of the United Nations. (2007). Codex Alimentarius – Food Import and Export Inspection and certification Systems (3rd Ed.). United Nations.

Quinn, M.S. (2001). Property Insurance and Paradigm Shifts, The Licensing Journal, pp. 31-32.

Vafidis, D. (2007). Approaches for knowledge and application creation in logistics. An empirical Analysis Based on Finnish and Swedish Doctorial Dissertations Published between 1994 and 2003 (Series A-3:2007), Turku School of Economics Sarja.

Viaene, J. and Verbeke W.A.J. Traceability as a key instrument towards supply chain and quality management in Belgian poultry meat chain, In: Journal of supply chain management. Vol. 3, No. 3, pp.139-141.

Verbeke, W.A.J. and Viaene J. (2000). Ethical challenges for livestock production: meeting consumer concerns about meat safety and animal welfare. In: Journal of Agricultural and Environmental Ethics. Vol. 12, pp. 141-151.

Wittgenstein, L. (1921), Tractatus logico-philosophicus,Thales 2005.

Yin, R. K. (2003), Case Study Research - Design and Methods, (3rd ed.), SAGE Publications, Thousand Oaks, US.

APPENDIX PAPER 2

TRACEABILITY IN THE FISH SUPPLY CHAIN
-EVALUATING TWO SUPPLY CHAIN MAPPING TECHNIQUES

Henrik Ringsberg and Kenth Lumsden

Published in the reviewed proceedings of the Nordic Logistics Research Networks (NOFOMA) annual conference, pp. 695-710, June 2009, Jönköping, Sweden

TRACEABILITY IN THE FISH SUPPLY CHAIN

- EVALUATING TWO SUPPLY CHAIN MAPPING TECHNIQUES

Henrik Ringsberg*

Kent Lumsden**

*) Department of Design Sciences, Packaging Logistics, Lund University, SE-221 00 Lund, Sweden
E-mail: henrik.ringsberg@plog.lth.se, Tel: +46 46 222 4042; Fax: +46 46 222 8060

**) Department of Transport and Logistics, Chalmers University of Technology,
SE-412 96 Gothenburg, Sweden.
E-mail: kenth.lumsden@chalmers.se, Tel: +46 31 772 1345; Fax: +46 31 772 1337

ABSTRACT

Purpose of this paper
The paper describes and examines the information flow in three fish supply chains, when the package is treated as an information carrier. Included is an evaluation of two supply chain mapping techniques for examining the interfaces for the achievement of better traceability and by this supply chain and logistic efficiency.

Design/methodology/approach
The research is based on a literature review and a single case study in which two different logistical mapping methods have been used in a new conceptual manner.

Findings
The paper shows that fish supply chains are complex and include interaction problems between authorities and actors in the supply chain. It identifies the importance of traceability in the fish industry from one government authority's point of view regarding existing laws and regulations. Finally two supply chain mapping techniques should be used as complements when analysing chilled supply chains for food.

Research limitations/implications
The research emphasises one case study of three supply chains for fresh fish carried out at the Swedish Board of Fisheries. The study shows the authority's point of view and excludes at present other actors' perspectives in food supply chains.

Practical implications
The two methods used are efficient ways for assessing and quantifying the potential effect of information visibility and interaction problematic in a fish food supply chain.

What is original/value of paper
The paper provides an extended understanding of interaction problems between the actors in a food supply chain and relevant authorities concerning traceability. The specific value is in the potential to improve the interfaces between authorities and commercial actors.

Keywords: supply chain management, traceability, cause-and-effect diagrams, interfaces, information**.**

1. INTRODUCTION

1.1 Background

The fish industry is a commercial industry sector in which traceability not only has become an important issue due to increased customer demands, but also a political issue of importance for authorities due to discussions about fish restrictions to guarantee environmental and sustainable fishing (Press release, 2008). Another driving force for traceability concerns securing food quality for customers. This is of particular importance for chilled food supply chains, since several studies have pointed out shortages in the distribution chain for temperature sensitive food (Björklund, 2002; Karlberg and Klevås, 2002).

Supply chains for food have also severely changed during the last years of the 19th century and the beginning years of the 20th century, from being locally to be become more globally established supply chains with decentralised and effective production and raw material chains (Thorén and Vinberg, 2000). This implicates that traceability needs to be studied from a holistic view of complete supply chains (Regulation [EC] No 178/2002). Additionally since the demands for traceability make the chains more complex (Stadig *et al.* 2002), traceability can be used as a competitive device, in which efficient supply chains compete with less efficient ones (Kim, 2006),

In modern supply chains there are several unsolved problems especially in the communication interfaces in which the information systems of different actors have to communicate with each other. This leads to the risk of losing information that is crucial for the achievement of good traceability. One way in which the communication interfaces in food supply chains can be investigated from a holistic perspective is through logistical surveys of the situation using process mapping methods (Pojasek, 2005; Keller and Jacka, 1999; Matsumoto *et al.*, 2005; Anjard, 1996). This is because a supply chain can be seen as a set of processes made up of several interlinked sub-processes with critical points in the interfaces between the actors.

This paper analyses and describes three different supply chains for chilled fish from a government authority perspective concerning traceability. It uses two supply chain mapping techniques: process mapping diagrams and modified cause-and-effect diagrams. In additional, the paper provides a brief description of traceability studies previously performed in the fish industry.

1.2 Aim

The aim of this paper is twofold: 1) to identify, visualise and analyse the critical points or the informative interfaces between the authority and the actors in chilled supply chains for fish concerning traceability 2) to evaluate two mapping techniques by analysing three different fish supply chains from a government authority's point of view.

1.3 Limitations

The study examines traceability from a Swedish government authority's perspective. It analyses three supply chains for chilled fish: one for cod, one for crayfish and one for herring. Another limitation is that the article explores traceability from information- and physical goods flow perspective where the package has a communicative function (Bowersox *et al.*, 2002; Lumsden, 2006; Thorén and Vinberg, 2000).

2. RESEARCH METHOD

2.1 Description

This paper describes an explorative study based on a literature review and a single case study performed at the Swedish Board of Fisheries during three month in the spring 2008. The case study strategy was chosen because, according to Eisenhardt (1989), "Building theory from case study research is most appropriate in the early stages of research on a topic" (Huber G.P, and Van de Ven A.H, p.87, 1995).Case studies can either be performed as single or multiple case-studies (Yin, 2009) both with advantages and disadvantages (Eisenhardt, 1989). A multiple case study was applied here since the research focus is on achieving greater depth about supply chain traceability in three different supply chains from an authority's point of view.

This can be done by adopting logistical supply chain mapping techniques. One of these techniques is the cause-and-effect diagram technique and another one is the process mapping technique.

2.2 Data Collection

The methods for collecting data in this case study were interviews and participant observations during meetings with the staff and managers at the Fish Control Division of the Swedish Board of Fisheries at the headquarters in Gothenburg. During the meetings managers as well as field staff attended who on the daily basis worked with fish-control issues. This was complemented with reviews of internal documents drawn up and discussed during some of the meetings, and information found in the literature about different supply chain mapping techniques.

The chosen data collection approach is based on recommendations by Yin (Yin, 2009) and Eisenhardt (Eisenhardt, 1989). Yin points out the sources "documentation, archival records, interviews, direct observation, participant-observation, and physical artefacts" (Yin, 2009 p.102) in particular. Eisenhardt (1989) mentions "archives, interviews, questionnaires and observations" (Eisenhardt, 1989 p.534).

The interviews were based on open-ended questions followed by open discussions with an explorative purpose to achieve a holistic view of the information flow between the authority and the actors connected to the three supply chains. After each meeting, notes were transcribed and sent to the respondents to minimising the risk of misunderstandings.

Observations performed in the case study were mainly limited to participant observations during the meetings held at the Swedish Board of Fisheries. The risk of observer impact on the process was thus minimised since the main purpose of the observations was to create an image of how the three supply chains from an information perspective work at present for finding the external information interfaces. The questions raised during the meetings were because of this mainly "how" questions, which is completely in line with that observations are suitable for performing, "experiments, historical reviews and case studies" (Yin, 2009 p. 9).

Internal documents such as internal reports, maps and procedural guidelines were later used to compare and supplement the information gained from observations and interviews.

Parameters for activity type and the time for creation of information were used to analyse the information flow in the external interfaces and were placed in relation to the physical goods flow in the three supply chains. Two different logistical supply chain mapping techniques were used to visualise the information collected from the case research: process mapping diagrams (Aronsson *et al.*, 2003), and cause-and-effect diagrams (Rydebrink, 1993).

These two supply chain mapping diagrams were then validated through open discussions in presentations held at meetings at the Swedish Board of Fisheries, and based on Yin's framework for testing case study research. (see Table 2.1.) (Yin, 2009).

Table 2.1 Framework for testing case study research (modified from Yin, 2009 p. 41).

Tests	**Definition**	**Case study tactic**	**Phase of research in which tactic occurs**
Construct validity	The degree to which collected data are free from biases.	Use multiple sources of evidence. Establish chain of evidence. Have key informants review draft case study report.	Used in the data collection procedure
Internal validity	The degree to which the findings match the subject of the question.	Do pattern matching. Do explanation building. Use logic models.	Used in the data analysis
External validity	The degree to which the findings can be generalised according to other settings similar to the ones used in the study.	Use theory in single case studies.	Used in the design of the case-
Reliability	The degree to which the findings can be replicated or reproduced by other researchers.	Use case study protocol.	Data collection

It is important to note that Yin's four-step framework is based on the positivistic belief of the existence of one single objective reality that should be studied using "objective" methods. This may lead to a mismatch between what is sought and what is going to be evaluated.

Furthermore, during visualisation and validation of the collected case study data, a gap was found between the ability to simultaneously visualise the time aspect along with the physical and information flow through the three supply chains.

This resulted in the creation and application of a modified version of the cause-and-effect supply chain mapping technique, which combined the two techniques already in use. In the combination of the two techniques the symbols in process mapping were combined with the central importance of time from the cause-and-effect diagram technique.

3. REVIEW OF TRACEABILITY IN THE FISH INDUSTRY

The fish industry is a commercial food sector in which traceability has become a legal and commercial necessity (Børresen, 2003). This as an effect of increased global trading and the lack of internationally established and applied standards, which have obstructed the identification of origin, history, processes for reclaiming products, and transmission of specific fish product information to customers.

As a result, there are several different efforts to establish traceability in fish supply chains in Japan (Hashimoto *et al.,* 2003), in Canada and Denmark (Frederiksen *et al.,* 2002), in Scotland and on the Shetland Islands (MacDubhghaill, 2000). Efforts have also been initiated and funded by the EU. These are divided into projects, such as "Tracefish", and the issuing of directives and regulations for increased fish control.

