Critical success factors for implementing supply chain information systems

INSIGHTS FROM THE PORK INDUSTRY

Janne M. Denolf

Thesis committee

Promotors
Prof. Dr S.W.F. Omta
Professor of Management Studies
Wageningen University

Prof. Dr J.G.A.J. van der Vorst
Professor of Logistics and Operations Research
Wageningen University

Co-promotor
Prof. Dr J.H. Trienekens
Personal chair at the Management Studies Group
Wageningen University

Other members
Prof. Dr H. Hogeveen, Wageningen University
Prof. Dr G. Schiefer, University of Bonn, Germany
Prof. A.J.M. Beulens, Wageningen University
Prof. Dr H. Hvolby, Aalborg University, Denmark

This research was conducted under the auspices of Wageningen School of Social Sciences (WASS)

Critical success factors for implementing supply chain information systems

Insights from the pork industry

Janne M. Denolf

Thesis
submitted in fulfilment of the requirements for the degree of doctor
at Wageningen University
by the authority of the Rector Magnificus
Prof. Dr M.J. Kropff,
in the presence of the
Thesis Committee appointed by the Academic Board
to be defended in public
on Monday 15 December 2014
at 1.30 p.m. in the Aula.

Janne M. Denolf
Critical success factors for implementing supply chain information systems – Insights from the pork industry
178 pages

PhD thesis, Wageningen University, Wageningen, NL (2014)
With references, with summaries in English and Dutch

ISBN 978-94-6257-159-4

Acknowledgements

This dissertation would not have been possible without the support of many people who deserve a special mention.

At first, I wish to express special gratitude to my supervisors Onno Omta, Jack van der Vorst, Jacques Trienekens, as well as Nel Wognum. A huge "thank you" to my promotors Onno and Jack. Onno, thanks for your thoughtful and professional guidance, your constructive comments, but especially for making my PhD journey at the MST department a relaxed and supremely enjoyable experience. Jack, I am most notably thankful for your critical advice and comments – particularly regarding the methodologies used – to significantly improve my work. I appreciated your continuing personal and intelligible supervising approach. I own my deepest gratitude to my daily supervisor Jacques; this thesis would not have been possible without you. On top of so much time and effort you have spent on revising my work and regularly discussing (conceivable) thoughts, I want to thank you for your ceaseless positivism, your ongoing encouragement, and your down-to-earth approach when giving comments. Jacques, thanks for always being available whenever I was struggling. Also, I would like to thank Nel for her help during the first years of my PhD. Even though our opinions often clashed, you have unquestionably contributed to this thesis and my personal development; you stimulated me to look more critically at my work and spurred me on to phrase my ideas in a more straightforward and comprehensible way. I benefited considerably from all four of you and I have been privileged to have you as my supervising team.

This research is part of the projects TIPO (Traceability and Identification of Pigs within the Organic meat supply chain) and Quarisma (QUality And RISk MAnagement in meat chains). The former is financed by the Province of Gelderland (the Netherlands) and the European Fund for Regional Development (EFRO), while the latter was funded by IAPP (Industry-Academia Partnerships and Pathways). Their financial support is gratefully acknowledged. Regarding the TIPO project, I would like to acknowledge the inspiring and pleasant collaboration with the project-team members involved: Henk, Iris, Jan, Chris, Ingo, Hans, Jascha, and Ton. Within the context of this project, I would like to show my gratitude to my WUR colleague Robert Hoste and former MSc student Karine Chartier for their highly esteemed contributions and ideas. The Quarisma project provided me with the opportunity to collect highly valuable data and, consequently, to give my research an extra dimension. From this perspective, I would like to show my gratitude to Verena Schütz, with whom I enjoyed working together at Deutscher Raiffeisenverband. I am particularly grateful for your useful methodological recommendations, constructive feedback for chapter 4, and for generously sharing your network. Moreover, I really enjoyed the time in Berlin with the DRV colleagues; it was always a pleasure going there. Thank you Anja, Elisabeth, and Carolin.

I am indebted to many colleagues who made my stay at the MST department joyful, inspiring, and – especially – memorable. The discussions, ranging from cultural diversities to politics, during coffee breaks (overabundance of coffee every so often), outings with the department, and other social activities have been indispensable to the process of getting my PhD. I would, therefore, like to acknowledge my (former) colleagues and friends: Alessia, Anne, Annie, Andrei, August, Delelegne, Djalal, Domenico, Emiel, Eva, Frances, Franco, Geoffrey, Gohar, Gumataw, Hanieh, Herman, Jack, Jaime, Jos, Johnnatan, Katia, Lavlu, Liesbeth, Lisa, Mark Wever, Mark Mobach, Mmpatla, Paul, Peng, Philipp, Rob, Ron, Sebastian, Silvia, Stefano, Suryani, Thomas, Valentina, Vincent, Wilfred, and Zhen.

Besides these prodigious colleagues, I am particularly grateful to a handful of colleagues who have been of tremendous value during my PhD journey. A word of genuine appreciation should be expressed to Etriya; you were (more than) always inclined to listen and help. Notwithstanding being a "disaster girl", thanks Azzurra for sharing an office for a while, for having animated conversations, and for being your problem solver. Grazie Mille! Christos, you deserve a special note of appreciation for sharing your experiences and opinions, for chatting about non-work related topics, and especially for motivating me during the arduous moments of my PhD project. Together with you, Verena, and Mersiha, I really relished the spontaneous drinks! Mersihi and Bitsy, I am elated that I could often jump in your office, the place where a laugh was never far away. Also, I would like to thank Ina Versteeg and Jeanette Lubbers, as well as Fenny for their support and willingness to listen over the years.

Looking back on my PhD experience, I realize that I have been blessed to meet amazing people, whose friendship I deeply value. I record my profound gratitude to my friends Yeray, Dimitrios, my former German flatmates – Stella, Hanna, and Inka –, Helga, and Maddy. Yeray, I do not need to express how important you were during my Wageningen stay. From the moment we met, you have always been available to listen to my nonsense or botheration, and discuss weighty and trivial issues. Muchas Gracias, Amigo! The same holds for you, Dimi. Throughout the Wageningen years, we have built up an extraordinary bond of friendship, in which nobody else could understand our hilarious conversations and which will undoubtedly stand the test of time. Σε ευχαριστώ αδερφε! Stella, Hanna, and Inka, thanks for sharing a house with me, where I really felt a congenial "family atmosphere". I truly appreciated sharing the simple and relaxing things in life! Stelli, I am so delighted that our paths have crossed in our beloved Wageningen. Also my stay at the Waterhouse is a cordial period to be remembered. Special thanks to all my former flatmates and Helga and Maddy in particular. Loretto also deserves a mention of appreciation; your "mind-boggling" words of positivism stood me in good stead for my final sprint towards graduation. I highly appreciate having met so many compelling people in Wageningen. This appreciation is unquestionably extended to my dearest and closest Belgian Friends Rutger, Karel, Charlotte, Marlies, and Ghyslaine. I greatly value our friendship. Sincere thanks!

My most profound thanks goes to my family and my girlfriend Jana; you have helped me beyond words. Jana, thanks for your continual stream of (emotional) support and optimism. I am really elated that you were there to distract me every now and then from my PhD quest. Lastly, I would like to express my gratitude to my closest family for their endless encouragement by always saying the right words, their belief in me, and understanding my mood swings on my PhD rollercoaster. I truly appreciate everything you have done during the last years.

Table of Contents

Chapter 1

General introduction

1. General introduction

In recent decades, globalization has drastically changed the way companies operate. While a global world brings opportunities to reach new markets and supply customers worldwide, companies are exposed to intensified competition. Companies soon realized that they should closely collaborate with their supply-chain partners to further cut costs and stay competitive (Baihaqia & Sohal, 2013). Supply chains aim to optimize the operational efficiency of delivering desired products or services to end consumers on time and at minimal cost (Sahin & Robinson, 2002). Since a large number of partners and markets need to be managed across the globe, the complexity of these supply chains is huge and continues to expand. Consequently, supply-chain partners need to share more information to make informed decisions and minimize the risks of disruptions (Cheng, 2011; Li & Lin, 2006; Yu et al., 2001). Information sharing and thus improved communication can be facilitated through the implementation of an information system.

However, when improving information sharing and implementing information systems in supply chains, various technical and organizational issues must be managed to achieve the proper techno-organizational fit (Bajaj & Nidumolu, 1998; Russell & Hoag, 2004; Stefanou, 1999). To do so, multiple supply-chain actors must be connected, each with their own company culture, power and leadership structure, management methods, and information systems (Lambert & Cooper, 2000). Furthermore, supply-chain actors might have different reasons for implementing supply chain information systems (SCISs) and, hence, have different implementation objectives. Moreover, such SCIS implementations might lead to high expenditure; companies and supply chains spend millions of euros on information systems. These have often incurred huge financial losses when the implemented information systems failed to deliver better performance or higher productivity (Venkatesh & Bala, 2008).

Information-system researchers, from industry and academia, have identified several approaches to increasing the chances of successfully implementing information systems. Identification of critical success factors (CSFs), which are important areas in which intervention is needed to successfully implement an information system, has given rise to a substantial amount of literature (Ang et al., 2002). In contrast to the literature investigating intra-organizational information systems, such as ERP (Enterprise Resource Planning), the implementation of supply chain information systems has, however, only been studied in a fragmentary fashion. As a result, compared to ERP literature, a consensus on critical success factors affecting the implementation outcome has not been achieved between supply-chain researchers. Since the supply-chain literature investigating CSFs for information sharing and implementing supply chain information systems is scarce, the following central objective is put forward in this book.

Main Objective. *To identify critical success factors for supply chain information sharing and implementing supply chain information systems.*

1.1 Research context – Pork supply chains

There is a great need for increased information sharing due to several drivers of change to which food supply chains have been exposed over the last few decades.

1.1.1 Drivers of change in food supply chains

On a global scale, food supply chains have been exposed to an increasing number of food scandals. For instance, there have been multiple meat scandals (Banati, 2011; Rample et al., 2012), such as BSE (beef), dioxin crises (pork, poultry), classical swine fever (pork), bird flu (poultry), and blue tongue (sheep) (e.g. Banati, 2011, 2014; Van Plaggenhoef, 2007). As a result, many consumers have lost confidence in the food industry (Zachmann & Ostby, 2011) and have become critical about the safety and quality of agricultural and food products (Banati, 2011; Verbeke et al., 2007).

Furthermore, the world economy has become global. Within the last 50 years, international trade of agricultural and food products has increased six-fold (Hazell & Wood, 2008). In a global agricultural economy food production and distribution becomes interconnected, making food products, services, people, skills, and ideas move – relatively – freely across geographical borders (Hitt et al., 2012). It implies that food products from everywhere around the world are available to consumers. Increased globalization has been facilitated and catalyzed by innovative communication technologies – e.g. the internet – and improved transportation facilities (Hitt et al., 2012).

These drivers of change – i.e. globalization and an increasing number of food scandals – have resulted in low profit margins and high customer expectations. Regarding the latter, consumers increasingly ask for food-safety information on the products they buy, such as origin, pesticides and additives used, production means, and hygiene (Trienekens & Wognum, 2009). With respect to low profit margins, globalization has intensified competition, which, consequently, has led to a continuous decline in world food prices (Hazell & Wood, 2008). To improve margins and food safety in food supply chains, business processes along the supply chain need to be made more effective and efficient. Information exchange is, therefore, urgently needed to adapt business processes in the food sector (Bahlmann & Spiller, 2009). The importance of information exchange in food supply chains has been emphasized by, for instance, Hill and Scudder (2002), Schulze et al. (2006), and Lehmann et al. (2012). More than ever, food supply chains need to implement or re-organize information systems that integrate actors in the whole supply chain (Wolfert et al., 2010).

1.1.2 Drivers of change in pork supply chains

In this thesis, we focus on the pork meat industry. This sector also has to cope with low profit margins and high customer expectations. For instance, intense pressure on retail margins has caused a cascade effect on the upstream supply-chain. In addition, high grain prices have made feed prices rise, increasing the cost of pig production. Furthermore, meat crises, such as the dioxin crisis and classical swine flu, have occurred during recent decades (Hartmann et al., 2013). To increase profit margins and cope with more food-safety demands, improved information exchange in pork supply chains is imperative.

In most pork supply chains, similar consecutive production and distribution stages are undertaken by the feed company, breeder, farrower, finisher, slaughterhouse, processor, and customer channels (see Figure 1.1). Breeding companies deliver sows, sperm, and boars to the farrowers, where piglets are reared to 25 kg. These pigs are then delivered to the finisher, who fattens the animals up to 110 kg slaughter weight. The farrowing and the finishing stages are often accomplished by a single farm. Thereafter, pigs are slaughtered, a process that entails several activities such as stunning, blood tapping, removing hairs, carcass and organ examining, splitting, chilling, and – sometimes – cutting. Slaughterhouses choose to deliver carcasses to the next actors as carcass halves or as six meat cuts. Whether carcasses are sold as carcass halves or as meat cuts, they are typically sold to processors, as well as wholesalers and retailers. Processing companies, which are either part of a slaughterhouse or act independently, process the carcass parts further into a wide range of meat products. Finally, the packaged meat is sold through various customer channels, most of it via the retailer. However, some of it is distributed through so-called out-of-home channels, such as restaurant, hospitals, and business canteens.

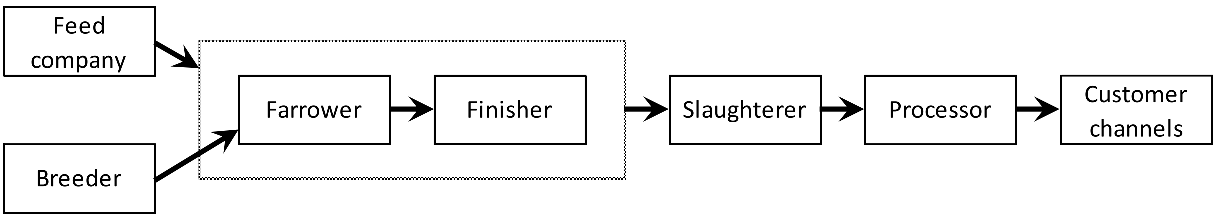


Figure 1.1 Pork supply chain

The pork industry is particularly interesting to investigate for the following three reasons:

- First, in pork supply chains, several successful and unsuccessful attempts have been made to improve information sharing and to implement supply chain information systems. There is great variation in these systems with respect to main functions and main addressees. Some systems, for instance, are built for farmers, slaughterhouses, and laboratories to coordinate salmonella monitoring. Others, however, are built mainly to exchange results regarding carcass grading, meat inspection, salmonella monitoring and inter-farm comparisons from slaughterhouse to farmers.

- Second, pork supply chains are in many cases organized differently. For instance, some are controlled by a supply-chain orchestrator, steering the supply and demand along the entire supply chain and forcing supply-chain actors to employ particular resources. In others, all chains actors work independently and are not obliged to use particular resources or deliver products at a certain point in time. In other words, a broad spectrum of supply-chain organizations can be found in the pork industry. Distinct supply-chain organizations can cause different technical or organizational issues or complexities that must be managed when implementing a supply chain information system.
- Third, several marketing strategies have been applied by pork supply chains. Some of them tend to produce bulk commodity products and others focus on brand-labeled production, emphasizing differentiating quality attributes (i.e. unique selling propositions). Differentiating supply chains can engender distinct information-sharing demands and supply chain information system implementations.

Despite the fact that the research in this thesis is conducted in the context of pork supply chains, our results should be of interest for other agri-food supply chains. The pork industry has been exposed to similar challenges to other food industries. Other food sectors also need to cope with low profit margins and face an increasing demand for healthy, safe, and high-quality food. In addition, pork supply chains have structural similarities with other food supply chains. For example, in other food supply chains, farmers – often united in a cooperative – take care of the primary production as well. Then, farmers deliver their products to processors, which are usually few in number. The main customers of these processors are retailers, who typically hold a very powerful position in food supply chains.

1.2 Managing the implementation of information systems

In this thesis, information is a central concept. Information is defined as a collection of data that are organized in such a way that they have additional value beyond the individual data (Stair & Reynolds, 2013). A possible way to turn data into information is by means of information systems. An information system can be defined as "a set of interrelated elements or components that collect (input), manipulate (process), store, and disseminate data and information (output) that provide a corrective reaction (feedback mechanisms) to meet an objective" (Stair & Reynolds, 2013, p. 8). Processing, which refers to transforming the data into useful information, can be done both manually and with computer assistance. In this book, emphasis is placed on computer-based information systems.

Several types of computer-based information systems have been developed for companies. These systems range from supporting simple transactions or happenings, also called transaction-processing systems, to supporting a wide range of managerial decisions in different functional areas, so-called decision support systems. Concerning the former, a company can implement a system that keeps track of the hours its employees work or of the amount of stock it holds. Such systems have existed since the sixties (Umble et al., 2003). Later, companies became increasingly aware that information systems could be employed to further enhance production processes by integrating several functionalities. For instance, since the nineties, ERP (Enterprise Resource Planning) systems have been designated and implemented with the intention of integrating information flows about finance, operations, sales, and HRM (Human Resource Management) across the company. The use of ERP systems may result in, for example, better forecasts, fewer operating costs, faster production cycles, customer-service improvements, and productivity enhancements (Botta-Genoulaz & Millet, 2005; Gargeya & Brady, 2005; Umble et al., 2003). Information systems developed for companies are called intra-organizational information systems.

However, as companies began to realize that they were being urged to cooperate with their supply-chain partners, the development and implementation of supply chain information systems emerged. More than ever, supply chains need to implement or re-organize information systems that integrate actors in the whole supply chain (Wolfert et al., 2010). Such information systems, known as "supply chain information systems" (SCISs) or "inter-organizational information systems" (IOSs), support information exchange in the supply chain by providing relevant information to all chain partners. The information exchanged can vary, for instance, from information about production processes to general customer or marketing information (Li & Lin, 2006; Mentzer et al., 2000). By providing relevant information, the supply chain and its actors are able to increase coordination and monitoring of their operations resulting in more efficient and effective value-adding activities (Lau & Lee, 2000).

The implementation of information systems, both intra-organizational and supply-chain ones, has often been characterized by high failure rates. Davenport (1998), Barker and Frolick (2003), Ehie and Madsen (2005), and Francoise et al. (2009) stressed, for instance, the high failure rate of ERP implementations. For the following reasons, the failure rate can also be high for supply chain information systems (SCISs). First, the implementation of a supply chain information system is often perceived and treated as a purely technical undertaking. However, both technical and organizational aspects require attention since implementing a SCIS entails integrating multiple supply-chain actors, each with their own company culture, power and leadership structure, management methods, and information systems (Lambert & Cooper, 2000). Moreover, different supply-chain actors may have different reasons for implementing a SCIS and, consequently, a different implementation objective. Second, the implementation of a SCIS is distinct from the supply-chain organization's daily practices. Due to its size, complexity, and importance, such an implementation typically requires the creation of a new project. Because the members of the "provisional" project team are often unfamiliar with project management, the implementation process might proceed more slowly than predicted. As a result, failures may occur due to poorly defined responsibilities or lack of appropriate knowledge, often resulting in mediocre decision-making by project-team members who are unfamiliar with the SCIS systems. In general, failures of information systems can be attributed to the many technical and organizational aspects that should be considered and, hence, the large amount of expertise that is compulsory to manage such an implementation.

In response, both academics and practitioners have identified several approaches or tools to cope with the technical and organizational complexities. Researchers have, amongst other things, identified barriers, risks, and critical success factors (CSFs) for implementing a supply chain information system. The last one in particular accounts for a substantial amount of literature. CSFs are the factors that must go well during an implementation and must, therefore, be given special and continual attention to successfully implement an information system (Bullen & Rockert, 1986). However, critical success factors have mainly been identified for the implementation of intra-organizational systems, such as ERP systems. Consequently, the literature investigating critical success factors (CSFs) for implementing supply chain information systems (SCISs) has been fragmented.

1.3 Theoretical perspective

In this book, various theoretical perspectives are used to shed light on the critical success factors for information sharing and implementing supply chain information systems. Generally, these perspectives have highlighted the fact that the successful implementation of an information system (or a supply chain information system) is dependent on the interaction of the organizational and technical system.

The literature dealing with the mutual impact of implemented technology and organization goes back a long way. Back in the 1950s, Leavitt and Whisler (1958) speculated about the possible role of (information) technology (IT) on the organization in their article "Management in the 1980's". Early research claimed that (information) technology determines the organization, meaning that the organizational structure and users' actions are predetermined by the technology (Leonardi & Barley, 2008; Markus & Robey, 1988). Later, contradictory results showed that such organizational change cannot be completely predetermined since the organization with its own culture, social context, and members influences the implementation direction to a great extent. Barley (1986), for instance, demonstrated that identical technologies can result in different outcomes due to distinct organizational structures and people.

The way information technology and organization impact each other has been investigated using several theoretical perspectives. In general, two extremes can be defined. At one end of the spectrum, a group of researchers has claimed that technology can be (easily) redesigned during implementation of the information technology. In this view the role of technology is relatively weak as (possible) users can redefine the technology based on their habits, behavior, or actions (Boudreau & Robey, 2005). At the other end of the spectrum, researchers have claimed that the role of technology has a major impact and constrains human action to a great extent (Gosain, 2004).

Several researchers have built theories for understanding the mutual impact of technology and organization and have tried to bridge the gap between the above-described extremes. Well-known examples are the Structuration Theory (e.g. Orlikowski 1992, 2008), the Actor-Network Theory (e.g. Walsham, 1997), and Theories of Change (Pettigrew, 1985). As indicated by Orlikowski (1992)[1], human actors, technology, and institutional properties interact with each other and are adjusted when implementing information technology. While technology refers to all material artefacts, such as tools, machines, and information systems, institutional properties denotes governance structures, business strategies, culture, control procedures, and standard procedures. Within the last few decades, there has generally been a high degree of consensus that the implementation of an information system triggers a dynamic process in which both technology and organization co-develop and need to be aligned (Leonard-Barton, 1988; Markus & Tanis, 2000; Orlikowski, 1992; Volkoff et al., 2008).

However, the structuration theory of Orlikowski and other theories only give general explanations for the co-development and impact of both organization and technology (Lyytinen & Newman, 2008). The development of such theories was, notwithstanding, never meant to provide a rich and practical guide on how to implement information technologies; hence, these theories are difficult to use empirically (Pozzebon & Pinsonneault, 2005). Tangible tools that consider these theories for implementing information technologies and supply chain information systems (SCISs) in particular are scarce.

To provide more ready-to-use methods, critical success factors (CSFs) for supply chain information sharing and implementing supply chain information systems are identified in this thesis. To classify these CSFs, researchers have built several frameworks, such as the MIT90s framework of Scott Morton (1991), the strategic-tactical framework of Holland and Light (1999), and the process-control-information (PCI) framework of Bemelmans (1998). In this thesis, we opted to structure and classify critical success factors in the dynamic MIT90s framework (Scott Morton, 1991), which covers organizational as well as technical aspects. This framework was developed in the 1990s to help managers understand IT-enabled organizational change (Scott Morton, 1991). Furthermore, the model is simple and easily extendable (Lyytinen & Newman, 2008) and can therefore be used in different settings for multiple purposes. For instance, the model was also applied in a supply-chain context by Verdecho et al. (2012). The MIT90s framework gives an indication of generic factors[2] (project strategy, structure, information systems, people, and management processes) that need to be considered when implementing a supply chain information system. Starting from the Scott Morton framework,

[1] According to Volkoff et al. (2007), the Structuration Theory of Orlikowski is the most commonly used theory to examine the organization-technology relationship.
[2] Note that the MIT90s framework is in line with the Structuration Theory of Orlikowski (1992) because technology refers to information systems in the MIT90s framework, human actors refer to people, and institutional properties refer to structure, project strategy, and management processes.

critical success factors for information sharing and implementing supply chain information systems are identified in this thesis.

1.4 Research Objectives

The overall aim of this book is to analyze information sharing in supply chains and the implementation of supply chain information systems by identifying technical and organizational critical success factors. This central objective is translated into three research objectives, described below. On the basis of three consecutive objectives, we are zooming in from general information sharing, via the implementation of (general) supply chain information systems, to the implementation of a traceability system, which is a specific supply chain information system. The first research objective, dealing with information sharing, forms a stepping stone to the rest of the thesis, focusing on the supply chain information systems.

1.4.1 Research objective 1

Regardless of its benefits, information sharing may create some drawbacks. Information security and information access privileges are of particular concern for collaborating supply-chain partners (Lee & Whang, 2000; Premkumar, 2000). To mitigate these concerns, relationships among the supply-chain actors need to be managed and require coordination mechanisms. Governance structures in particular need to be chosen carefully (Ghosh & Fedorowicz, 2009). A governance structure is defined as “the set of coordination mechanisms that create incentives to interact and safeguards that protect each party against the risk of opportunistic behavior on the part of the other” (Nicolaou, 2008, p. 222).

Despite initial research, shortcomings remain apparent in the supply-chain literature investigating the impact of governance structures on information sharing. What is missing in the literature is an intelligible analysis of how and to what extent information sharing can be attributed to governance structures in supply chains. First, the literature has not accounted for the multi-dimensionality of information sharing; specifications of which information to share and how to share it have been overlooked (Chandra et al., 2007; Kembro & Näslund, 2014; Yao et al., 2008). Second, most of this literature does not consider the complete supply chain as the unit of analysis (Kembro & Näslund, 2014). To date, results have often been derived from research considering only dyadic buyer-supplier relationships. To address these gaps, the following research objective was posed:

> ***Research Objective 1.*** *To investigate how and to what extent supply chain information sharing can be explained by supply chain governance structures*

1.4.2 Research objective 2

One of the information-sharing mechanisms commonly used to share supply-chain information is the supply chain information system (SCIS). The implementation of a SCIS acts as a catalyst of complex technical and organizational changes that need to be managed carefully. A wide range of academics and practitioners have delivered approaches to cope with such complexities and to increase the chances of successfully implementing a SCIS. One of the approaches is the use of “critical success factors” (CSFs), which can help managers to proactively tackle failures and implement a SCIS. CSFs are the organizational and technical factors that must go well during an implementation and must, therefore, be given special and continual attention to successfully implement an information system (Bullen & Rockart, 1986). So far, CSFs for implementing SCISs have only been investigated to a limited extent and in a fragmentary fashion. A limited number of supply-chain researchers identified only different and a limited set of critical success factors. Therefore, the following research objective was posed:

> ***Research Objective 2a.*** *To identify critical success factors (CSFs) for implementing supply chain information systems (SCISs)*

Despite their prominent position in information-systems literature, critical success factors are abstract as they have not been made “actionable” and are, therefore, only a partial aid to practitioners (Boynton & Zmud, 1984; Flynn & Arce, 1987; Francoise et al., 2009). To date, information-system researchers have mainly delivered “laundry lists” of CSFs for implementing SCISs. Therefore, to address this limitation, the following research objective was posed:

> ***Research Objective 2b.*** *To make critical success factors for implementing supply chain information systems “actionable”*

When implementing a supply chain information system, additional supportive (identification) technologies can be imperative for collecting the data. On the basis of the third research objective, a closer look is taken at the implementation of a traceability system, which is a specific supply chain information system.

1.4.3 Research objective 3

In many supply chains, information sharing is inadequate; stakeholders might not be satisfied with the information that has been put at their disposal. For instance, recent meat scandals have indicated that there are still gaps in current traceability systems. Traceability is defined as “the collection, documentation, maintenance, and application of information related to all processes in the supply chain in a manner that provides guarantees to consumer and stakeholders on origin, location, and life history of a product” (Opara, 2003). To close traceability gaps, improved traceability procedures and exchange of product information throughout the chain are required (Hanf & Hanf, 2007; Sporleder & Moss, 2002). Different enabling traceability technologies, such as Radio Frequency Identification (RFID), have been proposed to facilitate traceability and information exchange. RFID is an automatic identification technology that identifies units, collects info, and links different information files (Costa et al., 2013; Zhu et al., 2012). Besides technical measures, the literature has shown that complementary organizational measures are crucial for improving traceability.

Despite a number of traceability and RFID publications, knowledge gaps and methodological shortcomings are apparent in this emerging field. Traceability and RFID publications in particular fall short as they deal mainly with the general issue of traceability and are not really applicable for practitioners (Karlsen et al., 2010; Li et al., 2010; Zhu et al., 2012). It is, however, imperative for practitioners in supply chains to verify best practices, applications, impact, and feasibility for RFID deployment (Mehrjerdi, 2011; Nambiar, 2009). Identification of critical traceability points (CTPs) is a suitable method for making traceability research more applicable for practitioners. Critical traceability points are defined as "points where systematic information loss [may] occur when information about a product or process is not linked to a product" (Karlsen et al., 2011a, p. 1). However, in the literature on critical traceability points, researchers, such as Donnelly et al. (2009) and Karlsen et al. (2011a), have not verified how to manage critical traceability points through RFID. They used the critical traceability point analysis (CTPA) methodology, considering only the identification but not the verification of CTPs. Consequently, the possible added value of RFID and complementary organizational measures to manage these critical traceability points, have not been discussed. Moreover, none of the CTP publications has considered pork meat, the world's most consumed meat. The following research objective was, therefore, posed:

> ***Research Objective 3.*** *To identify critical traceability points (CTPs) in pork supply chains and to investigate how these CTPs can be managed through the application of new technologies (e.g. RFID) in organic pork supply chains*

1.5 Research design and thesis setup

Chapters 2, 3, 4, and 5 present four studies aiming to identify critical success factors, both organizational and technical, for sharing information and implementing supply chain information systems. Case research seems to be an appropriate way to investigate and comprehend the nuanced picture of implementing supply chain information systems and subsequent information sharing. According to Miles and Hubermann (1984), Yin (2003), and Eisenhardt (1989), case study research enables in-depth investigation and is an effective way of studying events of a highly complex nature in depth.

In **Chapter 2**, we explore how governance structures can impact information sharing in pork supply chains. To this end, three pork supply chains with a different supply-chain organization (i.e. different governance structures) were selected. For these cases, people with different positions and backgrounds were interviewed. During the interviews, an interview protocol was used to collect the information required, which were commonly recorded in (internal) reports. Based on the reports of the three supply chains, we indicate how and to what extent governance structures might lead to particular ways of information sharing and the type of information shared.

Chapter 2 is based on data from the Q-PorkChains project. Q-PorkChains was an integrated project under the EU's 6th framework program and focuses on the quality of pork and pork products by covering the total production chain from farm-to-fork. Sixty-two partners from 19 – mainly European – countries collaborated to develop and implement new innovative methods to improve and control the quality of pork. The Q-PorkChains project consisted of six modules focusing on consumers and citizens, pork production, product development, chain management, molecular quality control, and knowledge synthesis. The research presented here was performed within module four, focusing on developing tools to improve supply-chain integration and sustainable management of several distinct European pork production systems. Key activities included: quality management systems, chain communication, governance structures, and chain innovation. For more information on the project and its modules, please visit the website www.q-porkchains-industry.org

Based on a review of 31 articles on critical success factors (CSF), we describe in **Chapter 3** a framework of critical success factors (CSFs) for implementing supply chain information systems (SCISs). The literature focusing on ERP (Enterprise Resource Planning) systems forms a starting point for this study since it delivers explicit elaborate lists of base-line CSFs, both technical and organizational, that may play a role in SCIS implementations. Therefore, to start with, a literature review of critical success factors for ERP implementations was conducted, which resulted in a list of 10 key articles investigating CSFs for implementing ERP systems. These articles were reviewed and categorized to define CSFs. A final list of CSFs was used to further investigate the literature dealing with CSFs for implementing supply chain information systems. Due to the scarcity of SCIS articles, multiple search terms were used to identify articles investigating CSFs, resulting in 21 SCIS articles. These articles enabled us to build a framework of CSFs for SCIS implementations.

Critical success factors are made actionable in **Chapter 4**. Therefore, we define actions linked to CSFS for successfully implementing a SCIS in the food sector. To collect data, four German pork supply chains were investigated. To increase the representativeness of the case sample, we incorporated differences between supply chains. Regarding the selection of the interviewees, people with different positions and from different hierarchical levels in organizations and companies were interviewed. The interviews were conducted using the "critical incident technique" (CIT), which is a set of procedures for collecting data from the respondent's perspective in his or her own words. CIT does not force the respondents to talk about certain topics and can deliver top-of-mind answers. Based on four case studies in the

German pork sector, a number of actions connected to the different CSFs are identified. These actions enable better management of SCIS implementations.

The results are based on the Quarisma (Quality and Risk Management in Meat Chains) project. Quarisma is a European project funded by IAPP (Industry-Academia Partnerships and Pathways), part of the specific Program Marie-Curie Actions of the EU's 7th Framework Program. The goal of the project was to stimulate the development of sustainable meat supply chains in Europe and, in the Netherlands and Germany in particular. This was achieved by means of an interdisciplinary cross-border (i.e. Germany and the Netherlands) research network, translating practical questions into research questions and vice versa. This project consisted of several parallel work packages, which focused, amongst other things, on chain management, quality and information management, and food safety and risk management. The results in this book are based on module 1, focusing on optimized inter-company relationships from fork-to-farm. For more information on the Quarisma project and the different work packages, check the Quarisma website giqs.org/en/projects/completed-projects/quarisma

In **Chapter 5**, we identify points where traceability information may get lost and investigate which of these critical traceability points (CTPs) can be managed through RFID (Radio Frequency Identification) applications. We report the findings of an organic pork supply chain in which quality and authenticity guarantees are required. Current traceability procedures do not enable the supply chain to deliver these guarantees. For this chapter, the methods are – partly – based on the critical traceability point analysis of Karlsen and Olsen (2011). Our method, which consisted of 10 consecutive stages, allowed us to define traceability goals, identify critical traceability points, and verify which CTPs could be managed through RFID applications. During these stages, multiple research methods, including observations, interviews, document analysis, and group discussions, were used.

The results are based on the output of the three-year TIPO (Traceability of individual pigs in organic supply chain) project aiming to investigate if traceability technologies, such as RFID (Radio Frequency Identification), and complementary organizational measures can improve traceability in a European organic pork supply chain. The TIPO project was funded by the European Fund for Regional Development, which is one of the European funds designed to reduce major economic imbalances between European regions. Specifically, the following goals were set: to improve traceability through individual pig identification, obtain better meat quality through enhanced genetics, and improve the effectiveness of processes. Improving information exchange is a prerequisite for realizing those goals. In particular, the project partners wanted to investigate to what extent innovative traceability technologies could contribute to the aims set. The project consisted of five subsequent project modules. The results in Chapter 5 were based on module 1, in which current processes were mapped, traceability bottlenecks were identified, information exchange required was determined, and scenarios for the innovative technology solution were developed.

A general discussion and main conclusions are presented in **Chapter 6**. In addition, theoretical contributions and suggestions for further research are described.

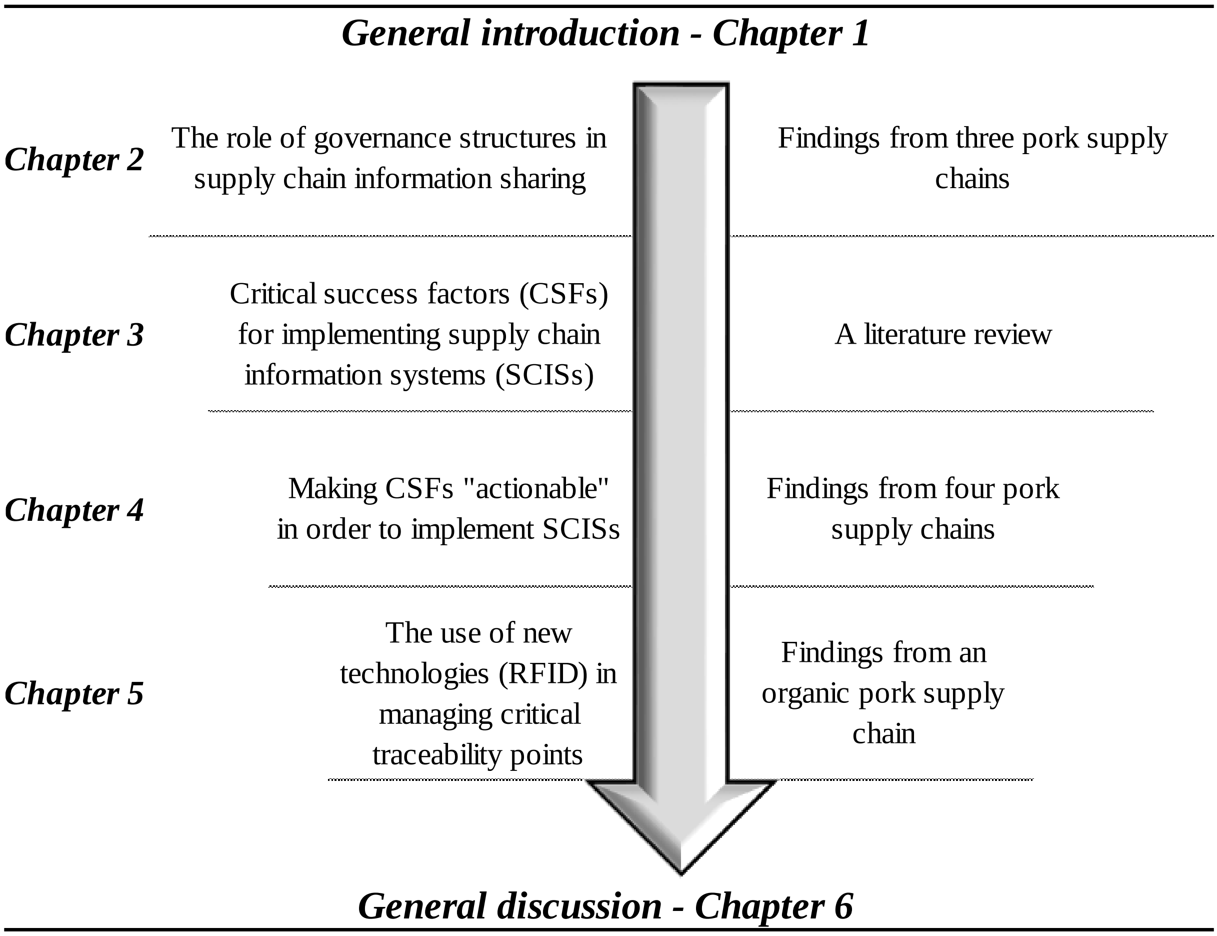


Figure 1.2 Thesis setup

Chapter 2

The role of governance structures in supply chain information sharing

Chapter is based on: Denolf, J.M., Trienekens, J.H., van der Vorst, J.G.A.J., & Omta, S.W.F. The role of governance structures in supply chain information sharing – Exploratory findings from three pork supply chains, submitted.

2. The role of governance structures in supply chain information sharing

2.1 Introduction

In order to reduce costs and remain competitive, companies are becoming aware that they should closely cooperate with their supply-chain partners (Baihaqia & Sohal. 2013; Ghosh & Fedorowicz, 2009). Supply chains aim to optimize the operational efficiency of delivering desired products or services to end consumers on time and at minimal cost (Ghosh & Fedorowicz, 2009). Therefore, supply-chain partners need to share information, resulting in better decision making in planning, ordering, and capacity allocation (Cheng, 2011). Such advantages have been widely and frequently documented (Baihaqia & Sohal, 2013; Cachon & Fisher, 2000; Cheng, 2011; Lee et al., 2000; Li & Lin, 2006; Yu et al., 2001;). Thus, through supply chain information sharing, a competitive advantage for the supply chain and a win-win situation for all supply-chain partners can be attained (Cheng, 2011; Li & Lin, 2006; Yu et al., 2001).

Information sharing may, however, result in some drawbacks. Information security, information access privileges, allocation of claimed benefits, and costs-benefit ratios are particular concerns for collaborating supply-chain partners (Lee & Whang, 2000; Premkumar, 2000). These concerns are derived from the fact that supply chain partners often have conflicting business goals and hence different reasons for information sharing. To mitigate such concerns in order to efficiently and effectively share information, relationships among the supply-chain actors need to be managed and effective governance structures need to be chosen (Ghosh & Fedorowicz, 2009). A governance structure is defined as "the set of coordination mechanisms that create incentives to interact and safeguards that protect each party against the risk of opportunistic behavior on the part of the other" (Nicolaou, 2008, p. 222). It is generally believed that closer relationships or more integrated governance structures result in more types of information being shared (Cheng et al., 2011).

Despite initial research, a comprehensible supply-chain analysis of the role of governance structures in information sharing is missing. The aim of this chapter is to investigate how and to what extent supply chain information sharing can be explained by supply chain governance structures. Since most of this literature has only considered the dyadic buyer-supplier relationship (Kembro & Näslund, 2014), the unit of analysis is extended to a four-tier supply chain. As advised by Chandra et al. (2007), Yao et al (2008), specifications of which information to share and how to share it are considered. By doing so, the multi-dimensionality of information sharing is taken into account. In line with the suggestions from Kembro and Näslund (2014), transaction-cost economics, which is a dominant theory for explaining governance-structure choices, is used to address the multi-dimensionality of information sharing. Since little in-depth research has been conducted on this relationship, exploratory case-study research is appropriate to obtain novel and nuanced insights into this link. In the present chapter, we focus on the European pork industry, in which the need for information sharing is high and distinct governance structures can be found.

The remainder of Chapter 2 is organized as follows. In Section 2.2, the conceptual research framework is presented. After outlining the research methods in Section 2.3, the background of three carefully selected pork supply chains is described in Section 2.4. A multiple case-study approach is selected, enabling us to clarify whether the findings are replicated by several cases. Then, the analysis, entailing a within-case and cross-case analysis, is discussed in Section 2.5 and 2.6. In the cross-case analysis, overarching patterns are identified and explanations are iteratively stipulated. Concluding remarks finalize Chapter 2.

2.2 Literature review

The performance of a supply chain largely depends on efficient and effective information sharing (Ghosh & Fedorowicz, 2008; Lee et al., 1997). Information sharing between supply-chain actors may, notwithstanding, create some drawbacks, such as information leakages and disproportionate allocation of information benefits in the supply chain. To mitigate these drawbacks, the supply-chain actors should agree on appropriate governance structures, which are arrangements on supply-chain transactions. Appropriate arrangements between the supply-chain actors might reduce the hazard of opportunistic behavior and eventually lead to improved information sharing.