3.1 The Tracefish Project

The Traceability of Fish Products Project (Tracefish) was an attempt to establish a traceability system funded by the European Union from 2000 to 2002. The project was structured as a consortium with members from institutes, export, import- and process industries and co-ordinated by the Norwegian Institute of Fisheries and Aquaculture. The aim of the project was to indentify information requirements and to produce voluntary standards for electronic data collection, distribution and transference of traceability information. Another aim was to gather companies and institutes to create a uniform view of how and what type of information should follow a fish product through the entire supply chain from the producer to the consumer (Derrick and Dillon, 2004) (www.tracefish.org).

The project resulted in a number of voluntary standards for handling production chains and information in data transference protocols for fish. This voluntary standard constitutes the body of the European standard for traceability which was accepted by the European Committee for Standardization (CEN) in 2005 (Thomsson and Sylvia, 2005).

3.2 European directives and regulations for increased fish control

According to European Regulation 1998/2006, every EU member state has to produce a strategic plan and an operational program for the development of the food industry between 2007 and 2013 (Regulation [EC] No 1198/2006).

This task includes an extra campaign for information interchange, which for the fish industry includes an advanced registration of four hours for some fish species prior to activity when the fish is brought ashore. This is to increase the ability to control the number and type of species being fished (Regulation [EG] No 1966/2006).

Furthermore, an additional European directive which can be linked to traceability in the fish industry is European Directive 2005/2006:171. It states that information about catchment and landing position must be specified for fishing in the European Union (Directive 2005/2006:171).

4. FRAME OF REFERERENCE

There are several techniques which can be used to analyse and map supply chains. In this article, two supply chain mapping techniques, cause-and-effect diagrams and process mapping diagrams, have been used in the analysis of three supply chains for chilled fish. The study has been performed from an informative perspective on traceability examining the information that flows and the informative barriers between an authority and the actors relatively to time and flow of goods. This since supply-chain consists of flows of materials and products of production and distribution processes which flows in a direction that is contrary to the direction of information flow (Scott and Westbrook, 1991).

4.1 Cause-and-effect diagrams (Ishikawa diagram)

Cause-and-effect diagrams, Ishikawa diagrams, or fishbone diagrams, structure the primary and secondary causes of a specific problem. The method was originally introduced in the 1960s by the Japanese management professor Kaoru Ishikawa at the Kawasaki shipyards (Rydebrink, 1993) (Hankins, 2001). In such a diagram, the main problem is visualised as a central horizontal line from which additional causes are linked and visualised as connected lines or "bones". These bones are drawn to the left giving the diagram a fish skeleton like layout (which is why Ishikawa diagrams are also called fishbone diagrams).

One of the strength of visualising an identified problem as a cause-and-effect diagram is that the technique reveals key relationships between different variables and provides insight into the behaviour of the process studied. When identifying the causes (usually through brainstorming) to be visualised in an Ishikawa diagram, it is important to note that they have to be specific, measureable and controllable. In this case study, the cause-and-effect diagrams utilised are a combination of an Ishikawa diagram and a process mapping diagram.

4.2 Process mapping

The second method used to examine the physical and informative flow in the supply chains for fish is a process mapping diagram technique (Aronsson *et al.*, 2003). The method centres on the physical material with symbols for activities, storages, flow of information, documents and decision points. However, it is mentioned that process mapping can be performed in greater or lesser detail with more detailed symbols in some occasions. Furthermore is one of the strengths with process mapping that the method identifies strengths or weaknesses within the supply-chain being mapped. Another method for mapping supply-chains is through the use of tools for lean production. This since lean production and logistics is a wide concept which consists of a variety of tools and techniques. Furthermore lean production and logistics aims at declining costs, zero defects, zero inventories, endless product variety, pull instead of push processes, waste elimination and short order cycles. Tools for reaching these objectives are for example Kaizen zero defects, Just-in-time supply systems, Kanban, and Processed teamwork. Additionally to this the benefits of using lean production tools are experienced and well documented.

In this study, however, the tools for lean production have not been used since one of the purposes was to identify, visualise and examine the interfaces for traceability from an authority point of view. The tools for lean production will instead be used in further articles on the subject.

5. EMPIRICAL FINDINGS

5.1 Case description

The Swedish Board of Fisheries was chosen because it was a governmental authority for which traceability has become an important issue. This entity is responsible for the preservation and use of Sweden's fish resources, comes under the Ministry of Agriculture. The Board of Fisheries contributes to international efforts concerning fish issues and negotiations in the EU, prepares legislation and long-term administration plans for guaranteeing ecologically sustainable and environmentally adapted fishing and the usage of water resources, and finally carries out research on fish, fish care, and in the development of new fishing methods and fish equipment. The Board is also responsible for comprehensive fishery control in Sweden (www.fiskeriverket.se). It is from this approach and from the perspective of importance for a governmental authority that traceability has been examined in this case study.

Traceability in the fish industry is an interesting topic since it involves products which are temperature sensitive especially in relation to time.

There are additional reasons for traceability, such as increased demands on the industry and authorities related to legislation, recent food scares and increased customer demands.

The case study included three different types of supply chains, which were chosen in respect to authority interest, media value, potential differences or similarities between the supply chains, choice of primary package (i.e. fish tray and batch/"bigbox"), and choice of temperature (i.e. that they have to be chilled). The three supply chains selected were for cod, herring and crayfish. The physical flow was mainly examined from an information perspective to find and further analyse the external technical communicative interfaces between the authority and the different actors in the three physical supply chains. This was accomplished by using two supply chain mapping techniques described.

5.2 Interpretation of modified cause-and-effect diagrams

Description of the cod and crayfish supply chains

The fish supply chain processes for cod and crayfish as being very similar illustrated (Figure 5.1), using the modified cause-and-effect diagram technique. The numbers in parentheses in the following description refer to the corresponding circled numbers of items in the diagram. The process starts with the fisherman being required to send in an effort report to the Board of Fisheries before he goes out fishing (1). This report includes information such as type of fish which will be fished, number of already completed and planned fishing days and where the fishing activity will approximately take place. Then the fishing activity (2) starts in which the fisherman puts out and collects his nets, or drag nets, and weighs the complete contents.

This weight, combined with information about the exact position of the fishing activity, number of fishing days and type of fish that have been caught are recorded in a log which is sent to the Board of Fisheries (3). The number of fishing days in the log is compared to the ones reported in the effort report (4).

The process continues with the caught fish being sorted, placed in fish trays with ice and weighed on the boat (5). The weight information is sent to the Board of Fisheries in an announcement report (6). The next step is the landing activity, where the caught and sorted fish are moved from boat to shore (7).

The catchment brought ashore is then weighed. In this process the "nomial" weight is used for cod and crayfish that are landed in Denmark. The responsibility for weighing the fish brought ashore in Sweden, however, is the shipper's (8). The estimated weight information is then entered in a landing declaration (9), which is sent in to the Board of Fisheries within 48 hours of landing. The reported weight information in the landing declaration is then checked (10) against information previously reported in the log (3) for the fishing effort, followed by checking the fishing position (11) according to the effort document (1) sent in at the beginning of the fishing process.

When controlling the landed volume (i.e. by comparing the weight reported in the log for the fishing effort with the weight in the landing declaration), a volume reduction of 8% for cod and crayfish is allowed due to water loss.

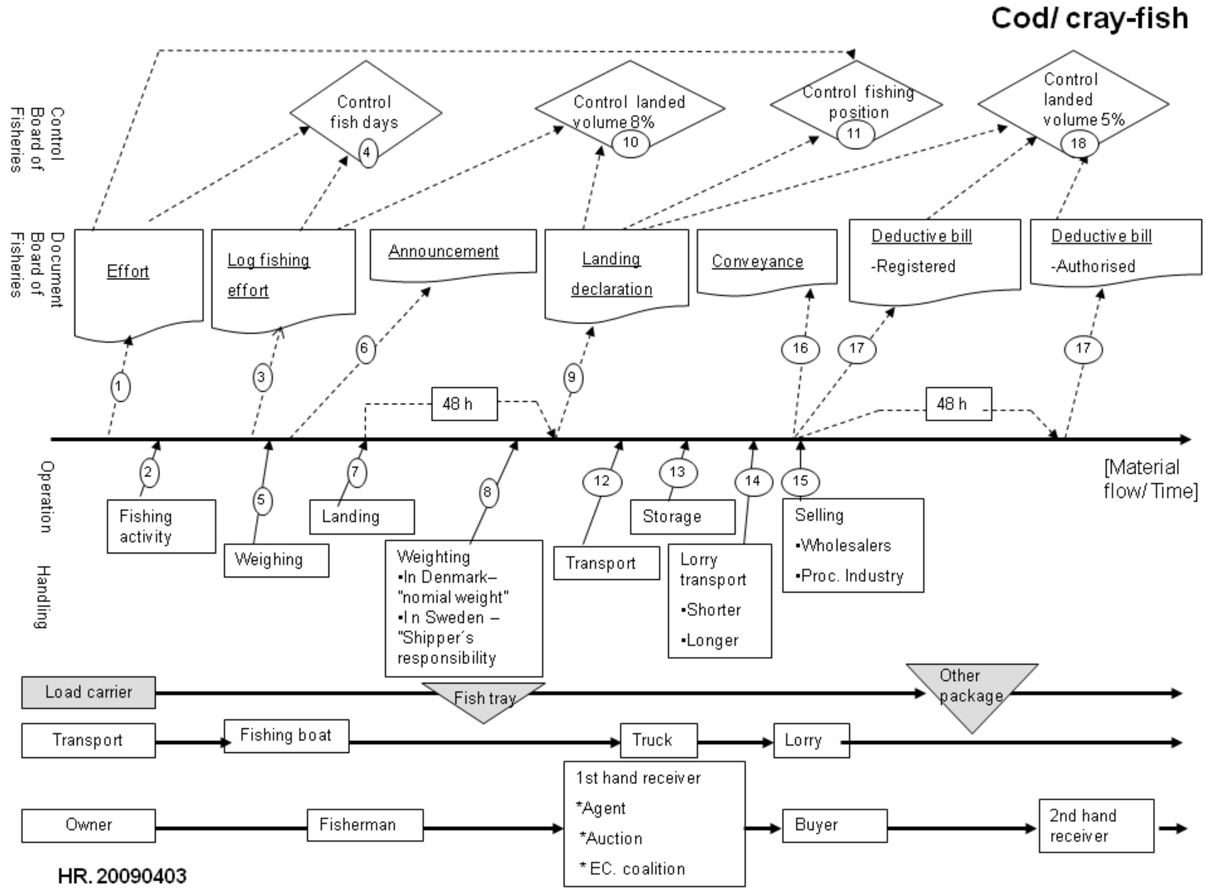

Figure 5.1 The cod- and crayfish supply chains adopting the developed cause and effect diagram technique.

The supply chains then continue with a transport step (12), which includes two types of transport: to cooling storage or to a cooling lorry for storage (13). These cooling facilities share the feature of being owned by a first-hand receiver, which can be a fish auctioneer, a fish agent or an economical coalition of several fishing boats. From the first-hand receiver, the fish is sold and transported further to wholesalers or to process industries (14). This ends in a selling process (15), either to a wholesaler or to an industry for further processing.