2.2.1 Supply chain governance structures

Considerable research has been conducted to explain the choices for particular governance structures. A dominant theory explaining these choices is the transaction-cost economics (TCE) theory, often linked with the work of Williamson (e.g. 1979, 1991). The central claim of TCE is that actors aim to minimize the cost of the transactions they conduct. To do so, these actors opt for a particular governance structure. In general, governance structures are placed on a continuum, ranging from *spot market* to *vertical integration* (e.g. Raynaud et al., 2005). Spot-market relations are based on price mechanisms and usually have a short-term focus; the composition of supply-chain actors involved may alter frequently. Actors are usually highly autonomous, making this governance structure suitable for adaption to price changes (Wever et al., 2010; Williamson, 1991). Hierarchical relations are based more on formal administrative control and less on price mechanisms. In the case of vertical integration, different stages of the supply chain are owned by one actor (Wever et al., 2010; Williamson, 1991). Therefore, while actors retain their decision rights in a spot market, this does not hold for vertical integration, in which actors are integrated into their buyer’s or supplier’s company.

Despite a consensus on the two polar forms of spot market and vertical integration, different hybrid governance structures have been defined, containing characteristics of spot market and vertical integration (See for instance: Gellynck & Molnar, 2009; Raynaud et al., 2005; Schulze et al., 2007; Wever et al., 2010). Williamson (1979) identified only one general category of hybrid governance structure, whereas other researchers identified three to five. In the present chapter, we use the widespread typology of Raynaud et al. (2005), who identified five governance structures: *spot market, verbal agreement, formal contract, equity-based contracts, and vertical integration* (see Figure 2.1).

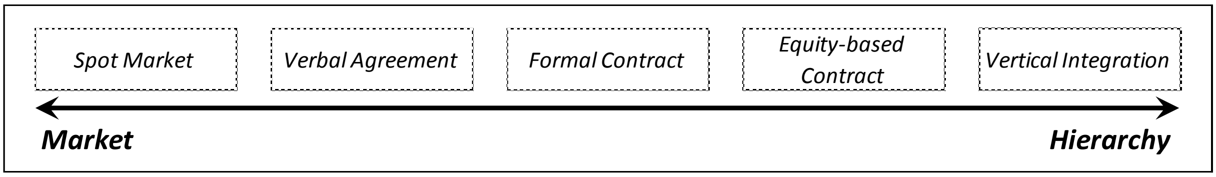


Figure 2.1 Typology of governance structures (Raynaud et al., 2005)

To describe and distinguish these governance structures, the variables "length/frequency", formality of relation", and "type of contract" are used (Lyons, 1996; Palmer & Mills, 2003; Zhang & Aramyan, 2009). First, the two-fold categorization *short* (i.e. single transaction) and *long-term* relationship is frequently used to characterize "length/frequency" (Raynaud et al., 2005; Webster et al., 1992; Wever, 2012). While governance structures with short relationships are closer to spot market, longer ones move away from spot market towards vertical integration. Second, another variable to distinguish governance structures is "formality of relation". *Formal relations* encompass specific procedures and structural settings for cross-company engagement whereas *informal relations* do not. For instance, formality can be augmented by means of cross-company teams and regularly-scheduled meetings (Cousins et al., 2006). More formalization is needed to decrease opportunistic behavior in the relationship; relations become more formalized as they move closer to vertical integration (Raynaud et al., 2005). Third, a last variable to distinguish governance structures is "type of contract" (Zhang & Aramyan, 2009). On the one hand, contracts can be classical enforcing the partners involved to strictly adhere to the written contractual terms and conditions (Lyons, 1996; Williamson, 1985). Classical contracts typically govern transactions that are limited in scope, anonymous, and measurable (Palmer & Mills, 2003). In relational contracts, on the other hand, written terms are not the only reference as harmonizing and preserving the relationships are more important (Palmer & Mills, 2003). Possible disputes are, therefore, resolved through behavior and norms (Lyons, 1996). Some governance structures are characterized by classical contracts, such as equity-based contract and formal contract; others are characterized by relational contracts, such as verbal agreement. As suggested by Raynaud et al. (2005), these variables allow us to distinguish between the distinct governance structures of Figure 2.1.

2.2.2 Supply chain information sharing

As the literature has conceptualized information sharing in different ways, researchers have suggested investigating the "what" and "how" of information sharing (Chandra et al., 2007; Christiaanse & Kumar, 2000; Ghosh & Fedorowicz, 2008; Yao et al., 2008). The "what" refers to which information to share, while the "how" denotes the mechanisms facilitating information sharing (Kembro & Näslund, 2014). The "how" and "what" have, however, often been investigated only focusing on specified information categories. Emphasis has been repeatedly placed on inventory and demand information (Jonsson & Mattson, 2013; Kembro & Näslund, 2014; Lau et al., 2004); other types of information have been less well considered. On top of that, information-sharing literature in many cases focuses on only one information-sharing mechanism. For instance, Yu et al. (2001) focused on EDI (electronic data interchange) as a mechanism for sharing information, excluding any attention to others. Therefore, unlike the current research, multiple types of information and information-sharing mechanisms are considered in this chapter.

Regarding the type of information shared, most research to date has mainly investigated information related to the planning of logistics processes (demand and inventory information) (Kembro & Näslund, 2014). *Planning information* relates to (re)scheduling orders and forecasting demands, such as customer orders, point-of-sales data, and availability of stock (Jonsson & Mattson, 2013). As product and process information are two other categories of particular importance for food industries, these categories are additionally considered in the analysis (Huang et al., 2003). While *product information* describes the characteristics or structure of manufactured products, *process information* describes the characteristics of the value-adding activities during supply-chain production stages. For instance, process information may encompass set-up time and the quality of the process (Huang et al., 2003).

Supply chains apply several information-sharing mechanisms for sharing information. Typically, since supply chains are increasingly utilizing automated (supply-chain) information systems, such systems often form the subject of research. Automated systems collect, store, process, and transmit information routinely throughout the supply chain in (near) real time (Bruns & McKinnon, 1993). However, much supply-chain information is traditionally exchanged through semi-automated systems (e.g. fax, phone, or e-mail) on top of paper-based systems (e.g. information reports) and face-to-face interactions (e.g. meetings or conversations) (Chow et al., 1999). In this study, four information-sharing mechanisms are considered: automated systems (e.g. supply chain information systems and EDI), semi-automated systems (e.g. e-mail, telephone, fax), non-automated systems (e.g. paper-based company reports), and face-to-face interaction (Mc Laren, 2002).

2.2.3 Conceptual research framework

In this research, we aim to investigate how and to what extent supply chain information sharing can be explained by supply chain governance structures. Based on a literature review, first, five governance structures have been identified. Second, regarding information sharing, three information types and four information-sharing mechanisms have been identified. Figure 2.2 summarizes the conceptual research framework.

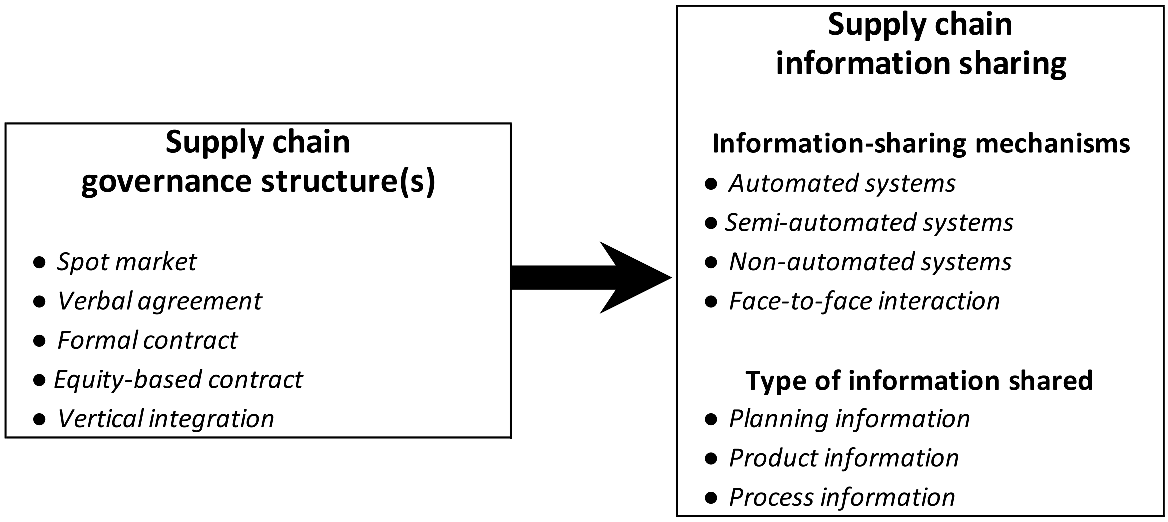


Figure 2.2 Conceptual research framework

2.3 Research methods

Based on a literature review, Kembro & Näslund (2014) concluded that the predominant method in information-sharing research is the survey method. They advised the application of case-study research to achieve a nuanced picture of information sharing in supply chains (Kembro & Näslund, 2014). According to Miles and Hubermann (1984), Yin (2003), and Eisenhardt (1989), case-study research is an effective method for exploratory research and enables in-depth investigation. In the present research, we aim to carry out an in-depth investigation of how and to what extent information sharing can be attributed to governance structures in supply chains. We selected a multiple case-study approach, enabling us to clarify whether findings are replicated by multiple cases (Eisenhardt, 1991; Yin, 2003).

2.3.1 Focus of the study

In the present chapter, we focus on the European pork industry in which there is an urgent need for information sharing and distinct governance structures can be found. This industry has to cope with low profit margins and high customer expectations. High grain prices have made feed prices rise increasing the cost of pig production, and the retailer price war has caused a cascade effect on the earnings of the upstream supply-chain partners. In addition, meat crises, such as the dioxin crisis and classical swine flu, have made consumers critical about food safety, resulting in higher customer expectations. To increase profit margins and to cope with higher food-safety demands, business processes along the European pork supply chains need to be made more efficient and effective. To do so, improved information exchange in pork supply chains is imperative. Furthermore, pork supply chains are often governed differently. For instance, some are highly integrated and are coordinated by a supply-chain orchestrator, steering supply and demand of the entire supply chain and enforcing supply-chain actors to use particular resources or follow particular quality regulations. In others, chains actors act more independently and, hence, the level of integration is low.

2.3.2 Data gathering

To build a representative case sample, three European pork supply chains with different governance structures were selected. For every case selected, 10 to 12 experts from research, supply-chain actors, and government were interviewed to achieve a multi-perspective picture of these supply chains (Eisenhardt & Graebner, 2007; Rowley, 2002; Yin, 2003).

An interview protocol was used to direct and conduct in-depth interviews with the respondents from every supply chain. Respondents were initially asked to answer contextual questions to obtain a background description of the pork supply chain. Among other things, questions were related to: type and number of actors, production volumes, distributions channels, general supply-chain coordination, and quality management systems (QMSs). Thereafter, the respondents were asked questions regarding (supply chain) information sharing and (supply chain) governance structures, based on the conceptual research framework (see Figure 2.2). In relation to the former, questions were focused on shared product, process, and planning information, and the information-sharing mechanisms used. While for the latter, questions were related to length/frequency, formality of exchange, and type of contract. Questions were also asked to gain insights into major bottlenecks, best practices, and major changes that occur regarding governance structures and information sharing. For the process of ordering the obtained data, the protocol also contained several supply-chain schemes, which permitted the interviewers to fill out information sharing and governance structures for every relation in the pork supply chain. The data were commonly recorded in internal reports (Briz et al., 2008; UB, 2008; Wever & Wognum, 2008), which formed the basis for the analysis of the present chapter.

Data are based on the results of the Q-PorkChains project, in which two of the authors were involved. The aims of the 6^{the} EU framework project, undertaken from 2007 till 2011, were to improve the quality of pork and pork products for the consumer and to develop innovative, integrated, and sustainable food production supply chains with low environmental impact. To do so, several modules were undertaken across multiple European countries. The reports used in the present chapter come from a module focusing on, amongst other things, advanced inter-enterprise information systems, use of information, and governance structures in pork chains.

2.3.3 Data analysis

The obtained data were coded based on the constructs defined in Section 2.2. In Table 2.1, the coding rules for governance structures are presented. Mainly based on the work of Raynaud et al. (2005), five governance structures are distinguished: spot market, verbal agreement, formal contract, equity-based contract, and vertical integration.

Table 2.1 Coding rules for supply chain governance structures (based on Raynaud et al., 2005; Schulze et al., 2007; Wever et al., 2010)

Spot Market	Exchanges are solely based on price mechanisms. Therefore, an invoice for instant exchange of goods or services is used.
Verbal agreement	Exchanges are not formalized into written, legally enforceable contracts. Performance or behavioral standards are unlikely to be specified, but if so, they are not formalized. Often, the agreements have a long-term focus.
Formal contract	Legal enforceable, written contracts are used to govern the transaction. Performance and behavioral standards, such as selling and buying obligations and details of the production process, are prescribed in the contract.
Equity-based contract	A chain actor owns stock of (one of) its suppliers/buyers. The chain actor stays independent, but is heavily reliant on other actors – e.g. its supplier(s) or buyer(s) – for several critical resources.
Vertical integration	Production and distribution of two (or more) successive stages are undertaken under common management and ownership (there is a joint-ownership of resources).

Table 2.2 depicts the coding rules for information sharing, conceptualized by “type of information shared” and “information-sharing mechanisms”. On the one hand, three types of information are distinguished: planning information, product information, and process information. On the other hand, regarding “information-sharing mechanisms”, automated systems, semi-automated systems, non-automated systems, and face-to-face interaction are distinguished (Mc Laren et al., 2002).

Table 2.2 Coding rules for supply chain information sharing
(based on Chow et al., 2003; Huang et al., 2003; Mc Laren et al., 2002)

Type of information shared	*Planning information*	Planning information relates to (re)scheduling orders and forecasting demands.
	Product information	Product information describes the characteristics or structure of the manufactured product.
	Process information	Process information describes the characteristics of the value-adding activities during supply-chain production stages, transforming the product or adding input materials.
Information sharing mechanisms	*Automated systems*	These systems facilitate information sharing in a routine/structured and automated (electronic) way through, for instance, EDI and supply chain information systems.
	Semi-automated systems	These systems facilitate information sharing in an unstructured and semi-automated way through, for instance, phone, fax, and email.
	Non-automated systems	These systems facilitate information sharing in a paper-based way through, for instance, paper-based reports, invoices, and non-electronic labels.
	Face-to-face interaction	These systems facilitate interpersonal information sharing through, for instance, meetings and visits.

Then, coded data were further analyzed. Following Miles and Hubermann (1984) and Eisenhardt (1989), data were initially analyzed per case. After a within-case analysis, a cross-case analysis was undertaken, comparing the findings across cases. In the analyzing process, overarching patterns between governance structures and information sharing were identified through "pattern matching" (Yin, 2003). To retain theoretical flexibility, propositions were not pre-built. Consequently, findings were based on empirical evidence rather than on the researchers' presumptions (Eisenhardt, 1989). Then, explanations were (iteratively) stipulated for the patterns found, trying to explain the phenomenon (Miles & Hubermann, 1984; Yin, 2003). Note that planning information is not discussed since no discrepancies across the supply chains regarding this information could be found.

2.4 Introduction to the case supply chains

In most European pork supply chains, similar consecutive stages, – farmer, slaughterhouse, processor, and retailer – accomplish primary chain processes (see Figure 2.3). In addition to these stages, others, such as feed company and breeder, deliver inputs for the primary chain actors. To start with, breeding companies, producing the genetic basis of pigs, deliver sows and semen to the farrowers. After insemination and a gestation period of two months, sows deliver around 12 piglets, weaned after two weeks. Then, piglets are reared to 25 kg in 10 weeks. These pigs are delivered to the finisher, who fattens the animals up to 110 kg slaughter weight, which takes about 6 months. The last two stages – i.e. farrowing and finishing – are often undertaken by a single farm. After farming, pigs are slaughtered, a process that entails several activities such as stunning, blood tapping, removing hairs, carcass and organ examining, splitting, chilling, and – sometimes – cutting. Slaughterhouses choose to deliver carcasses as carcass halves or as six meat cuts to the next actor. Whether carcasses are cut in two or six parts, they are typically sold to processors, as well as wholesalers and retailers. Processing companies, which might be part of a slaughterhouse or act independently, process the carcass parts further into a wide range of meat products, such as ham, steaks, loins, sausages, and spareribs. Finally, the packaged meat is sold through various customer channels, most of it through the retailer, which is the focus of this chapter. However, some is distributed through so-called out-of-home channels, such as restaurant, hospitals, and business canteens.

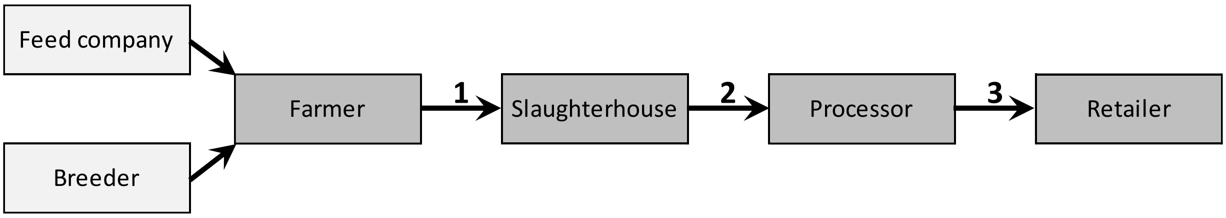


Figure 2.3 European pork supply chain

The main supply-chain stages in a (pork) supply chain are farmer, slaughterhouse, processor, and retailer. In these stages, the primary production takes place. For each relationship between these supply-chain stages, marked with 1, 2, and 3, governance structure(s) and information sharing are described. In the next sections, the selected supply chains are introduced by describing the background to the three supply chains and the supply-chain organization.

2.4.1 Supply chain A

Supply chain A is a regional supply chain that produces fresh processed pork meat in the Northwest of Germany. It operates in a central region of the 'pork belt', which has the highest density of pork production in Europe. Supply chain A produces around 1 % of the total German pig production, resulting yearly in 50,000 tons of processed pork meat. In particular, 500 pig farmers deliver 500,000 pigs to the farmers' cooperative every year. The cooperative has its own slaughterhouse and processing plant. The processed meat is, thereafter, distributed through 150 licensed distributors, such as local butchers and regional retailers, emphasizing the quality, the regional aspect, and the transparency of this supply-chain's meat.

Coordination of the supply chain is accomplished by the office of the farmers' cooperative. It steers the total pig/meat production of the supply chain and contractually enforces the supply-chain's actors to follow certain quality regulations and standards. These quality standards and regulations come on top of public national German quality standards. For instance, the cooperative sets specific demands on farm management regarding feed given, health management, and animal husbandry. If farmers do not grow the corn for the feed themselves, they are obliged to buy feed from one of the four preordained feed producers. The feed and additional supplements, such as vitamins, need to be mixed according to fixed feed recipes. Furthermore, no medicaments or antibiotics are allowed to be used; only vaccinations are permitted. Next to the farms, other supply-chain actors, such as slaughterhouse, processor, and service providers (e.g. pig transporters) are also obliged to follow certain regulations to assure quality.

2.4.2 Supply chain B

Supply chain B is a local and very traditional supply chain located in the Southwest of Spain. This chain is particularly known for its production of dry-cured ham and forelegs, derived from special breeds and pigs reared and fed in a specific ecosystem. Favorable climatic conditions, and other ecological, human, and technical factors, enable the production of particular dry-cured hams and forelegs. Around 2,000 farmers produce more than 500,000 pigs, slaughtered and processed at one of the 72 processing companies. In total, these companies produce more than 400,000 pieces of dry cured hams and forelegs, representing a market share of around 30 %. The primary customer's channels are delicatessen stores and specialized retailers.

Coordination in the supply chain is organized by an inspection body (i.e. Control Board), with whom the actors in the supply chain are contractually registered. The Control board monitors compliance with production standards under the umbrella of the European certification Designation of Origin (PDO). PDO regulations are used to classify and describe food produced in a particular European region with inherent natural factors. The regulations cover a wide range of subjects and impact the supply-chain's actors. For instance, regulations relate to identification, breed choice, weight of slaughtering, production of cured hams, etc. The control board and additional independent controlling inspection agencies inspect the farms involved, the slaughterhouses, and the processing companies to see whether they are following the regulations imposed.

2.4.3 Supply chain C

Supply chain C is located in the Netherlands. Pigs are delivered to several slaughterhouses by more than 2,000 farmers, which produce more than 7 million pigs. After being processed, meat is predominantly distributed through retailers. Since the supply chain does not have its own brand, most meat is sold through the retailer's own brand. This supply chain exports 70 % of its slaughtered or processed meat to countries all over the world. In the supply chain, the slaughterhouse and meat processing companies are owned by one (slaughtering) company. This company has one main agrarian shareholder, which is an association of almost 17,000 agricultural entrepreneurs. The association looks after the interests of its members by providing business advice to them and investing in companies and projects that positively affect (agricultural) entrepreneurship.

In supply chain C, the slaughtering company is supplied by independent farmers. Most partners in this chain (contractually) comply with Dutch IKB (integral chain management – integrale ketenbeheer) regulations. Participating partners need, therefore, to sign a yearly contract requiring compliance with the regulations. The aim of IKB is to regulate the meat production to ensure satisfactory quality and to safeguard animal health and welfare. Regulations are particularly related to product safety, traceability, animal health, animal welfare, feeding, and hygiene. For instance, at the farm level independent control bodies of IKB require extensive documentation of procedures regarding feeding, vaccinating, and housing.

2.5 Within-case analysis

The within-case analysis encompasses two objectives. After the data are presented per supply chain, explanations for the role of governance structures in information sharing are discussed. Before moving on to the cross-case analysis, the findings of the within-case analysis are summarized in Table 2.3.

2.5.1 Supply chain A

In supply chain A, the farmer-slaughterhouse relationship is steered by equity-based contracts, the slaughterhouse-processor relationship by vertical integration, and the processor-retailer relationship by verbal agreements. Slaughterhouse and processor are both owned by the farmers' cooperative and are hence vertically integrated; there is a joint ownership of resources. To become a member of the farmers' cooperative, farmers need to purchase a minimal financial stake in it. Consequently, equity-based contracts are put in place between farmer and slaughterhouse. Through the acquisition of a stake, farmers obtain decision rights and farm-management advice from the cooperative's consultants. The contracts also stipulate that (1) farmers must deliver all pigs to the slaughterhouse, which is obliged to take all pigs delivered, and (2) farmers and other actors in the supply chain must follow the supply chain's quality regulations and standards. Consequently, equity-based contracts prevent farmers from easily switching to an alternative buyer. Finally, the processor-retailer relationship is steered through verbal agreements, suggesting that retailers can easily change their meat supplier(s). Despite this, since retailers have particular customers demanding meat products with the supply-chain's brand, they have established long-term relationships with the processor. Considering the governance structures of Figure 2.1, supply chain A as a whole can be situated on the right side of the governance continuum; supply chain partners rely on more hierarchical governance forms to coordinate their transactions.

In the integrated relationships of farmer-slaughterhouse and slaughterhouse-processor, product information, mainly encompassing origin and quality of the pig and meat products, is shared between the partners. In particular, farm and slaughterhouse exchange the following information: farm identification, bearing conditions, health status, salmonella status, and quality status. All shared information between farmer and slaughterhouse is also available to the processor. In addition to this, slaughterhouse and processor also share information regarding sorting (inherent product characteristics of pork), and carcass cleanness (lab results). Processor and retailer, transacting through verbal agreements, share traceability and quality information (e.g. salmonella status) as well. Furthermore, process information, such as (pig) medicaments and feeding information is forwarded in the supply chain. However, between the processor and retailer, few types of process information are exchanged.

The following indications can be drawn regarding the role of governance structures in type of shared information in supply chain A. First, compared to the relations steered by verbal agreements, the more integrated farmer-slaughterhouse and slaughterhouse-processor relations share more types of detailed information, and more types of process information in particular. Presumably, more types of confidential process information are only shared in more integrated relationships, in which the risk of information leakage is low. Equity-based contracts might oblige supply-chain actors to share specific process information whereas vertical-integrated partners typically have access to the same information. Apart from governance structures, the type of exchanged information can be explained by the supply-chain's quality regulations and standards to a great extent. Since the farmers' cooperative makes requirements on the feed given, health management, and animal husbandry (see Section 2.4.1), particular quality information is shared throughout supply chain A. In the processor-retailer relationship, the processor forwards aggregated information regarding origin and product specifications (product quality) connected to the unique products delivered. The exchanged information reflects the two unique selling propositions (USPs) of the supply-chain's meat products.

A large part of the information in the farmer-slaughterhouse and slaughterhouse-processor relationships, steered by means of integrated governance structures, is (continuously) shared through the cooperative's automated supply chain information system. External buyers and suppliers, however, have no access to the cooperative's information system. Retailers do not share information with the processor through the cooperative's information system but through their own EDI (electronic data interchange) system. To complement continuous information exchange in supply chain A, complementary information between the supply-chain's actors is often exchanged by means of telephone, fax, and email.

The following indications can be drawn regarding the role of governance structures in information-sharing mechanisms. First of all, the high amount of information shared in supply chain A – between the farmers, slaughterhouse, and processor – is facilitated by the (automated) supply chain information system of the farmers' cooperative. Due to the high level of integration, risks for possible information leaking are low. The farmers' cooperative has invested in a supply chain information system to facilitate continuous information exchange between the supply-chain partners. However, less integrated *relationships, such as processor-retailer, also share information electronically through EDI. Usage of automated information systems in less integrated relationships can make transactions more cost-efficient. Finally, case A shows that the use of automated information systems is complemented by phone, fax, or email. Such semi-automated information mechanisms might be used by the supply-chain partners (1) to circumvent a technical defect of the automated information system(s), (2) to provide information in the format that the information receiver wants, or (3) to provide follow-up explanations with respect to the transaction(s). In particular, in this supply chain, the phone is often used because of personalized relationships between supply-chain partners due to long-term collaboration.*

2.5.2 Supply chain B

The relationships in supply chain B are directed through verbal agreements or spot market. On top of the farmer-slaughterhouse, slaughterhouse-processor, processor-retailer relationships, the farmer-processor relationship is also of importance as farmers and processors make bilateral agreements concerning the production and transaction of the supply-chain's pigs. Despite the fact that there are no written contracts between the long-term collaborating farmer and processor, they agree on the production and transaction at the beginning of the season. Farmers follow the PDO quality regulations (see Section 2.4.2) and have made farm investments to do so. The farmer-slaughterhouse and slaughterhouse-processor relationships are derived from the farmer-processor relationship. Solely based on price mechanisms, the farmer delivers its pigs to an accredited slaughterhouse, which after slaughtering forwards the pigs to the processor. Finally, the processor-retailer relationship is steered through verbal agreements, which are long-term and informal in nature. Exchanges are not formalized into written, legally enforceable contracts. Consequently, the level of integration is rather low and retailers can easily change their supplier. However, retailers do not often switch processor as they have long-term relationships with these actors. Considering the governance structures of Figure 2.1, supply chain B as a whole can be situated on the left side of the continuum; supply chain partners rely more on market governance forms to coordinate their transactions.

In the farmer-slaughterhouse relationship, steered by spot market, farmers share information with the slaughterhouse(s) regarding traceability and quality of the pigs delivered, including the following: traceability (requirements), type of carcass, final weight, and quality of the animal. In the slaughterhouse-processor relationship, governed by verbal agreements, (limited) information regarding traceability and type of carcass is forwarded. Between the farmer and processor, transacting pigs through verbal agreements, product information is also directly exchanged: illnesses, if applicable, traceability, feed, and quality information. Finally, processors deliver product information regarding type of product, preservation requirements, and used ingredients to the retailer. On top of product information, few types of process information are exchanged in the farmer-processor, slaughterhouse-processor, and processor-retailer relationships.

> *The following indications can be drawn regarding the role of governance structures in the type of information shared. First of all, it appears that all low-integrated relationships exchange few types of process information. Presumably, the involved supply-chain actors find process information confidential and do not want to share it since the risk of information leakage is high. Moreover, farmers and processor do not have close relationships with the slaughterhouse as the slaughterhouse is just an accredited service provider. Furthermore, regarding the type of shared information, it seems that particular genealogical information and feed information is exchanged (i.e. traceability and type of carcass/product) across the supply chain to classify the animals and products to the particular breed used in supply chain B. In other words, the quality regulations, which relate to identification, breed choice, feed, weight of slaughtering, and production of cured hams, (contractually) require the supply-chain partners to exchange particular information.*

In this supply chain, paper-based information-sharing mechanisms are employed in the four investigated relationships. In the farmer-slaughterhouse relationship, governed by spot market, labels (attached to the pigs) and (paper) invoices are mainly used to exchange product information. For instance, pigs delivered to the slaughterhouse are sealed with an identification number, indicating their provenance. In the other three relationships, steered by verbal agreements, differences in mechanisms can be observed. While (paper) invoices are mainly used in the slaughterhouse-processor relationship, all information-sharing mechanisms distinguished in this study are employed to share information in the processor-retailer relationship. In the farmer-processor relationship, except for automated systems, all information-sharing mechanisms are used.

> *Again, the following indications can be drawn with respect to the role of governance structures in information-sharing mechanisms. First, relationships steered by less integrated governance structures use, in supply chain B, non-automated information systems to support information sharing. Labels, invoices, phone, and face-to-face interaction are ways to exchange information. Moreover, in this supply chain, more than 2,000 traditional small farms and 72 traditional processing companies are involved, making it difficult to implement electronic information exchange between farmers and processing companies. These companies probably have little financial strength, limited power, and little willingness (actors are very traditional) to lead the design and implementation of an automated information system. In the farmer-processor relationship in particular, face-to-face interaction is used because the supply-chain partners know each other personally due to long-term collaboration.*

2.5.3 Supply chain C

In supply chain C, three governance structures can be distinguished: vertical integration, formal contract, and spot market. While the relationship between farmer and slaughterhouse is governed through the spot market, the slaughterhouse-processor and processor-retailer relationships are steered by respectively vertical integration and formal contracts. Transactions between farmer and slaughterhouse are solely based on price mechanisms and typically focused on the short term. However, around 90 % of the slaughterhouse's pigs are delivered by farmers with whom it has long-term relationships. The slaughterhouse is, further, vertically integrated with the processor since both slaughtering and processing are performed by a single company. Last, relationships between processor and retailer are increasingly long-term and strictly contractual in nature. These contracts encompass strict (quality) requirements, suggesting that non-compliance with requirements results in legally enforceable penalties for the processor. Furthermore, through contracts, the processor aims to have a constant demand and retailers a constant (preferably flexible) supply. Considering the governance structures of Figure 2.1, supply chain C as a whole can be situated in the middle of the continuum; supply chain partners rely on both hierarchical and market governance forms to coordinate their transactions.

In the three relationships of farmer-slaughterhouse, slaughterhouse-processor, and processor-retailer, product information is exchanged. In the farmer-slaughterhouse relationship, governed by spot market, farmers obtain detailed insights into the quality of the pigs delivered in the form of carcass information, such as fat-meat percentage and anomalies (e.g. lung problems and liver problems). This information permits the farmer to compare the quality of its carcasses with his previous deliveries and with his counterparts. Also in the other – more integrated – relationships of supply chain C, multiple types of product information are shared. While slaughterhouse and processor exchange product information with respect to animal welfare, food safety, product quality (cutting) and traceability, processor and retailer share transaction specific information – cutting and packaging – and info connected to the label (covering health status of animals, certification, and origin). Regarding process information, farmer and slaughterhouse share only feeding schemes whereas slaughterhouse and processor exchange only laboratory results of hygienic conditions. In the processor-retailer relationship, more types of information are shared: feeding schemes, vaccination schemes, and hygienic conditions of the slaughtering (in most cases through labels).

The following indications can be drawn regarding the role of governance structures in the type of shared information. First, it appears that integrated relationships share several types of product information. However, in the less-integrated farmer-slaughterhouse relationship, a rather equal level of product information is exchanged. Presumably, the slaughterhouse shares detailed carcasses information and provides access to it intended to build strong and long-term bonds with its farmers. Through such information, the farmer can enhance his decision making and can therefore improve his *farm management. Supply chain C also stipulates that, apart from governance structures, the IKB regulations (see Section 2.4.3) play a key role in the type of exchanged information. These regulations contractually oblige the supply-chain actors to share particular quality information. For instance, since IKB farmers are only allowed to buy feed from certified suppliers, feeding schemes information (i.e. process information) is exchanged between farmer and slaughterhouse. Moreover, as IKB also encompasses hygiene regulations, slaughterhouse and processor exchange lab results (regarding hygienic conditions). Supply chain C further indicates that differences in (bargaining) power between the supply-chain actors might play a role in information sharing. As they are highly concentrated, retailers in the Netherlands have a strong position and can, therefore, easily require processors to deliver particular product and process information (even beyond the stipulations of the formal contracts). The retailer, in turn, is less inclined to share customer information, despite the desire for information of the upstream partners.*

The overall observation is that all relationships of supply chain C share information through automated systems. To communicate with its large number of farmers, the slaughterhouse designed and implemented an automated system to exchange – mainly – carcass information. In this spot-market relationship, carcass information is also communicated to the farmers by means of paper bills. Also, farmers receive an electronic newsletter and a supplier magazine from the slaughterhouse. Furthermore, the vertically integrated slaughterhouse-processor relationship shares information by means of an internal information system whereas the processor and retailer, steered by formal contracts, mainly transfer information through an EDI system.

The following indications can be drawn regarding the role of governance structures in information-sharing mechanisms. In supply chain C, information is predominantly shared through automated information systems. The vertically-integrated slaughterhouse-processor relationship exchanges information through an internal information system as they are owned by the same company. Furthermore, retailer(s), that have formal contracts with the processor, have implemented an EDI system for order-efficiency reasons. Thus, an analysis of these relationships indicates that integrated relationships use automated systems to share information. However, supply chain C shows that less integrated relationships – such as farmer-slaughterhouse – also share information through an automated inter-organizational information system. Presumably, such a system is developed and implemented by the slaughterhouse (1) to build stronger and more long-term bonds with farmers (see 5.3.1) or (2) to make the recurrent information sharing more cost-efficient as the slaughterhouse is supplied by more than 2,000 farmers. In addition, this supply chain has supply-chain partners that have sufficient financial strength to design and implement automated information systems. Both slaughterhouse and retailer(s) use such an automated system to exchange *information with their suppliers. Finally, for the same reasons as mentioned in the other supply chains, analysis of case C reveals that automated information systems are complemented by other information-sharing mechanisms. In particular, it may be the case that farmers do not have internet access and are in favor of receiving information about their slaughtered pigs on paper, or via fax or telephone.*

2.5.4 Summary

As a segway to the cross-case analysis, the analysis of the three investigated cases are summarized in Table 2.3.

Table 2.3 Summary of within-case analysis

	Supply Chain A			Supply Chain B	
	FA-SL	SL-PR	PR-RE	FA-SL	FA-PR
Governance Structures	Equity-based Contract	Vertical Integration	Verbal Agreement	Spot Market	Verbal Agreement
Product Info	Traceability - Farm ID Product quality - Bearing conditions - Health status, incl. salmonella status	Traceability - Farm ID - Slaught. ID Product quality - e.g. Sorting - Bearing conditions - Health status, incl. salmonella status Lab results (pork) - cleanness	Traceability - Slaught. ID Product quality - Product specifications incl. salmonella status	Traceability requirements Product quality - Type of carcass - Final weight - ...	Traceability - Farm ID Product quality - e.g. Illnesses
Process Info	Operational info Feeding Medicament info Biological data	Operational info (FA + SH) Feeding (FA) Medicament info (FA) Biological data (FA)			Operational info Feeding
Information-Sharing Mechanisms	Automated - Supply chain information system Semi-automated - Phone, fax, e-mail	Automated - Supply chain information system Semi-automated - Phone, fax, e-mail	Automated - EDI Semi-automated - Phone, fax, e-mail	Non-automated - Invoices - Identification labels	Semi-automated Non-automated Face-to-face interaction

FA = Farm; SL = Slaughterhouse; PR = Processor; RE = Retailer

Supply Chain B		Supply chain C		
SL-PR	PR-RE	FA-SL	SL-PR	PR-RE
Verbal Agreement	Verbal Agreement	Spot Market	Vertical Integration	Formal Contract
Traceability requirements Product quality - Type of carcass	Traceabilty - Slaught./Proc. ID - Retailer Product quality - Type of product - Ingredients - Preservation requirements	Traceability - Farm ID Product quality - Carcass info - Technical info incl. liver or lung problems, & fat percentage	Traceability - Farm ID Product Quality - Cutting Lab results (pork) *(food safety)* Animal welfare	Traceability - Slaught./Proc. ID Product quality - Certification - Health status - Cutting/packaging
Operational info *(on request)*	Feeding	Feeding *(schemes)*	Feeding (FA) *(schemes)* Lab results (SH)	Feeding (FA) *(schemes)* Vaccinating *(schemes)* Lab results (SH)
Non-automated - Invoices - Identification labels	Automated - EDI Semi-automated Non-automated Face-to-face interaction	Automated - Inter-organizational information system Semi-automated - Phone Non-automated - Paper bills - Supplier magazine	Automated - Internal ICT system	Automated - EDI Non-automated - Invoices

2.6 Cross-case analysis

In Section 2.5 we presented and interpreted the link between supply chain governance structures and supply chain information sharing for each case. This step provides input for the cross-case analysis, where patterns across cases are built. Possible rival patterns are explained through the contextual factors of every case. As a result, the following main observations have been stipulated based on this cross-case analysis.

Observation 1: *Relationships steered by more integrated governance structures exchange more types of information (especially process information) than the ones governed by less integrated governance structures.*

First of all, we single out the overall observation that relationships steered by more integrated governance structures (e.g. vertical integration, equity-based contracts, and formal contracts) exchange more types of information than the ones governed by less integrated governance structures (e.g. spot market and verbal agreements). Observation 1 is consistent with the literature arguing that governance structures may facilitate information sharing among supply-chain members. Several authors have indicated that integrated supply chains share more (types of) information than less integrated ones (e.g. Dowlatshahi, 1997; Skjøtt-Larsen, 2003; Simpatupang et al., 2002). Increased access to product and process information can trigger several opportunities for the supply-chain partners to collaboratively improve decision making and processes. Integrated (supply chain) governance structures have lower risks of opportunistic behavior. Specifically, these structures can minimize information risks, such as information leakages, between supply-chain partners (Ghosh & Fedorowicz, 2008).

Furthermore, based on the cross-case analysis, it seems that process information in particular is shared more in integrated supply chain governance structures than in less integrated ones. Process information, such as feeding, vaccination schemes, operational information, and hygienic conditions, can be regarded as more confidential than product information since this information relates to the specifications of a firm's core production processes.

Observation 2: *Strong supply-chain partner(s) with sufficient financial strength and (bargaining) power may initiate information sharing through automated information systems, regardless of the type of governance structure.*

Apart from governance structures, the financial strength and (bargaining) power of the supply-chain partners impact information sharing. If there is a partner with sufficient financial strength and (bargaining) power, information may be exchanged through automated information systems as well. Observation 2 can be illustrated by comparing the farmer-slaughterhouse relationship of *supply chains B and C*. Even though both relationships are steered by the spot market, the way these actors share information is distinct. In *supply chain C*, farmer(s) and slaughterhouse share information through an online inter-organizational information system whereas labels (attached to the pigs), paper invoices, phone, and face-to-face interaction are mainly used to exchange product information in *supply chain B*. This discrepancy may be explained by the fact that processing in *supply chain B* is spread over 72 traditional processing companies (most having few resources). The context of supply chain B makes it difficult to implement automated information systems for information sharing between farmers and processing companies.

Furthermore, in all three cases, information between processor and retailer is typically shared by means of EDI systems. Due to the large number of transactions, retailers often require their suppliers to exchange information through EDI. Retailers can usually oblige their suppliers to do so because of their strong position in the supply chain. For instance, *supply chain C* shows that retailers in the Netherlands are highly concentrated and hence have a strong position; three retailers own more than 80 % of the market. Retailers, in turn, are less inclined to share customer data, despite the wishes of the upstream partners to do so. In summary, in relationships that have a strong partner with sufficient financial strength, most information is exchanged through automated information systems.

Note that observation 2 seems to contradict the existing literature base. Scholars, such as Auramo et al. (2005) and Vickery et al. (2003), claimed that relationships steered by more integrated governance structures commonly employ automated information systems. In this research, we illustrate that both integrated and non-integrated governance structures employ automated information systems. Cross-case analysis shows that the financial strength and bargaining power of the involved partners may provide a better explanation for the decision on whether or not to design and implement an automated information system.

Observation 3: Relationship management influences information sharing – i.e. both information-sharing mechanisms and type of information shared – in supply chains.

Particular information also seems to be exchanged with suppliers for relationship management. Especially when this information is valuable for better decision making and consequent process improvements, suppliers tend to continue the relationship with their buyer. This link is depicted in *supply chain C*. For example, in the farmer-slaughterhouse relationship of supply chain C, farmers obtain detailed dynamic insights into the quality of the pigs delivered in the form of carcass information, such as fat-meat percentage and anomalies (e.g. lung problems and liver problems). This information enables the farmer to make analyses by comparing the quality of his carcasses with his previous deliveries and with his counterparts. In this relationship, which is steered through the spot market, farmers often prefer to continue delivering to this slaughterhouse since such product information is valuable for the farmer and can help to improve farm management.

Next to the type of information shared, the choice of information-sharing mechanisms also seems to be affected by relationship management. Again, this can be illustrated by *supply chain C*. The carcass information, as described above, is sent to the farmer by means of an automated online inter-organizational information system. The automated system enables the farmer to easily access the carcass information and to make trend and benchmark analyses. However, farmers may not have internet access and might prefer to receive the information about their slaughtered pigs on paper, or by fax or telephone. To make concessions to the farmers, the slaughterhouse continues to send paper bills with quality data. Last, to further improve relations with its farmers, the slaughterhouse sends an electronic newsletter and a supplier magazine. Consequently, the slaughterhouse has built long-term (and trusting) relationships with most of its farmers; these relationships are shifting, therefore, on the governance continuum (see Figure 2.1) towards verbal agreements.

Observation 4: *Quality regulations influence the type of information shared in a supply chain to a great extent.*

Observation 4 holds for all relationships. From the cross-case analysis, we discovered that quality regulations greatly influence the type of information shared among supply-chain partners. In *supply chain A*, the farmers' cooperative, the supply-chain's coordinator, makes demands about feed given, health management, and animal husbandry (see Section 2.4.1). For instance, medicine information is forwarded as pigs should not be treated with medicines after they reach 40 kg. *In supply chain B*, PDO quality regulations (see Section 2.4.2), which relate to identification, breed choice, weight of slaughtering, and production of cured hams, require the supply-chain partners to exchange specific information. In particular, specific information is exchanged (i.e. traceability and type of carcass/product) across the supply chain to classify the animals and products to the particular breed used. Also *supply chain C* stipulates that IKB quality regulations (see Section 2.4.3) play a key role in the type of exchanged information. For example, since IKB farmers are only allowed to buy feed from certified suppliers, feeding schemes information (i.e. process information) is exchanged between farmer and slaughterhouse. In conclusion, quality regulations highly influence the type of information shared. Note that quality regulations is a mechanism, just like governance structure, to achieve coordination in the supply chain (Trienekens & Wognum, 2013).

2.7 Concluding remarks

The main contribution of Chapter 2 is to shed light and provide new insights into the complex interplay between governance structures and information sharing. First, the chapter accounts for the multidimensionality of information sharing; specifications of which information to share and how to share it are considered. Second, since most of this literature has only considered the dyadic buyer-supplier relationship, the unit of analysis is extended to a four-tier supply chain.

Based on empirical data, several main observations were culled. Generally, relationships steered by more integrated governance structures exchange more types of information than the ones governed by less integrated governance structures. In particular, more types of process information are shared in the former than the latter. Integrated (supply chain) governance structures decrease the risks of opportunistic behavior and minimize information risks, such as information leakages, between the supply-chain partners. First, this chapter also concludes that information sharing, conceptualized by the type of information shared and information-sharing mechanisms, cannot be solely explained by governance structures. Our study challenges the general assumption that more integrated governance structures are accompanied by more types of information shared through the use of automated information systems. Second, the study stipulates that, apart from governance structures, quality regulations play a key role in the type of exchanged product and process information as they require the supply-chain actors to share particular information. For safeguarding and control, the partners might require the exchange of information that allows them to verify if the quality protocols are being followed. The study shows as well that financial strength and relationship management play a role in the type of information shared and information-sharing mechanisms. If there is a partner with sufficient financial strength and (bargaining) power, information will in many cases be exchanged through automated information systems, e.g. for cost-efficiency reasons. Despite its striking relevance, the combination of postulated factors influencing information sharing has received little attention in the literature.

Built observations form a useful step for understanding a nuanced picture of the role of governance structures in information sharing. Since the observations in this study are based solely on three cases from the European pork industry, the generalizability of the observations can clearly be questioned. Consequently, to investigate whether the findings of the present study hold true for supply chains in other industries, further research in a wider range of contexts is compulsory. Furthermore, it would also be interesting to investigate how particular information that is shared through specific information-sharing mechanisms impact the performance of supply chains.

Chapter 3

A framework of critical success factors for implementing supply chain information systems

Chapter is based on: Denolf, J.M., Trienekens, J.H., Wognum, P.M., van der Vorst, J.G.A.J., & Omta, S.W.F. Towards a framework of critical success factors for implementing supply chain information systems, submitted.

3. A framework of critical success factors for implementing supply chain information systems

3.1 Introduction

In an increasingly competitive business environment, the success of a single enterprise depends on its ability to cooperate and integrate with other businesses as companies are no longer competing firm versus firm, but supply chain versus supply chain (Lambert & Cooper, 2000). For improved cooperation and integration, supply chains need, more than ever, to adopt and implement information systems. These supply chain information systems (SCIS) support information exchange and storage by automatically providing relevant information to the chain partners (Lau & Lee, 2000). Exchanged information can vary, for instance, from information about production processes to general customer or marketing information (Li & Lin, 2006; Mentzer et al., 2000). By providing relevant information, the supply chain and its actors are able to increase coordination and monitoring of its operations resulting in more efficient and effective value-adding activities (Lau & Lee, 2000). Implementing a SCIS is, however, a catalyst of complex technical and organizational changes that need to be managed carefully. Unfortunately, such changes have often led to implementation failures. In response, researchers have identified critical success factors (CSFs) that can help managers to proactively tackle failures and implement a SCIS. CSFs are the factors that must go right during an implementation and must, therefore, be given special and continual attention to successfully implement an information system (Bullen & Rockart, 1986). The literature addressing CSFs to implement SCISs is still novel.

The main objective of Chapter 3 is to build a framework of CSFs for implementing SCISs. So far, CSFs for implementing SCISs have only been investigated to a limited extent and in a fragmentary fashion. A limited number of supply-chain researchers, such as Koh et al. (2011), Ngai et al. (2004), and Lu et al. (2006), identified a non-exhaustive set of critical success factors. The literature focusing on ERP (Enterprise Resource Planning) systems forms a starting point for this study since this literature delivers explicit and elaborate lists of base-line CSFs that may play a role in SCIS implementations. Implementing an ERP system, which is a complex intra-organizational management system covering a wide array of functions, requires integrating multiple departments and branches, sometimes located in different places around the world. Each individual department or branch usually has its own culture, method of operation, and information system(s). Similar integration issues arise when implementing a supply chain information system: supply-chain organizations have different IT legacy systems and, often, incompatible organizational structures and cultures. Therefore, we believe that CSFs for ERP implementations are as such a good starting point for describing and analyzing CSFs for SCIS implementations. In addition, we expect that specific supply-chain characteristics will play a role in SCIS implementations. The resulting framework is of interest for both practitioners and academicians as it forms a basis for project management and further CSF research in the field of supply chain information systems.

The remainder of the chapter is organized as follows. Section 3.2 outlines our methodology and in Section 3.3, CSF definitions are presented. In Section 3.4, supply-chain complexities are identified while in Section 3.5, a compilation of CSFs for implementing SCISs is provided. A framework for CSF classification is presented in Section 3.6. After the discussion in Section 3.7, concluding remarks finalize Chapter 3.

3.2 Research methods

A comprehensive search of ERP and SCIS (supply chain information systems) literature was conducted to build a CSF (critical success factor) framework for implementing SCISs.

3.2.1 ERP literature

To start, a literature review of critical success factors for ERP implementations was conducted. To avoid repetition, we selected a set of key articles, which were found through the Scopus online database, based on the following criteria:

- contain “critical success factors”, and
- contain either the keyword “ERP” or “Enterprise Resource Planning”

These search criteria resulted in more than 200 articles. To select the key articles, first, in accordance with recommendations from other information-system researchers, such as Finney and Corbett (2007) and Nord and Nord (1995), only journals were considered as a source. Second, starting from the most-cited one, articles were selected that contained an elaborate list of CSFs for implementing ERP systems. From the moment redundancy of critical success factors appeared, article selection was stopped. Selection resulted in a final list of 10 key articles investigating CSFs for implementing ERP systems.

Thereafter, the articles were reviewed and categorized to define CSFs. Categorizing was performed, in the first instance, on the basis of the CSF list of Nah et al. (2001), which was the most comprehensive of the selected articles. Based on a literature review, Nah et al. (2001) grouped related sub-factors into a list of 11 CSFs. Through our categorizing, related sub-factors from other articles were grouped under these CSFs as well. CSFs or sub-factors that could not be classified into one of the 11 CSFs were categorized as a new critical success factor. The categorizing resulted in a final list of 13 CSFs, which was used to further investigate the literature dealing with CSFs for implementing supply chain information systems.

3.2.2 SCIS literature

Articles dealing with CSFs for implementing supply chain information systems (SCISs) were found in the Scopus online database. Due to the scarcity of SCIS articles, multiple search terms were used to identify articles investigating CSFs:

- contain the keyword "(critical) success factors", "factors", "barriers", "obstacles", "challenges", or "issues", and
- contain terms related to "systems", "technology", "ERP", and "EDI", "information sharing" or "supply chain management", and
- contain the term "supply chain" or "inter-organizational"

These search terms indicate that the articles found did not always refer to the word "success" as such; other search terms were used as well. For instance, the keyword "barriers" was defined as factors that complicate information-system implementations (Akintoye et al., 2000) or factors that cause problems during implementation (Ngai & Gunasekaran, 2004). These definitions clarify that barriers are reversely linked to CSFs. Again, if the article did not comprise an elaborate list of CSFs, factors, barriers, obstacles, challenges, or issues for implementing a SCIS, then the article was eliminated. This literature search resulted in a set of 21 SCIS articles.

Our initial list of CSFs, derived from the ERP literature, allowed us to categorize and describe CSFs for implementing supply chain information systems. CSFs, barriers, obstacles, or challenges found that were not related to the 13 ERP CSFs were categorized as another CSF. Categorizing and describing of CSFs enabled us to build a framework of CSFs for SCIS implementations.

3.3 CSFs based on ERP literature

Since the 1990s, ERP system implementations have been extensively investigated for three reasons. First, ERP systems are intended to integrate information flows about finance, operations, sales, and HRM across the company. Use of ERP systems may result in, for example, better forecasts, fewer operating costs, faster production cycles, customer-service improvements, and productivity enhancements (Botta-Genoulaz & Millet, 2005; Gargeya & Brady, 2005; Umble et al., 2003). Another reason for the ERP investigation popularity is the high failure rate of ERP implementations (Barker & Frolick, 2003; Davenport, 1998; Ehie & Madsen, 2005). Failures are due to, for example, poorly defined responsibilities or lack of appropriate knowledge, which often result in inadequate decision-making by people who are unfamiliar with ERP systems. Third, ERP systems often absorb a huge part of a company's budget (Ehie & Madsen, 2005). For instance, Hewlett Packard implemented an SAP ERP package that was five times more expensive than estimated due to order backlogs and lost revenues (Wailgum, 2009). For our study, we selected 10 key articles to define the critical success factors (CSFs) for implementing an ERP system (see Table 3.1).

Table 3.1 Key articles used for defining the critical success factors for ERP implementations

Article no.	Article	Journal
1	Holland and Light (1999)	IEEE Software
2	Nah et al. (2001)	Business Process Management Journal
3	Akkermans and van Helden (2002)	European Journal of Information Systems
4	Al-Mashari et al. (2003)	European Journal of Operational Research
5	Umble et al. (2003)	European Journal of Operational Research
6	Nah et al. (2003)	International Journal of Human-computer Interaction
7	Loh and Koh (2004)	International Journal of Production Research
8	Finney and Corbett (2007)	Business Process Management Journal
9	Ngai et al. (2008)	Computers in Industry
10	Françoise et al. (2009)	Business Process Management Journal

Thirteen critical success factors for implementing ERP systems were found through our literature review (see Table 3.2). These factors, which contain several sub-factors, were obtained through careful reviewing of the 10 key articles. Sub-factors are depicted in the second column of Table 3.2. Behind every sub-factor – between brackets – references to the article numbers of Table 3.1 are given.

Table 3.2 List of critical success factors for ERP implementations derived from the literature review

Communicate effectively	• Communicate with staff at all participating levels and departments of the organization (5, 8, 9) • Communicate scope, objectives, activities, expectations, promotion, user input, and progress (2, 4, 7, 9, 10) • Communicate in an open, effective, targeted, and honest way prior to and during implementation (4, 7, 8, 9, 10) • Implement a central communication system (9)
Select project champion	• Select a high-level executive with recognized power throughout the company to be project champion (2, 5, 9, 10) • Select a staff member with technical, business, and leadership skills to be project champion (2, 8)
Compose project team	• Select employees from all participating departments (8, 9, 10) • Select both internal staff and external consultants (2, 8, 10) • Select both business and technical people (2, 8, 9) • Select the best and brightest employees (1, 5, 8) based on: knowledge (2), reputation (5), influence (9, 10), flexibility (5), time available (10), past accomplishments (6), improvisation skills (3), and troubleshooting skills (1, 8)
Take top-management responsibility	• Recognize the project as a top priority (2, 7) • Articulate business vision (4) • Provide resources, like people and money (2, 6, 7) • Solve political conflicts and bring everybody on board (1, 2, 9) • Approve the ERP choice and the designed processes, organizational structure, policies, and responsibilities (1, 2, 6) • Inform the employees about the role of the system and the accompanying changes (2, 4)
Align vision & build plans	• Articulate a vision on how the organization will operate within five years by using an ERP system (8, 10) • Define a budget to justify the investments (risks included) (2, 5, 8, 9, 10) • Build a work plan that contains the scope and schedule of the ERP implementation (2, 5, 9) • Build a business plan, which contains the organizational change (4), the IS strategy (8), the objectives of the implementation (1, 2, 4, 5, 8, 9) and technology infrastructure (4, 8) • Build a communication plan (4, 8, 10) • Build a training plan (4, 10)
Assess business & IT legacy system	• Assess the business (organizational structure, skills, and culture) and information technology (4, 8, 9)

Table 3.2 Continued

Select standards, vendor & software package	• Define information-system requirements/standards (9) • Select a vendor based on reputation, financial strength, market focus, vision, and technical capabilities (9) • Select an ERP software package that fits best with business processes, data & software requirements, strategy (3, 4, 8) • After selection, transfer knowledge from the vendor to the company that bought the ERP system (8)
Reengineer processes	• Map the current processes using process modelling tools (1, 2, 4, 5) • Change the business processes and complementary structure, staff, policies, & responsibilities (2, 4, 5, 8)
Manage project	• Promote the project (10) • Motivate the participating employees (2, 8, 9) • Manage conflicts (2, 9) • Manage resistance (7) • Make resources available, assign responsibilities, and stimulate work environment (5, 10) • Make sure that the project-team members trust each other (5)
Configure, test & troubleshoot	• Integrate and configure the software package (4, 7, 8, 9) • Check if the software and designed processes work as planned (4, 7, 8, 9) • Repair or change the software and designed processes when problems arise (4, 7, 8, 9)
Manage data exchanged	• Validate and convert data into a single format (9) • Secure the data (9) • Educate users on the importance of data accuracy (5, 8) • Exchange the data accurately and on time within the organization (9) • Accomplish data quality control (9)
Manage change & deliver training	• Recognize the change (2, 7) • Manage the wide-range of organizational changes (4) • Involve future technology users when developing the information system and processes (2, 10) • Build a training plan, taking into account the strategy, the information system that will be implemented, and the skills and experience of the participating employees (4, 10) • Train the project champion on the objectives and impacts of the implementation (10) • Train the technology users on the changes, IT skills, importance of data accuracy, and responsibilities (4, 7, 8) • Train the project team members (8) • Support training through on-site support, conference rooms with training materials, and websites (5, 7)
Monitor & evaluate performance	• Build performance indicators to monitor the progress and to check whether the objectives are met (8, 9) • Update performance indicators during the project (10)

In conclusion, as a starting point for our research, a literature review on the critical success factors for implementing an ERP system was conducted. This review led to a list of base-line CSFs used to identify critical success factors for implementing supply chain information systems. In the next section, we explain how a supply chain context puts additional requirements on information-system implementations.

3.4 Supply-chain context

The success of an enterprise depends on its ability to cooperate and integrate with its supply-chain partners. Therefore, enterprises need to transcend the boundaries of their traditional intra-organizational system and are, more than ever, trying to implement supply chain information systems (SCISs). Such systems, also known as inter-organizational information systems, were originally defined as automated systems shared by two or more organizations (Barrett & Konsynski, 1982). Implementing a supply chain information system is complex due to three supply-chain characteristics.

Firstly, the scope of the supply chain refers to the number of participating actors (Cooper et al., 1997; Lambert & Cooper, 2000). An actor is a decision-making entity, which is an organization with multiple individuals (Eckartz et al., 2010). A rule of thumb in the supply-chain literature is that the complexity of a supply chain increases when more actors are involved (Craighead et al., 2007). Therefore, multinationals such as General Motors and General Electric reduced their number of suppliers as fewer supply chain actors result in a lower level of coordination needed in the chain (Choi & Krause, 2006). In summary, more supply-chain actors increase the level of coordination required to improve the operational efficiency of the chain.

Secondly, the supply-chain organization is the way relationships between partners are built and coordinated. Supply chains can be coordinated through *written contracts (1)*, which is a formal way of binding the supply chain (Jagdev & Thoben, 2001; Raynaud et al., 2005). Contracts are legal instruments that explicitly define the terms of inter-organizational agreements. Next, the *duration of the relationship (2)* among two or more supply-chain organizations is, according to Heikkilä (2002), a good predictor for successful supply-chain relationships; the longer the relationship, the higher the chances of success. Long-term relationships might also be an indicator of high levels of trust in a supply chain, which is a third variable. "*Trust* (3) is simply one's belief that one's supply chain partner will act in a consistent manner and do what he/she says he/she will do" (Spekman et al., 1998, p. 634). According to several researchers, such as Kwon and Suh (2005) and Lee and Whang (2000), trust among supply-chain partners is extremely important for commitment and, particularly, for information sharing. Managers in a high-trust relationship are less reluctant to share information and believe that the information they receive is credible and trustworthy (Kwon & Suh, 2005). Next, *power* (4) relationships across the supply-chain will affect its structure as well (Lambert & Cooper, 2000). According to Lambert and Cooper (2000) and Verwijmeren (2004), one or two leaders of a supply chain will steer and drive the organizational structure and management of that supply chain. In conclusion, the chapter addresses four variables to describe the supply-chain organization.

Thirdly, incompatibilities or differences between actors may be present in technical capabilities, operational practices, attitudes, culture, management techniques, etc. (Lambert & Cooper, 2000). Supply-chain actors cooperate more easily when they have similar technical capabilities. For instance, implementing a new supply chain information system is complex when an outdated operating system, such as DOS, Windows 3.0, or Windows 95, is still used by some supply-chain partners. Next, complexity increases when supply-chain partners have conflicting operational practices. For example, some partners might use a pull order system, others a push system (Choi & Krause, 2006). In addition, in terms of culture, employees of the supply-chain actors can be valued differently in their company. Such differences require meshing of culture and individuals' attitudes, certainly when the participating companies are located in different countries (Lambert & Cooper, 2000). Last, supply-chain partners might have dissimilar management techniques; for instance, management involvement in day-to-day operations may be different across supply-chain actors (Lambert & Cooper, 2000). Thus, more technical and organizational incompatibilities in a supply chain intensify its complexity.

Compared with an intra-organizational context, a supply-chain context incurs extra complexities for the implementation of an information system. Therefore, supply-chain characteristics, summarized in Table 3.3, require consideration when describing CSFs for implementing a SCIS.

Table 3.3 Elements to characterize supply chains

1. *Scope*	• Number of participating actors
2. *Supply-chain organization (i.e. relationships between the supply-chain actors)*	• Formality of the relationships (contracts) • Trust • Power • Duration of the relationships
3. *Incompatibility (i.e. differences between supply-chain actors)*	• Technological differences between the supply-chain actors • Organizational differences between the supply-chain actors

3.5 CSFs for implementing supply chain information systems

A total of 21 articles have been investigated to describe critical success factors (CSFs) for implementing a supply chain information system (SCIS) (see Table 3.3). These articles were investigated and categorized based on the earlier list of 13 critical success factors from the ERP literature. Factors that were not related to the 13 ERP CSFs were grouped as other CSFs. We also paid attention to the supply-chain characteristics of Section 3.4. In the end, we obtained two new factors, namely “manage relationships” and “share costs, benefits, and risks”; however, we found no reference to the CSFs “select project champion” and “configure, test and troubleshoot” (see Section 3.7.1).

Table 3.4 Articles used for analyzing the critical success factors for SCIS implementations

Article	Journal
Spekman et al. (1998)	Supply Chain Management: An International Journal
Akintoye et al. (2000)	European Journal of Purchasing & Supply Management
Allen et al. (2000)	Information Systems Journal
Lee and Whang (2000)	International Journal of Manufacturing Technology and Management
Mentzer et al. (2000)	Journal of Retailing
Premkumar (2000)	Information Systems Management
Mentzer et al. (2001)	Journal of Business Logistics
Childerhouse et al. (2003)	Industrial Management & Data Systems
Ngai et al. (2004)	Production, Planning & Control
Ngai and Gunasekaran (2004)	Industrial Management & Data Systems
Ruppel (2004)	Business Process Management Journal
Chae et al. (2005)	IEEE Transactions on Engineering Management
Jharkharia and Shankar (2005)	Journal of Enterprise Information Management
Li and Lin (2006)	Decision Support Systems
Lu et al. (2006)	Information & Management
Fawcett et al. (2007)	Supply Chain Management: An International Journal
Pramatari (2007)	Supply Chain Management: An International Journal
Fawcett et al. (2008)	Supply Chain Management: An International Journal
Adriaanse et al. (2010)	Automation in Construction
Khurana et al. (2011)	International Journal of Manufacturing Systems
Koh et al. (2011)	Journal of Strategic Information Systems

Consequently, 13 critical success factors are outlined below. For every CSF, the numbers 1 (scope), 2 (supply-chain organization), and 3 (incompatibility) are placed between brackets when the SCIS literature considered one of the supply-chain characteristics.

Communicate effectively – Implementing a supply chain information system requires effective communication in and between all (1) participating supply-chain organizations. The impact of the implementation has to be communicated within the supply chain prior to and during implementation (Allen et al., 2000; Koh et al., 2011). For instance, to reduce resistance and frustrations, future technology users of the organizations involved should be informed why certain decisions are made (Allen et al., 2000), or regular cross-organizational communication should be accomplished to align objectives (Allen et al., 2000; Lu et al., 2006). In general, when implementing such a supply chain information system, Ruppel (2004), Koh et al. (2011), and Fawcett et al. (2008) pointed out that open and frequent communication is vital. If there is a lack of communication, then an implementation failure may arise (Allen et al., 2000). All in all, the importance of effective communication has been widely recognized and emphasized in the literature.

Manage relationships – Relationship management, which has not been highlighted as such in the investigated ERP literature, refers to managing trust and power (2) among partners (1), and project-team members in particular. Trust (2), which is important in any relationship, is crucial for the supply chain when implementing an information system (Chae et al., 2005; Jharkharia & Shankar, 2005; Koh et al., 2011; Lee & Whang, 2000; Ruppel, 2004). It is particularly crucial since every supply-chain partner (1) wants to be sure that the shared information will be kept confidential and will not be exploited by its partners (Ruppel, 2004). Therefore, if trust (2) is created, information sharing is expected to increase (Li & Lin, 2006). Trust may, however, be reduced through the use of coercive power (2) among the participating partners (Allen et al., 2000). Akintoye et al. (2000) stated that effective communication and management of relationships are methods to keep mistrust to a minimum and to increase the chances of successfully implementing a SCIS.

Compose project-team – When implementing a supply chain information system, a cross-organizational implementation team, in which each supply chain partner (1) needs to be actively engaged, should facilitate successful projects (Fawcett et al., 2008; Lu et al., 2006). According to Lu et al. (2006), this team should consist of four sub-teams: technical team, partner team, business team, and management team (Lu et al., 2006). The management team contains top executives of all participating supply-chain organizations (1) (Fawcett et al., 2008; Lu et al., 2006), while the business team consists of representatives – the so-called project managers – from all organizations related to the project (1) (Lu et al., 2006). The technical team is composed of technicians, mainly from the vendor (Lu et al., 2006), and should be available to technically assist the implementation (Ngai & Gunasekaran, 2004).

Take top-management responsibility – Numerous studies have argued that involvement and commitment of top management of all collaborating partners (1) is a very important CSF (Akintoye et al., 2000; Khurana et al., 2011; Li & Lin, 2006; Ngai et al., 2004). A top-management team, having several responsibilities, should be composed of management representatives from all participating organizations (1) to increase cross-company interaction (Fawcett et al., 2008; Lu et al., 2006). According to Chae et al. (2005) and Ngai et al. (2004), the primary responsibility of a top-management team is to provide financial support, such as time, money, and facilities, because lack of such support will undoubtedly lead to an implementation failure. Besides financial support, top managers are responsible for supporting employees psychologically (Ngai et al., 2004), sharing expertise (Fawcett et al., 2008), and solving problems when they occur (Lu et al., 2006). Top-management support is initiated by their trust (2) and shared interest or attitude (3) (Akintoye et al., 2000; Chae et al., 2005; Lu et al., 2006). Lu et al. (2006) demonstrated that top managers of the collaborating partners were interested because the participating supply-chain partners could not achieve their business objectives without each other's support.

Align vision and build plans – All collaborating supply chain partners (1) need to share a "common view" (3) on the implementation (Lee & Whang, 2000) because it might lead to a reduction of opinion divergence concerning the implementation, a consistent implementation direction, and improved information exchange (Li & Lin, 2006; Lu et al., 2006). In particular, collaborating supply-chain partners need to align their visions when implementing a supply chain information system and build a joint business plan (Akintoye et al., 2000), which must be available to all participating participants (Ngai & Gunasekaran, 2004). To align the implementation vision, communication and open regular meetings among the top managers of all participating partners (1) seems crucial (Allen et al., 2000; Lu et al., 2006). Allen et al. (2000) who investigated the implementation of an inter-organizational electronic commerce system in the motor vehicle industry, stated that "the development and reinforcement of the common objectives took place during regular meetings between companies at which communications between parties was seen to be relatively open" (p. 32). Developing common objectives may, however, be impeded by differing cultures (3) among the participating supply-chain actors (Allen et al., 2000; Koh et al., 2011). Additionally, Lu et al. (2006) pointed out that dominant and hence powerful supply-chain organizations (2) can – during these meetings – push through their vision because other supply-chain organizations are often dependent on them. If the participating supply-chain partners with divergent objectives do not communicate properly with each other, then implementation difficulties (Mentzer et al., 2000; Premkumar, 2000), and, consequently, an implementation failure might arise (Allen et al., 2000).

Share costs, benefits, and risks – Besides the vision, budget consensus among the supply-chain partners (1) is critical because non-alignment might form an obstacle to successfully implementing a supply chain information system (Fawcett et al., 2007, 2008). This CSF has not been named as such in the ERP literature. Supply-chain partners need to negotiate and agree on distributing supply-chain costs, benefits and risks (Fawcett et al., 2008). However, Lee and Whang (2000) stated that – due to incompatibilities and relationships (2, 3) – supply-chain partners do not often agree on how to split implementation costs such as feasibility studies, system design, software, management, manpower, training, and maintenance (Fawcett et al., 2007, 2008). Therefore, Lu et al. (2006) suggested that the supply-chain organization gaining the most benefits from implementing the SCIS should financially compensate the ones that stand to gain fewer benefits.

Assess business and IT legacy system – The current business and IT legacy systems in the supply chain need to be assessed because the success of a SCIS implementation is dependent on the compatibility (3) of the supply-chain partners (1). First, assessing the business of the supply chain is essential because compatibility with respect to policies, procedures, job stability, culture, strategic horizons, control systems, goals, organizational hierarchy, and reputations (3) among the different organizations is important for implementing a supply chain information system (Allen et al., 2000; Chae et al., 2005; Fawcett et al., 2008; Jharkharia & Shankar, 2005; Koh et al., 2011; Mentzer et al., 2000). Second, the current IT needs to be assessed because according to Jharkharia and Shankar (2005), and Fawcett et al. (2007) IT incompatibility (3) of the collaborating partners (1) is a crucial barrier to successful SCIS implementation (Ngai & Gunasekaran, 2004). This view is supported by Lu et al. (2006), who stated that if a supply-chain partner does not have the internal information technology to transfer information with the SCIS, the value of the system is minimal for that supply-chain partner (3).

Select standards, vendor and software package – Before selecting a vendor, supply-chain partners (1) must agree on technology standards (Lee & Whang, 2000; Lu et al., 2006). Different harmonization mechanisms might be used to agree on such standards; however, some supply-chain partners might not agree to them if they are not compatible with their intra-organizational information systems (3) (Lee & Whang, 2000). Lu et al. (2006) stated that technology standards are usually chosen by the SCIS initiator (2), implying that problems might arise without an initiator. After agreeing on standards, the supply-chain partners should agree on the vendor and the software package/information-system selection. It is important when selecting the information system to consider the reliability of the system since the threat of a SCIS breakdown is a crucial barrier to successful implementation (Jharkharia & Shankar, 2005; Ngai et al., 2004).

Reengineer processes – Before production and information processes can be reengineered, the current processes need to be understood (Koh et al., 2011). When implementing a supply chain information system, the current (value-adding) processes need to be mapped for the lone enterprise and the entire supply chain (1) (Koh et al., 2011; Ngai & Gunasekaran, 2004). Thereafter, processes should be (re)designed to take advantage of the new supply chain information system and exploit additional value-creating opportunities (Allen et al., 2000; Fawcett et al., 2007; Koh et al., 2011). (Re)shaping production and information processes implies redesigning the duties and responsibilities of the participating employees (Jharkharia & Shankar, 2005; Lu et al., 2006), the organizational hierarchy (Jharkharia & Shankar, 2005), and the alliance guidelines among the partners (Fawcett et al., 2008).

Manage project – Especially important for the successful implementation of a SCIS is the (long-term) commitment (2) and strong motivation (or shared interests/attitudes) (3) of the participating partners to collaborate with each other (Chae et al., 2005; Koh et al., 2011; Lu et al., 2006; Premkumar, 2000). According to Lu et al. (2006), for instance, only when all partners (1) are actively involved, are strongly motivated, and implementation problems are timely solved by all partners, can mutual benefits be reaped. Motivation is frequently demonstrated by committing resources, such as facilities, expertise, and time (Chae et al., 2005; Fawcett et al., 2008).

Manage data exchanged – The effective implementation of a supply chain information system requires data-management strategies. Information security and information access privileges are of particular concern for the collaborating supply-chain partners (Jharkharia & Shankar, 2005; Lee & Whang, 2000; Premkumar, 2000). Lee and Whang (2000) gave the example that when "a supplier supplies a critical part to two manufacturers […] either manufacturer would not share information with the supplier unless guaranteed that the information is not leaked to the other manufacturer" (p. 385). Additionally, Premkumar (2000) remarked that security concerns usually get bigger when more competitors (1) are involved because supply-chain partners might be suspicious or distrustful (2) that some of their information will be leaked to others. These concerns can be tackled with safeguards, firewalls, or adequate training (Ngai & Gunasekaran, 2004; Premkumar, 2000). In addition, data need to be accurate and on time (Koh et al., 2011; Lee & Whang, 2000). If one or more supply-chain partners does not share their data accurately due to dissimilar operational practices or information systems (3), then the data cannot be aggregated (Lee & Whang, 2000). It has therefore been suggested by Koh et al. (2011) and Childerhouse et al. (2003) that information standards (i.e. the format of the exchanged information) need to be established when implementing SCISs.

Manage change and deliver training – Too often, when implementing a supply chain information system, there is a reluctance to use the information system and to share information. Several studies have revealed that many managers are unwilling to share value-added information (Fawcett et al., 2007, 2008; Jharkharia & Shankar, 2005; Lee & Whang, 2000). Moreover, employees prefer the status quo and are change-averse when implementing a supply chain information system (Fawcett et al., 2008; Jharkharia & Shankar, 2005; Koh et al., 2011; Ngai & Gunasekaran, 2004). Resistance is particularly challenging when external parties get involved because employees do not want to be told by another supply-chain organization to change their way of working (3) (Koh et al., 2011). Therefore, users from all the participating organizations (1) need to be involved in the design and selection of the information system (Ngai & Gunasekaran, 2004; Ruppel, 2004) and need to gain confidence in the system (Khurana et al., 2011). Akintoye et al. (2000), Ngai and Gunasekaran (2004), and Allen et al. (2000) suggested that increasing confidence in the system might be achieved by creating realistic expectations and training. Appropriate training should educate users on how the system works, as well as its benefits (Allen et al., 2000; Ngai & Gunasekaran, 2004).

Monitor and evaluate performance – After aligning vision and objectives, performance measurements need to be built among all participating supply-chain partners (1) (Premkumar, 2000). Considerable attention should be paid to this task as non-aligned performance measurements (3) may form crucial barriers for effective supply-chain management (Fawcett et al., 2008). Performance measurements should support, for instance, supply-chain process changes and information security (Fawcett et al., 2008; Premkumar, 2000). Agreeing on these measurements is a challenge in supply chains because performance measurements are usually constructed differently (3) among the firms and can alter the implementation direction (Koh et al., 2011).

3.6 Framework of critical success factors

Above, a list of stand-alone critical success factors has been presented. Critical success factors (CSFs) are, however, not stand-alone factors; they interact with each other. Researchers have built several frameworks to classify the critical success factors, such as the MIT90s framework of Scott Morton (1991), the project life-cycle framework of Markus and Tanis (2000), the strategic-tactical framework of Holland and Light (1999), and the process-control-information (PCI) framework of Bemelmans (1998). Multiple studies, such as Orlikowski (1992), Davenport (2000), and Doherty and King (2005), have highlighted that the successful implementation of an information system is dependent on the dynamics and interaction of the organizational and technical system. Therefore, we opted to structure and classify the above-described critical success factors in the dynamic MIT90s framework (Scott Morton, 1991), which covers organizational as well as technical aspects. This framework was developed in the 1990s to help managers understand IT-enabled organizational change (Scott Morton, 1991). Furthermore, the model is simple and is easily extendable (Lyytinen & Newman, 2008) and can therefore be used in different settings for multiple purposes. For instance, the model was also applied in a supply-chain context by Verdecho et al. (2012). The MIT90s framework contains the following interacting elements:

- **Project strategy**: project goals and how the supply-chain organizations fulfil these goals
- **Structure**: processes, functions, and structure of supply-chain and its organizations
- **Information system(s)**: the technology used for the business processes
- **People**: the roles, ambitions, skills, knowledge, social ties, and attitudes of people in a supply chain and its organizations
- **Management processes**: the management processes that steer the implementation project

Based on the descriptions of the critical success factors and the definitions of the MIT90s framework elements, the 13 CSFs are classified into the MIT90s framework (see Figure 3.1). As stated above, the MIT90s framework indicates that the successful implementation of an information system is dependent on the interaction of the organizational and technical system. Consequently, since “assess business and IT legacy system” covers both organizational and technical aspects, it brings added value to split this CSF into two separate critical success factors: “assess business system” and “assess IT legacy system”. As a result, 14 critical success factors are identified and classified.

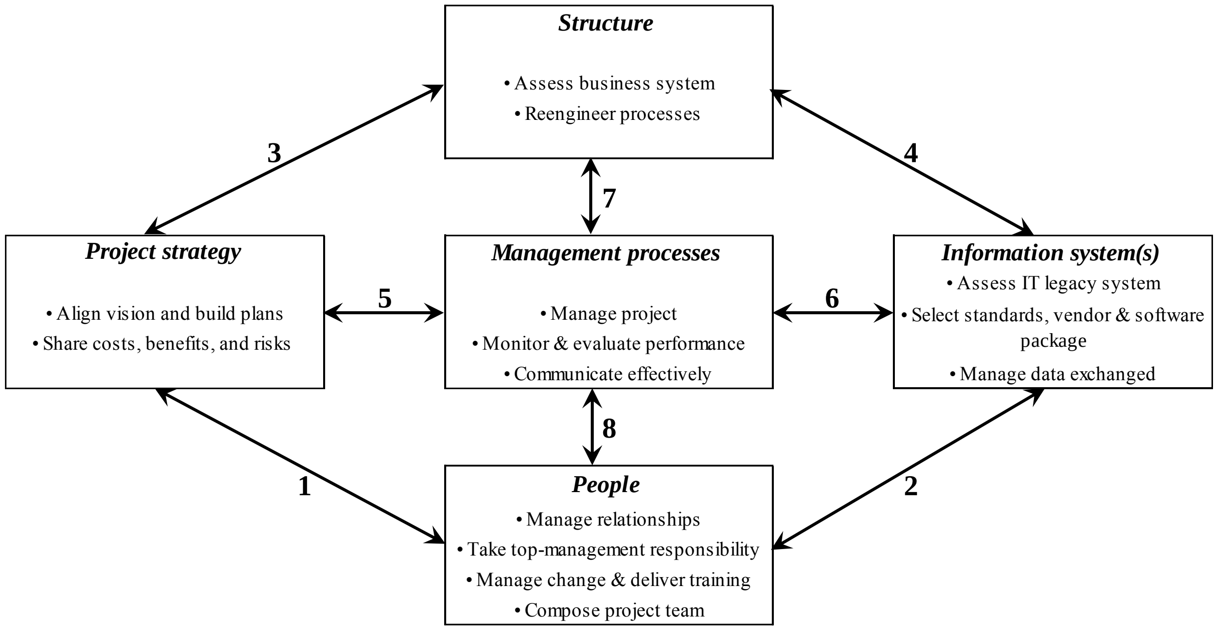


Figure 3.1 Framework of CSFs for SCIS implementations based on Scott Morton (1991)

The framework (see Figure 3.1) provides opportunities to better understand supply chain information system (SCIS) implementations. Classifying CSFs into the MIT90s framework of Scott Morton reveals, firstly, that from a management perspective, CSFs can be grouped into one of the five dimensions of the MIT90s framework. Secondly, the framework of CSFs also provides an understanding of the dynamics and cause-effect relationships of a complex SCIS implementation. The arrows in Figure 3.1 indicate that choices or changes in one of the five interacting elements of the framework require adaptations in the other four. Specifically, the double-headed arrows reflect the project life cycle of Markus and Tanis (2000). This cycle consists of four consecutive stages: the chartering phase, the project phase, the shakedown phase, and the onward and upward phase. While in the first phase decisions are taken to define the business case, phase two deals with getting the information system work. The information system is stabilized and possible "bugs" are eliminated in phase three. In the last phase, the information system is maintained, suggesting that users receive additional support and the system is upgraded. During these phases of the project life cycle, one element in the framework can be modified several times.

To illustrate the dynamics of a SCIS implementation, we take the chartering phase of such an implementation as an example (arrow numbers from Figure 3.1 are indicated in brackets). When a supply chain has a joint business vision to improve the quality of its products, which is the project strategy, then all other four elements need to be adapted as well. For instance, the project strategy leads to starting a new project and, therefore, to establishing a project team with staff from the participating supply-chain partners (1). The project team is in charge of assessing the current IT in the supply chain and selecting standards, vendor, and software package, for which several project meetings are organized (2). During such meetings, some supply-chain partners may be more decisive than others, possibly resulting in distrust among the partners. Therefore, proper relationship management is crucial. Approving standards, vendor, and information system (software) might be even more challenging as some supply-chain partners may have an outdated operating system, which is not compatible with the chosen SCIS and technology standards. Approval also requires the support of the top management of the participating supply-chain partners (2), which in turn results in a project plan and budget (1). At the same time, the business vision implies assessing the current processes and designing new business and information processes in the supply chain (3). Assessment has to be done before selecting technology standards, vendor and software package (4). It is worth noting that to (re)design the processes, negotiations (i.e. part of manage project) among the supply-chain partners are required to match the different requirements and opinions (7). As visualized in Figure 3.1, the centre of the implementation is reserved for “management processes”, which steers all four other elements of the MIT90s framework (5, 6, 7, and 8). “Communicate effectively” also plays a crucial role in all other critical success factors; therefore, it received a central role in the framework.

3.7 Discussion

Identifying and understanding critical success factors (CSFs) is crucial for successfully implementing a supply chain information system (SCIS). Chapter 3 identified a comprehensive framework of CSFs for implementing supply chain information systems. When drawing a comparison with the ERP CSFs, it becomes apparent that our investigated literature has not described these CSFs one by one. Next, when considering the supply-chain context, it becomes clear that supply-chain characteristics have not been fully considered by the investigated SCIS literature. Moreover, we become aware that concrete guidance for applying CSFs has not been provided by the literature. Below, these three phenomena will be discussed.

3.7.1 Comparison with ERP literature

In the present chapter, we described CSFs for implementing a supply chain information system. To do so, we started from a list of CSFs for implementing ERP systems. Through categorizing, it becomes clear that most ERP CSFs have also been considered by the investigated SCIS literature. However, two new critical success factors are identified: “manage relationships” and “share costs, benefits, and risks”. The first new factor is not surprising because implementing a supply chain information system is affected by the organization of the supply-chain, which is made up of multiple (independent) actors. The second factor is in line with supply-chain literature since all supply-chain actors require net benefits, leading – sometimes – to a redistribution of costs and benefits among chain partners. This redistribution, in particular, may create intensive negotiations and tensions.

Moreover, by drawing a comparison with the ERP literature, we notice that the investigated SC literature has not devoted any attention to the CSFs “select project champion” and “configure, test and troubleshoot”. In the ERP literature, without denying its importance, the CSF “configure, test and troubleshoot” has been considered as one of the least-critical factors in successful implementation (Finney & Corbett, 2007; Ngai et al., 2008). Generally, this CSF was not given much attention after the nineties. Therefore, it is not surprising that it has not received a lot of attention in the SCIS literature either. In addition, regarding the factor “select project champion”, Nah et al. (2003) claimed that this factor is one of the most crucial predictors of an ERP implementation’s success. Similar claims were made by other ERP researchers as well, such as Ngai et al. (2008). Supply-chain researchers such as Bryde (2008) stated that joint top management acts as a project champion. Consequently, stating that the CSF “select project champion” is part of the CSF “take top-management responsibility” may – partly – explain why the CSF “select project champion” has not been named as such in our investigated literature.

3.7.2 Impact of supply-chain characteristics

Compared with an intra-organizational context, a supply-chain context brings with it extra challenges for implementing an information system. Therefore, we believe that supply-chain characteristics require consideration when describing CSFs. However, the literature investigating CSFs for SCISs considered the supply-chain characteristics scope, supply-chain organization, and incompatibility to a limited extent. Whereas most of the investigated literature considered the scope of the supply chain, the impact of supply-chain organization and incompatibility on CSFs requires further investigation (see Table 3.5).

The investigated literature has considered incompatibility to a small degree. In particular, the literature has discussed why these CSFs were challenging due to technological and organizational differences between supply-chain actors. The following examples can be given. Concerning “assess IT legacy systems”, Lu et al. (2006) remarked that if a supply chain does not have the internal information technology to transfer information with the SCIS, then the value of the system is minimal for that supply-chain partner. Or, with respect to “select standards, vendor, and software package”, Lee and Whang (2000) stated that if one or more supply-chain partners do not share their data properly due to dissimilar operational practices or information systems, then the data cannot be aggregated. Column three of Table 3.5 indicates for which CSFs organizational or technical incompatibilities have explicitly been considered in the investigated literature. Since we believe that incompatibility impacts all critical success factors, more attention should be paid to this supply-chain characteristic for the CSFs “reengineer processes”, “communicate effectively”, “manage relationships”, “take top-management responsibility”, and “compose project team”. For instance, joint top-management responsibility might be more challenging to achieve if management involvement in day-to-day operations is different across supply-chain actors (i.e. the CSF “take top-management responsibility”).