What these two selling processes share in common are the two types of documents which have to be sent in to the Board of Fisheries: a conveyance document (16) and a deductive bill (17) which include volume information of the fish sold. This final document must be sent in immediately for a registered industry or wholesaler, or within 48 hours for an authorised industry or wholesaler. The volume information in the deductive bill is checked (18) against the weight volume reported in the landing declaration in which a 5% volume reduction is allowed due to water loss.

Description of the herring supply chain

The supply chain for herring was also analysed by using the cause-and-effect diagram technique (Figure 5.2). This flow could be presented in the same manner as the supply chain for cod and crayfish using the same numbers in the parentheses which refer to the corresponding circled numbers of items in the diagram for the description of the supply chain. However it should be noted that there are some differences between the two supply chains.

These can be summarised in that the weight for herring is taken by bearing (5), that herring is pumped (ashore or to another boat) (7), that other restriction are used in the second weighting activity and that this weight have to be reported in a weight report to the Board of Fisheries.

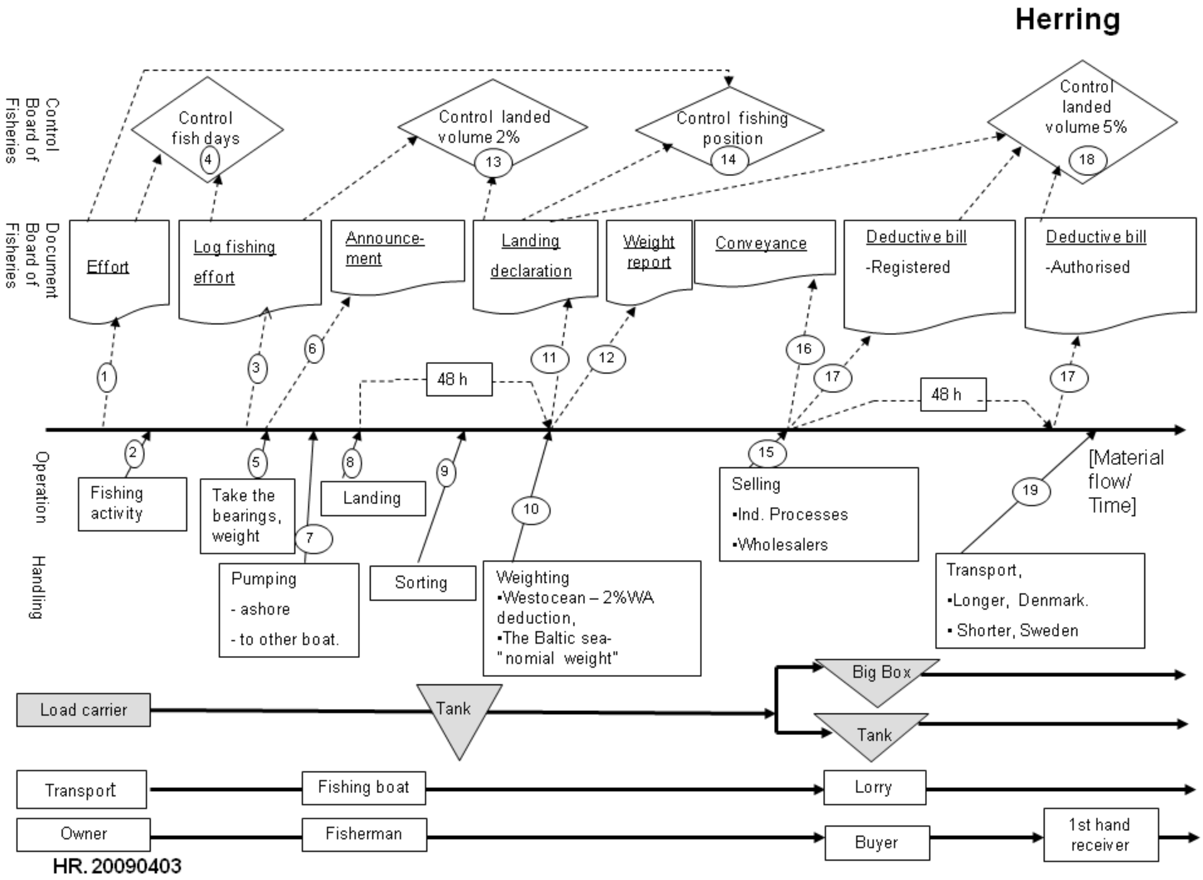

Figure 5.2 The herring supply chain adopting the developed cause and effect diagram technique.

Other differences are that herring isn´t stored (i.e sold directly), that the first hand receivers for herring are wholesalers or industrial companies in Denmark or Sweden, and finally that the tertiary and secondary package for herring are tank (tertiary package) and tank or “big box” (secondary package).

Discussion of the modified cause-and-effect diagram technique

Using a cause-and-effect diagram when analysing the fish supply chains for cod, crayfish and herring illustrates how different activities not only are linked to each other, but are also related to the time aspect of when they occur. An additional strength of using cause-and-effect diagrams is the ability to visualise when different actors will affect the supply chain and what kind of information has to be sent to an authority and exactly when. This is of great significance in achieving traceability and why traceability is also an important issue for an authority like the Swedish Board of Fisheries. However, it should be noted that the cause-and-effect diagram method sometimes is difficult to use, especially when it comes to supply chains with many multiple parallel sub-processes.

5.3 Process mapping technology for fish supply chains

Description of the cod and crayfish supply chains

The fish supply chain processes for cod and crayfish are illustrated (Figure 5.3), using a process mapping diagram. The numbers in parentheses in the following description refer to the corresponding circled numbers of items in the diagram. The process in the diagram is identical to the one described in section 5.2.1 up to number 11, control of fishing position. After the landed fish volume and the fishing position have been checked at the Swedish Board of Fisheries, the supply chains continue with a transport step (12), which includes two types of transports: into a cooling storage (13a) or into a cooling lorry for storage (13b).

These cooling facilities share the feature of being owned by a first-hand receiver, which can be a fish auctioneer, a fish agent or an economical coalition of several fishing boats. From the first-hand receiver the fish is sold and transported further to whole sale dealers or to process industries (14). This ends in a selling process either to a wholesale dealer (15a) dealer or to an industry (15b) for further processing.

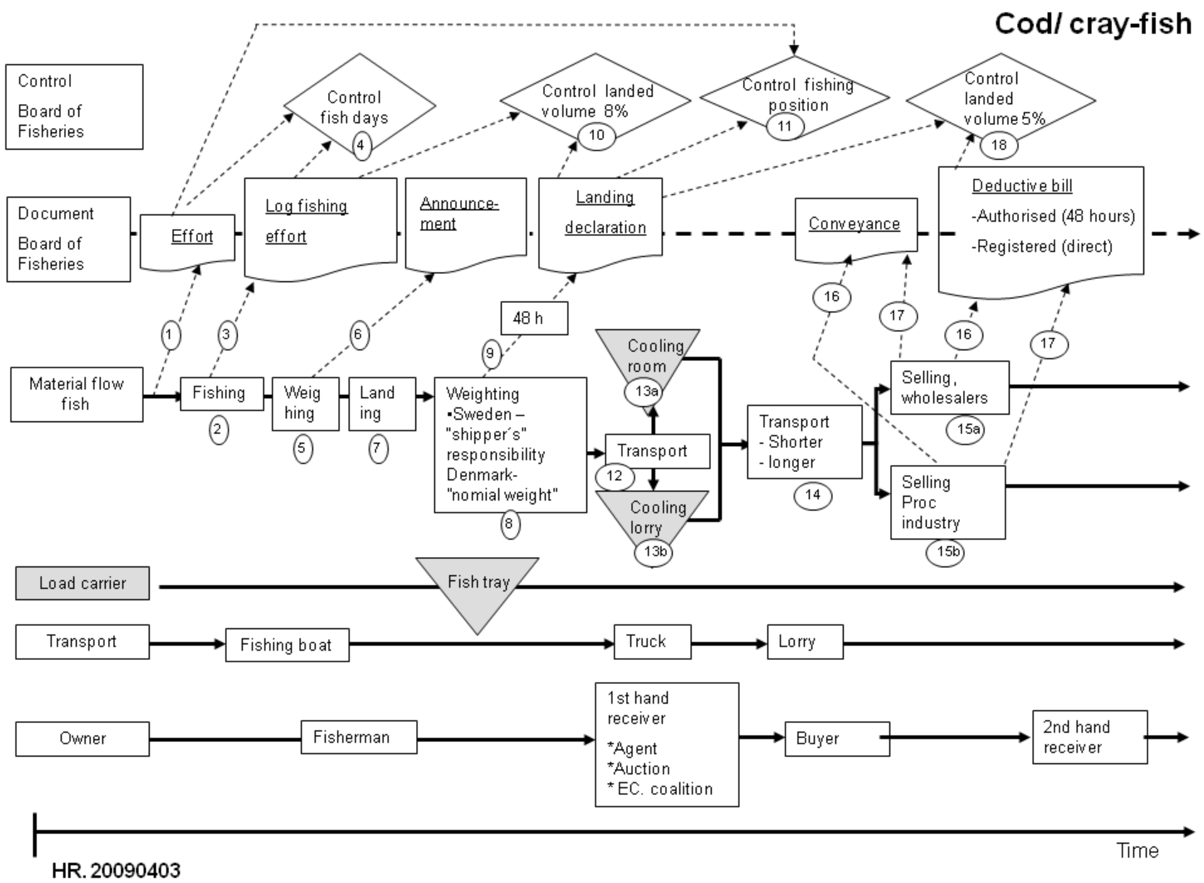

Figure 5.3 Developed process mapping diagram applied on cod/crayfish supply chains.

What these two selling processes share in common are that two types of documents have to be sent in to the Board of Fisheries: a conveyance document (16) and a deductive bill (17) which include volume information of the fish sold. This last document mentioned must be sent in immediately for a registered industry or wholesale dealer, or within 48 hours for an authorised industry or wholesale dealer.

The volume information in the deductive bill is checked (18) against the weight volume reported in the landing declaration in which a 5% volume reduction is allowed for water loss, (See Figure 5.3, above).

Description of the herring supply chain
In order to compare the two supply chain mapping tools, the supply chain for herring has also been analysed with the process mapping technique (Figure 5.4).