In addition, the supply-chain organization, and more specifically the variables trust and power, have – partly – been taken into account for several CSFs. Again, examples are provided. For the CSF "manage data exchanged", reasons were given why implementing a SCIS was challenging in a supply-chain context. According to Jharkharia and Shankar (2005), Lee and Whang (2000), and Premkumar (2000), information security and information access privileges are concerns for the collaborating supply-chain partners during implementation because supply-chain partners are concerned that confidential information concerning their operations will leak out (Premkumar, 2000). In other words, possible absence of trust among the supply chain partners may impact data sharing. Additionally, for the CSF "articulate vision and plans", Lu et al. (2006) pointed out that the dominant supply-chain organization – i.e. based on power – can push through their vision because other supply-chain organizations are often dependent on them. In summary, the variables "power" and "trust" of the supply-chain characteristic supply-chain organization have partly been considered by the investigated literature. However, the other two variables "formality of the relationships" and "duration of the relationships" have barely been taken into account. More importantly, the supply-chain characteristic supply-chain organization has not been considered for the critical success factors "assess business system", "reengineer processes", "monitor and evaluate performance", "communicate effectively", "manage change and deliver training", and "compose project team". Notwithstanding, supply-chain organization can incur several challenges for these CSFs. For instance, regarding the CSF "communicate effectively", open and frequent communication may be challenging when relationships are temporary and trust is scarce between supply-chain partners.

It is, however, imperative to fully understand the impact of the supply-chain context on the critical success factors. In other words, it is essential for project managers to be aware which challenges can arise during a SCIS implementation due to these supply-chain characteristics. Being aware of such challenges allows project managers to detect them and react faster when they occur. In summary, supply-chain characteristics require further attention in the literature that investigates CSFs for implementing supply chain information systems.

Table 3.5 Supply-chain characteristics that have explicitly been considered per CSF

Scott-Morton element	Critical success factor (CSF)	Scope	Supply-chain organization	Incompatibility
Project strategy	*Align vision & build plans*	X	X	X
	Share costs, benefits, & risks	X	X	X
Structure	*Assess business system*	X		X
	Reengineer processes	X		
Management processes	*Manage project*	X	X	X
	Monitor & evaluate performance	X		X
	Communicate effectively	X		
People	*Manage relationships*	X	X	
	Take top-management responsibility	X	X	
	Manage change & deliver training	X		X
	Compose project team	X		
Information system(s)	*Assess IT legacy system*	X		X
	Select standards, vendor & software package	X	X	X
	Manage data exchanged	X	X	X

3.7.3 Applying critical success factors

Although supply-chain researchers have agreed on the importance of most CSFs, concrete guidance for applying CSFs has not been provided by these researchers; there is a gap between the rather abstract CSFs for SCIS implementations and operational project management. Concrete guidance requires specific tactics with linked responsibilities.

With respect to some CSFs, general strategies have been given to use CSFs for implementing a supply chain information system. For example, concerning the CSF "manage relationships", Akintoye et al. (2000) stated that management of relationships and communication are methods for keeping distrust to a minimum. Furthermore, for the critical success factor "share costs, benefits, and risks", supply-chain partners need to negotiate on the distribution of these items (Fawcett et al., 2008). In addition, regarding the CSF "project-team composition", it was suggested by Lu et al. (2006) that each supply-chain partner needs to be actively engaged to build a successful implementation team. These examples indicate that, for a few CSFs, general strategies have been defined to control the critical success factors. However, specific actions or tactics for applying CSFs have not been specified and, therefore, CSFs may be difficult for project managers to use.

Besides specific actions that need to be undertaken, responsibilities for CSFs have been largely overlooked. Implementation chances are, notwithstanding, likely to increase when specific supply-chain roles are made responsible for different actions during the implementation trajectory (Gottschalk, 2001). To illustrate, with respect to "reengineer processes", the CSF literature has not been clear about which supply-chain role needs to initiate process mapping. Or, for "manage change and deliver training", it has not been specified who in the chain should create realistic expectations and train users to motivate future information-system users. Since such shortcomings can be identified for all CSFs, one can state that it has not been clarified how to handle CSFs when implementing a SCIS. The literature that investigates CSFs for implementing supply chain information systems should identify actions with linked responsibilities – considering supply-chain characteristics – for the CSFs identified (as presented in the framework). Consequently, the framework of CSFs forms a starting point for project management.

3.8 Concluding remarks

Research on critical success factors (CSFs) for supply chain information system (SCIS) implementations has been scarce and fragmented; to date, no consensus has been achieved on SCIS CSFs. A better understanding of these CSFs might, however, allow supply chains to increase their chances of successfully implementing SCISs. The main objective was therefore to build a framework of CSFs for implementing SCISs. To do so, we took base-line CSFs for ERP implementations as a starting point. A total of 31 articles were investigated to identify and describe 14 critical success factors for implementing supply chain information systems. From the literature review, it becomes apparent that the ERP CSFs "select project champion" and "configure, test and troubleshoot" have not been highlighted in the investigated SCIS literature. However, compared with the ERP literature, "manage relationships" and "share costs, benefits, and risks" form new CSFs for implementing supply chain information systems. Finally, 14 CSFs are classified into the MIT90s framework of Scott Morton. Although this chapter does not claim to be exhaustive, the framework is of interest for academicians and practitioners as it forms a starting point for project management and for further research on CSFs for implementing supply chain information systems.

The framework indicates the nature of CSFs and helps to clarify the dynamics of a complex SCIS implementation. First, it can serve as a checklist of areas that require attention when implementing a supply chain information system. The 14 CSFs form an important step in giving a comprehensive overview of predictors for successfully implementing a SCIS as, to date, no consensus has been achieved about which CSFs are crucial. Second, through grouping, critical success factors are presented in a more systematic way. It shows, from a management perspective, that CSFs can be grouped into the following dimensions: "project strategy", "people", "structure", "management processes", and "information systems". It is worth noting that the framework offers a comprehensive set of dimensions in which every CSF should be part of at least one dimension. Third, despite the fact that CSF literature has delivered laundry lists of CSFs, the framework indicates that CSFs do not work in isolation. Specifically, the arrows of the framework indicate that choices or changes in any one of these five elements require adaptations in the other four elements. By using the framework, as suggested by Belassi and Tukel (1996), project managers can, therefore, easily identify cause-effect relationships.

In view of the phenomena discussed in Section 3.7, three areas need to be addressed in further research. First, it is highly recommended that further CSF research should investigate the application of our CSF framework. The framework should be used as a basis for undertaking CSF research in various types of supply chains. Second, more effort should be directed at revealing the impact of the supply-chain characteristics – as defined in Section 3.4 – on the identified CSFs. Specifically, it would be helpful to know what typical challenges arise when implementing a SCIS due to the supply-chain context. Third, there is a need to identify specific tactics per critical success factor as actions with linked responsibilities will allow project managers of SCIS implementations to control the critical success factors better.

Chapter 4

Actionable critical success factors to implement supply chain information systems

Chapter is based on: Denolf, J.M., Trienekens, J.H., Wognum, P.M., Schütz, V., van der Vorst, J.G.A.J., & Omta, S.W.F. "Actionable" critical success factors for supply chain information system implementations – Exploratory findings from four German pork supply chains, submitted.

4. "Actionable" CSFs to implement supply chain information systems

4.1 Introduction

Worldwide, the food sector has been exposed to globalization, climate change, increasing population, a global economic downturn, and an increasing number of food scandals. These challenges have led to low profit margins and high customer expectations (e.g. higher food safety demands). To improve margins and food safety in food supply chains, business processes along the supply chain need to be made more effective and efficient. Information exchange is, therefore, urgently needed to adapt business processes in the food sector (Bahlmann & Spiller, 2009). The importance of information exchange in food supply chains has been emphasized by, for instance, Hill and Scudder (2002), Schulze et al. (2006) and Lehmann et al. (2012). More than ever, food supply chains need to implement or re-organize information systems that integrate actors in the whole supply chain (Wolfert et al., 2010). Such information systems, known as "supply chain information systems" (SCISs) or "inter-organizational information systems" (IOSs), support information exchange in the supply chain by providing relevant information to all chain partners.

Implementing an information system in supply chains is, however, complex. For instance, farmers might not be willing to use a new information system because of the changes needed in business practices and the investments required. For managing such complexities, information-system researchers have identified generic "critical success factors" (CSFs) for implementing a supply chain information system. These have taken a prominent position in the information-system (IS) literature. The concept of CSFs was developed by Bullen and Rockart (1986). CSFs were defined as: the key areas where things must go right to ensure successful competitive performance for the organization or supply chain (Ngai et al., 2008). To date, information-system researchers have delivered "laundry lists" of CSFs for implementing SCISs. However, according to Boynton and Zmud (1984), Flynn and Arce (1997), and Françoise et al. (2009), these lists are abstract as they have not been made "actionable" and are, therefore, only a partial aid to practitioners. To address this limitation, we aim to make CSFs actionable for implementing SCISs in the food sector.

In Chapter 4, we use the German pork meat industry as an illustration. In the German pork sector, which is the largest pig producer in the European Union, high pressure on retail margins causes a cascade effect on the upstream supply-chain partners. Moreover, in recent decades, the German pork sector has been exposed to many food scandals, such as the dioxin crisis and classical swine flu (Hartmann et al., 2013). To increase profit margins and to cope with food safety, business processes along the pork meat supply chain need to be made more effective and efficient. For example, selection processes for sows and boars can be improved and feed choices can be optimized, leading to better piglets. To do so, several attempts have been made to implement SCISs within the German pork industry (Bahlmann & Spiller, 2009).

To make CSFs actionable, we used a list of CSFs as the starting point. Then, we investigated the implementation of supply chain information systems (SCISs) in four German pork supply chains. Based on these case studies, we defined actions – linked to supply-chain responsibilities – that have proved crucial for implementing a SCIS. By defining actions, we bridge the gap between CSFs and practical project management.

4.2 Literature review

Implementing a supply chain information system (SCIS) is complex because it requires integrating multiple supply-chain actors, each with their own company culture, power and leadership structure, management methods, and information systems (Lambert & Cooper, 2000). Moreover, different supply-chain actors may have other reasons for implementing a SCIS and, therefore, a different implementation objective. A wide range of academicians and practitioners has delivered approaches to cope with such complexities and to increase the chances of successfully implementing a SCIS. One of the approaches is the use of "critical success factors" (CSFs), which are important areas in which intervention is needed and can hence be seen as an information-system planning tool (Boynton & Zmud, 1984). Identification of "critical success factors" has given rise to a substantial amount of literature (Ang et al., 2002). Despite the popularity of CSFs in information-system literature, critical success factors have remained highly abstract and have not been made "actionable".

To make CSFs actionable, we use the CSF framework of Denolf et al. (2014), who undertook a literature review of CSFs for implementing supply chain information systems. They used the socio-technical MIT90s framework of Scott Morton (1991) to classify the CSFs found. The framework, which was developed to help managers understand IT-enabled organizational change, consists of five interacting elements:

- **Project strategy**: the goals of the project and how the supply chain endeavors to fulfil these goals
- **Structure**: the structure of the supply chain and its organizations
- **Information system(s)**: the technology used
- **People**: the roles, knowledge, skills, ambitions, attitudes and social ties of people in the supply chain
- **Management processes**: the management processes that steer the project

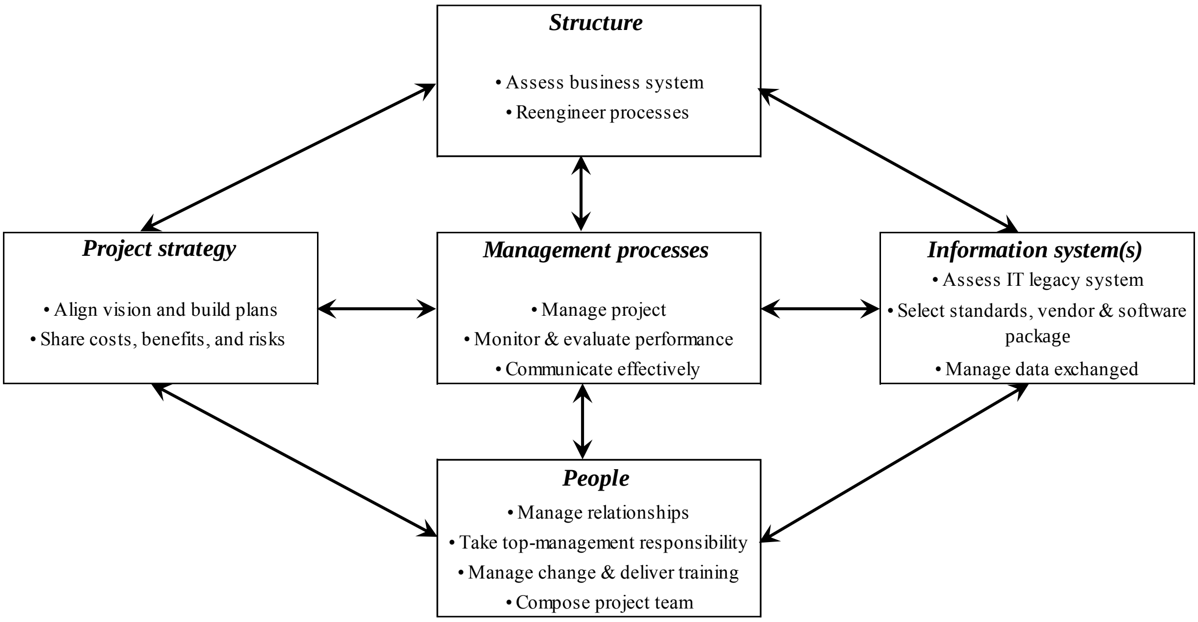


Figure 4.1 Classification of CSFs for SCIS implementation in the MIT90s framework of Scott Morton (1991) (Denolf et al., 2014)

Fourteen critical success factors, which were classified in the MIT90s framework, are described below:

- **Align vision and build plans** – To successfully implement a SCIS, vision alignment and joint business plans across all involved supply-chain partners are crucial as it might lead to a consistent implementation direction and, consequently, to enhanced information sharing (Li & Lin, 2006; Lu et al., 2006).
- **Share costs, benefits, and risks** – Supply chain partners have to agree to distribute supply-chain benefits, costs, and risks, which is often perceived as extremely challenging (Fawcett et al., 2008; Lee & Whang, 2000). Lu et al. (2006) proposed, therefore, that the supply-chain partners gaining the most benefits from the SCIS implementation should financially compensate the partners with fewer benefits.
- **Assess business system** – When implementing a SCIS, business systems need to be assessed since compatibility is an important predictor for success. Regarding the business, compatibility with respect to culture, job stability, reputations, organizational hierarchy, procedures, policies, and strategic horizons across the supply-chain organizations should be assessed (Allen et al., 2000; Jharkharia & Shankar, 2005; Mentzer et al., 2000).
- **Reengineer processes** – Implementing a SCIS usually requires adaptation and creation of business and information processes. To do so, current processes should be analyzed by means of mapping, for all collaborating supply-chain partners (Koh et al., 2011; Ngai & Gunasekaran, 2004). Thereafter, to fully exploit the new supply chain information

system, processes, responsibilities, and alliance guidelines need to be redesigned as well (Allen et al., 2000; Fawcett et al., 2007; Koh et al., 2011).

- **Assess IT legacy system** – Assessment of current IT is required as IT compatibility in the supply chain is indispensable for successfully implementing a SCIS (Fawcett et al., 2007; Jharkharia & Shankar, 2005; Khurana et al., 2011; Ruppel, 2004).
- **Select standards, vendor, and software package** – Before selecting a vendor, agreements on technology standards should be attained when implementing a SCIS (Lu et al., 2006). Most commonly, a SCIS initiator pushes the technology-standard decision through, which means that difficulties might arise without an initiator. Then, the supply chain needs to agree on the technical specifications of the supply chain information system, leading to a vendor and a software package selection (Lee & Whang, 2000).
- **Manage data exchanged** – When implementing a supply chain information system (SCIS), exchanged data have to be properly managed since information access privileges and information security are crucial attention points for the participating supply-chain partners (Jharkharia & Shankar, 2005; Lee & Whang, 2000; Ngai & Gunasekaran, 2004). Security concerns typically increase when more horizontal partners are involved because these partners may be suspicious about confidential information being leaked to their competitors (Premkumar, 2000).
- **Manage project** – In a supply chain, strong collaborative motivation and long-term commitment are prerequisites for successfully implementing an information system, since only then can mutual benefits be reaped (Chae et al., 2005; Koh et al., 2011; Lu et al., 2006; Premkumar, 2000). Chae et al. (2005) and Fawcett et al. (2007) stated that committing resources is an indication of strong motivation.
- **Monitor and evaluate performance** – Monitoring and evaluating the performance has been defined as another crucial predictor of a SCIS implementation's success. After vision alignment, performance measures should be designed and agreed on; this is often challenging since these measures are usually different from one firm to another (Koh et al., 2011).
- **Communicate effectively** – Effective communication, which affects all other CSFs, is a prerequisite prior to and during the SCIS implementation trajectory. The large number of employees working for different supply-chain actors makes this CSF especially challenging. Communication refers mainly to communicating the work changes to the participating staff members, which is essential to reduce resistance to change (Allen et al., 2000; Koh et al., 2011). In general, during the implementation trajectory of a SCIS, open and frequent communication among the staff involved is critical (Allen et al., 2000; Fawcett et al., 2008; Ruppel, 2004).
- **Manage relationships** – Building trust has been regarded as essential for successfully implementing an information system (Chae et al., 2005; Koh et al., 2011; Lee & Whang, 2000; Ruppel, 2004). To keep distrust to a minimum, effective communication, for instance, is useful (Akintoye et al., 2000).

- **Take top-management responsibility** – Top-management support has been an often-cited predictor for successful SCIS implementation (Khurana et al., 2011; Sohal et al., 2001). The major responsibility of top management is to provide financial support, which is regularly initiated by their intrinsic motivation and shared implementation interest (Chae et al., 2005; Ngai et al., 2004). Supply chain top management may refer to the top-management of a coordinating or governing organization or to a top-management committee with representatives from every participating supply-chain organization.
- **Manage change and deliver training** – An often-mentioned phenomenon when implementing a SCIS is resistance to change, which, as a result, requires proper change management (Fawcett et al., 2008; Jharkharia & Shankar, 2005; Koh et al., 2011; Ngai & Gunasekaran, 2004). Therefore, users of all collaborating partners should be involved in the design of the information system (Ngai & Gunasekaran, 2004; Ruppel, 2004) and should receive training about the SCIS (Akintoye et al., 2000; Allen et al., 2000).
- **Compose project team** – Quite a few supply-chain researchers have emphasized the need for a multidisciplinary project team, composed of staff from every participating supply-chain organization (Fawcett et al., 2008; Lu et al., 2006). Lu et al. (2006) suggested that the team should contain four sub-teams: a partner team, a technical team, a business team, and a management team.

The critical success factors above are the subject of further analysis to determine actions that are crucial for implementing a supply chain information system in the food industry.

4.3 Research methods

According to Miles and Huberman (1984), Yin (2003), and Eisenhardt (1989), case study research enables in-depth investigation and is an effective way to study events of a highly complex nature in more depth. In the present research, we investigated the implementation of supply chain information systems (SCISs) in German pork supply chains. We opted for a multiple case-study approach, which permits comparisons that clarify whether a finding is replicated by multiple cases (Eisenhardt, 1991; Yin, 2003).

Special attention was given to the selection process. It was important to select supply chains that completed the implementation of a supply chain information system because we wanted to learn from the whole project life cycle. Furthermore, to increase the representativeness of the case sample, we incorporated differences between supply chains, such as geography, size, information system, and supply-chain organization. Such a case-selection strategy is suitable for explorative research and has been named “diverse-case method” (Seawright & Gerring, 2008). We selected supply chains that produce and slaughter different amounts of pigs in different regions of Germany, that implemented a SCIS with different purposes, and that were organized differently. Regarding the selection of the interviewees, as advised by Rowley

(2002), Yin (2003), and Eisenhardt and Graebner (2007), people with different positions and from different hierarchical levels and organizations were interviewed. As a result, we interviewed on average five individuals per case, resulting in 19 in total. Specifically, we interviewed top managers, external people (i.e. vendors and/or consultants), project managers, and employees who are/were supposed to work with the system. We selected these people using the snowball sampling method, meaning that we contacted the CEO or main project manager and asked him or her which other people from the supply chain were involved in the project. We then further selected the interviewees based on their position and hierarchical level in the organization. Interviews lasted on average one hour and were tape-recorded.

To conduct the interviews, we applied the "critical incident technique" (CIT), which was developed by Flanagan (1954) within the area of psychology. This technique has been used in other fields as well, such as information-seeking behavior (Bitner et al., 1990) and marketing (Wilkinson, 2001). The critical incident technique is a set of procedures for collecting data from the respondent's perspective in his or her own words. CIT does not force the respondents to talk about certain topics and can deliver top-of-mind answers. In our study, respondents were initially asked to answer background questions regarding their position, the supply-chain organization, the implementation objective, and the main functions of the system. Thereafter, we asked the respondents to describe crucial challenges during the project and actions taken to cope with these challenges. A challenge is something important that happened during the implementation and positively or negatively impacted the supply chain. Challenges are assigned to CSFs and form a basis to take actions, which are activities that the participating managers carry out to control and master the various CSFs (Françoise et al., 2009) (see Figure 4.2). It is crucial to link actions with different actors in the supply chain because the chances of successfully implementing a SCIS are likely to increase when actions are linked to responsibilities (Gottschalk, 2001). Therefore, per challenge, we asked our respondents which actions were taken and by whom.

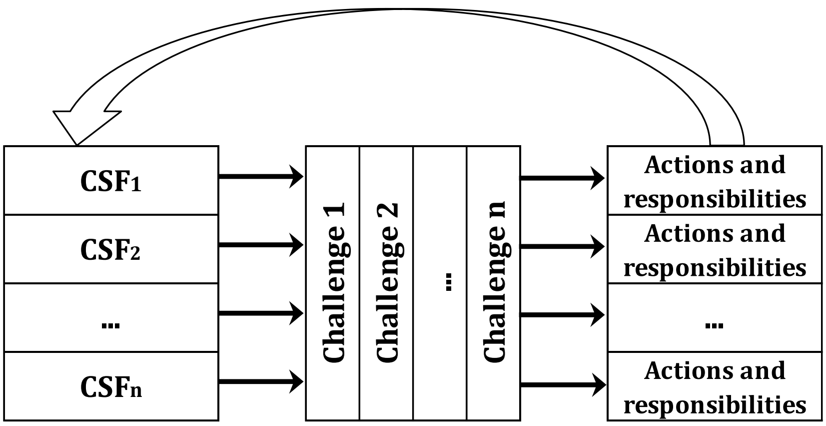


Figure 4.2 Analytical Framework – based on Francoise et al. (2009)

Through an iterative process, our transcribed interviews were analyzed to define challenges and actions connected to CSFs. In a first phase, the challenges were linked to the different critical success factors from the literature. Every challenge could be easily linked to one or more CSFs because of the CSFs' generic character. Thereafter, in a second phase, the actions were identified and also linked to the critical success factors. All actions that were mentioned by our respondents were taken into account. However, any indication of difference in importance among the actions was not considered. In addition, the actions that were mentioned by multiple respondents were not indicated as more crucial or critical.

4.4 Introduction to the case supply chains

In this section, we introduce the four supply chains that have implemented a supply chain information system. A background to the four supply chains, their supply-chain organization, their information system (SCIS), and the challenges that arose during the SCIS implementation are given. The challenges are visualized in a "Gantt-chart", containing a time dimension.

4.4.1 Supply chain A

Supply chain A is a local supply chain that produces fresh processed pork meat in the north-western area of Germany. This supply chain produces more than 500,000 pigs per year, which is around 1 % of the total German pig production, resulting yearly in 50,000 tons of processed pork meat. The processed meat is distributed through 150 licensed distributors, such as butchers and retailers, emphasizing the quality, the regional aspect, and the transparency of this supply-chain's meat.

The local supply chain is a fully integrated supply chain, coordinated and governed by a cooperative of 500 pig farmers, both farrowers and finishers. The cooperative owns a slaughterhouse in which 100 % of the pigs are slaughtered and a meat processing firm in which part of the carcasses are processed. Relationships in the supply chain have a long-term basis and are governed through written contracts with quality requirements on feeding, animal husbandry, and health management. For instance, the cooperative obliges their farmers to buy feed from a limited number of feed producers.

Supply chain A implemented a supply chain information system to improve the health of the pigs by delivering better management information to their farmers. Management information is communicated to the farmers by farm veterinarians and cooperative consultants, who visit the farms on a regular basis. Before implementing the supply chain information system, veterinarians and cooperative consultants were not able to digitally register their actions and did not have instant access to slaughter information. The checklists for health status –so-called protocols for veterinarian visits – were filled out manually by veterinarians and were sent to the cooperative. With the SCIS, veterinarians can now enter the data directly in an online checklist on the farm. The checklists (i.e. filled-out protocols) are immediately available to the cooperative consultants and the veterinarians. Slaughter information and protocols are used as a basis for advice to improve farmers' performance and the health status of their pigs.

The interviewees mentioned some challenges that arose during the implementation of the SCIS (see Figure 4.3). The implementation lasted seven years and was finished in 2010. In addition to selecting the interface standard for exchanging information, it took several years to develop the protocols. Principally, the cooperative had an IT staff member whose work schedule made it challenging for him to support the implementation. After building the protocols, users needed to be convinced and motivated to use them. Motivating the farm veterinarians to use the SCIS took some time since making veterinary practices more transparent is a challenge for them. After 2010, when the implementation was officially finished, protocols were further developed because they were too long, which led to extra administration for the veterinarians. In Figure 4.3, an overview of the main challenges reported is given.

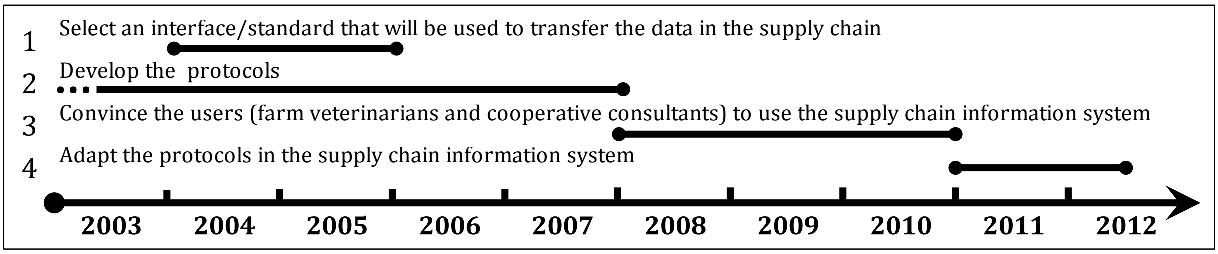


Figure 4.3 Identified challenges with their duration during the information system implementation in supply chain A

4.4.2 Supply chain B

The cooperative, coordinating supply chain B, is one of the three main pork processors of Germany. Like many other pork meat companies, the slaughterhouses and meat-processing companies of this cooperative are located in the north-western area of Germany. The supply chain slaughters more than 7,000,000 pigs per year, which is 12 % of the total German production. Up to 50 % of its processed meat is exported.

The cooperative has 2200 farmers, who own and supply the slaughterhouses, and several meat processing companies. This cooperative has marketing contracts with 80 % of its farmers with whom it has long-term relationships. Marketing contracts are contracts that incorporate buying and selling obligations, meaning that the slaughterhouse has a stable and secure supply of pigs and the farmers have a stable market access. With regards to quality, the cooperative does impose a few restrictions in addition to legal requirements.

In 2002, supply chain B finalized the implementation of their supply chain information system (SCIS) between the slaughterhouse and farmers. The SCIS is an in-house developed web-based information system to deliver slaughter information to farmers, the main users of the system. Through this system, farmers receive information about their slaughtered pigs, such as carcass grading, meat-inspection results, and inter-farm comparisons. Our interviewees identified four implementation challenges, which were directly or indirectly related to the system users (see Figure 4.4). At the start, to define the farmers' requirements, innovative farmers had to be involved to develop the new SCIS (challenge 5) and, thereafter, all farmers needed to be convinced to use the new information system (6). The large number of farmers in particular made this challenge complex. Crucial during this stage was technical support for the implementation because many farmers had questions on the new system and had different PCs at their farm (7). After 2002, the cooperative took into account the users' feedback to further continuously develop the information system because, over time, farmers have defined more information-system requirements (8).

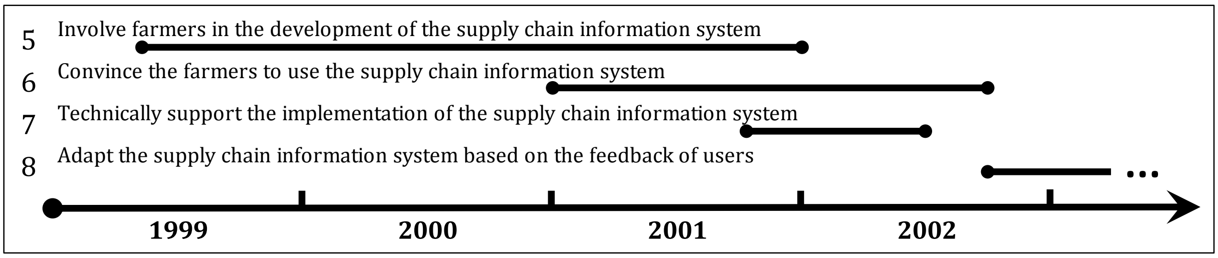


Figure 4.4 Identified challenges with their duration during the information system implementation in supply chain B

4.4.3 Supply chain C

Supply chain C is a local supply chain that produces pork meat in the northern area of Germany, close to the Danish border. It produces about 550,000 pigs per year, which is around 1 % of the total amount of slaughtered pigs in Germany. A big part of this pork meat is sold to one supermarket chain under a specific quality label.

The cooperative coordinates and governs part of the local supply chain. In particular, it has its own breeding line, but not its own slaughterhouse or processing company. The cooperative has marketing contracts with its farmers and almost 50 % of the raised pigs are delivered to one slaughterhouse, where all pigs intended for the previously mentioned quality label are slaughtered. These pigs, therefore, need to comply with certain quality label requirements. Thereafter, all pig carcasses are delivered to the processor, with whom the cooperative has a long-term relationship.

Transparency across the entire value chain was the main motive for implementing two parallel supply chain information systems in this supply chain. End-consumers and other actors in the pork meat supply chain want to know the origin and quality of the meat. The first information system is a website that end-consumers of the specific labelled meat can access to check from which farm(s) their meat comes and which feed was delivered to these farms. The second information system enables an efficient electronic data exchange between all project partners – cooperative, slaughterhouse, and processor – and supports the exchange of pig information, such as slaughter data. In case of an emergency, the information system ensures central access to all relevant product and process information. This eBusiness solution was based on open and globally recognized standards and built by two system developers who also developed the intra-organizational systems for the slaughterhouse and the cooperative.

Figure 4.5 gives an overview of the different implementation challenges of supply chain information system one and two. Our respondents identified seven challenges for the first information system and five for the second one. During project two, two challenges took almost as long as the complete project duration (challenge 16 and 18). In particular, separating the projects was considered crucial because project-team members often confused both projects; the project team composition was almost the same for both projects and objectives were linked. In both projects, defining the required data flows was an important step for implementing a SCIS (13 and 19). At the start of project one, project-team composition was considered challenging (9). In the middle of project one, the system developer explained to the project partners that new available data could be bundled to obtain more relevant information (13). Thereafter, organizations that delivered data to the new information system, such as farmers and feed producers (11 and 12), also needed to be convinced. This was challenging because neither party received any information; they were just required to deliver data to the SCIS. Due to the large number of farmers, it took time to convince the farmers. At the end of the project (14 and 15), the information system was further publicized at a press conference, which was crucial since the information system was consumer-oriented. The supply chain wanted to strengthen end-consumer confidence and to increase sales of their quality-labelled meat. Finally, IT was also challenging for the second project (17 and 20). Challenge 20 was a challenge because IT staff of the system developers had to be taught how to program the chosen EDI standards.

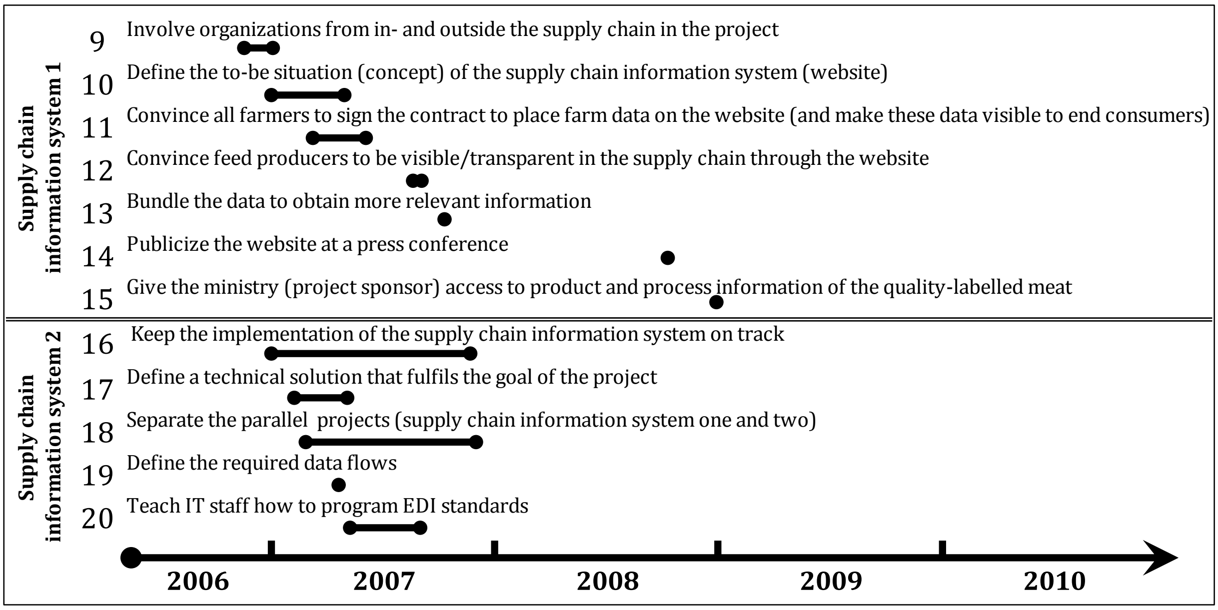


Figure 4.5 Identified challenges with their duration during the implementation of information systems in supply chain C

4.4.4 Supply chain D

Supply chain D is a local supply chain that produces pork meat in the south of Germany, close to the Austrian border. The supply chain produces approximately 1,100,000 pigs per year, which is around 2 % of the total amount of slaughtered pigs in Germany. After rearing and fattening, pigs are slaughtered in one of the four slaughterhouses owned by one of the largest pig meat producers in Germany.

The coordinating office coordinates and governs part of the supply chain. The cooperative has marketing contracts with its farmers, but does not have its own slaughterhouse or processing company. The cooperative, instead, has long-term relationships with the four slaughterhouses, one of which is 20 % owned by the cooperative.

Between 2006 and 2010, the supply chain implemented a supply chain information system, which was financed by several partners. With this system, farmers, slaughterhouses and other actors in the supply chain have the opportunity to view and retrieve subscriber-related product and production data about the slaughtered pigs. For instance, farmers can view their pig slaughter data and blood test results. In addition, shipping agents, consultants, farm veterinarians, slaughterhouse veterinarians, and other people have access to new data through the supply chain information system. The data are available to them for documentation, evaluation, and promotion purposes. The centralized storage of all data enables the transparent representation of the origin of all animals slaughtered.

According to the employees, eight challenges arose during the SCIS implementation (see Figure 4.6). Three of them had to do with convincing the users, such as farmers (challenge 22), shipping agents (26), and veterinarians who inspect the carcasses at the slaughterhouse (28). For example, challenge 26 was considered important because shipping agents were often resistant to new technologies as they are not regarded as being "IT-minded". Before convincing the users, the functionalities of SCIS had to be defined (21 and 23), planned (24), and developed (25). These challenges took a lot of time because new functionalities were not implemented simultaneously. The project partners believed that implementing a complex SCIS should be done by starting with one functionality; thereafter, functionalities should be implemented one after the other. A last challenge (27) had to do with changing the legacy operating system because the slaughterhouses still used the outdated MS DOS operating system, which was not compatible with the new SCIS.

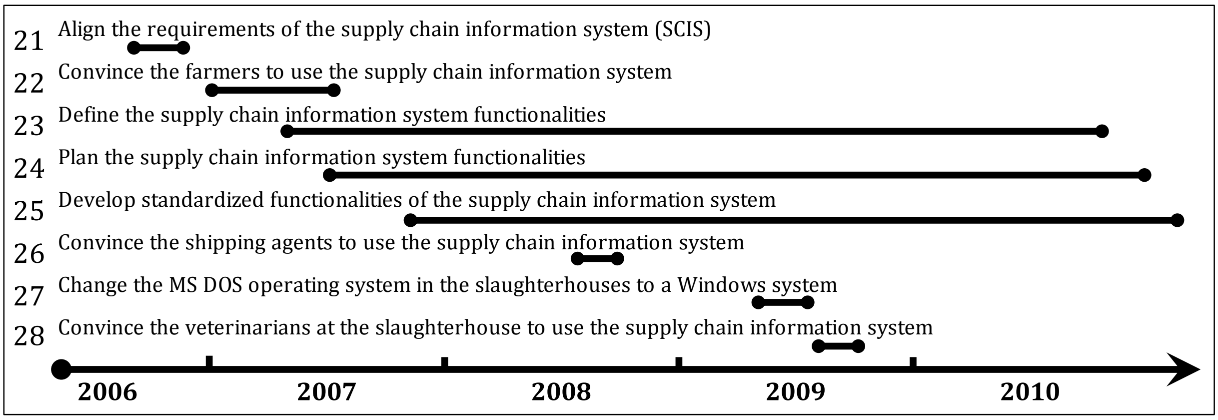


Figure 4.6 Identified challenges with their duration during the information system implementation in supply chain D

4.5 Results

As explained in the previous section, our respondents mentioned multiple challenges that arose when implementing a supply chain information system (SCIS). In Table 4.1, the 28 challenges presented in section 4 are assigned to critical success factors (CSFs), which are in turn connected to an element of Scott-Morton's framework. Challenges form the basis to take "actions" when implementing a supply chain information system. The challenge numbers in Table 4.1 (see column 3) refer to the challenge numbers of section 4.4.

Table 4.1 Identified challenges connected to the critical success factors (CSFs)

Scott-Morton element	CSF	Challenge number	Challenges	Case
Project strategy	*Align vision and build plans*	• 24 • 10 • 18 • 16	• Plan the development of the SCIS • Define an interface to exchange information • Separate parallel projects • Keep the implementation project on track	• D • C • C • C
Structure	*Reengineer processes*	• 19	• Define the required information flows	• C
Information systems	*Assess IT legacy system*	• 27	• Change the computer operating system	• D
	Select standards, vendor, software package	• 3/17/21/23 • 2/25 • 1/10 • 7 • 4/8	• Define the functional requirements of the SCIS • Build the new supply chain information system • Define an interface to exchange information • Technically support the implementation of the SCIS • Adapt the SCIS based on the users' feedback	• A, C, D • A, D • A, C • B • A, B
	Manage data exchanged	• 4/19 • 13 • 15	• Define the required information flows • Bundle the new obtained data to obtain more information • Give information access to external organizations	• A C • C • C
People	*Compose project team*	• 9	• Involve organizations in the project team from in- and outside the supply chain	• C
	Take top-management responsibility	• 19 • 1/10	• Define the required information flows • Define an interface to exchange information	• C • A, C
	Manage change and deliver training	• 5 • 11/12 • 3/6/22/26/28 • 20 • 14	• Involve the future users to develop the new SCIS • Convince supply-chain organizations that are not using any data to deliver certain data • Convince future users to use the new SCIS • Teach IT staff how to program/build the new SCIS • Make the information-system more visible through public communication	• B • C • A, B, D • C • C
	Manage relationships	• 1/3/5/6/10/11/12/14/19/20/22/26/28	• See section 4.5.4	• A, B, C, D
Management processes	*Manage project*	• 18 • 16	• Separate parallel projects • Keep the project on track	• C • C
	Communicate effectively	• 1 • 3 to 23 • 25 to 28	• See section 4.5.5	• A, B, C, D

Through our four case studies, we identified actions that were taken in the projects when the above-mentioned challenges arose. These actions may be linked to different actors in the SCIS implementation trajectory. Based on Markus and Tanis (2000) and our four case studies, the following six actors were identified (see Table 4.2): project team (PT), supply chain stage representatives (SSRs), project coordinator (PC), information-system developer/vendor (ISD), company executives or top managers (TMs), and operational staff members of the supply chain stages (OSs). The project team contains the supply-chain representatives of the involved supply-chain stages, the project coordinator, the information-system developer, and sometimes top managers of the involved supply-chain stages. In a supply-chain context, one player needs to take the lead; therefore, a project coordinator was appointed in all cases. Next, the executives of the different supply-chain stages play a key role during the implementation trajectory and are sometimes part of the project team. Finally, when decisions are taken, the supply chain stage representatives often pass responsibility to operational staff members, who are not part of the project team.

After having analyzed the four cases, a list of key actions to implement a supply chain information system becomes apparent. Below, after briefly describing the challenges, the actions are defined for each critical success factor. Whenever appropriate, examples from the case studies are given to illustrate the actions. The identified actions are preceded by a supply-chain actor (see Table 4.2).

Table 4.2 Involved supply-chain actors during a SCIS implementation, based on Markus and Tanis (2000) and the case studies

Supply-chain actor	Abbreviation
Project team	PT
Representatives of the involved supply-chain stages	SSRs
Project coordinator	PC
Information-system developer/vendor	ISD
Top managers of the involved supply-chain stages	TMs
Operational staff members of the involved supply chain stages	OSs

4.5.1 Project strategy

Align vision and build plans – Our respondents named several challenges related to defining the project goal and planning the different functionalities of the new supply chain information system. With respect to the former, every project partner may have different project goals – and consequently different functional requirements – when implementing a supply chain information system. Therefore, several actions need to be taken to match the different goals and requirements of the involved supply-chain partners (see Table 4.3). In case D, for instance, some organizations asked the system developer to build functionalities before a definite deadline (i.e. requirements with a high priority), while other organizations asked the system developer to automate a manual data process; in other words, changes that would make the data process more efficient (i.e. requirements with a low priority). Due to the large number of requirements, the system developer in case D took care that functional requirements with a high priority were planned before those with a low priority.