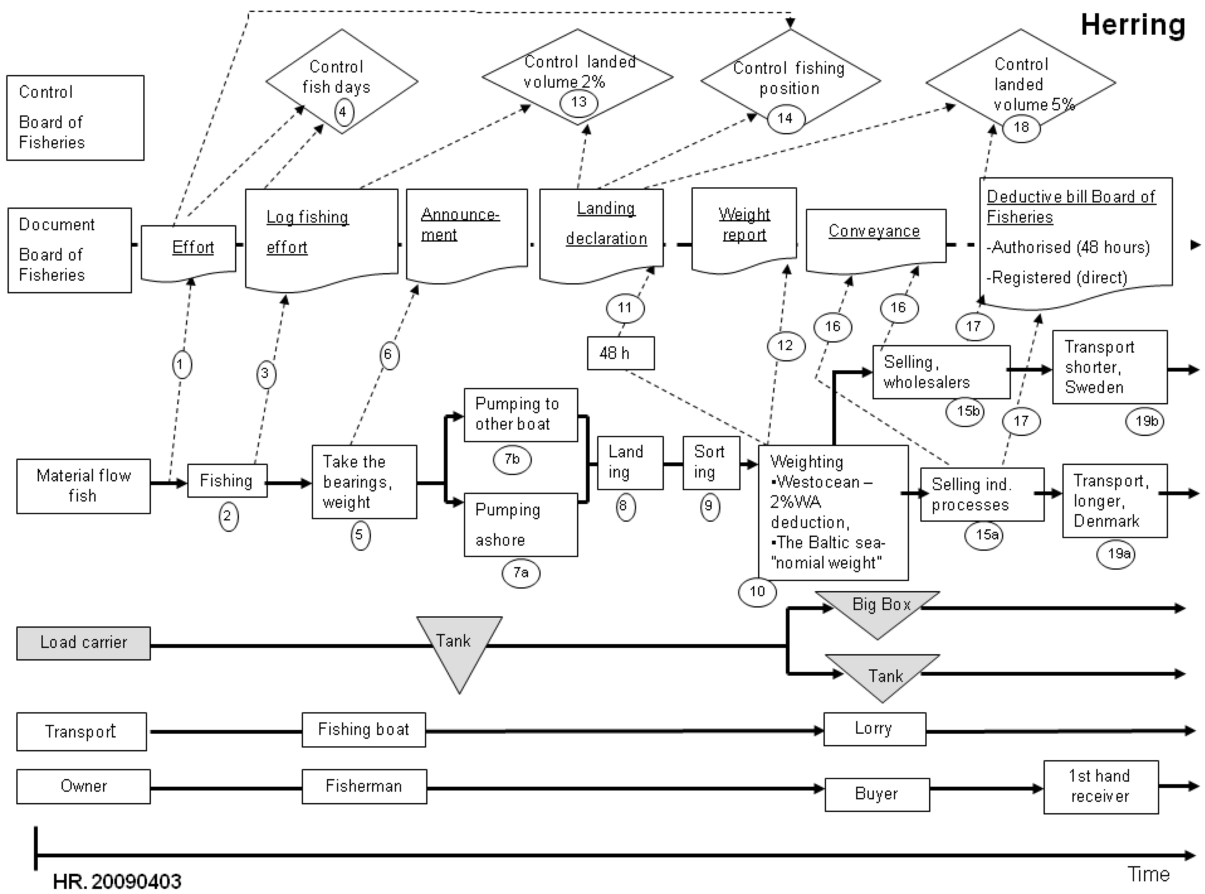

Figure 5.4 Developed process mapping diagram applied on herring supply chain.

Discussion of the applied process mapping technique
Analysing the supply chains for cod, crayfish and herring with a process mapping tool not only clearly visualises existing parallel processes but also the physical and information flow in the chain. However, it should be noted that the process map technique as a supply chain analysis tool does not consider the time aspect as to when activities in the supply chain have occurred and how different activities are connected to one another as clearly as the cause-and-effect diagram technique (which is one of the strength with the latter mentioned cause-and-effect diagram technique). This is because process mapping focuses on the physical flow through a supply chain.

5.4 Comparison of the supply-chain mapping techniques

Analysing the three different fish supply chains using two supply chain mapping techniques highlights not only the differences but also when each technique is most appropriate to use is shown (Table 5.6). The outcome in this study of using these two mapping techniques have been evaluated the following way; equal appropriate (+/-), most appropriate (+) and less appropriate (-).

The analysis of the three supply chains is based on the effort to explore traceability from an authority's point of view. In the analysis, both the physical material flow and information flow have been analysed concerning parameters for information control, load carrier, transport, ownership and time. The evaluation of when each mapping technique is most appropriate to use is shown in Table 5.6.

Table 5.6 Comparison between the cause-and-effect diagram and the process mapping techniques.

Mapping technique	Control	Information flow	Material flow	Time	Load carrier	Transport	Ownership
Cause-and-effect diagram (Ishikawa)	+/-	+/-	-	+	+/-	+/-	+/-
Process mapping	+/-	+/-	+	-	+/-	+/-	+/-

6. CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

The analyses of the three fish supply chains confirm that traceability is an important issue for government authorities and that the supply chains are complex. This is because of the existence of several external interfaces between the authority and the producers (i.e the fisherman) and also between the authority and other actors, such as first and second-hand receivers in a food supply chain. These external interfaces contain information which is continuously checked and controlled throughout the entire supply chain for fish and also is mandatory for the achievement of traceability.

The results of the case studies and the comparison between two supply chain mapping techniques show that the external interfaces between an authority and the actors in a food supply chain can be identified and analysed by using a combination of two effective logistical mapping techniques: cause-and-effect diagrams and supply chain mapping diagrams.

A more general result is that a combination of the two supply chain mapping techniques presented and analysed – cause-and-effect diagrams and process mapping diagrams – should be used as complements when analysing chilled supply chains for food. This for a comparison between the two supply chain mapping techniques shows on most parameters, that the two selected supply chain mapping techniques are equal to use, but not so on when it comes to material flow and time.

Furthermore, the analysis of the three supply chains in the case-study, i.e for herring, cod and crayfish, reveals differences and similarities. One difference is that the supply chain for herring differs from that for cod and crayfish, which are more similar to one another. This supports the conclusion that both methods should be used when analysing their supply-chain and that the supply-chains analyse can be very similar to each other. Another, but more detailed, difference is in how fish are handled in Sweden and Denmark. However, it should be noted that there are two minor differences between the supply chains for cod and crayfish. The first concerns the control of the landed volume where a reduction of 8% is allowed for cod while only 5% is allowed for crayfish. The second difference is that cod is packed differently than crayfish after the first-hand receiver step.

A suggestion for further development of the conclusions drawn would hence be to see if the presented and analysed supply chain techniques can be generalised to other chilled food supply chains.

ACKNOWLEDGEMENTS

This article has been written in co-operation with the Swedish Board of Fisheries. We are very thankful to Maria Hellsten, Johan Löwen-Adler Dawidsson and Ingvar Tjäder at the Division for Fishing Control, Swedish Board of Fisheries, Gothenburg.

We are also very grateful to Professor Gunilla Jönson at the Department of Design Sciences, Division of Packaging Logistics, Lund University, concerning comments which have made this article possible.

Finally we would like to thank Anders Carlberg at Västra Götalandsregionen, for financing the GIS Fish Project on which this article is partly based.

REFERENCES

Books and reports:

Anjard, R.P. (1996), “Process Mapping: one of three, new special quality tools for management, quality and all other professional”, *Microelectronics and Reliability,* Vol. 36 No.2. pp 223-225.

Aronsson, H., Ekdahl, B. and Oskarsson, B.(2003), *Modern Logistik – för ökad lönsamhet*, Liber förlag, Malmö, pp. 173-177.

Björklund, M., (2002), “Distribution av temperaturkänsliga livsmedel”, Master Thesis Dept. of Design Sciences, Div. of Packaging Logistics, Lund University, Lund, Sweden, LUTMDN/TMFL 02/5010 – SE.

Bowersox, D., Closs, D., Bixby-Cooper M. (2002), *Supply Chain Logistics Management*, 2nd Ed., McGraw Hill/ Irwing Series, Boston

Børresen, T. (2003), “Traceability in the fishery chain to increase consumer confidence in fish products – application of molecular biology techniques”, in *Proceedings 1st Joint Trans-Atlantic Fisheries Technology Conference –TAFT 2003 in Reykjavik, Iceland,* 11-4 June 2003.

Derrick S., Dillon M., (2004), “A guide to traceability – within the Fish Industry”, SIPPO/EUROFISH, ISBN: 1 900134187

Directive 2005/2006:171, “Evaluation report of catch registration in Baltic Sea member states 2005-2006”, version 3.0 (24 Jan. 2007), European Commission Directive General for Fisheries and Maritime Affairs – Fisheries Inspection, unit D2.

Eisenhardt, K.M., (1989), “Building Theories from Case study Research”, *The Academy of Management Review,* Vol. 14 No. 4, pp. 532-550.

Frederiksen, M., Osterberg, C., Silberg, S., Larsen, E. and Bremner, A. (2002), “Info-Fisk. Development and validation of an internet based traceability system in a Danish domestic fish chain”. *Journal of Aquatic Food Product Technology,* Vol. 11 No. 2, pp.13-34.

Hankins, J. (2001). *Infusion Therapy in Clinical Practice,* Infusion Nurses Society Better World Books, Mishawaka, USA pp. 42.

Hashimoto, T., Tanaka, K., and Niwa H. (2003), “Trial of farmed fish traceability in Japan”. in *Proceedings 1st Joint Trans-Atlantic Fisheries Technology Conference –TAFT 2003 in Reykjavik, Iceland,* 11-4 June 2003.

Huber, G.P. and Van de Ven A.H. (1995) ”Longitudinal Field Research Methods: Studying Processes of Organizational Change”, Sage Publications, Thousand Oaks, USA pp. 67-89.

Karlberg, M. and Klevås, J. (2002), “Evaluating Packaging Logistics Development at IKEA for Improvements in Product and Packaging Development”, research paper, Dept. of Design Sciences, Div. of Packaging Logistics, Lund University, Lund, Sweden.

Keller, P.J. and Jacka, J.M. (1999), “Process Mapping”, *Internal Auditor,* Vol. 41 No. 5, pp. 60-65.

Kim, D. (2006), “Process chain: A new paradigm of collaborative commerce and synchronized supply chain”, *Business Horizons,* Vol. 49 No. 5, p. 359.

Lumsden K. (2006), *Logistikens grunder*, 2nd Ed., Studentlitteratur, Poland, pp 486 – 488.

Matsumoto, I.T., Stapleton, J., Glass, J. and Thorpe, T. (2005), “Use of process maps to develop a management briefing sheet for design consultancy”, *Engineering, Construction and Architectural Management*, Vol. 12 No. 5.

MacDubhghaill, U. (2000), *The outlook for the UK fishing industry*, Bodø, Norway

Pojasek, R.B. (2005), “Quality Toolbox – Understanding Processes with Hierchical Process Mapping”, Environmental Quality Management No Winter.

Regulation (EC) No 178/2002. (2002), “Laying down the general principles and requirements of food law, establishing the European Food SafetyAuthorityand laying down procedures in matters of food safety”, The European Parliament and the Council of the European Union.

Regulation (EG) No 1966/2006. (2006), “On electronic recording and reporting of fishing activities and on means of remote sensing”, The European Parliament and the Council of the European Union.

Regulation (EC) No 1198/2006. (2006), “On the European Fisheries Fund”, The European parliament and the Council of the European Union.