Table 4.3 Reported key actions with linked responsibilities to master the CSF "Align vision and build plans"

PC[1]	• Write a project plan • Organize a kick-off meeting with the project team • Explain the overall goal to the project team at the start of the kick-off meeting
PT[2]	• Define the goals and milestones in depth at the kick-off meeting • Agree on the project plan at the kick-off meeting
ISD[3]	• Plan the functional requirements of the SCIS with a high priority before the ones with a low priority; some requirements are a necessity, while others are nice to have

1. Project coordinator; 2. Project team; 3. Information-system developer/vendor

4.5.2 Structure

Reengineer processes – Before reengineering the processes, current processes must be visualized and analyzed. To cope with this challenge, respondents named a few actions (see Table 4.4). Actions to reengineer the information processes are assigned to the critical success factor "manage data exchanged" (see 4.5.3).

Table 4.4 Reported key actions with linked responsibilities to master the CSF "Reengineer processes"

PC[1]	• Contact every participating supply-chain partner to define the current information flows in the supply chain
PT[2]	• Analyze the current information flows to check which processes should be reengineered

1. Project coordinator; 2. Project team

4.5.3 Information systems

Assess IT legacy system – Respondents of case D named the challenge "change the operating system" because one involved supply-chain partner had an outdated operating system, incompatible with the new SCIS. This challenge was classified under the CSF "assess IT legacy system". If not compatible with the new SCIS, outdated operating systems must be replaced, entailing some actions. For instance, in case D, the information-system developers explained the management of the involved slaughterhouses that a new operating system (Windows instead of DOS) was required for building the SCIS functionalities. Table 4.5 gives an overview of the key actions that our respondents considered necessary.

Table 4.5 Reported key actions with linked responsibilities to master the CSF "Assess IT legacy system"

ISD[1]	• Map the current IT of the supply-chain for its compatibility with the new SCIS • Explain to the management of the supply-chain partners that have a legacy system the disadvantages of such a system and the advantages of a new operating system, to convince them to replace their outdated legacy system

1. Information-system developer/vendor

Select standards, vendor and software package – The respondents mentioned that defining functional requirements, selecting a standard, building and adapting the SCIS, and technically supporting the implementation were challenges that arose when implementing a supply chain information system. All these challenges were classified under the CSF "select standards, vendor, and software package". Several actions were identified to cope with these challenges (see Table 4.6). Regarding the challenge "defining functional requirements" two options, entailing specific actions, can be practiced: the project team defines the functional requirements or the project coordinator talks separately with the representatives of the organizations/supply chain stages who required the same functionality. Furthermore, the implementation trajectory of every information system is sprinkled with obstacles, inducing the challenge "technically supporting the implementation". Some respondents of case B indicated that a crucial action to cope with this challenge is releasing an internet platform where farmers could discuss general SCIS issues, weight and slaughter information, technical issues, and further SCIS developments.

Table 4.6 Reported key actions with linked responsibilities to master the CSF "select standards, vendor, and software package"

PC[1]	• Organize multiple meetings among the project partners to define the functional requirements or, when no meetings are organized, ask the project partners to express their functional requirements • If the project partners are asked separately to express their functional requirements: ➢ Have multiple separate conversations (from general to more specific) with the representatives of the organizations/supply-chain stages who require the same functionality (i.e. principal) to register and describe the functional requirements for clarifying the following questions: "What does the principal want?", "What are the goals of the functionalities?", "When does the principal want the functionality to be ready?", "What can the information-system developer build for the principal?" ➢ Check the organizational and technical feasibility of the functional requirements ➢ Find a compromise for all functional requirements that are suitable for the supply-chain stages who require the same functionality ➢ Send a concept of the new SCIS back to the involved principals and ask for feedback • Propose and explain in depth and with a lot of visual aids (i.e. presentations and pictures) different technical standards to cope with the goal of a project during a project meeting by asking the following questions: Which standards exist?, How do they function?, In which processes could these standards be used?, What are the advantages and disadvantages of the different standards? • Discuss with the board of the supply-chain orchestrator what the interface should look like when no agreement could be achieved in the project team • Record and bundle all the received users' comments, which were received by phone, email, or face-to-face • Discuss regularly with the information-system developer the users' wishes and remarks
SSRs[2]	• Present the concept internally to get feedback from employees • Communicate the feedback of internal employees back to the information-system developer
PT[3]	• If multiple meetings among the project partners are organized to define functional requirements: ➢ Invite innovative users to several workshops to define the functional requirements ➢ Discuss defining the functional requirements during a project meeting • Decide which technical standards to use in the supply chain to reach the project goal by discussing what should be achieved with the interface • Select an information-system developer that has expertise in the food industry, and with whom the participating project partners have positive experiences
ISD[4]	• Build a SCIS that is user-friendly, does not contain unnecessary colorful pictures, does not contain unnecessary data, has a fast processing speed, and is compatible with the existing information systems in the supply chain • Install a telephone hotline that the users can call when they have technical problems • Release an internet forum where users can discuss the new SCIS • Continue to build the SCIS based on the users' remarks during the SCIS implementation trajectory

1. Project coordinator; 2. Supply chain stage representatives; 3. Project team; 4. Information-system developer/vendor

Manage data exchanged – Several actions were mentioned to tackle the challenges "define the required information flows", and "bundle the new obtained data to obtain more information". These two challenges were classified under the CSF "manage data exchanged". Regarding the first challenge, the supply chain needs to agree on which information should be available to whom because some supply-chain partners may be resistant to more transparency. With respect to the second challenge, the cases illustrate that not all data possibilities can be overseen at the start of the project. Throughout the implementation trajectory of the SCIS, opportunities for linking new available data become more and more clear. The information-system developer needs to accomplish several actions to bundle and link the available data (see Table 4.7). In case C, at the start of every project meeting, the system developer presented the work that had been done since the last meeting, which formed the basis for the project-meeting discussion. Thereafter, the system developer discovered that the available data, obtained through the new information system, could be bundled to attain more information. To master the CSF "manage data exchanged", our results specify that the project team is a central actor; however, actions also need to be fulfilled by the project coordinator and the information-system developer (see Table 4.7).

Table 4.7 Reported key actions with linked responsibilities to master the CSF "Manage data exchanged"

PT[1]	• Ask advice from internal top managers with respect to required information flows – as input for the project meeting • Present at the start of every meeting the stage of development of the SCIS along the project trajectory • Check which data are IT-relevant and bring added value to the supply chain during a meeting • Agree during the project meetings – from general to specific – which information should be available to whom and where, which data are required to make this information available, and what needs to be done by whom • Discuss openly during the project meetings • Be constructive during the meeting
PC[2]	• Organize meetings with the project partners together or separately to define the functional requirements • Involve top management of the participating supply-chain partners in the project meetings to define the required information flows, and consequently easily convert these decisions into practice
ISD[3]	• Explain proactively to the project partners which data could be bundled to provide new information • Discuss with every project partner which extra information they would like to have based on the new available data • Send log-in data for the SCIS per e-mail to (the responsible person of) the users

1. Project team; 2. Project coordinator; 3. Information-system developer/vendor

4.5.4 People

Compose project team – Only one challenge was mentioned that could be linked to the CSF "compose project team". As a result, a limited number of actions were noted (see Table 4.8). Results indicate that both external and supply-chain organizations need to be involved in the project. Moreover, results show that the project-team members cannot have all the required knowledge to take decisions during implementation. Consequently, the project coordinator of case C, for instance, brought an IT staff member to the project meeting when different technical standards had to be explained.

Table 4.8 Reported key actions with linked responsibilities to master the CSF "Compose project team"

PC[1]	• Involve every supply-chain stage in the project • Involve people from your personal network in the project with whom you have had a positive experience and whom you trust • Involve the top management of the supply-chain partners in project meetings for strategic and tactical decisions • Involve project people who have implemented similar IT projects before • Involve external, neutral sectorial organizations as project observer
PT[2]	• Bring along a specialist to the meeting when necessary

1. Project coordinator; 2. Project team

Take top-management responsibility – Several challenges were linked to the CSF "take top-management responsibility". By naming a number of actions, our respondents pointed out that top-management involvement is beneficial when implementing a supply chain information system (see Table 4.9). Case C illustrates that when top management of all collaborating supply-chain partners are involved in the project, then implementation is accomplished faster because decisions taken during project meetings are easily converted into practice. Involvement of top-managers in project meetings is, however, not required as their suggestions can be put forward by their project managers, as part of the project team. In conclusion, several actions are listed to master the critical success factor "take top-management responsibility" (see Table 4.9).

Table 4.9 Reported key actions with linked responsibilities to master the CSF "Take top-management responsibility"

SSRs[1]	• Involve top management of project partners in project meetings to take strategic and tactical decisions, or, • Request input from the top managers of the participating project partners before the project meetings
TMs[2]	• Place high priority on the implementation of the new SCIS • Give suggestions to the project managers concerning strategic and tactical decisions on the SCIS
PT[3]	• Discuss with the board of the supply chain orchestrator when no agreement can be reached in the project team concerning tactical or strategic decisions

1. Supply chain stage representatives; 2. Top managers of the involved supply-chain stages; 3. Project team

Manage change and deliver training – "Manage change and deliver training" raised a huge amount of interest among our respondents, given the many challenges. "To convince future users to use the new supply chain information system" was frequently mentioned since some users are scared of more transparency, especially when there is competition among partners at the same supply-chain stage. In addition, in such a supply-chain context, some supply-chain stages may need to be convinced to deliver certain data without retrieving any information from the new supply chain information system. Next, a supply chain information system is occasionally developed for end-consumers, who are often large in number. If the latter occurs, then press agencies work as a mediator to convince consumers to use the new system. The work practices of other staff members may also be influenced. There is, for instance, the possibility that the IT staff of the information-system developers do not possess sufficient IT knowledge, calling for more actions. In conclusion, to cope with all the challenges, several supply-chain actors need to accomplish actions (see Table 4.10).

In case C, feed producers had to deliver data without actually using any. Therefore, to convince these feed producers, the cooperative and the processor invited the most innovative one for a discussion at the premises of the processor. These organizations explained to the innovative feed producer the idea behind and the need for the SCIS (i.e. a website). That explanation convinced this feed producer to deliver the required data, which created an incentive for the other feed producers since cooperative and processor told them that they could no longer supply feed to the farmers if they didn't deliver the required data. To further convince the feed producers, they were also told to receive an internet platform on which to present themselves (i.e. a link to their company on the website).

Table 4.10 Reported key actions with linked responsibilities to master the CSF "Manage change and deliver training"

PC[1]	• Organize workshops with some innovative users or the representative of the supply-chain stage(s) who understands and looks after the users' needs to define the SCIS requirements • During a seminar for "every type of user" use power-points and online demonstrations to outline the reason for the SCIS, the benefits of the new SCIS for their jobs, what the new SCIS looks like and the fact that the output of the SCIS looks just like the system used before, when it is applicable, and how to use it • Give information on the SCIS to the users through information brochures/newsletters/ website • Present and discuss examples in small user groups showing the benefits of the SCIS • Give users the opportunity to give feedback by appointing a trustful contact person whom the users can call, by creating an email-address or during the seminar/personal visits • Record and bundle the wishes of users and answer all users' questions • Impose a deadline, from which point on the users have to use the system • When end-consumers are intended to use the system, organize a press conference, considering the proximity of relevant press agencies, the market area of the supply chain, and the required conference facilities, by involving managers with a big network, sending an invitation per post to potentially interesting press contacts, preparing presentations, inviting influenceable people with different backgrounds, providing the participants with the opportunity to ask questions, a discussion session to create trust in the system, and something to eat at the end of the conference
SSR[2] & *PC*[1]	• If some supply-chain stages need to deliver data without themselves using information, first convince an innovative organization (at the same supply-chain stage that needs to deliver data to the SCIS) by explaining the necessity of the new SCIS • After having convinced one organization, present the SCIS during a seminar and give an explanation to the organizations that need to deliver data: the reason for the information-system development, the expectations, the benefits of using the new SCIS, the negative consequences of not delivering the data to the new information system, and the opportunities and challenges/risks of the new information system • Create a corporate identity for the supply-chain organizations that need to deliver data without using any new info • Give a gift to organizations that have to deliver data (without using any new information) and future users
ISD[3]	• Release an internet platform where users can discuss the SCIS
OS[4]	• If necessary, explain to the IT staff of the system developer how to read certain standards, necessary for the SCIS • Convince future users to use the SCIS during a visit by using positive experiences of other users, by explaining how to get the data out of the SCIS, by explaining the advantages, by creating a "Eureka" effect, and by giving suggestions about what to do with available data • Convince organizations to deliver data (without using any new information) to the new SCIS during a visit by explaining: the advantages of delivering the data to the new SCIS, which data are going to be visible on the SCIS, the benefits of using the SCIS, the necessity of using the new SCIS, that other similar organizations did not have problems with delivering data to the new SCIS (e.g. by using positive stories)

1. Project coordinator; 2. Supply chain stage representatives; 3. Vendor; 4. Operational staff members of involved supply-chain stages

Manage relationships – "Manage relationships" is permanent prior to and during SCIS implementation and is part of every other "people" critical success factor described above: i.e. "compose project team", "take top-management responsibility", and "manage change and deliver training". Good and trustful relationships are built and strengthened through, for instance, effective, regular, and open communication among project-team members and towards users (See 4.5.5 – Communicate effectively). Besides communication actions, the other actions identified also contribute to mastering this CSF. For instance, in case D, shipping agents were given a printer as a motivator to use the new supply chain information system. Such actions can be perceived as strengthening the relationship as well. Next, our results specify that selecting trustful project members is useful for proper relationship management. For instance, in case D, when experiencing a problem with the SCIS, farmers (i.e. users) were given the opportunity to call a contact person whom they had known and had a positive relationship with. In summary, however not stated as such, several challenges and actions may be linked to the CSF "manage relationships".

4.5.5 Management processes

Manage project – Project management plays an important role in SCIS implementation as our respondents mentioned the challenges "keep the project on track" and "separate parallel projects". The project coordinator is a central actor when tackling these challenges because he has to be aware that parallel projects might be closely linked to each other. For instance, project partners may be the same or project goals may be related. Moreover, in a supply chain, certain project partners may perceive there to be less benefit from the planned project outcome than others. Such critical partners might slow down the implementation and thus require several actions, taken by the project coordinator. To illustrate, before every meeting the project coordinator of Case C called the slaughterhouse representatives to remind them of their tasks since the slaughterhouse didn't recognize the benefits of improved information exchange. All in all, project coordinator and project team should fulfil several actions to control the CSF "manage project" (see Table 4.11).

Table 4.11 Reported key actions with linked responsibilities to master the CSF "Manage project"

PC[1]	• Organize regular meetings with all project partners and, when necessary, bring along a specialist • Prepare the following documents for the meetings: goals of the meeting, the content of the meeting, and the agenda • Take care that the project partners stick to the decisions taken by writing emails to explain the expectations • Call the critical project partners with the following purposes: to communicate – again – the goals for the next meeting, to check what the partner has prepared for the next meeting, to check if the partner understands his tasks, and if needed, to explain his tasks again
PT[2]	• Define the tasks for the project partners, the project goals in depth, the milestones, and the project goals that are not taken into account, during the project meeting • Make a summary: Where are we? What are the difficulties? What needs to be done by whom? • Communicate openly, frequently, and with confidence during the project meetings

1. Project coordinator; 2. Project team

Communicate effectively – Communication is permanent prior to and during SCIS implementation and is, principally, part of every critical success factor. "Communication actions" play, therefore, a central role when implementing a supply chain information system. Based on our interviews, effective communication refers, first of all, to actions related to communication tools such as project meetings, seminars, personal face-to-face conversations, newsletters, internet platforms, phone calls, etc. In addition, some actions refer to the manner of communication. For example, during the project meetings, project partners should discuss openly and constructively. Finally, different project partners communicate with each other: for example, project team member with the other members, project coordinator with the users, project managers with the top executives, project managers with the users, etc. To sum up, according to our four cases, communication actions are essential if all the above critical success factors are to be mastered.

4.6 Discussion

The results obtained indicated that the elements "information systems", "people" and, to a lesser degree, "management processes" of Scott-Morton's MIT90s framework raised a considerable amount of interest among our respondents, given the fact that many challenges (and linked key actions) were named for these elements (see Figure 4.7). Challenges mentioned in at least two cases were "convince future users to use the new SCIS" and "define the functional requirements of the SCIS" and to a lesser extent "build the new SCIS", "define an interface to exchange information", "adapt the SCIS based on the users' feedback", and "define the required information flows". Besides these six challenges, all other challenges were mentioned in only one case. A link to "management processes", and more precisely to the CSF "communicate effectively", was present in almost every challenge mentioned. The three Scott-Morton elements that should receive the most attention during SCIS implementation – people, information systems, and management processes – are described below.

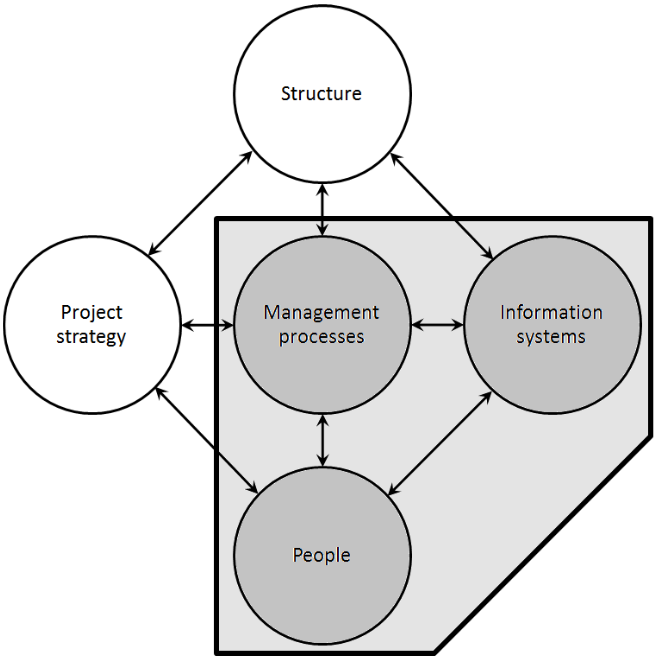


Figure 4.7 MIT90s elements that should receive the most attention during a SCIS implementation – i.e. grey zone

First, results showed that many challenges and linked key actions were identified for Scott-Morton’s element “people”. In particular, it became apparent that respondents from three cases mentioned the challenge “convince future users to use the new SCIS”. For instance, when implementing a supply chain information system, some users may not be willing to use the system because they are reluctant to be more transparent, certainly when there is competition among the horizontal supply-chain partners – as in case A. For this and other “people” challenges, the present chapter has provided a range of key actions that must be taken to implement a SCIS. It is worth noting that, in particular, the CSF “manage change and deliver training” and “manage relationships” received considerable interest among our respondents. Other researchers, such as Russell and Hoag (2004), pointed out as well that the people involved should receive considerable attention during a SCIS implementation.

Second, besides Scott-Morton’s element “people”, several challenges and linked key actions were identified for the element “information systems”. In the present chapter, the challenge “defining the functional requirements of the SCIS” in particular drew the attention of case A, C, and D respondents. Therefore, supply chains need to find compromises because the participating partners often have different functional requirements. To control such “information-system” challenges, actions need to be taken, most of them for the CSFs “select standards, vendor, and software package” and “manage data exchanged”. Other supply-chain researchers concluded as well that supply chains should indeed pay attention to these technical critical success factors (e.g. Lu et al., 2006; Premkumar, 2000).

Third, and to a lesser degree, challenges and linked key actions were identified for the element "management processes". Our results clarified that actions related to "communicate effectively" were part of almost every other critical success factor. Other SCIS researchers, such as Ngai et al. (2004) concluded as well that "communicate effectively" is indeed a very important CSF. Moreover, in a supply chain, certain project partners – as in case C – might perceive that they will get fewer benefits from the planned project outcome than other project partners. Such critical project partners may slow down the implementation. Several actions need to be taken regarding these partners, such as contacting the critical project partners to further explain the goals for the next meeting and to check what the partner has prepared for that meeting. These actions help control and master the CSF "manage project".

With respect to responsibilities, we conclude that the key actors during a SCIS implementation are project coordinator, information-system developer, and project team. This chapter showed that the project coordinator has to accomplish more actions than any other supply-chain actor. In particular, the coordinator, which can be the information-system developer, the cooperative – i.e. the chain orchestrator –, or another supply-chain actor, steers and leads the project. In addition, due to the importance of the CSF "select standards, vendor, and software package", the information-system developer is an important actor as well. The present study revealed that the information-system developer has to take proactive measures. He or she should make the involved partners aware of which available data could be bundled for obtaining more information. Due to the importance of negotiating, discussing, and compromising among the supply-chain organizations, the project team also needs to fulfil several actions. It is important to note that top management, supply chain stage representatives, and operational staff members should fulfil a limited number of actions.

Additionally, from a CSF perspective, the results obtained show that challenges – and connected actions – were identified for almost all 14 critical success factors. Not surprisingly, none of the challenges identified could be linked to the CSFs "share costs, benefits, and risks", "monitor and evaluate performance", and "assess business system". All supply chains received external financial support for implementing a supply chain information system; therefore, financial issues were not apparent. Furthermore, neither "monitor and evaluate performance" nor "assess business system" have received substantial interest from other supply-chain researchers. For instance Lu et al. (2006) and Ngai et al. (2004), who identified critical success factors for implementing supply chain information system, have not discussed these two particular CSFs.

Finally, our methodological choices do show some shortcomings. First, actions were identified in four German pork case studies; no other food sectors were considered. Nevertheless, our results give a good indication of actions that should be taken when implementing a supply chain information system in the food sector because we selected pork supply chains that are different in nature. Moreover, the pork industry has been exposed to similar challenges to other food industries. Other food industries also need to cope with low profit margins and face an increasing demand for healthy, safe, and high-quality food. In addition, meat supply chains have structural similarities with the other food supply chains. For example, in other food supply chains, farmers – often united in a cooperative – take care of the primary production as well. The second shortcoming is that all actions mentioned by our respondents were taken into account. This methodological choice implies that some actions were named in one case only, while others in multiple.

4.7 Concluding remarks

Due to the involvement of different organizations, implementing a supply chain information system (SCIS) is complex. From a technical point of view, every supply-chain organization has different IT operating systems, and wants to apply different standards to exchange data. Moreover, such organizations often have incompatible organizational structures and cultures. The concept of critical success factors (CSFs) has formed a promising approach to deal with these complexities and, as a result, to successfully implement supply chain information systems. However, information-system researchers so far have delivered rather abstract CSFs for implementing a SCIS that have not been made "actionable" for management practice.

To maximize the chances of successfully implementing a SCIS in the food industry, we aimed to identify key actions linked to CSFs. Therefore, we investigated four German pork supply chains that have implemented a supply chain information system. To identify the actions, we applied the critical incident technique and first asked our respondents to describe the challenges that arose when implementing their supply chain information system. Thereafter, key actions – with connected supply-chain responsibilities – were identified for every challenge.

To summarize, Chapter 4 sheds light on the complex implementation of supply chain information systems and extends the abstract concept of critical success factors. To do so, a list of challenges that might arise when implementing a SCIS was pinpointed. Specifically, our results show that the challenges "convince future users to use the new SCIS" – part of the CSF "manage change and deliver training" – and "define the functional requirements of the SCIS" – part of the CSF "select standards, vendor, and software package" – are most mentioned. Thereafter, possible critical actions – with connected supply-chain responsibilities – were identified for implementing a SCIS. By doing so, we link the concepts CSFs, challenges, actions, and responsibilities and bridge the gap between CSFs and operational project management for the implementation of a SCIS. Due to the latter, our results should be of interest to managers responsible for implementing a supply chain information system in the food sector.

The emerging field of CSFs for implementing supply chain information systems offers several potential areas for further research. First, due to the explorative character of the present study, further studies should verify the robustness of our findings as some actions may only be applicable in a specific context. For instance, certain actions might be relevant in one type of supply chain with a particular “supply-chain organization”, but not in another. Second, more effort should be made to further explore the interrelationships of CSFs and related actions for implementing SCISs because these have been presented as “laundry lists”. Such a presentation gives the impression that CSFs and their connected actions are stand-alone elements. Bringing together the CSF concept and the MIT90s framework has been a first step towards increasing the understanding of the interrelationships among CSFs to implement supply chain information systems. Third, it would be beneficial to investigate the relative importance of CSFs and related “actions” for implementing a supply chain information system. Such research needs to be conducted since, in the present study, any indication of difference in importance among actions was not considered and the actions that were mentioned by multiple respondents were not indicated as more crucial.

Chapter 5

The role of new technologies (RFID) in managing critical traceability points

Chapter is based on: Denolf, J.M., Trienekens, J.H., Wognum, P.M., van der Vorst, J.G.A.J., & Omta, S.W.F. The role of RFID in managing critical traceability points: insights from an organic pork supply chain, submitted.

5. The role of new technologies (RFID) in managing critical traceability points

5.1 Introduction

In recent decades, there has been an increasing number of meat scandals (Bánáti, 2011; Rampl et al., 2012), such as Bovine Spongiform Encephalopathy (beef), dioxin crises (pork, poultry), classical swine fever (pork), bird flu (poultry), and blue tongue (sheep) (Bánáti, 2011, 2014; Van Plaggenhoef, 2007). As a result, many consumers have lost their trust in the meat industry and have become critical about the safety and quality of meat products (Bánáti, 2011; Verbeke et al., 2007). As a result, the need for traceability from fork to farm has become apparent (Donnelly et al., 2009; Schwägele, 2005; Van der Vorst, 2006). Traceability is collecting, documenting, maintaining, and applying information related to supply-chain processes aiming to deliver guarantees to stakeholders on origin, location, and history of a product (Opara, 2003).

Governmental regulations and legislations have been imposed to ensure safe and high-quality food in an effort to restore consumers' confidence in meat (Bánáti, 2011; Brambilla & Filippis, 2005; Trienekens & Zuurbier, 2008). However, other recent European meat scandals – e.g., in 2013, horse meat was detected in packages claiming to contain only beef – have revealed gaps in current traceability systems. Improved traceability procedures and extensive exchange of product information throughout the chain are required (Hanf & Hanf, 2007; Sporleder & Moss, 2002), certainly in sectors where credence attributes play a role (Dabbene et al., 2014; Donnelly et al., 2009). Improvements in traceability and information exchange can be facilitated through Radio Frequency Identification (RFID), an automatic identification technology that identifies units, collects information, and links different information files (Costa et al., 2013; Zhu et al., 2012).

Although a large number of articles have addressed traceability and RFID, important knowledge gaps and methodological shortcomings are apparent in this emerging field. Traceability and RFID publications in particular fall short as they often deal with the general issue of traceability and are not really applicable for practitioners (Karlsen et al., 2010; Li et al., 2010; Zhu et al., 2012). It is, however, imperative for practitioners in supply chains to verify best practices, applications, impact, and feasibility for RFID deployment (Mehrjerdi, 2011; Nambiar, 2009). Identification of critical traceability points (CTPs) is a suitable method to make traceability research more applicable for practitioners. Critical traceability points are defined as "points where systematic information loss [*may*] occur when information about a product or process is not linked to a product" (Karlsen et al., 2011a, p. 1). However, in the literature on critical traceability points, researchers, such as Donnelly et al. (2009) and Karlsen et al. (2011a), have not verified how critical traceability points can be managed by using RFID. They used the critical traceability point analysis (CTPA) methodology, considering only the identification and not the verification of CTPs. Consequently, there was no discussion of the possible added value of RFID to manage these critical traceability points. Therefore, our aim is to identify critical traceability points (CTPs) and to verify how and to what extent these CTPs can be managed through the application of RFID technology. Methodologically, this chapter will make an important contribution by developing a roadmap for the analysis and management of CTPs by using RFID.

In Chapter 5, we focus on a European organic pork supply chain. Despite its fast growth, the organic market share has been lower than desired in many European countries. To further increase its market share, the organic supply chain aims to better inform its consumers and other stakeholders about product attributes thoroughly described (Midmore et al., 2005; Napolitano et al., 2010). Consumers buying organic products want to receive guarantees regarding quality and authenticity attributes (Midmore et al., 2005) since for many consumers the current organic labelling does not offer sufficient guarantees (Siderer et al., 2005). Consumers can be informed via improved traceability systems and the exchange of traceability information between supply-chain partners (Dabbene et al., 2014). Such information allows the organic supply chain to distinguish itself from the conventional one. To improve traceability, several CTPs in the supply chain need to be carefully managed.

The remainder of Chapter 5 is organized as follows. Section 5.2 explains the concept of food traceability. After describing the case background and methodologies in Section 5.3, processes, which are vital to define CTPs, are mapped in Section 5.4. Critical traceability points are described in Section 5.5 for farm and slaughterhouse. After verifying how and to what extent CTPs can be managed through the application of RFID technology, concluding remarks finalize this chapter.

5.2 Literature review

Within this section, an overview of the food-traceability concept is given.

5.2.1 Driving forces for food traceability

Numerous driving forces for improving food traceability have been identified in the literature. Complying with governmental regulations and legislation is a first priority (Bosona & Gebresenbet, 2013; Van der Vorst, 2006). A second one is accurately tracing contaminated food, resulting in reduced recall costs (Bosona & Gebresenbet, 2013; Mejia et al., 2010). The more precise the traceability, the more rapidly and economically the supply chain can identify and resolve food safety problems (Golan et al., 2003). Improving public trust and increasing consumer confidence through faster resolution of food-safety incidents is a third driving force. Faster resolution of such incidents leads to less bad publicity and, consequently, less disruption to commerce (Golan et al., 2003; Mejia et al., 2010; Mousavi et al., 2002). Fourth, improved traceability may be initiated by aiming at more effective and efficient production processes in the supply chain (Golan et al., 2003; Mejia et al., 2010; Van der Vorst, 2006). For instance, inventories can be managed more efficiently by reducing information asymmetries (Sahin et al., 2002). Improved traceability can be triggered by product differentiation or branding, which is a fifth driving force (Golan et al., 2003; Van der Vorst, 2006). In summary, crucial driving forces for food traceability are related to regulations and legislation, food-crisis management, consumer satisfaction and trust, process improvements, and product differentiation (Bosona & Gebresenbet, 2013).

5.2.2 Dimensions of traceability

Traceability can be defined in three dimensions: breadth, depth, and precision (Dabbene et al., 2014; Golan et al., 2003; Smith et al., 2005). Breadth refers to the amount of information connected to each traceable unit, which is one unique identifiable product or set of products, while depth refers to how far the information can be traced. A lot of information can be linked to the food that we eat. Supply chains need, therefore, to decide which data needs to be tracked and traced; not all possible data brings added value to the supply chain (Golan et al., 2003). Precision refers to the accuracy or the degree of assurance of tracking and tracing. To improve their traceability, supply chains should first determine the required depth, breadth, and precision of the traceability.

5.2.3 Prerequisites of traceability

Once the dimensions of traceability are determined, prerequisites to achieve traceability are (Karlsen et al., 2011b; Senneset et al., 2007; Storøy et al., 2013):

- The ability to uniquely identify traceable unit(s), such as a batch or animal (Caja et al., 2005; Karlsen et al., 2011b).
- Recording of transformations that the traceable unit(s) go through (Donnelly et al., 2009; Karlsen et al., 2011b). Transformations that can affect traceability are described in Table 5.1 (Bertolini et al., 2006; Bollen et al., 2006; Storøy et al., 2013).

Table 5.1 Transformation of resources (Donnelly et al., 2009)

Transformation	Relationship	Definition
Joining of resources	Many to one	Joining together of different units of a main resource
Transfer of resource	One to one	Transferral of a resource without it being split up or mixed
Addition of resource	Many to one	One main resource being mixed with other resources in lesser quantities
Splitting of resource	One to many	A resource being split up into multiple units

To achieve traceability, several critical process points need to be carefully managed. At these critical traceability points (CTPs), traceability units should be uniquely identified and transformations recorded. CTPs are typically defined as “points where systematic information loss occurs when information about a product or process is not linked to a product” (Karlsen et al., 2011a, p. 1). Contrary, we define CTPs as points where information loss *may* occur due to *possible* loss of identification and *flaws* in registering transformations. Hereby, we think to be able to provide a more complete picture of traceability challenges a company has.

Despite the fact that critical traceability points have been identified for a limited number of food supplies, such as lamb (Donnelly et al., 2009), water (Karlsen et al., 2010) and salmon (Karlsen et al., 2011a), knowledge gaps can be identified. First, CTP researchers, such as Donnelly et al. (2009) and Karlsen et al. (2011a), did not verify how to manage critical traceability points through RFID. Second, none of these publications considered pork meat, the world’s most consumed meat.

5.2.4 RFID technology

Information technology has made an important contribution to improvements in meat traceability; multiple traceability tools have been developed to identify livestock and derived meat products: brands, tattoos, RFID tags, and biometrics such as DNA profiling and iris scanning (Smith et al., 2005). Among academics and practitioners, RFID in particular has been regarded as a promising traceability tool (Zhu et al., 2012).

RFID consists of three complementary components: RFID tag, reader, and computer system (Costa et al., 2013; Nambiar, 2009; Roberts, 2006). The RFID tag, which is enclosed in a plastic round button with pen, contains a unique identification code, a chip, and an antenna (Costa et al., 2013; Zhu et al., 2012). The former is meant for storing and processing information and the latter for transmitting information with the reader through radio waves. Tags, attached to an animal or product to be identified, are either passive or active. Active RFID tags contain an internal power source while passive ones, which are cheaper, are energized and activated by waves from handheld or panel readers. Computer systems are required to store, analyze, and exchange information in the supply chain (Opara, 2003). To do so, different architectures can be built (Senneset et al., 2007). For instance, point-to-point connections between existing intra-organizational computer systems can be established. Or, a new overall system can be built with a central database that couples different existing computer systems for delivering the right information to the right chain actor (Kelepouris et al., 2007).

Due the capacity for data storage and real-time tracing, RFIDs can be placed in the category of smart tags (Costa et al., 2013). The benefits of using RFID are legion and include: reduction of labor costs, improvement in productivity, optimization of picking and packing, and reduction of inventory (Mehrjerdi, 2011; Ruiz-Garcia & Lunadei, 2011). Despite its multiple benefits, RFID also has technical and economical drawbacks (Ruiz-Garcia & Lunadei, 2011). For instance, the cost of RFID tags are still an issue in many industries (Irani et al., 2010) and RFID tag collision can occur (Roberts, 2006; Zhu et al., 2012). RFID tag collision takes place when several RFID tags are energized by an RFID reader at the same time, and send signals simultaneously back to the reader. In Table 5.2, an overview of the main benefits and drawbacks is given.

Table 5.2 Main benefits and drawbacks of RFID in the meat sector (mainly based on Ruiz-Garcia & Lunadei, 2011)

Main benefits of RFID	Main challenges and limitations of RFID
• Identification of animals and meat products, resulting in detailed information • Improvement in food crisis management (traceability) • Precision agriculture, leading to increased efficiencies, competitiveness, productivity, and profitability of food chain actors	• Huge volumes of data • Harsh environments, such as excessive dirt, dust, moisture, and extreme temperatures • Technical challenges, such as limited reading ranges, and tag collision • Costs • Physical limitations, possibly resulting in RFID tags that break or get lost

Currently, RFID publications are often remote from practice. Publications investigating best practices, application, impact, and feasibility of RFID in supply chains have not been directly applicable for practitioners (Li et al., 2010; Zhu et al., 2012). According to Li et al. (2010), the application of RFID technology in perishable supply chains, such as food supply chains, is an area for further research. In the present chapter, the organic pork industry is our object of research.

5.3 Research design

Case study research enables in-depth investigation and is an effective way to study events of a highly complex nature in depth (Eisenhardt, 1989; Miles & Huberman, 1984; Yin, 2003). In the present chapter, we selected a European supply chain producing organic pork meat, which is the world's most consumed meat. In this supply chain, we aimed to identify critical traceability points and possibilities to manage these points through RFID applications.

5.3.1 The organic pork chain

In most European pork supply chains, similar production stages can be recognized (see Figure 5.1). Breeding companies deliver sows, sperm, and boars to the farmers, where piglets are fattened up to 110 kg slaughter weight. Thereafter, pigs are slaughtered and processed, resulting in a wide range of meat products. Finally, packaged meat is sold through various customer channels, most of it via the retailer.

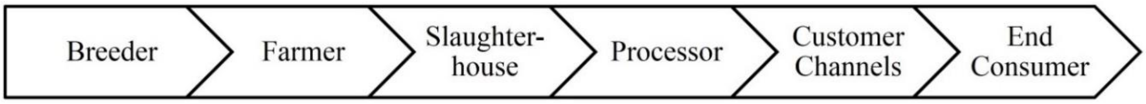


Figure 5.1 Key actors and main product flow in a pork supply chain

In the supply chain investigated, guarantees regarding pig quality and organic pig farming – i.e. housing conditions, feed, and health management – are required by consumers.

This research is part of a three-year project aiming to investigate if a combination of innovative technologies could improve traceability, resulting in more precise and faster recalls, process improvements, quality improvements, and more quality and authenticity guarantees to consumers and other stakeholders. In the present chapter, we focus on application of RFID technology for traceability purposes in the pork chain.

5.3.2 Investigation stages

The investigation was accomplished in several consecutive stages (see Figure 5.2). We have applied the critical traceability point analysis (CTPA) of Karlsen and Olsen (2011). In addition to the CTPA, we included several other stages. As well as identifying the critical traceability points as described in the method of Karlsen and Olsen (2011), we also defined traceability goals and verified which CTPs can be managed through RFID applications. Specifically, as traceability is a multidimensional concept (see 5.2.3), the desired level of traceability needs to be determined before one can identify CTPs and improve traceability (Golan et al., 2003). Furthermore, earlier studies (Donnelly et al., 2009) have not verified how to manage CTPs by using RFID. During the investigation, multiple research methods, including observations, interviews, document analysis, and group discussions, were used. By triangulation, weaknesses of one research method are compensated for by others and hence increase the validity of the case.

Stage 1. Define traceability goals – To start with, the traceability goals were defined: trace back to the individual pig at farm level starting from a package of organic pork meat in order to deliver guarantees regarding pig quality and organic pig farming.

Stage 2. Choose pilot companies – Then, pilot companies were selected: three farms and one slaughterhouse. In the slaughterhouse, all organic pigs of this supply chain are slaughtered.

Stage 3. Observe and outline – To obtain a first overview of production processes, one farm and the slaughterhouse were visited to follow the production process directly. Based on these visits, a first outline of production processes was mapped.

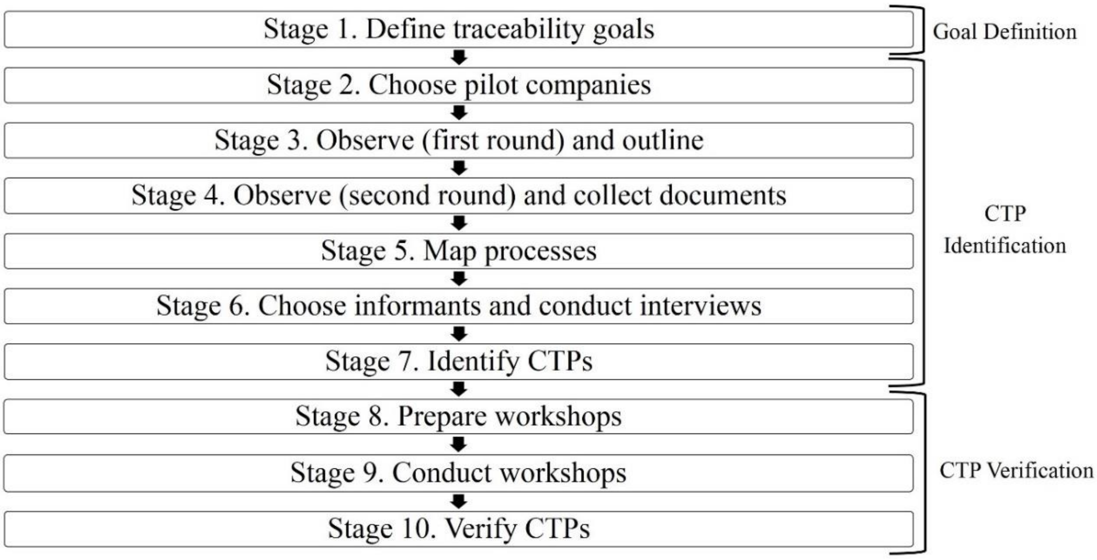


Figure 5.2 Research method used in the present study (based upon Karlsen & Olsen, 2011)

Stage 4. Observe and collect documents – Then, structured observations were conducted and documents collected. First, a second round of observations was performed at one farm and the slaughterhouse. We followed the production process and determined which traceability information was registered at each process step. To document and increase understanding, pictures were taken of production processes and identifications (i.e. labels) used. Second, relevant documents were collected, such as transport documents of pigs, delivery procedures of pigs, a model contract between feed producers and farmer, procedures for antibiotics usage at the farm, procedures for identification and traceability, basic flow charts, etc.

Stage 5. Map processes – Observations and documents were used to further map production processes and information flows.

Stage 6. Choose informants and conduct interviews – Interviewees were selected based on their knowledge of production processes and information flows. The following persons were interviewed: three farmers; four staff members of the slaughterhouse, responsible for quality and/or information provision; and the pig-supply manager of the supply chain. Consequently, nine interviews were carried out to validate our mapped processes and to identify critical traceability points. To increase validity, farmers with a different attitude towards new (traceability) technologies and slaughterhouse staff members with complementary views on traceability were selected. The questions posed were designed to be simple and were based on the earlier observations, process maps, literature on pork production, and literature on traceability. The interviewees were initially asked to validate if the production processes were correctly mapped and to describe how the information flows were organized. Thereafter, we asked them to identify points where traceability information may get lost.

Stage 7. Identify CTPs – Based on the interviews, process maps were adapted, and unique traceable units (including the link between the units) and transformations were determined to identify critical traceability points (CTPs).

Stage 8. Prepare workshops – To prepare the workshops, participants were selected and documents collected. Workshop participants were chosen based on their traceability (RFID) expertise. In addition to two of the authors, who are familiar with the traceability literature, employees from an innovative firm that manufactures smart technical solutions (for instance, for collecting and processing animal data through RFID applications) and a knowledge centre for breeding and artificial insemination were part of the workshop. Staff members of the supply-chain orchestrator also took part. Special care was taken when selecting the participants. Two permanent workshops members – with complementary knowledge and different organizational position – were selected per company. According to the literature, 8 is a suitable number of participants for workshops (Sim, 1998). For some workshops, when the expertise was not satisfactory, additional or different participants were invited. To further prepare the workshops, multiple relevant documents were collected. First, project partner reports were collected, describing for instance different RFID technicalities, system architectures, and results of deploying RFID at farm and slaughterhouse. Second, literature investigating and describing RFID benefits was collected.

Stage 9. Conduct workshops – To arrive at the insights described in this chapter, several workshops were needed to reach consensus on RFID applications. Specifically, the technical applications and possible drawbacks of RFID were defined and discussed. Workshops are a useful way to explore the possibilities of RFID and to achieve synergies between the participants' opinions (Sim, 1998). To do so, documents of stage 8 were used as an input. Furthermore, these documents were adapted and new reports were drafted based on the workshops.

Stage 10. Verify CTPs – Based on data obtained (i.e. project reports of project partners, minutes of workshops, and RFID literature) we verified how and to what extent CTPs could be managed through the application of RFID technology.

Finally, the results are described, split up into three sections: process maps, describing material and information flows; critical traceability points; and specifications of technology applications to manage critical traceability points.

5.4 Process maps

In this section, the production processes – i.e. the transformations that pig and carcass undergo – and information flows are described for farm and slaughterhouse. Transformations are places in the chain were resources are added, split, joined, or transferred (see Table 5.1) (Donnelly et al., 2009; Storøy et al., 2013).

5.4.1 Farm

At the farm, as indicated in Figure 5.3, several transformations result in slaughter-weight pigs. Input resources, such as feed, antibiotics, and sperm, are delivered accompanied by a delivery document. Once delivered, sperm is inseminated into high-fertility sows and inseminations are registered in a sow management system (SMS), which is used by a large group of farmers. After a gestation period of 16 weeks, around 12 piglets are born; however, the number differs greatly. Therefore, to align the number of suckling piglets per sow, some piglets of one sow can be cross-fostered (i.e. relocated) to another that has fewer piglets. Before weaning, the piglets receive a non-electronic ear label containing a unique identification number. After several weeks of suckling, the sows are moved back to the sow pen, while the piglets are weaned and raised up to slaughter weight. Then, before the pigs are delivered to the slaughterhouse, the farmer or the shipping agent attaches a metal label, called a "slachtblik", to the pig. The "slachtblik" consists, again, of a unique identification number, different from the ear label number. This metal label is attached to the pig to retain individual identification during slaughtering since the other non-electronic plastic ear label might get burned or lost. Transportation of pigs to the slaughterhouse is accompanied by a delivery document. During its lifetime, an organic pig receives feed and a maximum of one antibiotic treatment. The latter is individually registered in a hand-written log form, while the former is registered on herd level in SMS.

5.4.2 Slaughterhouse

At the slaughterhouse, pigs are unloaded, counted, and checked by a veterinarian, and brought to a stable for resting. The accompanying delivery documents are checked and stored in a slaughterhouse database. At the stable, pigs are sprinkled with water to reduce stress. Then the slaughtering process commences with "dirty slaughtering", consisting of several consecutive transformations for cleaning the pigs. After being anaesthetized, the pig's blood is tapped and randomly inspected for diseases, such as Aujeszky and Salmonella. Thereafter, before hanging on a slaughter hook with serial number, the carcass is brewed and scraped. Once the carcass is hanging on a slaughter hook, it is scorched, scrubbed, and rinsed. At this moment in the slaughter process, the carcass is ready to be cut, which is the start of "clean slaughtering". After removing organs, such as lungs, liver, and intestines, carcass and organs are inspected and any identified anomalies are saved in a database. Next, the carcass is weighed and its muscle thickness and fat percentage are measured. These measures, which are again saved in a database, are imperative as they are linked to the farmers' remuneration. Immediately after, the "slachtblik" number is entered manually into a computer system and is matched with the UFN (unique farm number) and serial number of the slaughter hook. Thereafter, before the carcass can be stored in the cold room, it is cut into two. At the end of the slaughtering process, carcasses are further cut into six pieces and classified on a spreader based on quality. These spreaders are transported to the processor, accompanied by a delivery document.

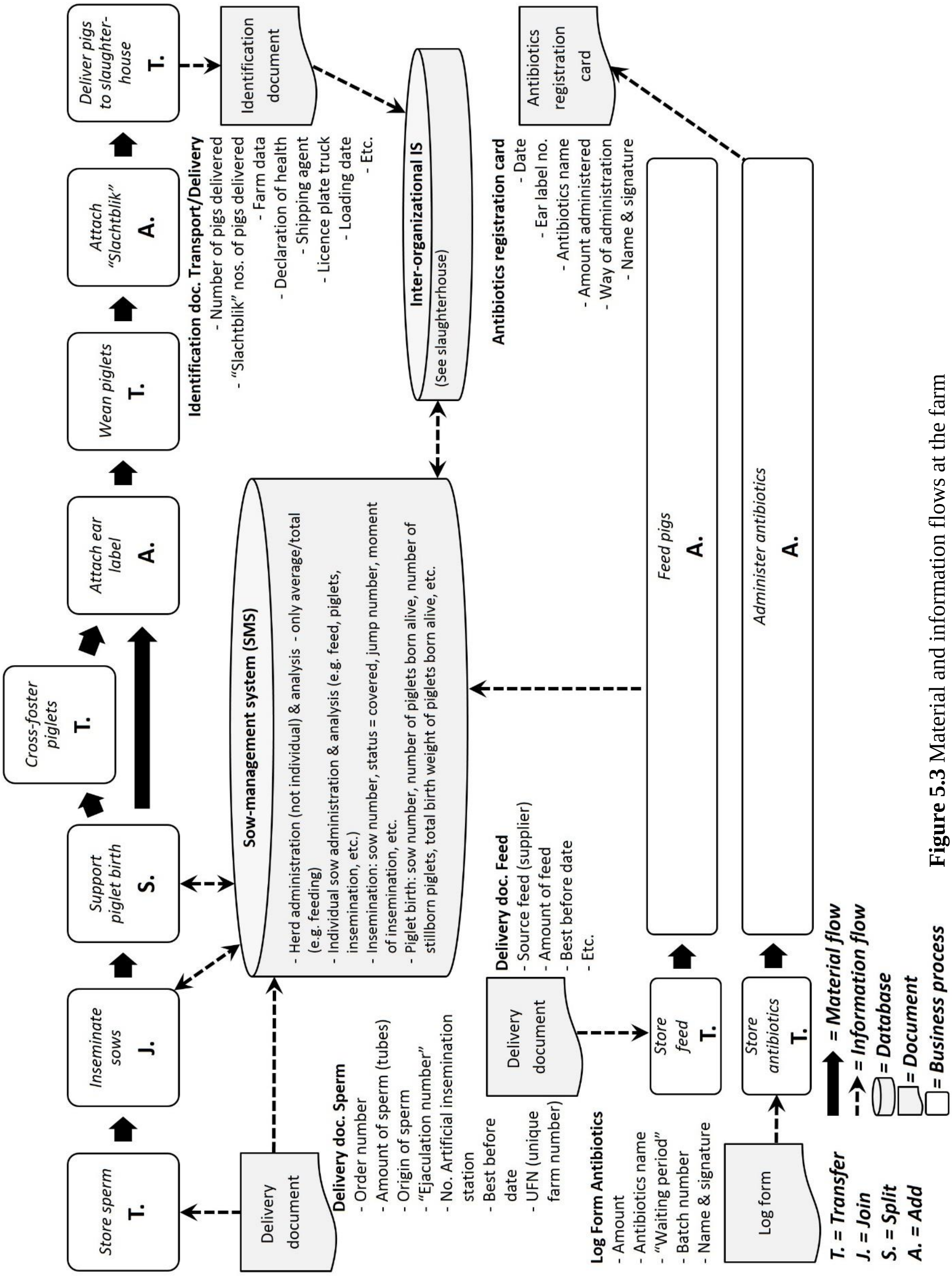


Figure 5.3 Material and information flows at the farm

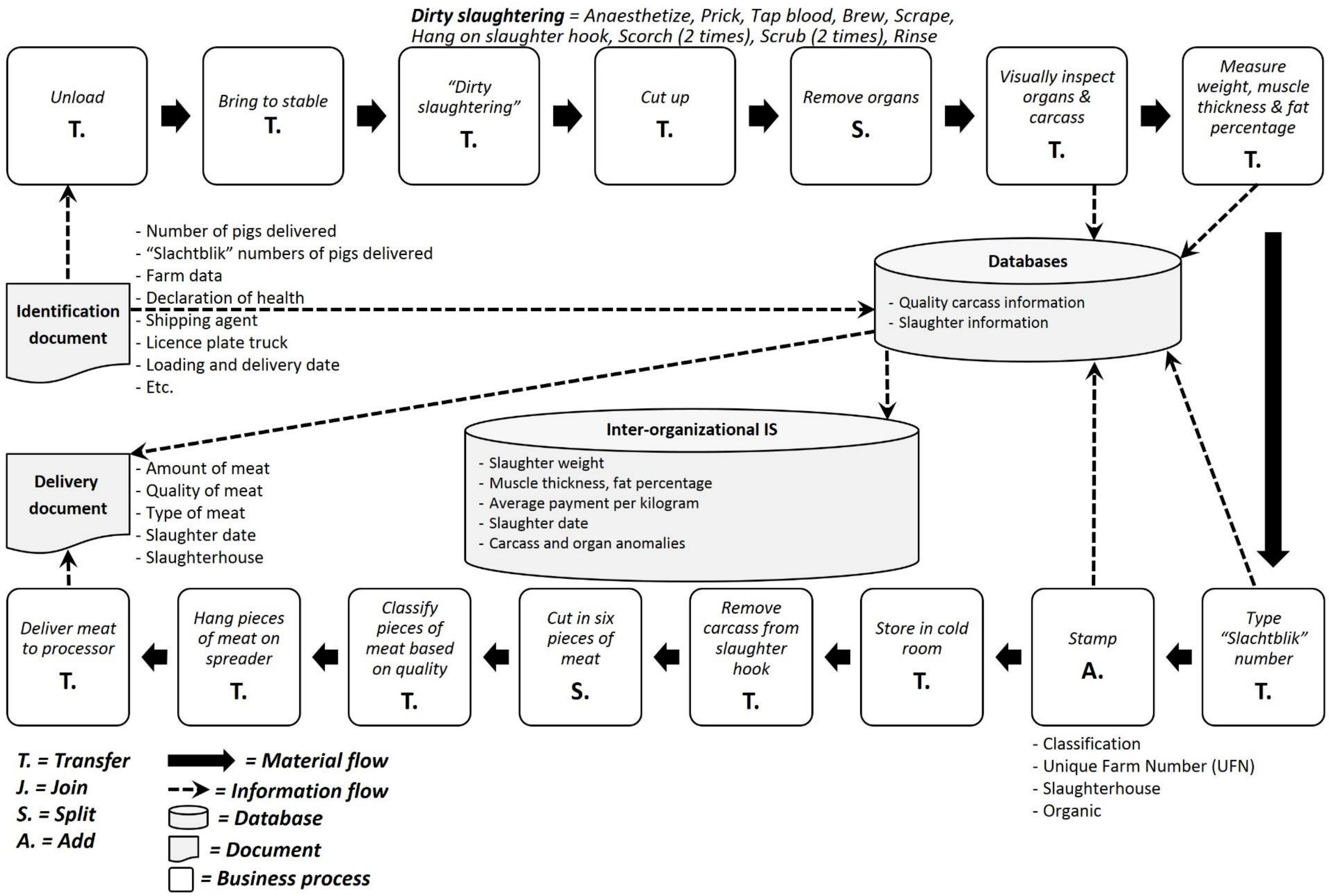


Figure 5.4 Material and information flows at the slaughterhouse

5.5 Critical traceability points

After having mapped the processes, we identified critical traceability points where information on pig quality and organic pig farming may get lost. To keep such information available for actors in the supply chain, pigs should be uniquely identified throughout the supply chain (Caja et al., 2005; Karlsen et al., 2011b; Storøy et al., 2013) and transformations at farm and slaughterhouse registered (Donnelly et al., 2009; Karlsen et al., 2011b; Schwägele, 2005; Storøy et al., 2013).

5.5.1 Critical traceability points at the farm

At the farm, 11 critical traceability points have been identified (see Figure 5.5); 4 of them relate to (possible loss of) unique identification of pigs and 7 to (incomplete) registration of transformations.

Unique identification of pigs

CTPs at the farm are based on unique pig identification. When born, pigs are not instantly labelled and are, therefore, not uniquely identified (CTP 1). After attaching, the ear label may get lost due to, for instance, fights with other pigs (CTP 2). Ear labelling is the leading system of individual pig identification at the farm. However, since the “slachtblik” label is used at the slaughterhouse, slaughter-weight pigs obtain a “slachtblik” at the end of the farming process. Notwithstanding, “slachtblik” number and ear label number are not systematically linked (CTP 3). Finally, this “slachtblik” might also get lost during transportation (CTP 4).

Registration of transformations

At the farm, several transformations, such as feeding, administering antibiotics, relocating, constitute critical traceability points. Without an ear tag, the connection between individual identifications (IDs) of sow and piglet may disappear when pigs are cross-fostered to another mother sow (CTP 5). In addition, attaching ear labels and relocation of pigs are usually not individually registered at the farm (CTP 6, 7, and 8). For instance, it is not clear in which particular stable pigs have been located during their lifetime. Delivering pigs to the slaughterhouse is another CTP as deliveries are manually registered through a delivery document, containing the “slachtblik” numbers of the pigs (CTP 9). Lastly, the feed given is not registered on an individual pig level (CTP 10), and medicine use is registered manually on antibiotic registration cards (CTP 11).

5.5.2 Critical traceability points at the slaughterhouse

At the slaughterhouse, 7 critical traceability points are identified (see Figure 5.6).

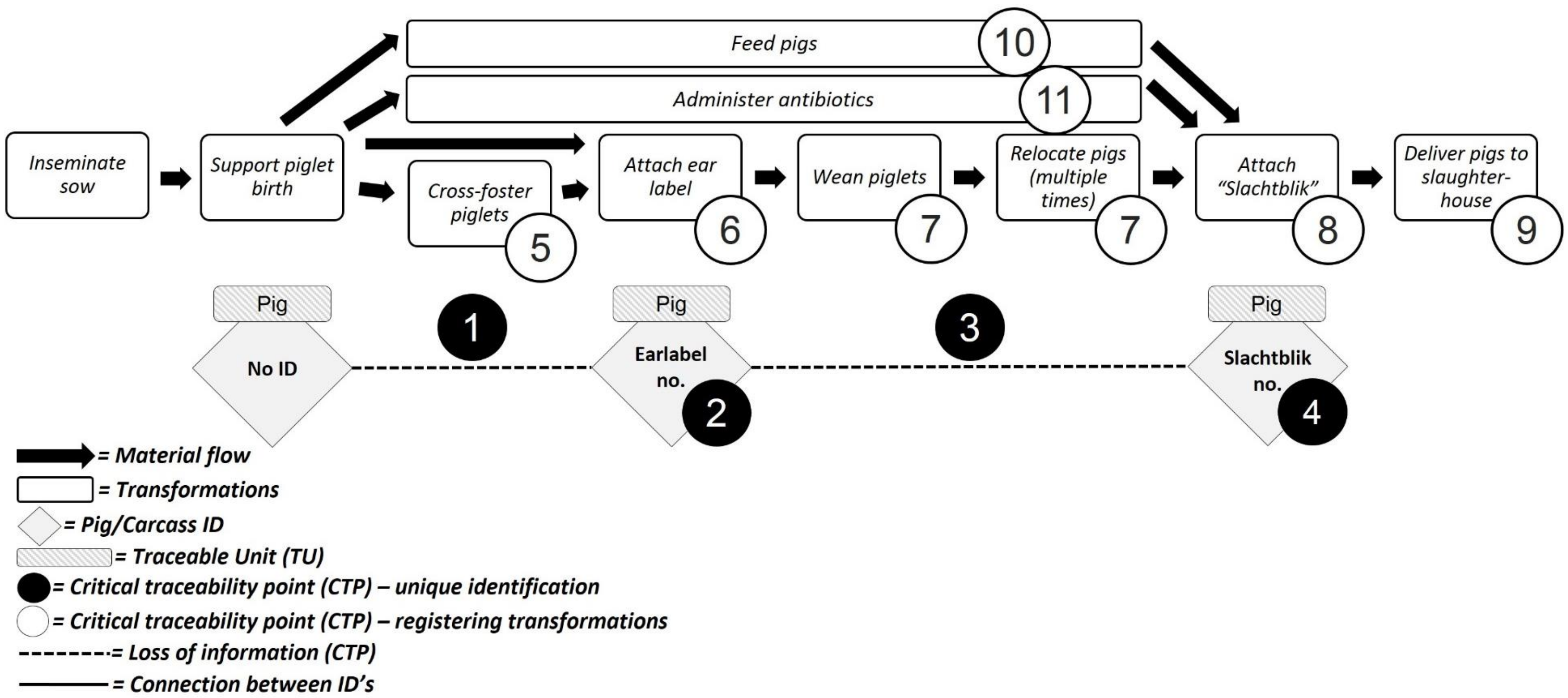


Figure 5.5 Critical traceability points at the farm

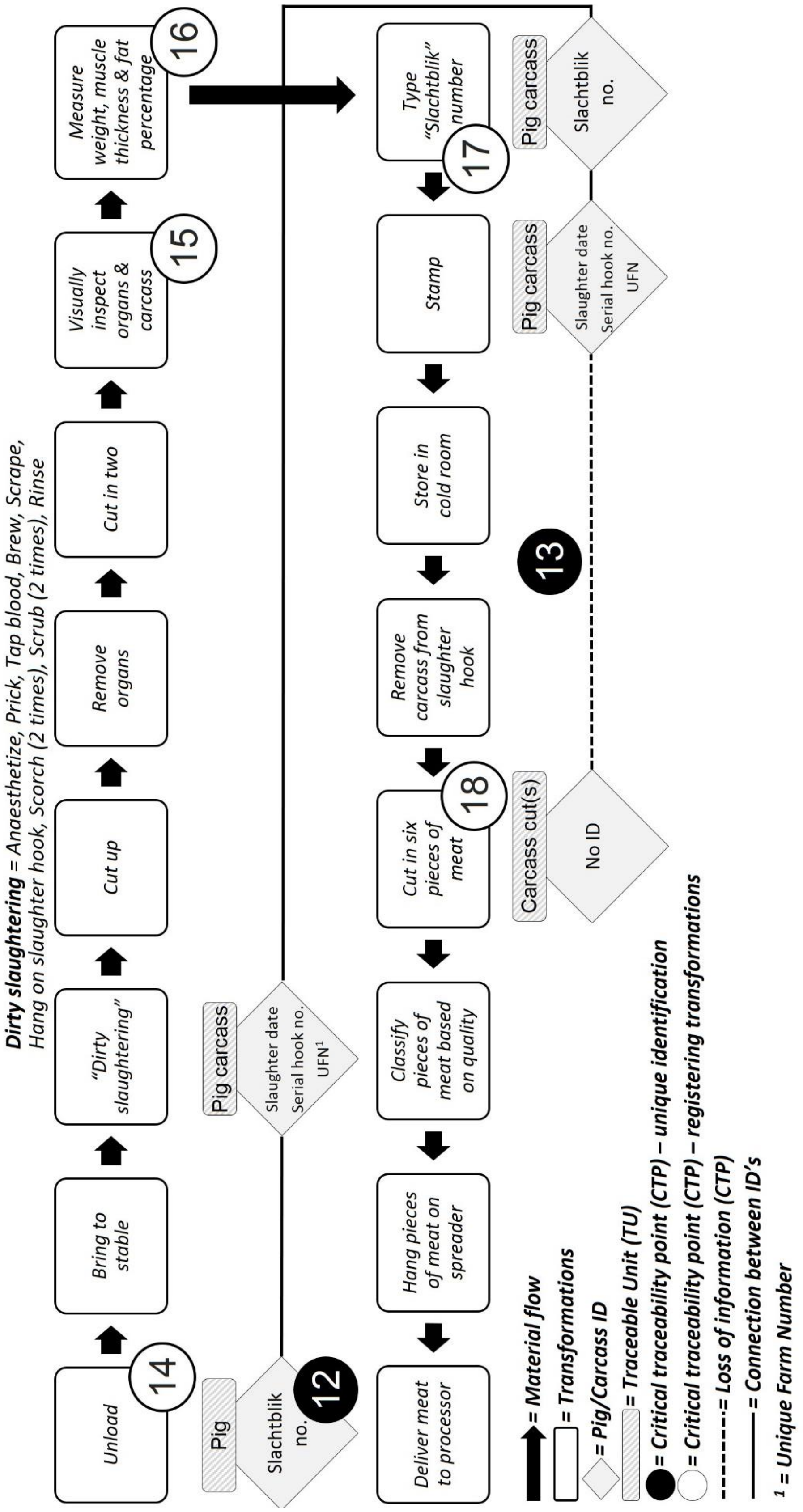


Figure 5.6 Critical traceability points at the slaughterhouse

Unique pig identification of pigs/carcasses

At the slaughterhouse, the following CTPs are related to (possible loss of) unique pig/carcass identification. During "dirty" and "clean" slaughtering, individual pigs/carcass identification is maintained through the "slachtblik". Notwithstanding, this "slachtblik" can, again, get lost during slaughtering (CTP 12). Later, when the carcass is cut into six, individual pig/carcass identification (ID) may disappear since meat cuts do not contain identification linked to the pig/carcass (CTP 13).

Registration of transformations

At the slaughterhouse, four transformations are crucial for delivering quality and authenticity guarantees and therefore constitute CTPs. When unloading, pigs are counted manually and checked by a veterinarian, but "slachtblik" numbers are not checked. A staff member usually verifies through the delivery documents which pigs have been delivered (CTP 14). Later, the registration of carcass and organ anomalies, muscle thickness, and fat percentage is done manually (CTP 15 and 16). Just after these registrations, slaughter hook ID is connected to the "slachtblik" number. Connection is also done manually and is relatively error-prone (CTP 17). Finally, at the end of the slaughtering process, the carcass is cut into six pieces. From that point onwards, individual carcass identification is lost (CTP 18).

5.5.3 Conclusion – Current traceability

Eighteen critical traceability points have been identified above. For a complete overview of the CTPs, see Table 5.3. Within the next section, we identify how and to what extent these critical traceability points can be managed through RFID applications.

5.6 RFID applications

In this section we investigate how RFID can be used to manage CTPs. Knowledge and insights were achieved from workshops, project partners' reports and RFID literature. Below, the technical specifications of the application of RFID in the management of CTPs are presented.

5.6.1 Technical specifications

The identified applications of RFID were as follows:

- At the farm, a passive RFID tag can be attached just after piglet birth. This RFID tag can replace the traditional non-electronic ear label. By using RFID tags, information about pigs can be registered at the farm and information about carcasses can be recorded at the slaughterhouse.

- At the farm, handheld readers can register several transformations, such as administration of antibiotics and delivery of pigs to the slaughterhouse.
- At the farm, a sorting system can be beneficial for registering individual weight developments of pigs. A sorting system recognizes the pigs when they visit the eating area and measures the exact weight.
- During fattening and transportation panel readers can be used to register pig movements. Panel readers may be attached to fences or walls and register both ID and timing of passing RFID tags.
- At the farm and slaughterhouse, computer(s) with database(s) are needed to store the registered data. Data from reader to computer can instantly be transferred through Wi-Fi.
- In the supply chain, a new supply chain information system should be built, coupling the different computer systems of the actors involved. In this information system, data from individual pigs can be collected and processed into information for the various actors in the supply chain.

5.6.2 Verifying RFID applications

We verified how and to what extent CTPs could be managed through RFID applications. An overview of CTPs with a description of potential bottlenecks (i.e. current situation) and potential of RFID applications (i.e. future situation) are described in Table 5.3. This table shows that several CTPs cannot be managed using RFID alone, as such tags have similar drawbacks to traditional non-electronic labels. Specifically, RFID tags will not be instantly attached at piglet birth (CTP 1 and 5 – see Table 5.3) and can get lost during farming and transporting (CTP 2 and 4). However, despite its shortcomings, RFID is good for managing many CTPs. At the farm, for instance, pig movements and antibiotics can be systematically and electronically registered (CTPs 7 and 11), and RFID tag and “slachtblik” can be systematically linked (CTP 3).

Table 5.3 Critical traceability points in an organic pork supply chain

CTP no.	Potential traceability bottlenecks (current situation)	Potential of RFID applications (future situation)
1	During the first days after birth, the pig is not uniquely identified since the piglet has not received its individual ear label yet. (link between pig and mother sow may get lost after cross-fostering)	Through application of RFID tags, pigs still do not receive a tag at birth; but only a few days after. *However, before attaching the RFID tag, the farmer can mark the piglets that received antibiotics or are relocated (i.e. cross-fostered) to another sow with a felt-tip pen. Once the RFID tag is attached to the ear, connections between the mother sow and piglets can be made by scanning (with hand-held reader) the RFID tags of both sow and piglet. Antibiotic usage can also be retrospectively registered.*
2	The ear label (identification (ID) label) may become detached from the pig due to, for instance, fights between the piglets.	RFID tags can also get lost during farming, meaning that this CTP cannot be managed better through RFID. In comparison with conventional ear tags, possible loss of RFID tags may be greater (Caja et al., 2005) or similar (Babot et al., 2006). Losses can be influenced by diameter, weight, form of tag, and moment of attaching. The earlier the farmer attaches the label to the piglet, the more chances that the ID label is no longer attached at a later stage of the farming process. Moreover, RFID tags can break, suffer from electronic failure, and their readability can diminish (Caja et al., 2005). *However, when only one pig of the herd loses its tag, a new one can be attached. If more than one loses its tag, then it is not clear which identification number belongs to which pig.*
3	Just before delivery to the slaughterhouse, the “slachtbliks” are attached to the pigs. The “slachtblik” number is the leading identification label (of pig and carcass) at the slaughterhouse. To date, there has not been a link between the individual “slachtblik” number and the ear label number used at the farm. Therefore, the farmer cannot link the slaughter data with the individual pig.	“Slachtblik” (leading ID at the slaughterhouse) can be linked to the RFID tag (leading ID at the farm). When attaching the “slachtbliks”, the farmer can type the first “slachtblik” number into his handheld reader and scan the first pig. Since “slachtblik” numbers are ascending one by one, the farmers just need to add one number to the first “slachtblik” number and scan the RFID tag of the next pig. Note that if the loss of “RFID tags” during transportation and slaughtering is as low as for “slachtbliks”, usage of “slachtbliks” can be omitted.

Table 5.3 Continued

CTP no.	Potential traceability bottlenecks (current situation)	Potential of RFID applications (future situation)
4	During transportation, the "slachtblik" may become detached from the pig due to, for instance, fights between the pigs.	RFID tags can also get disconnected during transport, meaning that this CTP cannot be managed better through RFID applications. Increased loss during transportation can be attributed to fights between pigs of mixed herds (Babot et al., 2006; Schmolke et al., 2004). *When only one pig of the herd loses its tag, a new one can be attached. If more than one loses its tag, then it is not clear which identification number belongs to which pig.*
5	Cross-fostering (relocating piglets to other sows just after birth) cannot be individually registered since the piglet is not uniquely identified at this stage in the farming process.	See CTP 1
6	Attaching ear label is not individually registered.	With RFID, attaching an individual ear label can be individually registered by scanning every labelled pig with a handheld reader (Morris et al., 2012).
7	Weaning and relocating are not individually registered.	With RFID, registering weaning and relocating becomes possible since panel readers can be installed at the farm to automatically register each animal passing the reader (Morris et al., 2012). Note that for RFID-based systems, tags must pass within a certain distance – depending on type of RFID tag and reader – of the reader (Morris et al., 2012; Roberts, 2006).
8	Attaching "slachtblik" is not individually registered.	See CTP 3
9	At the farm, delivery of pigs to slaughterhouse is registered manually on a delivery document, containing the individual "slachtblik" numbers of the pigs.	See CTP 3

Table 5.3 Continued

CTP no.	Potential traceability bottlenecks (current situation)	Potential of RFID applications (future situation)
10	There is no link registered between the feed given and the ID of the pig, since the feed given is not individually registered.	With RFID, a sorting system may recognize each pig at each visit to the eating area and measure the exact weight. Based on growth and gender, the pig is automatically routed to the appropriate feed type. Again, note that RFID tags must pass within a certain distance of the reader (Morris et al., 2012; Roberts, 2006).
11	Medicine registration at the organic pig farm is done manually (through antibiotic registration cards), and therefore relatively error-prone.	With RFID, medication/antibiotic registration can be done electronically since the farmer can scan pig and medicine administered with a handheld reader (Chen et al., 2008). Handheld readers can also contain an electronic clock and, therefore, the time at which antibiotics were administered can be registered (Want, 2006).
12	During the slaughtering the "slachtblik" may become detached from the pig.	Also during slaughtering, there is a certain percentage of RFID tag losses, usually higher than for "slachtbliks" (Santamarina et al., 2007). With RFID, it is fairly easy to fill the traceability gap(s) when an RFID tag gets lost during slaughtering, since one can place a panel reader before and after every step in the slaughtering process. The only requirement is that the order of carcasses does not change during these steps. Note that RFID tags must pass within a certain distance of the reader (Morris et al., 2012; Roberts, 2006). Readability can also be diminished by the high temperature of certain slaughter equipment.
13	When the carcass of the pig has been removed from the slaughter hook and cut into six pieces, individual pig identification is lost.	With RFID, meat pieces/cuts/packages of one pig can be linked to the individual pig. *However, redesigning the end of slaughtering and processing – i.e. where meat cuts are further processed – to keep individual pig identification is complicated and expensive. A cheaper and more accurate alternative is DNA profiling. Through DNA profiling, one can link meat to the origin of the pig, bypassing the expensive step of the processing plant (Yordanov & Angelova, 2006; Webb, 2004).One reference sample, such as blood, hair, or saliva, of all pigs slaughtered needs to be kept for comparison with the DNA of the meat that needs to be traced (Shackell & Dodds, 2008). Specifically, it is common to take a DNA sample when attaching the RFID tag because RFID tags with a connected tube – identified through a barcode – are already available for storing a piece of the ear (meat punch).*

Table 5.3 Continued

CTP no.	Potential traceability bottlenecks (current situation)	Potential of RFID applications (future situation)
14	When unloading, pigs are counted manually by a veterinarian. Usually, the “slachtblik” no. of the pigs is not checked; a staff member usually verifies which pigs have been delivered via the delivery document and registers them in a computer system.	With RFID, unloaded pigs can be registered electronically since the slaughterhouse can place a panel reader at the entrance to the slaughterhouse stables. Again, note that RFID tags must pass within a certain distance of the reader (Morris et al., 2012; Roberts, 2006).
15	When the carcass is hanging on the slaughterhook, a veterinarian visually inspects the carcass and organs and registers possible anomalies by entering a code in a computer system. This is done manually and therefore relatively error-prone.	RFID does not offer opportunities to manage this CTP better
16	When the carcass in hanging on the slaughterhook, a staff member at the slaughterhouse measures muscle thickness and fat percentage by placing a “pistol” on a specific place of the carcass. This is done manually and therefore relatively error-prone.	RFID does not offer opportunities to manage this CTP better
17	At this point, the “slachtblik” number is entered manually into a computer system and is matched with UFN (unique farm number) and serial number of the slaughter hook. This is done manually and therefore relatively error-prone.	With RFID, carcasses can be automatically linked to slaughter hook at the end of the slaughtering process (or somewhere before, where the carcass is hanging on the slaughter hook) by installing a panel reader. RFID ID is hence matched with UFN (unique farm number) and serial number of slaughter hook.
18	There is no link registered between the six meat cuts and the carcass ID.	See CTP 13

Table 5.3 also indicates that several CTPs can be managed through additional organizational measures and technologies (see Table 5.3 – in italics). Several critical traceability points, such as CTP 1 and 2, can be managed through organizational measures. For instance, pigs do not receive an RFID tag at birth (CTP 1). However, before attaching an RFID tag, the farmer can, for instance, mark the piglets that have received antibiotics with a felt-tip pen. Once an RFID tag is attached to the ear, antibiotic usage can be retrospectively registered. Besides organizational measures, CTP 18 can be managed through additional technologies. At this CTP, when the carcass is cut into 6 meat cuts, individual pig/carcass identification stops. However, to deliver authenticity and quality guarantees, individual identification must be maintained throughout the complete supply chain, including at the end of slaughtering and processing. Our workshops have indicated that redesigning the end of slaughtering and processing is complicated and expensive. To date, meat cuts and products have been kept together based on type of meat item and quality and not based on individual pig. Choosing the latter induces changes in production processes and procedures, resulting in huge investments and costs outweighing possible benefits. Webb (2004) also stated that tracing pork throughout processing is costly and extremely complex as each carcass is cut into dozens of items at numerous production lines. One solution for retaining individual identification throughout the complete supply chain is biometrics identification, e.g. DNA profiling. DNA is made up of nucleotides, arranged in a specific sequence. Variations in sequencing at a position are called single nuclear polymorphisms (SNPs), the so-called DNA markers. Through DNA profiling, meat can be linked back to the individual pig, circumventing the costly and complex step of traceability in the processing plant(s) (Webb, 2004; Yordanov & Angelova, 2006). However, reference samples, such as blood, hair, or saliva, of all pigs slaughtered would need to be kept for comparison to retrace the origin (Shackell & Dodds, 2008). All in all, with additional organizational measures and DNA technology, most CTPs can be managed and, consequently, quality and authenticity guarantees can be delivered to end consumers and other stakeholders.

5.7 Discussion and concluding remarks

Traceability studies and recent meat scandals in Europe have indicated that there are still gaps in traceability systems of meat supply chains. Therefore, improved traceability procedures are required, certainly in sectors where credence attributes play a role. In the present chapter, we focused on the organic pork industry, focusing on farmer and slaughterhouse stages, in which consumers and other stakeholders ask for authenticity and quality guarantees. In this supply chain, we identified critical traceability points (CTPs), where traceability information may get lost. In total, 18 critical traceability points were identified; six CTPs relate to (possible loss of) unique identification of pigs and 12 to (incomplete) registration of transformations. Then, we verified how and to what extent RFID can improve traceability. From the 18 CTPs, most can be managed by applying RFID. With additional organizational measures and the use of identification technologies, such as DNA profiling, almost all CTPs can be managed.

The results of the Chapter 5 help to increase the understanding of processes in the pork supply chain, traceability of pork, critical traceability points, and RFID. To identify CTPs, the production and information flows of an organic pork supply chain have been mapped. The analysis increases the comprehension of pork supply chains in general and forms a valuable input for further research in the pork industry. The results of our case study also enhance the knowledge of traceability in the pork sector. We have responded to the comments of Donnelly et al. (2009) and Regattieri et al. (2007), who remarked that literature on real-life traceability case studies including traceability bottlenecks and best practices is scarce. By verifying how CTPs can be managed using RFID technology, we have also reacted to Li et al. (2010) and Zhu et al. (2012), who stated that RFID research is often remote from practice. Since applied studies are scarce, more applications for deploying RFID should be identified and rigorously described (Li et al., 2010; Regattieri et al., 2007). The present study has shown that RFID on its own is not sufficient to improve traceability. Our findings are therefore in line with Nambiar (2009), who stated that RFID is not the "silver-bullet" to manage all critical traceability points. In summary, the findings of this study form a valuable input for both practitioners and academics in the field of traceability.

From a methodological perspective, this chapter connects RFID research and Critical Traceability Points (CTP) research for the first time. We contribute to both RFID and CTP research by presenting how critical traceability points (CTPs) can be managed using RFID. First, we have extended and enriched critical traceability point analysis (CTPA), which has – so far – not allowed for the definition of traceability goals and the systematic investigation of how to manage critical traceability points. In particular, four extra stages have been added enabling us to define traceability goals and verify the critical traceability points identified. By doing this, we have constructed a roadmap to identify and verify critical CTPs. Furthermore, compared to earlier CTP studies, the description of processes and critical traceability points has been conducted in-depth; all transformations that could possibly affect traceability have been mapped and every CTP have has been described. Second, the extended CTPA seems to be a useful method for an in-depth and structural investigation of the application, added value, and impact of RFID. In conclusion, we believe that conducting further CTP research as presented in this study will allow rigorous identification and verification of critical traceability points.

Above, we have broached the issue of additional organizational measures to a limited extent. Implementing a traceability system entails redesigning and redefining multiple tasks, responsibilities, authorities, processes, etc.; every CTP may entail several organizational adaptations. Traceability researchers, such as Mehrjerdi (2011), emphasized the need to identify rules and guidelines, and develop new ways of management when applying RFID. Furthermore, Senneset et al. (2007) also suggested that organizational implications need to be further investigated when improving supply chain traceability. For instance, data authorities should be defined since supply-chain actors may be concerned that information will be exploited by other participating partners (Lee & Whang, 2000; Premkumar, 2000). In addition, production processes and information flows should be (re)designed to take advantage of the RFID-based system and exploit its value-creating opportunities (Fawcett et al., 2007; Koh et al., 2011). How organization and technology should be redesigned concurrently is a challenging field for further research.

Chapter 6

General discussion

6. General discussion

The final chapter of this thesis presents a general discussion of the overall findings. Section 6.1 presents the findings on the individual research objectives. Section 6.2 presents the main conclusions and outlines the conclusions regarding the overall research objective. After having discussed scientific contributions in Section 6.3, limitations and directions for further research are described in the final Section 6.4.

6.1 Conclusions regarding research objectives

Implementing information systems and improving information sharing in supply chains is multifaceted. Several technical and organizational issues require attention to achieve the right techno-organizational fit in supply chains. Therefore, information-system researchers have identified tools to support the implementation of (supply chain) information systems. However, supply-chain literature investigating information sharing and implementing supply chain information systems is scarce and the available tools are rather abstract. Consequently, as has been indicated in Chapter 1, the main objective of the thesis was to identify organizational and technical critical success factors for sharing information and implementing supply chain information systems.

This central objective has been investigated using multiple perspectives, resulting in three main research objectives. From an empirical point of view, the pork industry was used to accomplish this research. The pork industry was interesting to investigate because (1) several successful and unsuccessful attempts have been made to improve information sharing and to implement supply chain information systems, (2) pork supply chains are in many cases organized differently, and (3) several marketing strategies have been applied by pork supply chains.

6.1.1 Conclusions regarding research objective 1

Chapter 2 took a first step towards coping with the research objective. The aim of Chapter 2 was to give an indication of the multidimensionality of information sharing and its determining factors. The focus was, therefore, on information sharing in supply chains. Supply chains aim to optimize the operational efficiency of delivering desired products or services to end consumers on time and at minimal cost. Therefore, supply-chain partners need to share information, resulting in better decision making in planning, ordering, and capacity allocation (Cheng, 2011).

To effectively and efficiently share information, relationships among the supply-chain partners have to be managed and effective governance structures need to be chosen. Despite initial research, shortcomings stay apparent in the supply-chain literature investigating the impact of governance structures on information sharing. First, the literature has not accounted for the multi-dimensionality of information sharing; as stated by Chandra et al. (2007) and Yao et al. (2008), the specifications of which information to share and how to share it have often been overlooked. Second, Kembro and Näslund (204) indicated that most of this literature does not consider the entire supply chain as the unit of analysis. To date, results have often been derived from research considering only dyadic buyer-supplier relationships. To cope with these shortcomings, the following objective was posed:

> ***Research Objective 1.*** *To investigate how and to what extent supply chain information sharing can be explained by supply chain governance structures*

For the insights gathered on research objective 1, two main steps were undertaken.

First, based on a literature review, schemes to classify information sharing and governance structures were developed. Information sharing was conceptualized by "type of information shared" and "information-sharing mechanisms". The former refers to which information to share while the latter denotes the mechanisms facilitating information sharing (Kembro & Näslund, 2014). To take into account the multidimensionality of information sharing, three types of information shared were considered (process, product, and planning information), and four information-sharing mechanisms (automated, semi-automated, non-automated systems, and face-to-face interaction). Regarding governance structures, a distinction was made based on their degree of integration. In total, five types of governance structures were considered in Chapter 2: spot market, verbal agreement, formal contract, equity-based contract, and vertical integration[3].

Second, to cope with the first research objective, we investigated three European pork supply chains. To build a representative case sample, pork supply chains with different governance structures were selected. Respondents of every case were asked to answer contextual questions and questions regarding (supply-chain) information sharing and (supply chain) governance structures. The interviews resulted in several reports, which formed the basis for the analysis. In the analyzing process, overarching patterns between governance structures and information sharing were identified through "pattern matching". Then, explanations were (iteratively) stipulated for the patterns found, in an attempt to elucidate the phenomenon.

Based on empirical data, the following patterns were extracted. First of all, relationships steered by more integrated governance structures exchange more types of information than the ones governed by less integrated governance structures. In particular, more types of process information are shared in the former than the latter. Apart from governance structures, the study stipulated that quality regulations play a key role in the type of exchanged product and process information as they require the supply-chain actors to share particular information. Moreover, the study showed as well that financial strength and relationship management play a role in the

[3] See Section 2.3.3 for an overview of the coding rules for both governance structures and information sharing.

type of information shared and information-sharing mechanisms. If there is a partner with sufficient financial strength, information will in many cases be exchanged through automated information systems, for example for cost-efficiency reasons. Furthermore, the results of Chapter 2 also showed that exchanging specific information through particular information systems is undertaken for relationship management as well.

By identifying several factors influencing information sharing, we challenged the general assumption that more integrated governance structures are linked with more types of information shared through the use of automated information systems. Consequently, in Chapter 2, new insights were provided to understand the role of governance structures in information sharing. All in all, the opening Chapter 2 provided a general picture of the multidimensionality of information sharing and how it is impacted by several factors.

6.1.2 Conclusions regarding research objective 2

The results of Chapter 2 showed that several factors can impact information sharing in a supply chain. Specifically, this chapter indicated that for improved cooperation and integration, for cost reductions, and for better relationship management, supply chains share more and more information through automated supply chain information systems. Implementing a supply chain information system, which was the focus of research objective 2, triggers various technical and organizational changes that need to be managed carefully. Therefore, researchers have identified critical success factors (CSFs) that can help managers to implement a SCIS. Research on CSFs for supply chain information system implementations has, however, been scarce and fragmented. To date, no consensus has been reached on SCIS CSFs. Consequently, the following second objective was posed:

> ***Research Objective 2a.*** *To identify critical success factors (CSFs) for implementing supply chain information systems (SCISs)*

The insights gathered on this research objective were articulated in two steps.

First, base-line CSFs for (widely-investigated intra-organizational) ERP implementations formed a starting point. To a certain extent, implementing an intra-organizational information system creates issues similar to those for implementing a supply chain information system. However, due to the supply-chain context, implementing a supply chain information system is more complex. Complexity is induced by three factors: the number of participating actors, the way relationships between partners are built and coordinated, and the organizational and technical differences between actors. All in all, 10 key state-of-the-art ERP articles were initially investigated to build a list of base-line critical success factors.