Rydebrink, P. (1993), *Verktygslådan – En sammanställning av 21 verktyg för kvalitetsarbete*, IVF-skrift 93816, Institutet för Verkstadsteknisk Forskning (IVF), Mölndal, Sweden, pp. 26-27.

Scott, C. and Westbrook, R. (1991), "New Strategic Tools for Supply Chain Management", *International Journal of Physical Distribution & logistics Management*, Vol. 21 No. 1, pp. 23-33.

Thorén, A. and Vinberg, B. (2000), *Pocket book of packaging*, Packforsk, Kista, Sweden.

Thomsson, M. and Sylvia, G. (2005), "Seafood traceability in the United States: Current trends, system design, and potential application", *Comprehensive Reviews Food Science and Food Safety*, Vol. 1 pp. 1-7.

Yin, R.K. (2009), *Case study research: design and methods*, Sage Publications, Thousand Oaks, USA.

Internet based sources

Education Material Ishikawa Diagram, Luleå University of Technology, available at: http://ies.ltu.se/kml/utbildning/iek323/webmaterial/kap10/ishikawadiagram.htm (accessed 9 February 2009).

Press release (2008) "Nordiska Ministerrådets sommarmöte, juni 2008", available at: http://www.regeringen.se/sb/d/9321/a/107987 (accessed 25 February 2009).

Tracefish homepage, available at http://www.tracefish.org (accessed 3 March 2008)

The Swedish Board of Fisheries homepage, available at http://www.fiskeriverket.se (accessed 10 February 2009)

APPENDIX PAPER 3

EFFECTS OF USING SMART GOODS ON TRACEABILITY INFORMATION AND CARRIED OUT ACTIVITIES IN SUPPLY CHAINS OF FRESH FOOD

– A CROSS CASE ANALYSIS

Vahid Mirzabeiki, Henrik Ringsberg and Kenth Lumsden

Published in the reviewed proceedings of the Nordic Logistics Research Networks (NOFOMA) annual conference, pp. 421-436, June 2010, Kolding, Denmark

EFFECTS OF USING SMART GOODS ON TRACEABILITY INFORMATION AND CARRIED OUT ACTIVITIES IN SUPPLY CHAINS OF FRESH FOOD
– A CROSS CASE ANALYSIS

Vahid Mirzabeiki*
Henrik Ringsberg**

Kent Lumsden***

*) Department of Transport and Logistics, Chalmers University of Technology, SE-412 96 Gothenburg, Sweden, E-mail: vahid.mirzabeiki@chalmers.se, Tel: +46 31 772 1354, Fax: +46 31 772 1337
**) Department of Design Sciences, Packaging Logistics, Lund University, SE-221 00 Lund, Sweden, E-mail: henrik.ringsberg@plog.lth.se, Tel: +46 46 222 4042; Fax: +46 46 222 8060

***) Department of Transport and Logistics, Chalmers University of Technology, SE-412 96 Gothenburg, Sweden, E-mail: kenth.lumsden@chalmers.se, Tel: +46 31 772 1345; Fax: +46 31 772 1337

ABSTRACT

Purpose of this paper
The purpose of this paper is to investigate the effects of using the smart goods on traceability information and consequently on the carried out activities for different actors of the fresh food supply chains. Identification of the valuable traceability information types in fresh food supply chains is conducted as the first step to reach the purpose.

Design/methodology/approach
Literature is reviewed to identify a theoretical frame for the smart goods and traceability in the fresh food supply chains. Three Nordic supply chains of fresh food are studied for answering the research questions.

Findings
The valuable types of traceability information from perspective of different actors of the fresh food supply chains are identified as an outcome of the paper. Advantages and disadvantages of using the traditional and smart-goods-based traceability systems are found. The traceability information and activities in the fresh food supply chains that are affected by using the smart goods and kinds of such effects are generated out of this research.

Research implications
This paper is contributing to the literature on the traceability especially in the food supply chains. The smart goods concept developed by literature is empirically analyzed and evaluated in this paper.

Practical implications
The results of this paper are useful for operations managers of the fresh food supply chains to understand the effects of using the smart goods to manage their supply chain information and activities.

What is original/value of paper
This paper evaluates the effects of using the smart goods from perspective of different actors including authorities in fresh food supply chains. Supply chains with both centralized and decentralized information systems are studied in this paper.

Keywords: Supply Chain (SC), Fresh food, Smart goods, Traceability, Information, Activities.

1. INTRODUCTION

Smart goods equipped with smart tags with capability of communication to the supply chain infrastructure is introduced and investigated form different perspectives in recent literature (e.g. Meyer et. al., 2009; Wong et. al., 2002; Lumsden and Stefansson, 2007; Holmqvist and Stefansson 2006; Stefansson and Lumsden, 2009). Different studies have analyzed application of the smart goods by using combinations of different technologies and systems for storing more types of information on the goods. Such goods are used to enable local decision making and to increase different performance criteria in supply chains by their capability of communication to the transportation infrastructure (Meyer et. al., 2009; Wong et. al., 2002).

According to the literature one of the most significant applications of the smart goods is to increase traceability in the supply chains. A number of studies have determined the advantages and disadvantages of using the smart goods for achieving traceability of the items through different industrial supply chains generally and a group of published studies have investigated the willingness of different actors of industrial supply chains to apply the smart goods in the future (Johansson and Pålsson, 2009).

An interesting area for investigation of the traceability in supply chain is the fresh foods industries. Consumer and government economic losses, resource losses, undermining of eco-campaigns and health problems are some of the consequences of lack of appropriate traceability in fresh food supply chains. Liberalization of trade is another significant reason for increasing concerns on traceability of all products including fresh food (Jacquet and Pauly, 2008). Reviewing the related literature indicates that still there is lack of research on the effects of using the smart goods on the activities carried out to transport the goods from upstream to downstream of the supply chains of the fresh food considering the special features of these supply chains.

According to the discussion above, the purpose of this paper is to investigate the effects of using the smart goods on traceability information and consequently on the carried out activities for actors of the fresh food supply chains. This purpose is reached through studying different elements of the information systems used for transferring the traceability information between partners of the supply chains of fresh food. The research questions below are formulated to be answered in order to achieve the purpose of the paper:

RQ1: What types of information related to the goods are valuable for achieving traceability in supply chains of fresh food?

RQ2: What type of activities do different actors of the fresh food supply chains carry out by using the traceability information?

RQ3: What are the advantages and disadvantages of traditional and smart-goods-based traceability systems for the supply chains of fresh food?

A simplified model of fresh food supply chain used for analysis in this paper is introduced on the figure 1.1. This model shows the actors in the fresh food supply chains that are studied in this research.

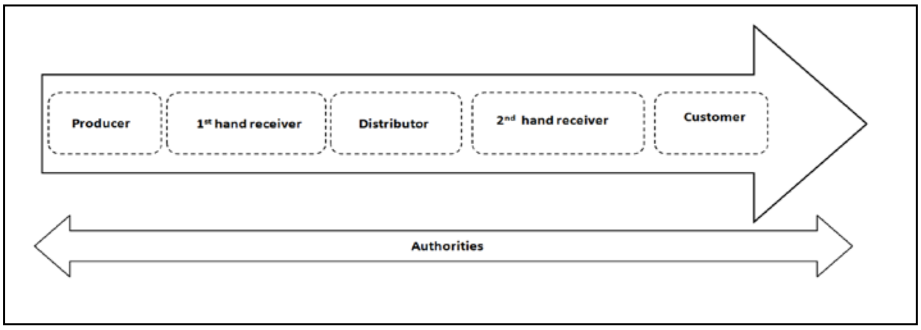

Figure 1.1 - Actors of the fresh food supply chain used for analysis in this paper

The concept of *smart goods* is introduced by different names in books and papers but all of such terms carry almost the same meaning. Some of the terms used are *intelligent goods*, *intelligent freight* or *smart freight*. The term used in this paper for describing this concept is *smart goods*.
Traceability information is the information that is needed to be available with the goods during the transportation to achieve high level of traceability.

Except from the traceability perspective mentioned above, the paper has an operational perspective on application of the smart goods for transportation and material handling of fresh food in a supply chain. The results indicate some of the effects of using the smart goods on costs of operations in the fresh food supply chains.

2. METHODOLOGY

A research design is the logic that links the collected data to the initial question of a study (Yin, 2003). In this chapter after providing the motivations behind selecting the cases, the process of conducting the empirical data collection is described.

Literature in form of books, journal papers, conference papers, and organizations' websites are reviewed to identify a theoretical frame for the smart goods and traceability in the fresh food supply chains.

One Swedish supply chain of fresh fishes, one Danish supply chain of fresh fishes and one Norwegian supply chain of fresh meat are selected to be studied in this paper. The Swedish supply chain is using the traditional tags and delivering notes as carrier of information about the items. The Norwegian and Danish supply chains have been using the smart goods quipped with RFID tags on the packages to carry the information regarding the goods in their supply chains. This research is going to identify the important traceability information in the Swedish supply chain by conducting a deep empirical study. Then the Danish and Norwegian traceability systems are investigated and compared to the Swedish supply chain to identify the effects of using the smart goods on the traceability information and on the activities that are carried out by using such information in the fresh food supply chains.

Selection of the cases is based on these criteria that first the Nordic countries are large fresh fish producers and investigating two large supply chains from Nordic countries helps to better generalization of the results of the paper. All of these three supply chains use almost the same types of information for achieving traceability of goods that makes the comparisons between them possible. Another reason behind selection of these three supply chains for this research is that all of these supply chain have to follow the same European regulations and respect existing standards within the fresh food industry.

After selecting the cases, the data collection protocol was prepared and followed according to the Yin (2003). The protocol includes an overview of the project's objectives, case study issues, field procedures, case study questions and a guideline for the case study's report.

According to Yin (2003) the six sources of evidence in conducting case studies are: documentation, archival records, interviews, direct observations, participant observations, participant observations, and physical artifacts. Documentations and archival records of the actors of these three supply chains are used as sources of data. Direct observations from different operations of the supply chains are conducted by the authors. Interviews with representatives from actors of the supply chains are conducted as other significant source of empirical data for this research. 14 interviews are carried out by using semi-structured questions together with interview forms to be filled by the interviewees. All the interviews are recorded and saved together with filled interview forms in the prepared case study database. For increasing validity of the collected data, after finishing the interviews the results are again sent to the interviewees to be confirmed. In addition to the interviews, documentations from different actors were reviewed and when possible direct observations were conducted to make triangulation of data according to Yin, 2003. Cross-case conclusions are drawn after comparing the analyzed data from all three supply chains according to Eisenhardt (1989) and Yin (2003).

3. SMART GOODS

There are different definitions proposed for the intelligent or smart goods that have some similarities and difference (McFarlane et. al. 2003, Kärkkäinen et. al. 2003, Meyer et. al., 2009, Lumsden and Stefansson, 2007). According to McFarlane et. al. (2003), an intelligent or smart good has the following properties:

- Possesses a unique identification;
- Is capable of communicating effectively with its environment;
- Can retain or store data about itself;
- Deploys a language to display its features, production requirements.
- Is capable of participating in or making decisions relevant to its own destiny.