Second, the ERP CSF list was used to further investigate the literature dealing with CSFs for implementing supply chain information systems. 21 articles were categorized to identify and describe critical success factors for implementing supply chain information systems. Factors that were not related to the ERP CSFs were categorized as another CSF. The following 14 critical success factors were identified: align vision and build plans; share costs, benefits and risks; assess business system; reengineer processes; assess IT legacy system; select standards, vendor, and software package; manage data exchanged; manage project; monitor and evaluate performance; communicate effectively; manage relationships; take top-management responsibility; manage change and deliver training; compose project team. These 14 CSFs formed a vital step in giving a comprehensive overview of technical and organizational predictors for successfully implementing a SCIS.

When comparing with the ERP literature, two conclusions can be drawn. First, it becomes clear that most ERP CSFs have also been considered by the reviewed SCIS literature. However, two new critical success factors were identified: “manage relationships” and “share costs, benefits, and risks”. The first new factor is not surprising because implementing a supply chain information system is affected by the organization of the supply-chain, which is made up of multiple (independent) actors. The second factor is in line with supply-chain literature since all supply-chain actors require net benefits, leading – sometimes – to a redistribution of costs and benefits among chain partners. This redistribution, in particular, may create intensive negotiations and tensions. Second, it becomes clear that particular characteristics of a supply-chain context have only been considered to a limited extent. Compared with an intra-organizational context, a supply-chain context brings with it extra challenges for implementing an information system. Therefore, we believe that supply-chain characteristics require consideration when identifying CSFs.

Furthermore, although supply-chain researchers have agreed on the importance of CSFs, concrete guidance for applying CSFs has not been provided by these researchers. According to Boynton and Zmud (1984), Flynn and Arce (1997), and Francoise et al. (2009), there is a gap between the rather abstract CSFs for supply chain information system implementations and operational project management. Concrete guidance requires specific tactics with linked responsibilities. Consequently, the following objective was posed:

Research Objective 2b. *To make critical success factors for implementing supply chain information systems “actionable”*

The insights gained on this research objective were articulated in three steps.

First, to cope with the objective, we investigated the completed implementation of a supply chain information system (SCIS) in four German pork supply chains. To increase the representativeness of the case sample, different supply chains were selected and people with different positions and from different hierarchical levels and organizations were interviewed. To conduct the interviews, the “critical incident technique” (CIT) of Flanagan (1954) was applied; respondents were asked to describe crucial challenges during the project and actions taken to cope with these challenges.

Second, crucial challenges, which are important events during the implementation and positively or negatively impacted the supply chain, were identified. Challenges are assigned to CSFs and form a basis upon which to take actions. Specifically, our results suggested that the challenges "convince future users to use the new SCIS" – part of the CSF "manage change and deliver training" – and "define the functional requirements of the SCIS" – part of the CSF "select standards, vendor, and software package" – were mentioned in most cases. The CSF "manage change and deliver training" needs to be managed since resistance to change is an often-mentioned phenomenon when implementing a SCIS, requiring specific change management. In addition, the supply chain needs to agree on the technical specifications of the supply chain information system, leading to a vendor and a software package selection (i.e. CSF "select standard, vendor, and software package").

Third, possible critical actions – with connected supply-chain responsibilities – were identified for implementing a SCIS. Actions are activities that the participating managers should carry out to control the CSFs. Most actions were particularly identified for the CSFs "select standards, vendor, and software package" and "manage change and deliver training". Furthermore, many actions, were identified for the CSFs "manage data exchanged", "manage relationships" and "communicate effectively", however to a lesser extent. Regarding responsibilities, results showed that most actions during a SCIS implementation should be undertaken by the project coordinator. Besides this coordinator, the information-system developer and project team were also identified as critical key actors. All in all, through this research, we linked the concepts of CSFs, challenges, actions, and responsibilities and bridged the gap between CSFs and operational project management for the implementation of a SCIS.

6.1.3 Conclusions regarding the third research objective

In chapters 2, 3, and 4 of this thesis, we defined supply chain information systems in a broad sense. As a result, a wide range of supply chain information systems has been considered. The third research objective (i.e. Chapter 5) dealt with traceability systems, which is a specific supply chain information system. Traceability has been defined as "the collection, documentation, maintenance, and application of information related to all processes in the supply chain in a manner that provides guarantees to consumer and stakeholders on origin, location, and life history of a product" (Opara, 2003).

Despite a number of traceability and RFID publications, knowledge gaps and methodological shortcomings are apparent in this emerging field. According to Donnelly et al. (2009) and Regattieri et al. (2007), traceability and RFID publications in particular fall short as they deal mainly with the general issue of traceability and are not really applicable for practitioners (Karlsen et al., 2010; Li et al., 2010; Zhu et al., 2012). Identification of critical traceability points, which are points where information regarding traceability may get lost, is a suitable method to make traceability research more applicable for practitioners. However, first, in the literature on critical traceability points, little attention has been focused on how to manage critical traceability points through RFID applications. Second, none of the CTP publications has considered pork meat, the world's most consumed meat. The following research objective was, therefore, posed:

> ***Research Objective 3.*** *To identify critical traceability points (CTPs) in pork supply chains and to investigate how these CTPs can be managed through the application of new technologies (e.g. RFID) in organic pork supply chains*

Data were collected from an in-depth case study in the European pork industry. To cope with the research objective, three steps were accomplished:

First, the production processes – i.e. the transformations that pig and carcass undergo – and information flows were described for farm and slaughterhouse. Transformations are places in the chain where resources are added, split, joined, or transferred and can hence affect traceability.

Second, starting from the production processes and information flows, critical traceability points (where information on pig quality and organic pig farming may get lost) were identified. To keep such information available for actors in the supply chain, pigs should be uniquely identified throughout the supply chain and transformations at farm and slaughterhouse recorded. In the supply chain investigated, 18 critical traceability points were identified. Six CTPs are points where unique identification of pigs might get lost, and 12 others are points where transformations are possibly not registered.

Third, it was verified in what way and to what extent CTPs could be managed through RFID applications. The results indicated that several CTPs can be managed through RFID. At the farm, for instance, pig movements and antibiotics can be systematically and electronically registered. However, not all CTPs can be managed through application of RFID because such tags have similar drawbacks to traditional non-electronic labels. Through additional organizational measures, such as work practices, and the use of other identification technologies, such as DNA profiling, almost all CTPs can be managed. On top of that, a new supply chain information system should be built, coupling different existing computer systems of actors involved. In summary, the present study has shown that RFID on its own is not sufficient to improve traceability; the application of additional organizational measures and (identification) technologies is imperative.

6.2 Main conclusions

As stated in the General Introduction, multiple theories, such as the Structuration Theory of Orlikowski (1992; 2008), have given valuable insights into the complex interplay of organization and technology. However, tangible tools that consider these theories for implementing a supply chain information system are scarce. To provide more ready-to-use methods, we identified organizational and technical critical success factors – and connected actions – for information sharing and implementing supply chain information systems.

It can be concluded that 10 organizational and 4 technical critical success factors (CSFs) should be mastered to successfully implement a supply chain information system. These CSFs are classified in the MIT90s framework of Scott Morton (1991) (see Figure 6.1). Based on the framework, the following conclusions can be drawn. First, it offers a comprehensive set of dimensions in which every CSF should be part of at least one dimension (i.e. project strategy, structure, management processes, information systems, and people). Second, the framework indicates that CSFs do not work in isolation. Specifically, the arrows in Figure 6.1 indicate that choices or changes in one of the five interacting elements of the framework require adaptations in the other four.

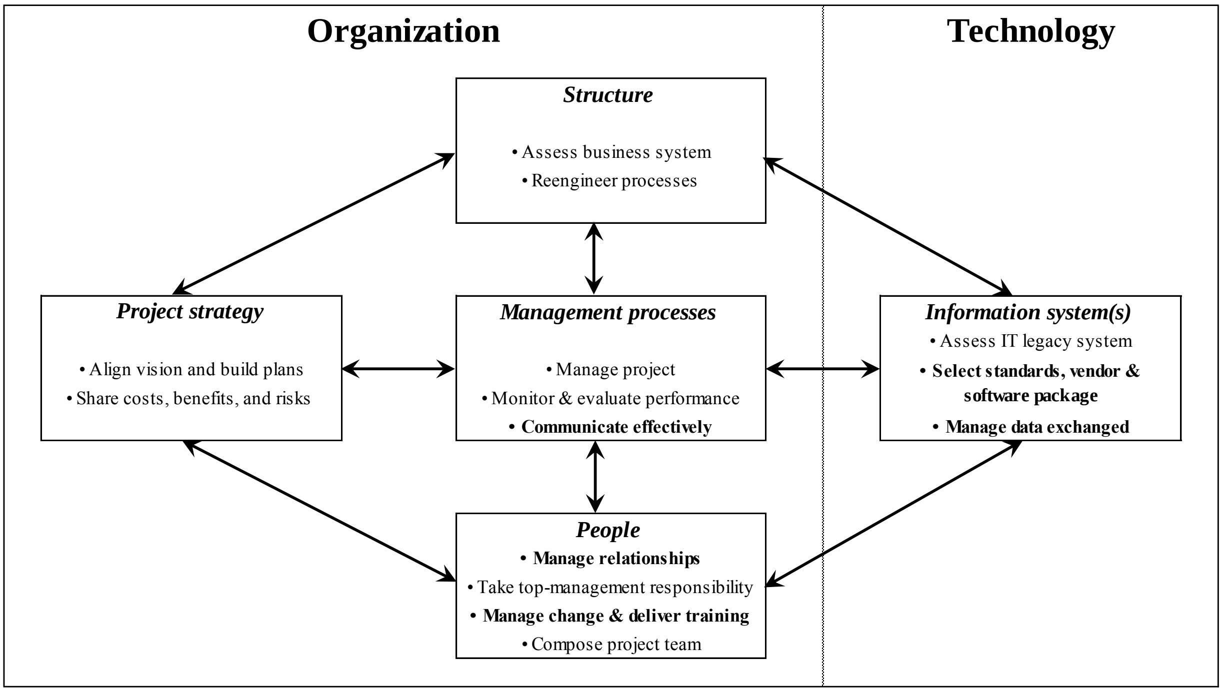


Figure 6.1 Framework of CSFs for SCIS implementations based on Scott Morton (1991)
Most important CSFs are marked in bold

In the framework, all CSFs are treated on the same level of importance. However, the thesis delivers primary indicative conclusions of which organizational and which technical CSFs are more important (See Figure 6.1 – Most important CSFs are marked in bold). Based on the results of Chapter 4, certain CSFs can be prioritized based on the number of challenges and actions that were assigned to the CSFs. First, the technical CSFs "select standards, vendor, and software package" and "manage data exchanged" seem to be imperative when implementing a supply chain information systems (SCIS). The latter is particularly relevant since the supply chain needs to agree on which information should be available to whom because some supply-chain partners may be resistant to more transparency. Furthermore, often, not all data possibilities can be overseen at the start of a project. Throughout the implementation trajectory of the SCIS, opportunities for linking new available data become more and more clear. The CSF "select standards, vendor, and software package" requires a lot of attention because defining the functional requirements and the interface of the SCIS is particularly challenging between supply-chain actors. Supply chains need to find compromises as the participating partners often have different functional requirements and levels of technological integration.

Second, the organizational CSFs "manage change and deliver training", "communicate effectively", and "manage relationships" seem to be very important CSFs as well. With respect to the first CSF, users often need to be convinced to use the new system or organizations should be convinced to deliver data. For instance, when implementing a supply chain information system, some users may not be willing to use the system because they are reluctant to be more transparent, certainly when there is competition among the horizontal supply-chain partners. Furthermore, it may be that some supply-chain stages need to be convinced to deliver certain data without retrieving any information from the new supply chain information system. Regarding the CSF "communicate effectively", certain project partners might perceive that they will get fewer benefits from the planned project outcome than other project partners. Such "critical" project partners may slow down the implementation. To master this CSF, open and constructive communication, facilitated by multiple communication tools, such as project meetings, seminars, personal face-to-face conversations, newsletters, internet platforms, phone calls, are needed. Last, the CSF "manage relationships" requires attention because building trust is particularly challenging between supply-chain or project-team partners. A supply-chain actor can, for instance, be suspicious that confidential information will be exploited by its partners; the level of trust between the partners might be low.

Furthermore, the dynamics of a SCIS implementation and the mutual impact of organizational and technical aspects were also found in Chapter 5. In this chapter, part of the implementation process of a traceability system, which is a specific supply chain information system, was the focus. In particular, a roadmap was built to identify and verify critical traceability points, which are points where traceability may get lost. First, as traceability is a multidimensional concept, the desired level needs to be determined before one can identify CTPs and improve traceability (i.e. CSF "align vision and build plans"). Then, to fully exploit the possibilities of the traceability system, production processes and information flows need to be reengineered. To do so, processes need to be mapped and critical traceability points identified (i.e. the CSF "reengineer processes"). Furthermore, Chapter 5 showed that, besides the SCIS, decisions need to be made regarding several supporting technologies, such as Radio Frequency Identification (RFID) (i.e. the CSF "select standards, vendor, and software package"). Due to technology limitations, simple additional technical tools, such as pencils and paper, need to be provided and work procedures (i.e. the CSF "reengineer processes") developed. In summary, despite the fact that only part of the implementation process was considered, Chapter 5 also indicates that implementing a SCIS requires both organizational and technical factors to be managed.

6.3 Scientific contributions

The present thesis has focused on contributions to the literature on critical success factors for supply chain information system implementations; all other investigated fields of the thesis can be directly or indirectly connected to the concept of critical success factors. CSFs are the factors that must go well during an implementation and must, therefore, be given special and continual attention to successfully implement an information system (Bullen & Rockart, 1986).

On a general level, this thesis makes a contribution to the theories examining and explaining the mutual interaction of organizational and technical aspects. Specifically, tangible tools are provided that consider these theories for implementing supply chain information systems (SCISs). Organizational and technical critical success factors were identified and classified in the MIT90s framework. The MIT90s framework is in line with the Structuration Theory of Orlikowski (1992)[4], explaining that human actors, technology, and institutional properties interact with each other. The technology refers to information systems in the MIT90s framework, human actors refer to people, and institutional properties refer to structure, project strategy, and management processes. Furthermore, the double-headed arrows of the framework reflect the project life-cycle of Markus and Tanis (2000). This cycle consists of four consecutive stages: the chartering phase, the project phase, the shakedown phase, and the onward and upward phase. While in the first phase decisions are taken to define the business case, phase two deals with getting the information system to work. The information system is stabilized and possible “bugs” are eliminated in phase three. In the last phase, the information system is maintained, suggesting that users receive additional support and the system is upgraded. During these phases of the project life-cycle, one element in the framework can be modified several times. Through the framework with 14 CSFs, a more ready-to-use method is provided for implementing SCIS.

6.3.1 Critical success factors

Three main contributions have been made regarding *critical success factors* for implementing supply chain information systems (Chapters 3 and 4).

First, this thesis has contributed to the identification of critical success factors for implementing supply chain information systems. Research on critical success factors (CSFs) for supply chain information system (SCIS) implementations has been scarce and fragmented. Supply-chain researchers, such as Koh et al. (2011), Ngai et al. (2004), and Lu et al. (2006), identified different critical success factors and did not find consensus on the CSFs for implementing a supply chain information system. For instance, the seven critical success factors identified by Lu et al. (2006) did not correspond to the five factors identified by Ngai et al. (2004);

[4] According to Volkoff et al. (2007), the Structuration Theory of Orlikowski is the most commonly used theory to examine the organization-technology relationship

furthermore, when factors correspond, they differ in terminology and in levels of specificity. In response, based on a literature review, 14 critical success factors for implementing supply-chain information systems were identified and thoroughly described. The CSFs are presented and described so that they are easy to understand and consistent. These CSFs extend the CSF literature base and form a starting point for further research on CSFs for implementing supply chain information systems.

Second, compared to other CSF studies (e.g. Lu et al., 2006; Ngai et al., 2004) that presented critical success factors for implementing SCISs as “laundry lists”, the present study considered interactions between these elements. To do so, the dynamics of the relationships between the critical success factors were visualized by building a framework of CSFs for implementing SCISs. In this book, critical success factors were classified in the MIT90s framework of Scott Morton (1991). We believe that this framework is suitable for classifying the CSFs since (1) it covers and emphasizes organizational as well as technical aspects, which is in line with theories examining information-system implementations, (2) the model is simple and is easily extendable and can therefore be used in different settings for multiple purposes, (3) it shows, from a management perspective, that CSFs can be grouped into the following dimensions: “project strategy”, “people”, “structure”, “management processes”, and “information systems”, and (4) it provides an understanding of the dynamics and cause-effect relationships of a complex SCIS implementation, reflecting the project life cycle of Markus and Tanis (2000). By making a link with the theories of Markus and Tanis (2000) and Orlikowski (1992), a more theoretical foundation has been given to critical success factor research. By doing so, we (partly) respond to Ross et al. (2002), who claimed that most CSF research lacks a strong theoretical foundation.

Third, key actions – with linked responsibilities – have been identified for the critical success factors since concrete guidance for applying CSFs has not been provided. By doing so, we responded to Boynton and Zmud (1984), Flynn and Arce (1997), and Francoise et al. (2009), who claimed that CSF lists are abstract because they have not been made “actionable”. By making the critical success factors “actionable”, we contribute to the CSF literature in three ways. First, the gap between CSFs and operational project management for the implementation of a SCIS is bridged. Second, actions were linked to responsibilities since this increases the chances of successfully implementing a SCIS (Gottschalk, 2001). Previous CSF research has barely considered responsibilities. Third, challenges for implementing supply chain information systems were identified. Being aware of such challenges allows project managers to detect them and react faster when they occur. In summary, we link the concepts CSFs, challenges, actions, and responsibilities and bridge the gap between CSFs and operational project management for the implementation of a SCIS.

6.3.2 Critical traceability points

Research on critical traceability points (CTPs) focuses on two particular CSFs: "reengineer processes" and "select standards, vendor, and software package". One of the first steps when implementing a supply chain information system is mapping the current production processes and information flows, which form a basis upon which to identify *critical traceability points* (points where traceability may get lost). Traceability information may get lost due to possible loss of unique identification of traceable units and incomplete registration of transformations. To manage these CTPs, technical and organizational solutions need to be identified. By identifying and verifying CTPs in an organic pork supply chain, we contributed to the CTP literature in four ways (Chapter 5).

First, the literature base investigating critical traceability points has been broadened. Critical success factors have been identified for a limited number of food supplies, such as lamb (Donnelly et al., 2009), water (Karlsen et al., 2010) and salmon (Karlsen et al., 2011a). In this thesis, an organic pork supply chain was the subject of an in-depth analysis of critical traceability points. No previous study has identified CTPs for a (organic) pork supply chain. Pork is, however, the most-consumed meat in the world and has been exposed to several scandals, such as the dioxin crisis and classical swine flu. Consequently, we respond to CTP researchers, such as Donnelly et al. (2009), who claimed that CTPs should be identified in other sectors.

Second, the definition of critical traceability points (used in the CTP literature) was adapted. Critical traceability points have been defined as "points at which information about a product of process is systematically lost" (Karlsen et al., 2010). In accordance with HACCP (Hazard Analysis and Critical Control Points), the definition was changed to: "points at which information about a product or process *may* get (systematically) lost due to possible loss of identification and flaws in registering transformations". According to HACCP, a control point is a point where failure of a standard operating procedure *may* cause harm to customers and to the business. A critical traceability point is thus a point that requires continuous attention; even when managed well. Such an adapted fine-tuned definition helps traceability researchers to obtain a more complete picture of the traceability challenges that a company or supply chain face.

Third, compared to previous research, we investigated how and to what extent critical traceability points can be managed through new technologies such as Radio Frequency Identification (RFID). For every critical traceability point identified, the added value of RFID was discussed. By doing so, we responded to Nambiar (2009) and Mehrjerdi (2011), who claimed that it is imperative for practitioners in supply chains to verify best practices and applications for RFID deployment. Previous research, such as Karlsen and Olsen (2011), has not verified how to manage critical traceability points or has verified it through other – more traditional – solutions, such as in Donnelly et al. (2009), who showed how CTPs can be managed using bar codes.

Fourth, the critical traceability point analysis (CTPA) of Karlsen and Olsen (2011) has been extended and enriched. The original method allows for identification of critical traceability points. However, additional steps in the CTPA can increase the added value and relevance of the method. First, the original method does not allow traceability goals to be defined. Notwithstanding, as traceability is a multidimensional concept, a target level of traceability needs to be determined before one can identify CTPs and improve traceability. Second, the method does not allow for a systematic investigation of how to manage critical traceability points. Consequently, the method means that the possible added value of innovative (traceability) technologies cannot be verified. Therefore, four extra stages have been added enabling us to define traceability goals and verify the critical traceability points identified. This extended method allows researchers to identify and verify critical traceability points in a systematic way.

6.4 Limitations and directions for further research

Specific limitations and directions for further research have been given in every chapter. Here, some general limitations and directions for further research are discussed.

First, it is highly recommended that further research should verify the robustness of our findings as the results are based on limited selected cases from the (European) pork industry. The degree to which the findings of this thesis also hold for other contexts is difficult to assess. Future studies should, therefore, investigate whether and to what extent the critical success factors for supply chain information systems and information sharing also apply to other industries, countries (continents), and sectors. Among other things, studies could examine to what extent "actionable" critical success factors for SCIS implementations of Chapter 4 and determining factors for information sharing of Chapter 2 also hold for other types of supply chains.

Nevertheless, our results give a good indication of critical success factors for implementing supply chain information systems in other (food) sectors as the theoretical perspective has not been developed specifically for the pork sector. Presumably, the main results can be extrapolated to the whole food industry as the pork industry has faced similar challenges to other food industries. Other food industries also need to cope with low profit margins and face an increasing demand for healthy, safe, and high-quality food. In addition, meat supply chains have structural similarities with the other food supply chains. For example, in other food supply chains, farmers – often united in a cooperative – take care of the primary production as well. Then, farmers deliver their products to processors, which are usually few in number. The main customers of these processors are retailers, who typically hold a very powerful position in food supply chains.

Second, despite first indications, the thesis has not directly addressed the way in which the critical success factors interrelate with each other. Therefore, more effort should be focused on exploring the interrelationships of CSFs and related actions (i.e. Chapter 3 and 4) for implementing SCISs. Researchers investigating the widely investigated (intra-organizational) ERP (Enterprise Resource Planning) systems, such as Akkermans and van Helden (2002) and King and Burgess (2006), have given indications of possible CSF interrelationships or have built a dynamic model. Such ERP research can form useful input for investigating the interrelationships of CSFs for implementing supply chain information systems. Bringing together the CSF concept and the MIT90s framework has formed a first step towards increasing the understanding of the interrelationships among CSFs. However, further research should investigate (1) which critical success factors (and actions) interrelate directly and indirectly, (2) in which order these CSFs interrelate, and (3) in which direction (positive or negative) they interrelate. These suggestions are in line with Lu et al. (2006), who advised investigating the interaction between the CSFs, and with Ram et al. (2013), who suggested investigating the two-way impact of critical success factors. Through such research, CSF researchers could further develop the proposed CSF framework (See Section 3.6).

Third, it would be beneficial to further investigate the relative importance of the results found. Despite indicative conclusions, the relative importance of critical success factors (i.e. Chapter 3) and linked actions (i.e. Chapter 4) for implementing supply chain information systems needs further investigation. Furthermore, in Chapter 5, critical traceability points were identified and verified; however, it was not investigated which CTPs were the most critical. As advised by Lu et al. (2006), in order to investigate the relative importance of the results found, further research may have to employ a more quantitative approach. In particular, as advised by Rowley (2002), Yin (2003), and Eisenhardt and Graebner (2007), a survey should include a sample of people in different positions and from different hierarchical levels and organizations. Furthermore, different supply chains from a diverse range of sectors need to be considered. Therefore, top managers, external people (i.e. vendors and/or consultants), project managers, and employees who are/were supposed to work with the system from different supply chains/sectors should be interviewed. So far, most researchers investigating the implementation of supply chain information systems, such as Koh et al. (2011), have only considered the opinions of high-level executives.

Fourth, researchers could attempt to examine whether implementing different supply chain information systems means focusing on the same critical success factors. In this thesis, emphasis was not placed on one particular supply chain information system. We defined supply chain information systems in a broad way: "supply chain information systems (SCIS) support information exchange and storage by automatically providing relevant information to the chain partners". In this book, a wide range of supply chain information systems has been considered. Therefore, in line with intra-organizational information systems research, further research should consider distinct supply chain information systems. For instance, research that has identified critical success factors for intra-organizational information systems predominantly focused first on MRP (Material Requirements Planning) systems and later on ERP (Enterprise Resource Planning) systems (e.g. Finney & Corbett, 2007; Holland & Light, 1999; Nah et al., 2001)[5].

[5] See table 3.1 of Section 3.3

Summary

Due to intensified competition, companies realize that they should closely collaborate with their supply-chain partners to further cut costs and stay competitive. To do so, supply-chain partners should share more information, which is often facilitated through supply chain information systems (SCIS). The numerous examples of implementation failures or even complete abandonment of systems indicate how complex it can be to implement a supply chain information system. Such an implementation entails the collaboration of several supply-chain actors, each with their own company culture, power and leadership structure, management methods, and information systems. Furthermore, implementing a SCIS is distinct from the supply-chain actors' daily practices. Due to its size, complexity, and importance, such an implementation typically requires the formation of a new project. Since the members of the "provisional" project team are often unfamiliar with project-management practices, the implementation process might proceed more slowly than predicted. In general, the umpteen technical and organizational aspects that require consideration make a SCIS implementation a complex undertaking.

Complex supply chain information system implementations have given rise to a large number of publications. A broad range of approaches has been suggested to increase the chances of successfully implementing information systems. The identification of critical success factors (CSFs) has been perceived as an important approach. Critical success factors are the factors that must go well during implementation and must, therefore, be given special and continual attention to successfully implement an information system. In contrast to the CSF literature investigating intra-organizational information systems, such as ERP (Enterprise Resource Planning), the implementation of supply chain information systems has only been studied in a fragmentary fashion. Consequently, in this book, we aim to identify critical success factors for supply chain information sharing and implementing supply chain information systems.

This central objective is investigated by means of multiple perspectives, resulting in three main research objectives. Various theories explaining the mutual impact of organization and technology form the theoretical foundation for the thesis. From an empirical point of view, the pork industry is used to accomplish the research.

The role of governance structures in supply chain information sharing

In Chapter 2, we pay particular attention to (supply chain) information sharing. The literature indicates that the relationships among the supply-chain partners have to be managed, and effective governance structures – i.e. arrangements on supply-chain transactions – need to be chosen for effective and efficient information sharing. Despite initial research, shortcomings remain apparent in the supply-chain literature investigating the impact of governance structures on information sharing. The literature has not accounted for the multi-dimensionality of information sharing and does not consider the complete supply chain as the unit of analysis. This leads to the first research objective of the thesis:

Research Objective 1. *To investigate how and to what extent supply chain information sharing can be explained by supply chain governance structures.*

To gain insights regarding the research objective, three European pork supply chains with different governance structures were investigated. Through cross-case analysis, the following overarching patterns are extracted. The study stipulates that more-integrated relationships exchange more types of information than the less integrated ones. In particular more types of process information are shared in the former than the latter. Apart from governance structures, the study reveals that quality regulations play a key role in the type of exchanged product and process information as such regulations require the supply-chain actors to share particular information. Moreover, the financial strength (of one or more supply-chain partners) and relationship management also seems to influence information sharing to a great extent. For instance, if there is a partner with sufficient financial strength, information will in many cases be exchanged through automated information systems, e.g. for cost-efficiency reasons. By identifying the postulated (critical success) factors for (improved) information sharing, we challenge the general assumption that more integrated governance structures undoubtedly result in sharing more types of information by means of automated information systems.

A framework of CSFs for implementing supply chain information systems

An interesting conclusion of Chapter 2 is that supply chains increasingly share information through automated supply chain information systems for improved cooperation and integration, for cost reductions, and for better relationship management. Supply chain information system (SCIS) implementation forms the central focus of research objective 2. As stated above, various technical and organizational changes turn SCIS implementations into complex undertakings. To manage these endeavors carefully, the study of critical success factors (CSFs) for SCIS implementations forms a promising approach. Since to date no consensus has been reached on SCIS critical success factors (CSFs), the second objective is posed:

Research Objective 2a. *To identify critical success factors (CSFs) for implementing supply chain information systems (SCISs)*

To address research objective 2a, CSFs for (intra-organizational) ERP implementations form an appropriate starting point because, to a certain extent, implementing such a system raises similar issues to those for implementing a supply chain information system. 10 state-of-the-art ERP articles were initially investigated to build a list of base-line critical success factors. This ERP CSF list was used to further investigate the literature dealing with CSFs for implementing supply chain information systems, which is more multifaceted due to its supply-chain context. 21 articles were categorized to identify and describe critical success factors for implementing supply chain information systems. Factors that were not related to the ERP CSFs were categorized as another CSF.

In summary, 14 critical success factors are identified. To highlight the dynamics and the interaction of the organizational and technical system, the CSFs are classified in the MIT90s framework of Scott Morton (1991) (See Figure 1).

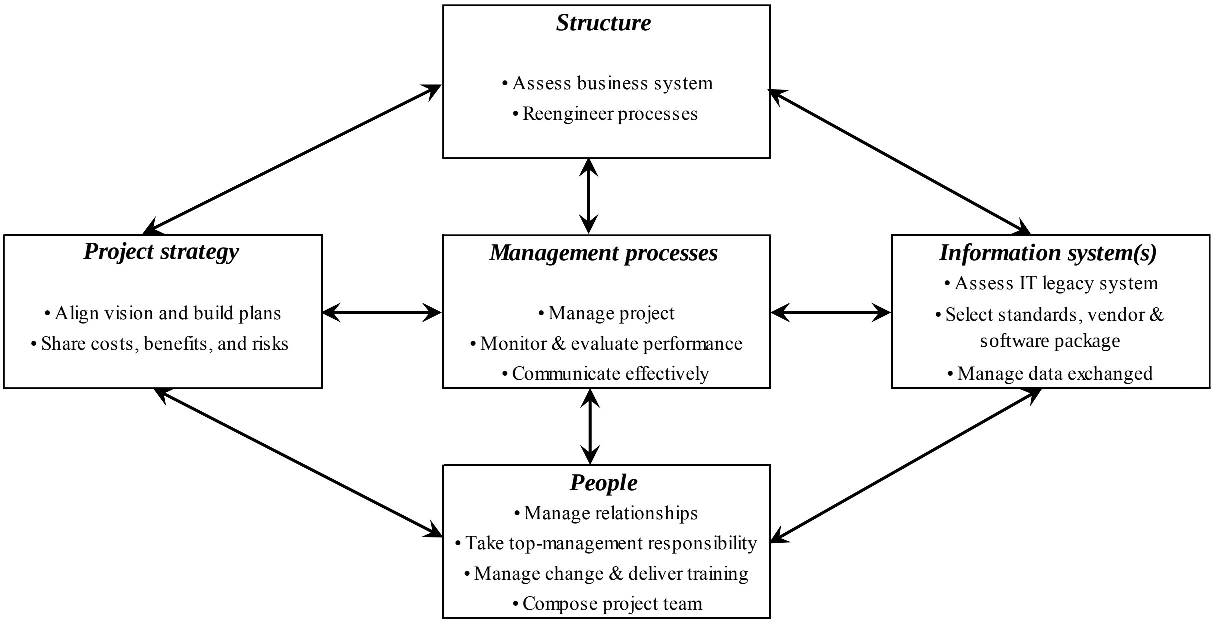


Figure 1 Framework of CSFs for SCIS implementations

The framework indicates the nature of CSFs and helps to clarify the dynamics of a complex SCIS implementation. First, it can serve as a checklist of areas that require attention when implementing a supply chain information system. The 14 CSFs form an important step in giving a comprehensive overview of predictors for successfully implementing a SCIS as, to date, no consensus has been reached about the SCIS CSFs. Second, by means of grouping, critical success factors are presented in a more systematic way. It shows, from a management perspective, that CSFs can be grouped into the following dimensions: "project strategy", "people", "structure", "management processes", and "information systems". It is worth noting that the framework offers a comprehensive set of dimensions in which every CSF should be part of at least one dimension. Third, despite the fact that CSF literature has delivered laundry lists of CSFs, the framework indicates that CSFs do not work in isolation. Specifically, the arrows of the framework indicate that choices or changes in any one of these five elements require adaptations in the other four elements.

Actionable CSFs to implement supply chain information systems

Chapter 3 identifies a comprehensive framework of CSFs for implementing supply chain information systems. Concrete guidance for applying CSFs has, however, not been provided by the CSF literature. There is a gap between the rather abstract CSFs for SCIS implementations and operational project management. Consequently, the following objective is posed:

Research Objective 2b. *To make critical success factors for implementing supply chain information systems "actionable"*

To deal with this objective, we investigated the completed implementation of supply chain information systems (SCISs) in four German pork supply chains. To increase the representativeness of the case sample, different supply chains were selected and people with different positions and from different hierarchical levels and organizations were interviewed. Next, to conduct the interviews, the "critical incident technique" (CIT) of Flanagan (1954) was applied. Respondents were asked to describe crucial challenges during the project and actions taken to cope with these challenges, which are important events during the implementation and positively or negatively impacted the supply chain. Challenges were assigned to CSFs and form a basis upon which to take actions. Actions are activities that the participating managers should carry out to control the CSFs.

Our results suggest that "convince future users to use the new SCIS" – part of the CSF "manage change and deliver training" – and "define the functional requirements of the SCIS" – part of the CSF "select standards, vendor, and software package" – are frequently mentioned challenges. Furthermore, possible critical actions – with connected supply-chain responsibilities – are identified for implementing a SCIS. Regarding responsibilities, the results show that the main key actor during a SCIS implementation is the project coordinator. All in all, through this research, we link the concepts CSFs, challenges, actions, and responsibilities and bridge the gap between CSFs and operational project management for the implementation of a SCIS.

The role of new technologies (RFID) in managing critical traceability points

In Chapters 2, 3, and 4, supply chain information systems are defined in a broad sense. Therefore, a wide range of systems is considered. The third research objective deals with traceability systems, which are specific supply chain information systems, aiming at the collection, documentation, maintenance, and application of information related to all processes in the supply chain in a manner that provides guarantees to consumers and stakeholders on origin, location, and life-history of a product.

Despite a number of traceability and RFID publications, these publications fall short as they often deal with the general issue of traceability and are not really applicable for practitioners. Identification of critical traceability points (CTPs), which are points where information regarding traceability may get lost, is a suitable method for making traceability research more applicable. However, in the CTP literature, little attention has been given to the management of critical traceability points through RFID. Moreover, none of the CTP publications has considered pork meat, the world's most consumed meat. The following research objective is, therefore, posed:

Research Objective 3. *To identify critical traceability points (CTPs) in pork supply chains and to investigate how these CTPs can be managed through the application of new technologies (e.g. RFID) in organic pork supply chains*

Data were collected through an in-depth case study in the European pork industry. After having mapped the production processes and information flows for farm and slaughterhouse, critical traceability points (where information on pig quality and organic pig farming may get lost) were identified. To keep such information available for actors in the supply chain, pigs should be uniquely identified throughout the supply chain and transformations at farm and slaughterhouse recorded. In the supply chain investigated, 18 critical traceability points are identified. Six CTPs are points where unique identification of pigs might get lost, and 12 others are points where transformations might possibly not be registered.

Then, it was verified how and to what extent CTPs could be managed using RFID applications. The results indicate that several CTPs can be managed using RFID. At the farm, for instance, pig movements and antibiotics can be systematically and electronically registered. However, not all CTPs can be managed using RFID tags because such tags have drawbacks similar to those of traditional non-electronic labels. With additional organizational measures (i.e. developing work procedures) and the use of other identification technologies, such as DNA profiling, almost all CTPs can be managed. On top of that, a new supply chain information system should be built, coupling different existing computer systems of actors involved. In summary, the present study shows that RFID on its own is not sufficient to improve traceability; the application of additional organizational measures and identification technologies is imperative.

Discussion

On a general level, this thesis makes a contribution to the theories examining and explaining the mutual interaction of organizational and technical aspects. Specifically, tangible tools are provided that consider these theories for implementing supply chain information systems

(SCISs). Organizational and technical critical success factors – and connected actions – are identified and classified in the MIT90s framework, which is in line with the Structuration Theory of Orlikowski (1992) and reflects the project life cycle of Markus and Tanis (2000). Using the framework of 14 CSFs, a more ready-to-use method is provided for implementing SCIS.

Specifically, the thesis makes contributions to the literature on critical success factors (CSF) and critical traceability points (CTP). *First*, by identifying critical success factors (CSFs) for implementing supply chain information systems, the CSF literature base is extended. Since research on CSFs for supply chain information system (SCIS) implementation has been scarce and fragmented, 14 CSFs for implementing supply-chain information are thoroughly described. To visualize the dynamics of the relationships between the CSFs, these critical success factors are classified in the MIT90s framework. The framework with 14 CSFs forms a starting point for further research on CSFs for implementing supply chain information systems. Moreover, through identification of key actions for the CSFs, this thesis responds to a stream of researchers claiming that CSFs are not "actionable". By linking the concepts of CSFs, challenges, actions, and responsibilities, we bridge the gap between CSFs and operational project management for the implementation of a SCIS. *Second*, compared to previous research, we investigate how and to what extent critical traceability points can be managed using new technologies such as Radio Frequency Identification (RFID). By verifying best practices and applications for RFID deployment, we provide a response to a group of researchers who stated that RFID and traceability research are not really applicable for practitioners. Furthermore, the critical traceability point analysis (CTPA) of Karlsen and Olsen (2011) is extended and enriched. Since this method has – so far – not allowed for the definition of traceability goals and the systematic investigation of how to manage critical traceability points, four extra stages are added to the CTPA. This extended method allows researchers to identify and verify critical traceability points systematically.

Samenvatting

Als gevolg van toegenomen wereldwijde concurrentie beseffen bedrijven dat ze nauw met hun ketenpartners moeten samenwerken om kosten te verlagen en concurrerend te blijven. Om dit te doen moeten deze partners meer informatie met elkaar delen, wat door middel van keteninformatiesystemen (KISn) gefaciliteerd wordt. De talrijke voorbeelden van mislukte implementaties geven aan hoe complex het kan zijn om zo een ketenbreed informatiesysteem te implementeren. Een dergelijke implementatie vereist de samenwerking van meerdere ketenpartners, elk met hun eigen bedrijfscultuur, structuur, management methodes en informatiesystemen. Daarnaast staat het implementeren van een KIS los van de dagelijkse praktijk van de betrokken bedrijven. Door zijn omvang, complexiteit, en grote belang vergt een dergelijke implementatie meestal de opstart van een nieuw project. Aangezien de leden van het (tijdelijke) projectteam vaak niet bekend zijn met projectmanagement praktijken en methodes, verloopt het implementatieproces vaak langzamer dan gepland. Samenvattend kan gesteld worden dat talloze technische en organisatorische aspecten aandacht vereisen tijdens een KIS implementatie.

Complexe implementaties van keteninformatiesystemen hebben tot een groot aantal publicaties geleid. Een breed scala aan benaderingen, methoden en hulpmiddelen is ontwikkeld om de kans op succesvolle implementaties te verhogen. Een belangrijke methode die in de literatuur vaak wordt genoemd is het toepassen van kritische succesfactoren (KSFn). Kritische succesfactoren zijn de factoren die goed moeten gaan tijdens de implementatie van een informatiesysteem en daarom bijzondere en voortdurende aandacht moeten krijgen. In tegenstelling tot de KSF literatuur die de implementatie van bedrijfsinformatiesystemen (bv. ERP – Enterprise Resource Planning) onderzoekt, werd de implementatie van keteninformatiesystemen tot dusver alleen fragmentarisch onderzocht. Bijgevolg willen we in dit boek kritische succesfactoren voor informatie-uitwisseling in de keten en voor het implementeren van keteninformatiesystemen identificeren.

Deze centrale doelstelling wordt onderzocht aan de hand van meerdere perspectieven, wat resulteert in drie belangrijke onderzoeksdoelstellingen. Verschillende theorieën die de wederzijdse interactie van organisatie en technologie verklaren, vormen de theoretische basis voor het proefschrift.

De rol van de besturingsmechanismen in ketenbrede informatie-uitwisseling

In hoofdstuk 2 besteden we bijzondere aandacht aan informatie-uitwisseling binnen de keten. De literatuur geeft aan dat de relaties tussen de ketenpartners onderhouden moeten worden en effectieve besturingsmechanismen – d.w.z. afspraken over ketentransacties – gekozen moeten worden voor een effectieve en efficiënte informatie-uitwisseling. De literatuur houdt echter geen rekening met de multi-dimensionaliteit van ketenbrede informatie-uitwisseling en neemt de complete keten niet in acht als analyse-eenheid. Deze tekortkomingen leiden tot de eerste doelstelling van dit proefschrift:

Onderzoeksdoelstelling 1. *Onderzoeken hoe en in welke mate ketenbrede informatie-uitwisseling kan worden verklaard door (keten)besturingsmechanismen.*

Voor doelstelling 1 zijn drie Europese varkensketens met verschillende besturingsmechanismen onderzocht. Door middel van cross-case analyse komen we tot de volgende observaties. De studie toont aan dat bedrijven met meer geïntegreerde relaties meer typen informatie uitwisselen dan minder geïntegreerde bedrijven. Afgezien van besturingsmechanismen blijkt verder dat kwaliteitsregelgeving een belangrijke rol speelt in het type uitgewisselde informatie. Bovendien lijken de financiële kracht (van één of meerdere ketenpartners) en het relatiebeheer de uitwisseling van informatie ook in grote mate te beïnvloeden. Als in een keten bijvoorbeeld een partner voldoende financiële middelen bezit, zal de informatie vaak worden uitgewisseld middels geautomatiseerde informatiesystemen.