According to Holmqvist and Stefansson (2006), *Smart Goods* is characterized by a higher level of sophistication than traditional goods identification. This means that instead of using former technologies such as barcodes to identify an item, it is now possible to identify the freight, either individual items or the load unit, with new smart technologies like RFID tag as a carrier of data. Combination of the auto identification tags with sensors that measure and record different physical attributes of the goods are used for creating advanced generations of the smart goods (Lumsden and Mirzabeiki, 2008). Several technologies that are combined for making the smart goods, including RFID, GSM/GRPS and web technology are introduced and explained in the literature (Kärkkäinen et al., 2003; Ghribi and Logrippo, 2000).

According to the literature application of smart goods provides new opportunities for increasing efficiency of transportation operations. According to Lumsden and Stefansson (2007), the concept of smart goods is defined on different levels of packaging such as the container level, pallets level, and item level depending on transportation activities to be carried out in supply chain. There are different classifications based on levels of smartness of the smart goods depending on the level of sophistication of technologies applied in them.

Two levels of smartness are defined by literature for the smart goods. In the level 1 the smartness of the goods is information-oriented based and allows the product to communicate with its environment regarding its status. In the level 2 the smartness of the goods is decision-oriented. In this level the smart goods can influence on their functions in addition to communicating its status with environment and other smart goods (Wong et. al., 2002; McFarlane et al., 2003; Johansson 2009). Examples of the information systems functioning by using the smart goods concept are described in below:

Auto identification (ID) systems for goods management: A basic purpose of introducing the smart goods concept in the supply chain is to maintain the identity of the products. Optical and RFID labels are used for goods identification to fulfill customers' orders, for checking goods in and out of the warehouse, and for keeping an up-to-date inventory. As a result one of the advantages of the smart goods is to increase the security of the supply chains. By maintaining the identity of the product or shipment it is possible to pinpoint where thefts occur and to verify the authenticity of the item and reduce the risk of forgery (Meyer et. al., 2009).

Tracking systems for moving goods through a supply chain: The software and hardware components together make the information systems that are used for controlling the location of the products through the supply chain. Such information systems update the location of the shipments when they pass the checkpoints or they are used for querying or updating product information in general (Meyer et. al., 2009).

Systems for controlling the physical features of the goods: different types of sensors together with an RFID tag and a memory to save the information gives this capability to the goods to store data regarding physical condition of itself during shipment or storage. Temperature, humidity, impact and light are some of the attributes that are stored on memory of the smart tags. This information could be transmitted to the central operation centre as well (Lumsden and Mirzabeiki, 2008).

4. TRACEABILITY IN FRESH FOOD SUPPLY CHAINS

There are several definitions for traceability in supply chains of the fresh food. According to the International Standardization Organization (ISO), traceability is defined as ''*the ability to trace the history, application or location of that which is under consideration*" or ''*when considering a product, traceability can be related to the origin of materials and parts, the processing history, and the distribution and location of the product after delivery*". The EU Regulation 178/2002 describes the food traceability as ''*the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution*". (Abad et al, 2009).

According to Abad et al, 2009 the smart goods provide real-time traceability information of the product to the different actors of the food supply chain, allow tracing if the expected physical condition were maintained for the fresh food on its way from the producer to the consumer, and allow getting a better safety and quality control along the food supply chain. Therefore, the smart goods developed can help to improve the competitiveness of the food companies, to improve their logistic management, and also to reinforce the confidence of the consumers in the food supply chain (Abad et al, 2009; Jacquet and Pauly, 2008).

Regulatory aspects of food traceability are a very important issue to be considered in management of the fresh food supply chains (Regattieri et al. 2007). In the recent years more fish stocks collapsed around the world, and the issue of traceability, particularly for illegal, unreported, and unregulated fisheries, was identified as a factor for controlling the overfishing (Jacquet and Pauly, 2008). Different standard data models are created to enable traceability of products, product authentication, diversion detection and other similar applications across multiple actors of supply chains. Electronic Product Code Information Service (EPCIS) is one of such standard data models that by using it each trading partner or actor keep their data and only share information that they wish with the other actors of the supply chain (EPC Global, 2010).

5. ANALYSIS MODEL

The analysis model used in this paper is illustrated on the figure 5.1. According to a number of published studies the smart goods affect different types of traceability information in a supply chain of the fresh food. Such effects could be on accuracy, timeliness or exchange of traceability information or other information quality dimensions. One important reason for these effects is reduction of the amount of manual data entry and copying into the information systems of different actors compared to the traditional goods tracing systems. Consequently the activities carried out by using traceability information are affected by application of the smart goods as a hypothesis. In the next chapters of the paper this relationship would be identified and validated through analyzing the collected empirical data from three selected supply chains of the fresh food. Identification of the valuable traceability information is conducted before studying the affected activities by using the smart goods.

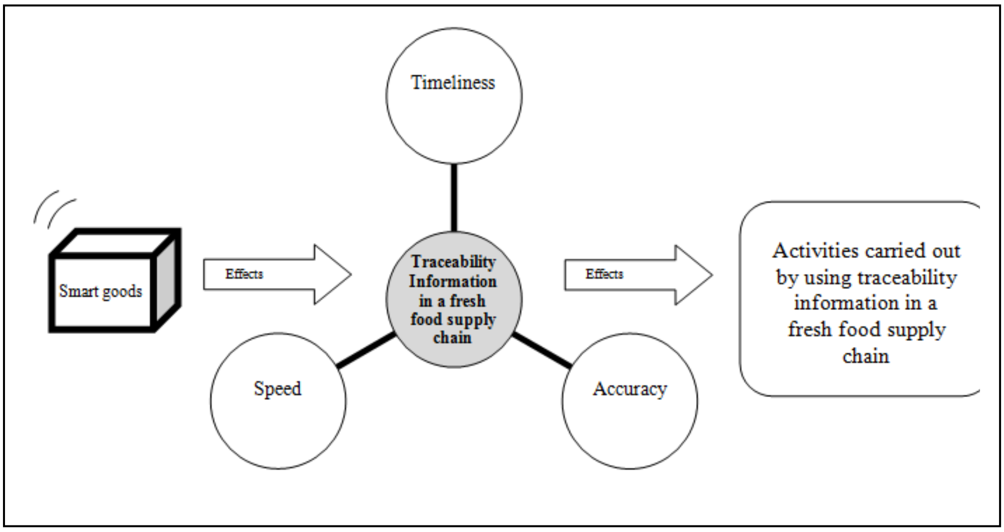

Figure 5.2 Analysis model to identify the effects of using smart goods on traceability information and consequently on the activities carried out by using such information in the fresh food supply chains.

6. EMPIRICAL FINDINGS

In the first part of the empirical studies information systems used in order to transfer the information in the fresh food supply chains are investigated. The second part includes identification and evaluation of traceability information and identification of the affected information and activities by using the smart goods in fresh food supply chains.

6.1 The Swedish supply chain

The information system used to transfer the information between actors of the Swedish supply chain is decentralized. It means that each actor in the supply chain has their own information system which is not electronically integrated with each other. The labeling stickers, delivery notes, and at some points, EAN-bar codes are used to capture and transfer the information between actors in the supply chain. Storage of transferred information is based on manual hand writing. The only direct electronically transfer and storage of information, without any human interference in the supply chain is the transfer of vessel position information to authorities to control the position of fishing.

Figure 6.1 shows the information flow, and tools or technologies used for information transfer between different actors in the supply chain for fresh fish in Sweden.

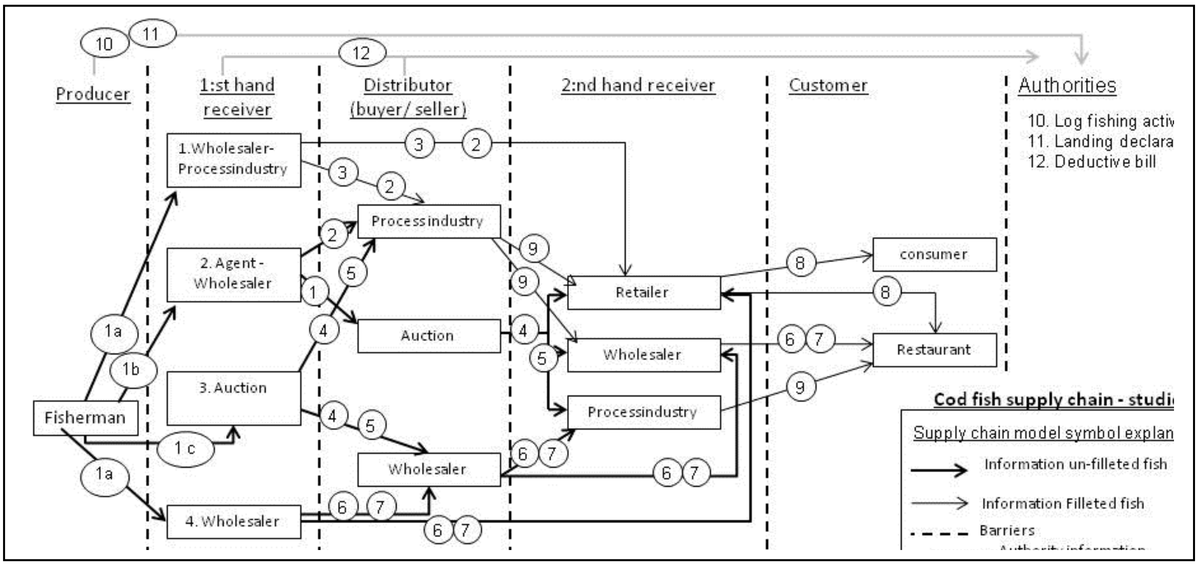

Figure 6.3 Information exchange in Swedish fresh fish supply chain.

On the figure 6.1 the information at different stages is shown by numbers between 1 and 9. The tools used for information transfer and types of transmitted information related to each number are introduced below:

1. Tag-stickers: a) Vessel external marketing, landing quantity (kg), name of receiver, name of fishing area, fishing zone (according to ICES- International Council for Exploration of the Sea), specie denotation (Swedish), date of fishing activity, size class. b) Vessel denotation, landing quantity (kg), name of receiver, specie denotation (English), date of fishing activity. c) Vessel external marketing, specie denotation (Swedish), size class.
2. Delivery note: Vessel external marketing, landing quantity (kg), name receiver, name of fishing area, fishing zone (ICES), specie denotation (Swedish), date of fishing activity, size class, batch/ lot number.
3. Tag-sticker: Production date, net-weight, name of receiver, name of seller, name of fishing area, fishing zone (ICES), specie denotation (English), specie denotation (Swedish), temperature.

4. Barcodes: Vessel external marketing, seller name, specie denotation (English), specie denotation (Swedish), size class, date landing.
5. Delivery note: Vessel external marketing, captain name, date/ time landing, net- weight, internal batch, internal lot number, name of seller, name buyer, selling date, name of fishing area, fishing zone (ICES).
6. Barcodes, tag- stickers: Fishing tackle/ method, date/ time landing, production date, best before date, net- weight, batch number, name seller, selling date, name of fishing area, fishing zone (ICES), specie denotation (English), specie denotation (Swedish), processing degree/class, size class, date fishing activity.
7. Delivery note: Fishing tackle/ method, net- weight, batch number, name seller, name buyer, selling date, buy off date, specie denotation (English), specie denotation (Swedish), processing degree/class, size class, prize information.
8. Tag-stickers: Vessel name, vessel external marketing, production date, packing date, best before date, net weight, name seller, name of fishing area, fishing zone (ICES), specie denotation (English), specie denotation (Swedish), prize information, nutrition information.
9. Tag-stickers: Production date, net-weight, name receiver, name seller, name of fishing area, fishing zone (ICES), specie denotation (English), specie denotation (Swedish), temperature.
10. Fax, email: Log fishing activity: Position ICES zone, third country fishing zone, net weight (kg), processing degree/ class, quantities (kg), quantities (units), Captain name, name receiver.
11. Fax, email: Landing declaration: Vessel name, vessel external marketing, captain name, date/ time departure, date/ time arrival, date/ time landing, landing place, departure place, arrival place, fishing tackle, date for transshipment, name of receiving vessel (transshipment), external marketing of receiving vessel (transshipment), Nationality of receiving vessel (transshipment), date fishing activity, number of fishing operations, position statistical rectangle, position ICES zone, third country fishing zone, net weight (kg).
12. Fax, email: Deductive bill: Name receiver, deductive bill nr, buy-off date, date landing, captain name, third country name, vessel external marketing, specie denotation (English), specie code, processing degree, size class, freshness class, net weight, price.

6.2 The Danish supply chain

The information system used in Danish supply chain for tracing and tracking of the fresh fishes is developed based on cooperation between a software development company and the major supplier of Danish fish crates. The system is created for asset management of fish crates and contains approximately 40 000 RFID tagged fish crates and an ISO-certified (ISO 2001:2000) IT-solution implemented in four different harbors. The system has a holistic view on the fish supply chain through cooperation between different actors such as producers, distributors, buyers, restaurants, retailers, auctions, wholesalers, collectors, washing companies, and customers. For collection of information from the actors, the system include installed RFID portals/ scanners at key sites in the supply chain, i.e. at crate wash area, crate dispatch area, on fishing vessels, at collector terminals, auctions, harbors and at exporters. These portals and scanners have the ability to read the RFID-tagged fish crates from a distance between 0.5 -12 meters. Each fish crate in the system is tagged with two RFID-tags molded into the plastic material of the crate which has a GRAI number (Global Returnable Asset Identifier, identification key used by GS1 for identification of returnable assets) for unique identification. Figure 6.2 shows the information system used for traceability of the crates through the Danish fish supply chain by using smart goods.

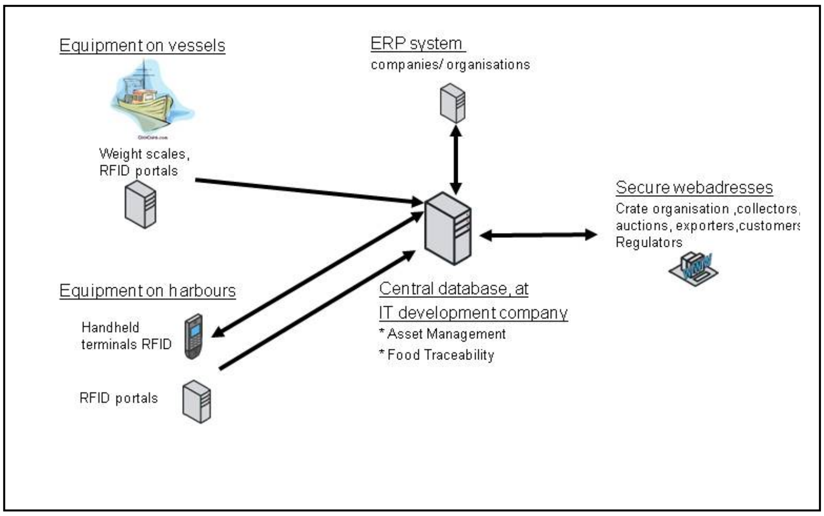

Figure 6.2 System descriptions for traceability of fish within Danish supply chain. The information flow is illustrated by the arrows.

Asset management information stored within the system includes the GRAI number of each crate and the actual location of the crate (last place of registration through the supply chain). This traceability information is stored in the system's central database structured according to the GS1 Tracefish standard. This standard includes parameters such as fishing vessel's name, vessel's denotation, specie, size and weight of fishes, time of fishing, name of fishing area, name of current owner, parties and timestamp for each handover of the crate between the actors.

6.3 The Norwegian supply chain

Activities conducted in the Norwegian supply chain include slaughtering, cutting, processing and distribution of meat by using RFID tagged crates and pallets from one of the largest returnable asset providers in Norway. The aim of implementation of this system was to reduce paper handling, less manual information acquisition and to create more secure readings, efficient asset management and traceability.

By each handover of crates in the supply chain, process information, i.e. information about when, what and why the crate is moved, are transferred to the next actor. This information is then combined with information that each actor are willing to share with each other within the meat supply chain. The system is built up from the principle that no central database for achievement of traceability is needed since all needed information already is stored in information systems of every actor in the supply chain. Each actor decides which information that is going to be shared and sent further to other actors in the supply chain. Therefore in this system actors are able to make the information unreadable for other actors if necessary. For exchange of traceability information between the actors the EPCIS (Electronic Product Code Information Service) standard is used. Therefore the information on the crate tags is structured according to this standard.

Each crate in this system has a GRAI number. It is only the GRAI-number of each crate that is transferred, making connections to information at different actors, GTIN-numbers (Global Trade Item Number, identification key used by GS1 to identify trade items) and product information stored at EPC. The figure 6.3 show the basic principle of the Norwegian traceability information system studied.

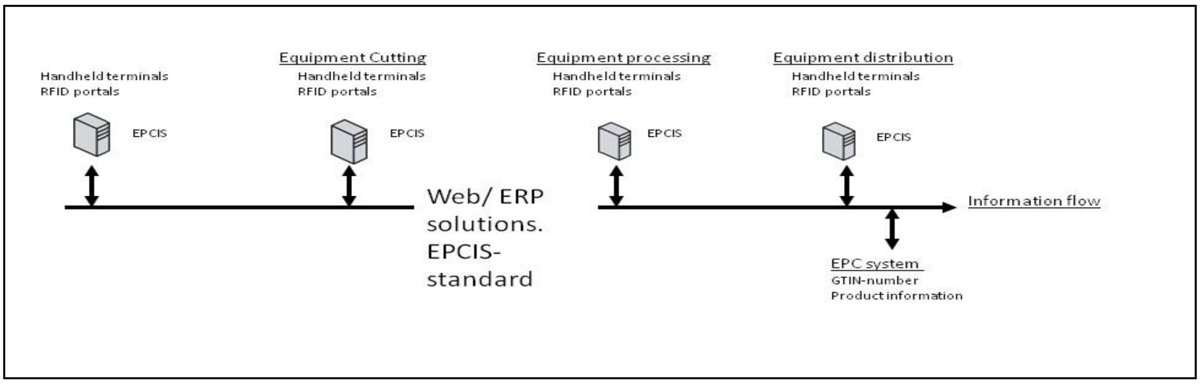

Figure 6.3 The Norwegian traceability system working based on EPCIS standard. The information flow is illustrated by the arrows.

6.4 Overview of the studied cases

Table 6.1 summarizes characteristics of the three studied supply chains according to the type of goods, number of actors and the systems used to transfer the information between different actors.

Table 6.1 Overview of characteristics of the information systems used for traceability of goods in the three studied supply chains.

Attributes	Swedish supply chain	Danish supply chain	Norwegian supply chain
Type of system used for traceability	None	Asset management system	Traceability system
Type of goods	Non-smart	Smart-level 1	Smart-level 1
No. of actors that goods is transported in between	6	10	4
Information storage	Decentralized, i.e. at each actor	Central i.e. database at IT-company	Decentralized, i.e. at each actor
Technology used	Paper, stickers, barcodes (at some points)	UHF-RFID passive tags	UHF-RFID passive tags
Reading range (m)	Direct, 0- 2 (bar-codes).	0.5 – 12	5-15
Standards information transfer	None	EPC Gen 2	EPCIS, EPC Gen 2
Connection to the information systems	None	Secure web-access (XML), ERP solutions	Secure web-access (XML), ERP solutions

7. EVALUATION AND ANALYSIS

Table 7.1 shows advantages and disadvantages related to application of the current traditional system for traceability of items in the supply chain for fishes in Sweden according to the empirical studies.

Table 7.1 Advantages and disadvantages related to application of the traditional traceability system in Swedish fish supply chain.

Swedish fish supply chain traceability	***Aspect***	***Description***	***Affected actor(s)***
Disadvantages	Labeling	Sticker left-over problems	Fisherman; Receiver
	Cost	High buying cost High operation cost	Fisherman; Receiver; Wholesaler; Retailer
	Tagging	Glue problems caused by low Temperature Glue problems caused by water	Fisherman, Receiver
	Printing	Stickers get stuck in printers	Wholesaler, Retailer
Advantages	Simplicity of use	Easy to use for personnel	Receiver, Distributor, Wholesaler, Retailer
	Understandability	Easy to understand/ deliver information	Fisherman, Receiver, Distributor, Wholesaler, Retailer
	Security	Easy (hand ability) to use for personnel for showing all information	Distributor, Retailer

According to the analysis model introduced in the chapter 5, application of the smart goods affects traceability information and consequently has impacts on the activities carried out by using such information in the fresh food supply chains. Therefore first the traceability information in the fresh food supply chain is identified and then the consequences of application of smart goods on such information are recognized. The consequences of application of the smart goods on the carried out activities in the fresh food supply chains is identified as the next step. According to the empirical data from the three studied supply chains, information in the fresh fish supply chain can be divided into three categories including: production-related information, transportation-related information and item-related information. Each of these developed information categories contains different information types. The three main information categories and information types related to each category from perspective of the actors of the Swedish fresh fish supply chain are shown on the table 7.2. The last column of the table shows the information types that are the most important traceability parameters in the fresh food supply chains according to the empirical studies.

Table 7.2 Information categories, information types related to each category and valuable traceability parameters in the fresh food supply chain.

Information categories	*Information types related to each category*	*Valuable traceability parameters from the industry*
Production information	Vessel name, vessel external marketing, Captain name, Fishing tackle/ method, Date/ time (departure), Date/ time (arrival), Date/ time (landing), Date for transhipment Name of receiving vessel (transhipment), Nationality of receiving vessel (transhipment), Id number (logbook), Productions date, Packing date, Best before date, Landing quantity (kg), Landing quantity (units),Transhipment quantity (kg) Transhipment quantity (units)	Vessel name Vessel external marketing Best before date Name receiver
Transportation information	Net weight (kg), Batch number, Lot number, Name receiver, Name seller, Name buyer, Buy off date, Selling date	Name seller Name buyer
Item information	Specie denotation (English), Specie denotation (English), Specie denotation (Swedish), Specie code, Processing degree/ class, Size-class, Freshness class, Date (fishing activity), Id number, deductive bill, Selling price information, Temperature	Specie denotation (Swedish) Size-class Selling date

Table 7.3 shows the activities carried out by using the traceability information for different partners in the Swedish fresh fish supply chain. Comparison of the Swedish supply chain with the Danish and Norwegian supply chains shows the effects of the smart goods on the supply chain information and activities.

Table 7.3 Activities carried out by using different traceability information by different actors in the fresh food supply chain.

Information Category	Actors				
	Producer	**1st hand receiver**	**Distributor**	**2nd hand receiver**	**Costumer**
Production information	Producing (fishing), landing, managing Reporting (to authorities)	Managing Reporting (to authorities)	Managing Reporting (to authorities)	Managing	Selection of specific producer Creation of added values
Transport	Labeling, selling	Labeling, selling storing	Labeling, selling storing Product recall	Labeling, selling storing Product recall	
Item information	Identifying, cost reduction Prove quality	Identifying Buying	Identifying Buying Prove quality	Identifying Buying Prove quality Creation of safer food Creation of added values	Demand safer food Buying Ability demand quality

Table 7.4 shows the effects of using the smart goods on traceability informaiton and consequently on the activities that are carried out by using such informaiton for different actors in the three studied supply chains of fresh food. On the table the positive or benefitial identified effects are indicated by "+" and the negative or harmful effects are indicated by "-". This table is describing the effects caused by application of the smart goods in the food supply chains that is correlated to the analysis model introduced in chapter 5.

As shown on the table 7.4, the affected activities after using the smart goods are divided into three categories. These categories are logistics-related, control-related, and buying-selling-related activities. The logistics-related group represent the activities that are a part of the logistics operations in the fresh food supply chains. The control- related activities are activities conducted to have better control over the assets in order to reduce the number of missed items or activities conducted to have better quality of products when arriving to the customers. The buying-selling effects shown on the table 7.4 are related to different types of costs involved in traceability operaitons of the fresh food. As shown on the table 7.4 the negative effects of application of the smart goods indicated by actors of the studied fresh food supply chains are caused by high costs of implementaiton of the information systems that work by using the smart goods. Some of such costs include buying the smart tags, readers or crates quipped with the smart tags. As shown on the table 7.4 the smart goods has possitive effects on many of the logistics-related or control-related activities for different actors of the studied fresh food supply chains. As the table shows, the actors of the studied supply chains are put into three segments of producer, distributor and customer. This segmentation makes comparisons of the studied supply chains based on their actors possible.

Table 7.4. Effects of using smart goods on traceability information, costs of operations and activities carried out in fresh food supply chain.

Application of smart goods	Comparison between the three different supply chains								
	Swedish			Danish			Norwegian		
Supply chain actors	Producer	Distributor 1st hand receiver, wholesaler, auction, retailer	Customer	Producer	Distributor Auction, wholesaler, collector, washing companies, retailer	Customer Buyer, restaurant	Producer Slaughtering, cutting	Distributor	Cust-omer
Affected information types	*Production, transportation, item*	*Production, transportation, item*	*Production, transportation, item*	*Production, transportation, item*	*Production, transportation, item*	*Production, transportation, item*	*Production, transportation, item*	*Production, transportation, item*	*Production, transportation, item*
Affected logistics activities	+ Easier tagging + Quicker tagging + Quicker landing + Identification of crates	+ Easier tagging + Quicker tagging + Quicker storage + Identification of crates + Quicker deliveries + Handling of product recalls	+ Selection of specific producer/ product + Clear product information on labels + Product recalls	+ Easier tagging + Quicker tagging + Quicker landing + Identification of crates	+ Easier tagging + Quicker tagging + Quicker storage + Identification of crates		+ Easier tagging + Quicker tagging + identification of crates +Less paper work and manual data acquisition	+ Easier tagging + Quicker tagging + Quicker storage + Identification of crates +Less paper work and manual data acquisition	
Affected control activities	+ Quicker/ easier report into authorities + Better abilities to prove product quality	+ Quicker/ easier report into authorities + Better abilities to prove product quality	+ Product quality	+ Control of crates	+ Control of crates	+ Product quality	+ Control of crates + More secure readings + Traceability	+ Control of crates + More secure readings + Traceability	+ Traceability + Demand product quality
Affected buying-selling activities	+Better price from sales + Cost reduction (tagging/ labeling)	+ Better price from sales + Cost reduction (tagging/ labeling) + Increased no. customers -Buying costs from producers -System/ transaction costs	-Buying costs in stores	+ Cost reduction (tagging/ labeling) + Cost reduction crate management - System costs, traceability - Costs smart goods technique	+ Cost reduction (tagging/ labeling) + Cost reduction crate management + Cost reduction crates - Costs smart goods technique - System costs traceability		+ Cost reduction (tagging/ labeling) + Cost reduction crate management	+ Cost reduction (tagging/ labeling) + Cost reduction crate management + Cost reduction crates - Costs of smart goods technique	

8. CONCLUSIONS AND FURTHER RESEARCH

The most valuable information for traceability of the goods through different actors in a supply chain for fresh food is mainly related to three categories. The first category is production information that has an important impact on willingness of the customer to pay for the product. The second category is transportation information that is important from the shipping and material handling perspective. Information related to the quality attributes of the goods such as their weight or their specie is the third significant type of information for the customers and an important pricing factor.

Application of the smart goods with capability of auto-identification has a positive effects on different activities carried out in the supply chains for fresh foods. Such activities include different logistics operations, activities related to control the quality of the transported fresh food and management of the assets and resources used for transportation such as the crates. Buying and selling activities are affected by using the smart goods in the fresh foods supply chains. The most important negative effects of application of the smart goods is related to its costs of implementation for some of the actors in the supply chains.

Studying application of the smart goods with higher levels of smartness, for example by using sensors that can record different information regarding the physical characteristics of the goods, is an interesting subject for further research on this area.

In recent years there has been a significant interest for actors of the supply chains to decrease the environmental side effects of their operations. Studying the applications of the smart goods for this purpose is an interesting subject for research in the future.

According to the empirical studies, currently no international standard is used for labeling of the items through the supply chains in specially fish industries. Developing such standards to be followed by different actors of the fresh food supply chains is suggested by the authors as a solution to improve efficiency of the supply chain operations.

This paper is contributing to the literature written on the smart goods and traceability in food supply chain by studying three supply chains in form of a cross case analysis.

Different actors of the supply chains of fresh food can use this study for having a better vision of how to implement smart goods for traceability of products. The advantages and disadvantages related to application of the smart goods generated in this paper are used as a decision support for implementation of the smart goods.

References

Abad, E., Palacio, F., Nuin, M., Gonzalez de Zarate, A., Juarros, A., Gomez, J.M., Marco, S., (2009), “RFID smart tag for traceability and cold chain monitoring of foods: Demonstration in an intercontinental fresh fish logistic chain”, , *Journal of Food Engineering*, No. 93, pp. 394-399.

Eisenhardt, K.M. (1989), “Building Theories from Case study Research”, *The Academy of Management Review*, Vol. 14, No.4, pp. 532-550.

EPC Global (2010), “EPCIS standard”, available at: http://www.epcglobalinc.org/home/ (accessed 19 March 2010).

Ghribi, B. and Logrippo, L. (2000), “Understanding GPRS: The GSM Packet Radio Service”, *Computer Networks*, Vol. 34, pp. 763-779.

GS1 EPCglobal, (2009). “GS1 EPCglobal Glossary – terms and terminology within the GS1 EPCglobal standards”, available at: http://gdd.gs1.org/gdd/public/searchableglossary.asp (accessed 31 March 2010).

Holmqvist, M. and Stefansson, G. (2006), “Smart Goods' and Mobile RFID-A Case With Innovation From Volvo”, *Journal of Business Logistics*, Vol. 27 No. 2, pp. 251-272.

Jacquet, J., L., and Pauly, D. (2008), “Trade secrets: Renaming and mislabeling of seafood”, *Marine Policy,* Vol. 32, pp. 309–318.

Johansson, O. and Pålsson, H. (2009), “The impact of auto-ID on logistics performance- a benchmarking survey of Swedish manufacturing industries”, *Benchmarking: An international journal*, Vol. 16 No. 4, pp. 504-522.

Johansson, O. (2009), *PhD dissertation: On the value of intelligent packaging- a packaging logistics perspective*, Division of Packaging Logistics, Lund University of Technology, Lund, Sweden.

Kärkkäinen, M., Holmström, J., Främling K. and Artto, K. (2003), “Intelligent products—a step towards a more effective project delivery chain”, *Journal of Computers in Industry*, Vol. 50, pp.141–151.

Lumsden, K. and Mirzabeiki, V. (2008), "Determining the value of information for different partners in the supply chain", *International Journal of Physical Distribution & Logistics Management*, Vol. 38 No. 9, pp. 659-673.

Lumsden, K. and Stefansson, G. (2007), “Smart freight to enhance control of supply chains”, *International Journal of Logistics Systems and Management*, Vol. 3 No. 3, pp.315 – 329.

McFarlane, D., Sarma, S., Chirn, J.L., Wong, C.Y. and Ashton, K. (2003), “Auto id systems and intelligent manufacturing control”, *Journal of Engineering Applications of Artificial Intelligence*, Vol. 16 No. 4, pp. 365–376.

Meyer, G., Främling, K. and Holmström, J. (2009), “Intelligent Products: A survey”, *Computers in Industry*, Vol. 60, pp. 137–148.

Regattieri, A., Gamberi, M., Manzini, R. (2007), “Traceability of food products: general framework and experimental evidence”. *Journal of Food Engineering*, Vol.81, No.29, pp. 347–356.

Ringsberg, H. and Lumsden, K. (2009), “Traceability in the fish supply chain – evaluating two supply chain mapping techniques”, in *NOFOMA proceedings* of the NOFOMA-conference in Jönköping, Sweden, 2009, Jönköping international business school Jönköping University, Jönköping, pp. 695-711.

Stefansson, G. and Lumsden, K. (2009), “Performance Issues of Smart Transportation Management Systems”, *International Journal of Productivity and Performance Management,* Vol. 58 No. 1, pp. 54-70.

Wong, C.Y., McFarlane, D., Zaharudin, A. and Agarwal, V. (2002), "The intelligent product driven supply chain", in *Supply chain management* 2002 proceedings of the international conference in Götet, Sweden, 2002, Springer-Verlag, Vienna, pp. 888-32.

Yin, R. K. (2003), *Case Study Research - Design and Methods*, Third Edition, SAGE Publications, Thousand Oaks, US.