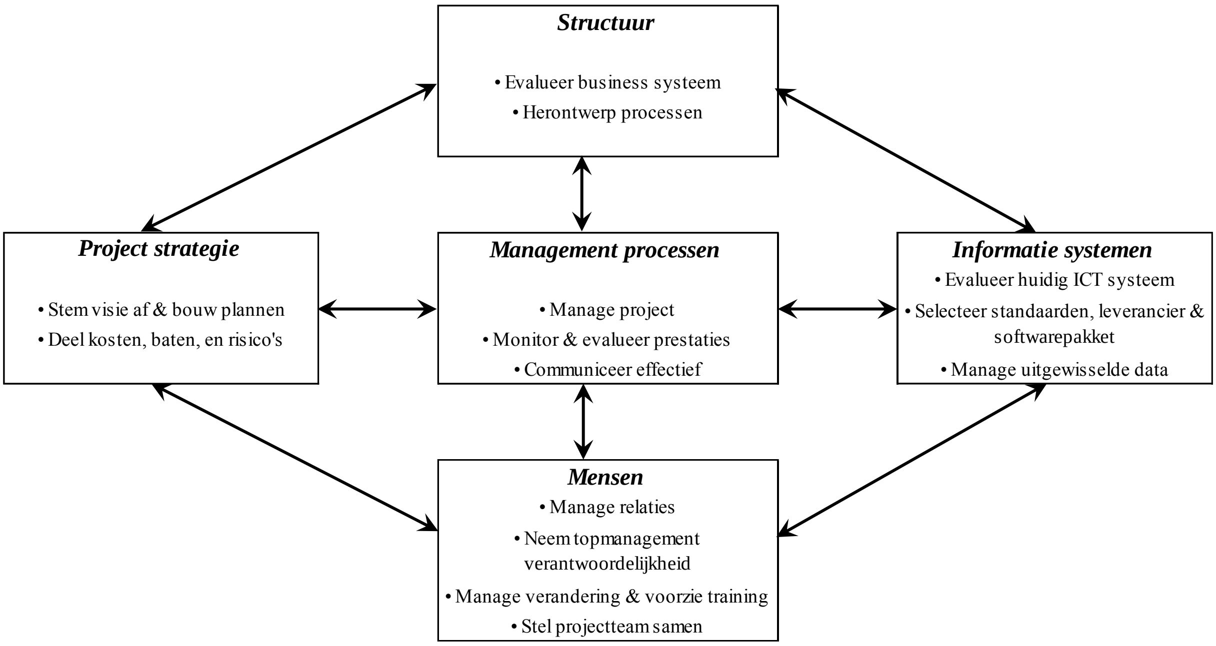
Een raamwerk van KSFn voor de implementatie van KISn

Een interessante conclusie van hoofdstuk 2 is dat ketens steeds meer informatie uitwisselen door middel van geautomatiseerde KISn voor (1) betere samenwerking en integratie, voor (2) kostenreductie, en (3) voor beter relatiebeheer. De implementatie van KISn vormt de focus van de volgende doelstelling. Zoals hierboven vermeld, maken diverse technische en organisatorische veranderingen KIS-implementaties een complexe onderneming. Om deze veranderingen zorgvuldig te managen, vormt het beheersen van de KSFn voor KIS implementaties een veelbelovende aanpak. Aangezien tot op heden geen consensus is bereikt over KIS kritische succesfactoren, wordt de volgende doelstelling geformuleerd:

Onderzoeksdoelstelling 2a. *Het identificeren van kritische succesfactoren (KSFn) voor het implementeren van keteninformatiesystemen (KISn)*

Om onderzoeksdoelstelling 2a aan te pakken, vormen de kritische succesfactoren voor ERP-implementaties een goed uitgangspunt omdat – tot op zekere hoogte – de implementatie van een dergelijk systeem tot dezelfde problemen leidt als die voor de implementatie van een KIS. In eerste instantie werden 10 state-of-the-art ERP artikelen onderzocht om een basislijst van KSFn op te stellen. Deze ERP-KSF lijst werd gebruikt om de literatuur van KSFn voor de implementatie van (meer complexe) KISn te onderzoeken. 21 artikelen werden onderzocht om de factoren te identificeren en te beschrijven. Factoren die niet gelinkt waren aan de bestaande ERP-KSFn, werden gecategoriseerd als een nieuwe KSF.

Samengevat zijn er 14 KSFn geïdentificeerd. Om de dynamiek en de interactie van het organisatorisch en technisch systeem te benadrukken, zijn de KSFn ingedeeld in het MIT90s raamwerk van Scott Morton (1991) (zie figuur 1).



Figuur 1 Raamwerk van KSFn voor KIS implementaties

Het raamwerk geeft de aard van KSFn aan en helpt om de dynamiek van een complexe KIS implementatie te begrijpen. Ten eerste kan het dienen als een checklist van gebieden die aandacht verdienen bij de implementatie van een keteninformatiesysteem. Omdat tot op heden geen consensus is bereikt over de KIS KSFn, vormen de 14 KSFn een belangrijke stap voor het identificeren van indicatoren die beheerd moeten worden om tot een succesvolle implementatie te komen. Ten tweede worden de KSFn door middel van groepering op een meer systematische manier gepresenteerd. Vanuit een management perspectief kunnen de KSFn worden gegroepeerd in één van de volgende categorieën: "project strategie", "mensen", "structuur", "management processen", en "informatiesystemen". Ten derde, ondanks het feit dat de KSF literatuur “statische lijsten” van alleenstaande KSFn beschrijft, geeft het raamwerk aan dat de KSFn niet in isolatie werken. De pijlen van het raamwerk tonen aan dat veranderingen in één van de vijf dimensies aanpassingen vergen in de andere vier dimensies.

Actiegerichte KSFn voor het implementeren van KISn

Hoofdstuk 3 geeft een raamwerk van de KSFn voor de implementatie van KISn. Concrete richtlijnen voor de toepassing van de KSFn zijn echter niet verstrekt door de KSF literatuur. Er is m.a.w. een kloof tussen de nogal abstracte KSFn voor KIS implementaties en operationeel projectmanagement. Bijgevolg is het volgende doel geformuleerd:

Onderzoeksdoelstelling 2b. *Het identificeren van "actiegerichte" kritische succesfactoren (KSFn) voor de implementatie van ketenbrede informatiesystemen (KISn)*

Voor deze onderzoeksdoelstelling hebben we de voltooide implementatie van KISn in vier Duitse varkensvleesketens onderzocht. Om de representativiteit van de steekproef te verhogen, werden verschillende ketens geselecteerd en mensen met verschillende functies uit verschillende organisaties geïnterviewd. Om de interviews uit te voeren, werd de "critical incident technique" (CIT) van Flanagan (1954) gebruikt. De respondenten werd gevraagd om cruciale uitdagingen (belangrijke gebeurtenissen tijdens de KIS implementatie die een positieve of negatieve invloed op het proces hebben) en ondernomen acties te beschrijven. Uitdagingen zijn vervolgens toegewezen aan de KSFn en vormen een basis om acties te nemen. Acties zijn activiteiten die de betrokken managers moeten uitvoeren om de KSFn te managen.

De resultaten suggereren dat "de toekomstige gebruikers overtuigen om het nieuwe KIS te gebruiken" (deel van de KSF "manage verandering en voorzie training") en "definiëren van de functionele eisen van het KIS" (deel van de KSF "selecteer standaarden, leverancier, en softwarepakket") vaak genoemde uitdagingen zijn. Bovendien zijn kritische acties voor de implementatie van een KIS geïdentificeerd. Met betrekking tot de verantwoordelijkheden laten de resultaten zien dat de belangrijkste actor tijdens een KIS implementatie de projectcoördinator is. Algemeen kan geconcludeerd worden dat we door middel van dit onderzoek de concepten KSFn, uitdagingen, acties, en verantwoordelijkheden koppelen en zo de kloof tussen de KSFn en operationeel projectmanagement voor de implementatie van een KIS dichten.

De rol van nieuwe technologieën (RFID) voor het beheer van kritieke traceringspunten

In de hoofdstukken 2, 3 en 4 worden KISn in brede zin gedefinieerd. De derde onderzoeksdoelstelling focust op traceringssystemen. Dit zijn specifieke KIS die informatie met betrekking tot ketenprocessen verzamelen, documenteren, onderhouden, en gebruiken zodat garanties aan consumenten en andere stakeholders kunnen worden gegeven betreffende oorsprong, locatie, en geschiedenis van het product.

Tot dusver vertonen traceerbaarheid en RFID publicaties tekortkomingen omdat ze met name betrekking hebben op de algemene problematiek van traceerbaarheid en daarom niet toepasbaar zijn voor managers. Identificatie van kritische traceringspunten (KTPn) (plaatsen waar informatie betreffende de traceerbaarheid verloren kan gaan) is een geschikte methode om traceerbaarheidsonderzoek meer toepasbaar te maken. In de KTP literatuur is echter weinig aandacht besteed aan het managen van kritische traceringspunten door middel van Radio Frequency Identification (RFID). Bovendien heeft geen enkele CTP publicatie de varkensvleessector onderzocht. De volgende onderzoeksdoelstelling is daarom ook geformuleerd:

Onderzoeksdoelstelling 3. *Identificeren van kritische traceringspunten (KTPn) in biologische varkensvleesketens en onderzoeken hoe deze KTPn kunnen worden beheerd door de toepassing van nieuwe technologieën (zoals RFID).*

De gegevens zijn verzameld door middel van een diepgaande case studie in de Europese varkenssector. Na de productieprocessen voor boerderij en slachthuis in kaart te hebben gebracht, zijn kritische traceringspunten (plaatsen waar informatie over varkenskwaliteit en biologische eigenschappen verloren kan gaan) geïdentificeerd. Om dergelijke informatie voor de actoren in de keten beschikbaar te houden, moeten varkens door de gehele keten uniek geïdentificeerd kunnen worden en transformaties op boerderij en slachthuis worden geregistreerd. In dit onderzoek zijn 18 kritische traceringspunten geïdentificeerd. Zes KTPn zijn punten waar de unieke identificatie van varkens verloren kan gaan, en 12 andere zijn punten waar transformaties mogelijk niet worden geregistreerd.

Vervolgens is gecontroleerd hoe en in welke mate KTPn kunnen worden gemanaged met behulp van RFID-toepassingen. De resultaten geven aan dat verschillende KTPn kunnen worden beheerd door het inzetten van RFID. Op de boerderij kunnen bijvoorbeeld verplaatsingen van varkens en het toedienen van antibiotica systematisch en elektronisch worden geregistreerd. Niet alle KTPn kunnen echter worden beheerd met RFID labels omdat dergelijke tags – tot op zekere hoogte – dezelfde nadelen hebben als die van traditionele niet-elektronische labels. Door extra organisatorische maatregelen (d.w.z. het ontwikkelen van werkprocedures) en het gebruik van andere identificatie-technologieën, zoals DNA typering, kunnen bijna alle KTPn worden beheerd. Daarnaast moet een nieuw KIS worden gebouwd, die de verschillende bestaande computersystemen van de betrokken partners koppelt. Kortom, de huidige studie toont aan dat RFID an sich onvoldoende is om de traceerbaarheid te verbeteren; aanvullende organisatorische maatregelen en identificatie-technologieën zijn noodzakelijk.

Discussie

Gebaseerd op de theorieën die de onderlinge interactie van organisatorische en technische aspecten onderzoeken en verklaren, zijn in deze thesis concrete instrumenten aangeleverd voor de implementatie van KISn. Organisatorische en technische kritische succesfactoren zijn geïdentificeerd en ingedeeld in het MIT90s raamwerk. Dit raamwerk is in lijn met de structuratietheorie van Orlikowski (1992) en weerspiegelt de projectlevenscyclus van Markus en Tanis (2000). Met behulp van het raamwerk van 14 KSFn wordt een kant-en-klare methode verstrekt voor de implementatie van KISn.

Dit proefschrift levert bijdragen aan de literatuur over kritische succesfactoren (KSF) en kritische traceringspunten (KTPn). Ten eerste, door het identificeren van kritische succesfactoren (KSF) voor de implementatie van KIS is een waardevolle toevoeging aan de KSF literatuur geleverd. Aangezien onderzoek naar KSFn voor de implementatie van KIS beperkt is, zijn 14 KSFn geïdentificeerd en beschreven. Om de dynamiek van de relaties tussen de KSFn te visualiseren, zijn deze kritische succesfactoren ingedeeld in het MIT90s raamwerk. Het raamwerk vormt een uitgangspunt voor verder onderzoek naar de KSFn voor de implementatie van KIS. Door de identificatie van de belangrijkste acties voor het managen van KSFn beantwoordt dit proefschrift bovendien aan de vraag van een groep van onderzoekers die beweren dat de KSFn te abstract en niet bruikbaar voor managers zijn. Door het linken van de concepten KSFn, uitdagingen, acties, en verantwoordelijkheden dichten we de kloof tussen de KSFn en operationeel projectmanagement voor de implementatie van een KIS. In vergelijking met eerder onderzoek, onderzoeken we ten tweede hoe en in welke mate kritische traceringspunten kunnen worden beheerd met behulp van nieuwe technologieën zoals RFID. Door het controleren van de toepassingen voor RFID bieden we een antwoord op de vraag van een groep onderzoekers die verklaart dat RFID en traceerbaarheidsonderzoek niet echt operationeel zijn. Verder wordt de kritische traceringspuntanalyse (KTPA) van Karlsen en Olsen (2011) uitgebreid met vier extra stappen. Deze uitgebreide methode stelt onderzoekers in staat om systematisch kritische traceringspunten te identificeren en te verifiëren.

References

Adriaanse, A., Voordijk, H., & Dewulf, G. (2010). Adoption and use of interorganizational ICT in a construction project. *Journal of Construction Engineering and Management, 136*(9), 1003-1014.

Akintoye, A., McIntosh, G., & Fitzgerald, E. (2000). A survey of supply chain collaboration and management in the UK construction industry. *European Journal of Purchasing & Supply Management, 6*(3), 159-168.

Akkermans, H., & van Helden, K. (2002). Vicious and virtuous cycles in ERP implementation: a case study of interrelations between critical success factors. *European Journal of Information Systems, 11*(1), 35-46.

Al-Mashari, M., Al-Mudimigh, A., & Zairi, M. (2003). Enterprise resource planning: a taxonomy of critical factors. *European Journal of Operational Research, 146*(2), 352-364.

Allen, D. K., Colligan, D., Finnie, A., & Kern, T. (2000). Trust, power and interorganizational information systems: the case of the electronic trading community TransLease. *Information Systems Journal, 10*(1), 21-40.

Ang, J. S., Sum, C. C., & Yeo, L. N. (2002). A multiple-case design methodology for studying MRP success and CSFs. *Information & Management, 39*(4), 271-281.

Auramo, J., Kauremaa, J., & Tanskanen, K. (2005). Benefits of IT in supply chain management: an explorative study of progressive companies. *International Journal of Physical Distribution & Logistics Management, 35*(2), 82-100.

Babot, D., Hernández-Jover, M., Caja, G., Santamarina, C., & Ghirardi, J. (2006). Comparison of visual and electronic identification devices in pigs: On-farm performances. *Journal of Animal Science, 84*(9), 2575-2581.

Bahlmann, J., & Spiller, A. (2009). Inter-organizational information systems in meat chains: the linkage between supply chain organization and system requirements. *Journal on Chain and Network Science, 9*(1), 59-69.

Baihaqi, I., & Sohal, A. S. (2013). The impact of information sharing in supply chains on organisational performance: an empirical study. *Production Planning & Control, 24*(8-9), 743-758.

Bajaj, A., & Nidumolu, S. R. (1998). A feedback model to understand information system usage. *Information & Management, 33*(4), 213-224.

Bánáti, D. (2011). Consumer response to food scandals and scares. *Trends in Food Science & Technology, 22*(2), 56-60.

Bánáti, D. (2014). European perspectives of food safety. *Journal of the Science of Food and Agriculture, 94*(10), 1941-1946.

Barker, T., & Frolick, M. N. (2003). ERP implementation failure: A case study. *Information Systems Management, 20*(4), 43-49.

Barley, S. R. (1986). Technology as an occasion for structuring: Evidence from observations of CT scanners and the social order of radiology departments. *Administrative Science Quarterly, 31*(1), 78-108.

Barrett, S., & Konsynski, B. (1982). Inter-organization information sharing systems. *MIS Quarterly, 6*(4), 93-105.

Belassi, W., & Tukel, O. I. (1996). A new framework for determining critical success/failure factors in projects. *International Journal of Project Management, 14*(3), 141-151.

Bemelmans, T. (1998). *Administrative information systems and automation*. Deventer, the Netherlands: Kluwer Bedrijfswetenschappen.

Bertolini, M., Bevilacqua, M., & Massini, R. (2006). FMECA approach to product traceability in the food industry. *Food Control, 17*(2), 137-145.

Bitner, M. J., Booms, B. H., & Tetreault, M. S. (1990). The service encounter: Diagnosing favorable and unfavorable incidents. *Journal of Marketing, 54*(1), 71-84.

Bollen, A. F., Riden, C. P., & Opara, L. U. (2006). Traceability in postharvest quality management. *International Journal of Postharvest Technology and Innovation, 1*(1), 93-105.

Bosona, T., & Gebresenbet, G. (2013). Food traceability as an integral part of logistics management in food and agricultural supply chain. *Food Control, 33*(1), 32-48.

Botta-Genoulaz, V., & Millet, P.-A. (2005). A classification for better use of ERP systems. *Computers in Industry, 56*(6), 573-587.

Boudreau, M.-C., & Robey, D. (2005). Enacting integrated information technology: A human agency perspective. *Organization Science, 16*(1), 3-18.

Boynton, A. C., & Zmud, R. W. (1984). An assessment of critical success factors. *Sloan Management Review, 25*(4), 17-27.

Brambilla, G., & Filippis, S. D. (2005). Trends in animal feed composition and the possible consequences on residue tests. *Analytica Chimica Acta, 529*(1), 7-13.

Briz, J., De Felipe, I., & Peña, S. (2008). *D-4.1.1: Pork meat chains in Spain.* Madrid: Universidad Politecnica de Madrid (unpublished manuscript, contact J. Briz).

Bruns Jr, W. J., & McKinnon, S. M. (1993). Information and managers: a field study. *Journal of Management Accounting Research, 5*, 84-108.

Bryde, D. (2008). Perceptions of the impact of project sponsorship practices on project success. *International Journal of Project Management, 26*(8), 800-809.

Bullen, C. V., & Rockart, J. F. (1986). A Primer on critical success factors. In C. V. Bullen & J. F. Rockart (Eds.), *The Rise of Managerial Computing: The Best of the Center for Information System Research* (pp. 383-423). Homewood, IL: Dow Jones-Irwin.

Cachon, G. P., & Fisher, M. (2000). Supply chain inventory management and the value of shared information. *Management Science, 46*(8), 1032-1048.

Caja, G., Hernandez-Jover, M., Conill, C., Garin, D., Alabern, X., Farriol, B., & Ghirardi, J. (2005). Use of ear tags and injectable transponders for the identification and traceability of pigs from birth to the end of the slaughter line. *Journal of Animal Science, 83*(9), 2215-2224.

Chae, B., Yen, H. R., & Sheu, C. (2005). Information technology and supply chain collaboration: moderating effects of existing relationships between partners. *Engineering Management, IEEE Transactions on, 52*(4), 440-448.

Chandra, C., Grabis, J., & Tumanyan, A. (2007). Problem taxonomy: a step towards effective information sharing in supply chain management. *International Journal of Production Research, 45*(11), 2507-2544.

Chen, R.-S., Chen, C., Yeh, K., Chen, Y., & Kuo, C. (2008). Using RFID technology in food produce traceability. *WSEAS Transactions on Information Science and Applications, 5*(11), 1551-1560.

Cheng, J.-H. (2011). Inter-organizational relationships and information sharing in supply chains. *International Journal of Information Management, 31*(4), 374-384.

Childerhouse, P., Hermiz, R., Mason-Jones, R., Popp, A., & Towill, D. R. (2003). Information flow in automotive supply chains–identifying and learning to overcome barriers to change. *Industrial Management & Data Systems, 103*(7), 491-502.

Choi, T. Y., & Krause, D. R. (2006). The supply base and its complexity: implications for transaction costs, risks, responsiveness, and innovation. *Journal of Operations Management, 24*(5), 637-652.

Chow, C. W., Harrison, G. L., McKinnon, J. L., & Wu, A. (1999). Cultural influences on informal information sharing in Chinese and Anglo-American organizations: an exploratory study. *Accounting, Organizations and Society, 24*(7), 561-582.

Christiaanse, E., & Kumar, K. (2000). ICT-enabled coordination of dynamic supply webs. *International Journal of Physical Distribution & Logistics Management, 30*(3/4), 268-285.

Cooper, M. C., Lambert, D. M., & Pagh, J. D. (1997). Supply chain management: more than a new name for logistics. *The International Journal of Logistics Management, 8*(1), 1-14.

Costa, C., Antonucci, F., Pallottino, F., Aguzzi, J., Sarriá, D., & Menesatti, P. (2013). A review on agri-food supply chain traceability by means of RFID technology. *Food and Bioprocess Technology, 6*(2), 353-366.

Cousins, P. D., Handfield, R. B., Lawson, B., & Petersen, K. J. (2006). Creating supply chain relational capital: the impact of formal and informal socialization processes. *Journal of Operations Management, 24*(6), 851-863.

Craighead, C. W., Blackhurst, J., Rungtusanatham, M. J., & Handfield, R. B. (2007). The severity of supply chain disruptions: design characteristics and mitigation capabilities. *Decision Sciences, 38*(1), 131-156.

Dabbene, F., Gay, P., & Tortia, C. (2014). Traceability issues in food supply chain management: a review. *Biosystems Engineering, 120*, 65-80.

Davenport, T. H. (1998). Putting the enterprise into the enterprise system. *Harvard Business Review, 76*(4), 121-132.

Davenport, T. H. (2000). *Mission critical: realizing the promise of enterprise systems*. Boston, MA: Harvard Business Press.

Denolf, J. M., Trienekens, J. H., Wognum, P. M., van der Vorst, J. G. A. J., & Omta, S. W. F. (2014). A framework of critical success factors for implementing supply chain information systems. *Computers in Industry, In review*.

Doherty, N. F., & King, M. (2005). From technical to socio-technical change: tackling the human and organisational aspects of systems development projects. *European Journal of Information Systems, 14*(1), 1-5.

Donnelly, K., Karlsen, K., & Olsen, P. (2009). The importance of transformations for traceability–a case study of lamb and lamb products. *Meat Science, 83*(1), 68-73.

Dowlatshahi, S. (1997). The role of product design in designer-buyer-supplier interface. *Production Planning & Control, 8*(6), 522-532.

Eckartz, S., Katsma, C., & Daneva, M. (2010). The Inter-organizational Business Case in ES Implementations: Exploring the Impact of Coordination Structures and Their Properties. In J. Quintela Varajao, M. Cruz-Cunha, G. Putnik & A. Trigo (Eds.), *Enterprise Information Systems* (pp. 188-197). Berlin Heilderberg: Springer.

Ehie, I. C., & Madsen, M. (2005). Identifying critical issues in enterprise resource planning (ERP) implementation. *Computers in Industry, 56*(6), 545-557.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review, 14*(4), 532-550.
Eisenhardt, K. M. (1991). Better stories and better constructs: the case for rigor and comparative logic. *Academy of Management Review, 16*(3), 620-627.
Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: opportunities and challenges. *Academy of Management Journal, 50*(1), 25-32.
Fawcett, S. E., Magnan, G. M., & McCarter, M. W. (2008). Benefits, barriers, and bridges to effective supply chain management. *Supply Chain Management: An International Journal, 13*(1), 35-48.
Fawcett, S. E., Osterhaus, P., Magnan, G. M., Brau, J. C., & McCarter, M. W. (2007). Information sharing and supply chain performance: the role of connectivity and willingness. *Supply Chain Management: An International Journal, 12*(5), 358-368.
Finney, S., & Corbett, M. (2007). ERP implementation: a compilation and analysis of critical success factors. *Business Process Management Journal, 13*(3), 329-347.
Flanagan, J. C. (1954). The critical incident technique. *Psychological Bulletin, 51*(4), 327-358.
Flynn, D. J., & Arce, E. A. (1997). A CASE tool to support critical success factors analysis in IT planning and requirements determination. *Information and Software Technology, 39*(5), 311-321.
Françoise, O., Bourgault, M., & Pellerin, R. (2009). ERP implementation through critical success factors' management. *Business Process Management Journal, 15*(3), 371-394.
Gargeya, V. B., & Brady, C. (2005). Success and failure factors of adopting SAP in ERP system implementation. *Business Process Management Journal, 11*(5), 501-516.
Gellynck, X., & Molnár, A. (2009). Chain governance structures: the European traditional food sector. *British Food Journal, 111*(8), 762-775.
Ghosh, A., & Fedorowicz, J. (2008). The role of trust in supply chain governance. *Business Process Management Journal, 14*(4), 453-470.
Golan, E., Krissoff, B., Kuchler, F., Nelson, K., Price, G., & Calvin, L. (2003). Traceability in the US food supply: dead end or superhighway. *Choices, 18*(2), 17-20.
Gosain, S. (2004). Enterprise information systems as objects and carriers of institutional forces: the new iron cage?. *Journal of the Association for Information Systems, 5*(4), 151-182.
Gottschalk, P. (2001). Descriptions of responsibility for implementation: a content analysis of strategic information systems/technology planning documents. *Technological Forecasting and Social Change, 68*(2), 207-221.
Hanf, J., & Hanf, C.-H. (2007). Does food quality management create a competitive advantage. In L. Theuvsen, A. Spiller, M. Peupert & G. Jahn (Eds.), *Quality Management in Food Chains* (pp. 489-499). Wageningen, the Netherlands: Wageningen Academic Publishers.
Hartmann, M., Heinen, S., Melis, S., & Simons, J. (2013). Consumers' awareness of CSR in the German pork industry. *British Food Journal, 115*(1), 124-141.
Hazell, P., & Wood, S. (2008). Drivers of change in global agriculture. *Philosophical Transactions of the Royal Society B: Biological Sciences, 363*(1491), 495-515.
Heikkilä, J. (2002). From supply to demand chain management: efficiency and customer satisfaction. *Journal of Operations Management, 20*(6), 747-767.
Hill, C. A., & Scudder, G. D. (2002). The use of electronic data interchange for supply chain coordination in the food industry. *Journal of Operations Management, 20*(4), 375-387.

Hitt, M., Ireland, R. D., & Hoskisson, R. (2012). *Strategic management cases: competitiveness and globalization* (10^{th} ed.). Cincinnati, OH: Southwestern College Publishing Company.

Holland, C. P., & Light, B. (1999). A critical success factors model for ERP implementation. *IEEE Software, 16*(3), 30-36.

Huang, G. Q., Lau, J. S., & Mak, K. (2003). The impacts of sharing production information on supply chain dynamics: a review of the literature. *International Journal of Production Research, 41*(7), 1483-1517.

Irani, Z., Gunasekaran, A., & Dwivedi, Y. K. (2010). Radio frequency identification (RFID): research trends and framework. *International Journal of Production Research, 48*(9), 2485-2511.

Jagdev, H. S., & Thoben, K.-D. (2001). Anatomy of enterprise collaborations. *Production Planning & Control, 12*(5), 437-451.

Jharkharia, S., & Shankar, R. (2005). IT-enablement of supply chains: understanding the barriers. *Journal of Enterprise Information Management, 18*(1), 11-27.

Jonsson, P., & Mattsson, S.-A. (2013). The value of sharing planning information in supply chains. *International Journal of Physical Distribution & Logistics Management, 43*(4), 282-299.

Karlsen, K., Donnelly, K., & Olsen, P. (2011a). Granularity and its importance for traceability in a farmed salmon supply chain. *Journal of Food Engineering, 102*(1), 1-8.

Karlsen, K., & Olsen, P. (2011). Validity of method for analysing critical traceability points. *Food Control, 22*(8), 1209-1215.

Karlsen, K., Olsen, P., & Donnelly, K. (2010). Implementing traceability: practical challenges at a mineral water bottling plant. *British Food Journal, 112*(2), 187-197.

Karlsen, K., Sørensen, C., Forås, F., & Olsen, P. (2011b). Critical criteria when implementing electronic chain traceability in a fish supply chain. *Food Control, 22*(8), 1339-1347.

Kelepouris, T., Pramatari, K., & Doukidis, G. (2007). RFID-enabled traceability in the food supply chain. *Industrial Management & Data Systems, 107*(2), 183-200.

Kembro, J., & Näslund, D. (2014). Information sharing in supply chains, myth or reality? A critical analysis of empirical literature. *International Journal of Physical Distribution & Logistics Management, 44*(3), 179-200.

Khurana, M., Mishra, P., & Singh, A. (2011). Barriers to information sharing in supply chain of manufacturing industries. *International Journal of Manufacturing Systems, 1*(1), 9-29.

King, S. F., & Burgess, T. F. (2006). Beyond critical success factors: A dynamic model of enterprise system innovation. *International Journal of Information Management, 26*(1), 59-69.

Koh, S. L., Gunasekaran, A., & Goodman, T. (2011). Drivers, barriers and critical success factors for ERPII implementation in supply chains: A critical analysis. *The Journal of Strategic Information Systems, 20*(4), 385-402.

Kwon, I.-W. G., & Suh, T. (2005). Trust, commitment and relationships in supply chain management: a path analysis. *Supply Chain Management: An International Journal, 10*(1), 26-33.

Lambert, D. M., & Cooper, M. C. (2000). Issues in supply chain management. *Industrial Marketing Management, 29*(1), 65-83.

Lau, H., & Lee, W. (2000). On a responsive supply chain information system. *International Journal of Physical Distribution & Logistics Management, 30*(7/8), 598-610.

Lau, J. S., Huang, G. Q., & Mak, K. (2004). Impact of information sharing on inventory replenishment in divergent supply chains. *International Journal of Production Research, 42*(5), 919-941.

Leavitt, H. J., & Whisler, T. L. (1958). Management in the 1980's. *Harvard Business Review, 36*(Nov./Dec.), 41-48.

Lee, H. L., Padmanabhan, V., & Whang, S. (1997). The bullwhip effect in supply chains. *Sloan Management Review*, *38*(3), 93-102.

Lee, H. L., So, K. C., & Tang, C. S. (2000). The value of information sharing in a two-level supply chain. *Management Science, 46*(5), 626-643.

Lee, H. L., & Whang, S. (2000). Information sharing in a supply chain. *International Journal of Manufacturing Technology and Management, 1*(1), 79-93.

Lehmann, R. J., Reiche, R., & Schiefer, G. (2012). Future internet and the agri-food sector: State-of-the-art in literature and research. *Computers and Electronics in Agriculture, 89*, 158-174.

Leonard-Barton, D. (1988). Implementation as mutual adaptation of technology and organization. *Research Policy*, *17*(5), 251-267.

Leonardi, P. M., & Barley, S. R. (2008). Materiality and change: Challenges to building better theory about technology and organizing. *Information and Organization, 18*(3), 159-176.

Li, S., Godon, D., & Visich, J. K. (2010). An exploratory study of RFID implementation in the supply chain. *Management Research Review, 33*(10), 1005-1015.

Li, S., & Lin, B. (2006). Accessing information sharing and information quality in supply chain management. *Decision Support Systems, 42*(3), 1641-1656.

Loh, T. C., & Koh, S. (2004). Critical elements for a successful enterprise resource planning implementation in small-and medium-sized enterprises. *International Journal of Production Research, 42*(17), 3433-3455.

Lu, X.-H., Huang, L.-H., & Heng, M. S. (2006). Critical success factors of inter-organizational information systems—A case study of Cisco and Xiao Tong in China. *Information & Management, 43*(3), 395-408.

Lyons, B. R. (1996). Empirical relevance of efficient contract theory: inter-firm contracts. *Oxford Review of Economic Policy, 12*(4), 27-52.

Lyytinen, K., & Newman, M. (2008). Explaining information systems change: a punctuated socio-technical change model. *European Journal of Information Systems, 17*(6), 589-613.

Markus, M. L., & Robey, D. (1988). Information technology and organizational change: causal structure in theory and research. *Management Science*, *34*(5), 583-598.

Markus, M. L., & Tanis, C. (2000). The enterprise systems experience–from adoption to success. In R. W. Zmud (Ed.), *Framing the domains of IT research: Glimpsing the future through the past* (pp. 207-173). Cincinnatti, OH: Pinnaflex Educational Resources, Inc.

McLaren, T., Head, M., & Yuan, Y. (2002). Supply chain collaboration alternatives: understanding the expected costs and benefits. *Internet Research, 12*(4), 348-364.

Mehrjerdi, Y. Z. (2011). RFID and its benefits: a multiple case analysis. *Assembly Automation, 31*(3), 251-262.

Mejia, C., McEntire, J., Keener, K., Muth, M. K., Nganje, W., Stinson, T., & Jensen, H. (2010). Traceability (product tracing) in food systems: An IFT report submitted to the

FDA, volume 2: Cost considerations and implications. *Comprehensive Reviews in Food Science and Food Safety, 9*(1), 159-175.
Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). Defining supply chain management. *Journal of Business logistics, 22*(2), 1-25.
Mentzer, J. T., Min, S., & Zacharia, Z. G. (2000). The nature of interfirm partnering in supply chain management. *Journal of Retailing, 76*(4), 549-568.
Midmore, P., Naspetti, S., Sherwood, A.-M., Vairo, D., Wier, M., & Zanoli, R. (2005). Consumer attitudes to quality and safety of organic and low input foods: a review. *Report of EU-funded project "Improving Quality and Safety and Reduction of Cost in the European Organic and 'Low Input'Food Supply Chains." Univ. Wales, Aberystwyth, UK.*
Miles, M. B., & Huberman, A. M. (1984). *Qualitative data analysis: A sourcebook of new methods*. Beverly Hills, CA: Sage publications.
Morris, J. E., Cronin, G. M., & Bush, R. D. (2012). Improving sheep production and welfare in extensive systems through precision sheep management. *Animal Production Science, 52*(7), 665-670.
Mousavi, A., Sarhadi, M., Lenk, A., & Fawcett, S. (2002). Tracking and traceability in the meat processing industry: a solution. *British Food Journal, 104*(1), 7-19.
Nah, F. F.-H., Lau, J. L.-S., & Kuang, J. (2001). Critical factors for successful implementation of enterprise systems. *Business Process Management Journal, 7*(3), 285-296.
Nah, F. F.-H., Zuckweiler, K. M., & Lau, J. L.-S. (2003). ERP implementation: chief information officers' perceptions of critical success factors. *International Journal of Human-Computer Interaction, 16*(1), 5-22.
Nambiar, A. N. (2009). RFID technology: A review of its applications. In S. I. Ao, C. Douglas, W. S. Grundfest & J. Burgstone (Eds.), *Proceedings of the world congress on engineering and computer science.* Paper presented at the World Congress on Engineering and Computer Science, San Fransisco, USA, 20-22 October (pp. 1253-1259). Hong Kong: Newswood Limited.
Napolitano, F., Braghieri, A., Piasentier, E., Favotto, S., Naspetti, S., & Zanoli, R. (2010). Effect of information about organic production on beef liking and consumer willingness to pay. *Food Quality and Preference, 21*(2), 207-212.
Ngai, E., Cheng, T., & Ho, S. (2004). Critical success factors of web-based supply-chain management systems: an exploratory study. *Production Planning & Control, 15*(6), 622-630.
Ngai, E. W., & Gunasekaran, A. (2004). Implementation of EDI in Hong Kong: an empirical analysis. *Industrial Management & Data Systems, 104*(1), 88-100.
Ngai, E. W., Law, C. C., & Wat, F. K. (2008). Examining the critical success factors in the adoption of enterprise resource planning. *Computers in Industry, 59*(6), 548-564.
Nicolaou, A. I. (2008). Research issues on the use of ERPS in interorganizational relationships. *International Journal of Accounting Information Systems, 9*(4), 216-226.
Nord, J. H., & Nord, G. D. (1995). MIS research: journal status assessment and analysis. *Information & Management, 29*(1), 29-42.
Opara, L. U. (2003). Traceability in agriculture and food supply chain: a review of basic concepts, technological implications, and future prospects. *Journal of Food Agriculture and Environment, 1*, 101-106.

Orlikowski, W. J. (1992). The duality of technology: Rethinking the concept of technology in organizations. *Organization Science, 3*(3), 398-427.
Orlikowski, W. J. (2008). Using technology and constituting structures: A practice lens for studying technology in organizations. In M. S. Ackerman, C. A. Halverson, Th. Erickson & W. A. Kellogg (Eds.), *Resources, co-evolution and artifacts* (pp. 255-305). London, UK: Springer.
Palmer, N., & Mills, A. (2003). Classical versus relational approaches to understanding controls on a contract with independent GPs in South Africa. *Health Economics, 12*(12), 1005-1020.
Pettigrew, A. M. (1985). Contextualist research and the study of organizational change processes. In E. Mumford, R. Hirschheim, G. Fitzgerald & A. T. Wood-Harper (Eds.), *Research Methods in Informations* (pp. 53-78). Amsterdam, the Netherlands: North Holland.
Pozzebon, M., & Pinsonneault, A. (2005). Challenges in conducting empirical work using structuration theory: Learning from IT research. *Organization Studies, 26*(9), 1353-1376.
Pramatari, K. (2007). Collaborative supply chain practices and evolving technological approaches. *Supply Chain Management: An International Journal, 12*(3), 210-220.
Premkumar, G. P. (2000). Interorganization systems and supply chain management. *Information Systems Management, 17*(3), 56-69.
Ram, J., Corkindale, D., & Wu, M. L. (2013). Implementation critical success factors (CSFs) for ERP: Do they contribute to implementation success and post-implementation performance?. *International Journal of Production Economics*, *144*(1), 157-174.
Rampl, L. V., Eberhardt, T., Schütte, R., & Kenning, P. (2012). Consumer trust in food retailers: conceptual framework and empirical evidence. *International Journal of Retail & Distribution Management, 40*(4), 254-272.
Raynaud, E., Sauvee, L., & Valceschini, E. (2005). Alignment between quality enforcement devices and governance structures in the agro-food vertical chains. *Journal of Management & Governance, 9*(1), 47-77.
Regattieri, A., Gamberi, M., & Manzini, R. (2007). Traceability of food products: General framework and experimental evidence. *Journal of Food Engineering, 81*(2), 347-356.
Roberts, C. M. (2006). Radio frequency identification (RFID). *Computers & Security*, *25*(1), 18-26.
Rowley, J. (2002). Using case studies in research. *Management Research News, 25*(1), 16-27.
Ruiz-Garcia, L., & Lunadei, L. (2011). The role of RFID in agriculture: Applications, limitations and challenges. *Computers and Electronics in Agriculture*, *79*(1), 42-50.
Ruppel, C. (2004). An information systems perspective of supply chain tool compatibility: the roles of technology fit and relationships. *Business Process Management Journal, 10*(3), 311-324.
Russell, D. M., & Hoag, A. M. (2004). People and information technology in the supply chain: social and organizational influences on adoption. *International Journal of Physical Distribution & Logistics Management*, *34*(2), 102-122.
Sahin, E., Dallery, Y., & Gershwin, S. (2002). Performance evaluation of a traceability system. An application to the radio frequency identification technology. In A. El Kame1, K. Mellouli & P. Borne (Eds.), *Bridging the Digital Divide Cyber-development, Human Progress, Peace and Prosperity*. Paper presented at the IEEE

international conference on Systems, Man and Cybernetics, Yasmine Hammamet, Tunisia, 6-9 October (pp. 210-218). New York, NY: IEEE.
Sahin, F., & Robinson, E. P. (2002). Flow coordination and information sharing in supply chains: review, implications, and directions for future research. *Decision Sciences, 33*(4), 505-536.
Santamarina, C., Hernández-Jover, M., Babot, D., & Caja, G. (2007). Comparison of visual and electronic identification devices in pigs: Slaughterhouse performance. *Journal of Animal Science, 85*(2), 497-502.
Schmolke, S. A., Li, Y. Z., & Gonyou, H. W. (2004). Effects of group size on social behavior following regrouping of growing–finishing pigs. *Applied Animal Behaviour Science, 88*(1), 27-38.
Schulze, B., Spiller, A., & Theuvsen, L. (2006). Is more vertical integration the future of food supply chains? Empirical evidence and theoretical considerations from German pork production. In J. Bijman, O. Omta, J. Trienekens, J. Wijnands & E. Wubben (Eds.), *International agri-food chains and networks: management and organization, Wageningen* (pp. 49-63). Wageningen, the Netherlands: Wageningen Academic Publishers.
Schulze, B., Spiller, A., & Theuvsen, L. (2007). A broader view on vertical coordination: lessons from German pork production. *Journal on Chain and Network Science, 7*(1), 35-53.
Schwägele, F. (2005). Traceability from a European perspective. *Meat Science, 71*(1), 164-173.
Scott Morton, M. S. (Ed.). (1991). *The corporation of the 1990s: Information technology and organizational transformation*. New York, NY: Oxford University Press.
Seawright, J., & Gerring, J. (2008). Case Selection Techniques in Case Study Research A Menu of Qualitative and Quantitative Options. *Political Research Quarterly, 61*(2), 294-308.
Senneset, G., Forås, E., & Fremme, K. M. (2007). Challenges regarding implementation of electronic chain traceability. *British Food Journal, 109*(10), 805-818.
Shackell, G., & Dodds, K. (2008). DNA-based traceability of meat. In F. Toldra (Ed.), *Meat Biotechnology* (pp. 61-88). New York, NY: Springer.
Skjøtt-Larsen, T., Kotzab, H., & Grieger, M. (2003). Electronic marketplaces and supply chain relationships. *Industrial Marketing Management, 32*(3), 199-210.
Siderer, Y., Maquet, A., & Anklam, E. (2005). Need for research to support consumer confidence in the growing organic food market. *Trends in Food Science & Technology, 16*(8), 332-343.
Sim, J. (1998). Collecting and analysing qualitative data: issues raised by the focus group. *Journal of Advanced Nursing, 28*(2), 345-352.
Simatupang, T. M., Wright, A. C., & Sridharan, R. (2002). The knowledge of coordination for supply chain integration. *Business Process Management Journal, 8*(3), 289-308.
Smith, G., Tatum, J., Belk, K., Scanga, J., Grandin, T., & Sofos, J. (2005). Traceability from a US perspective. *Meat Science, 71*(1), 174-193.
Sohal, A. S., Moss, S., & Ng, L. (2001). Comparing IT success in manufacturing and service industries. *International Journal of Operations & Production Management, 21*(1/2), 30-45.

Spekman, R. E., Kamauff Jr, J. W., & Myhr, N. (1998). An empirical investigation into supply chain management: a perspective on partnerships. *Supply Chain Management: An International Journal, 3*(2), 53-67.

Sporleder, T. L., & Moss, L. E. (2002). Knowledge management in the global food system: network embeddedness and social capital. *American Journal of Agricultural Economics, 84*(5), 1345-1352.

Stair, R., & Reynolds, G. (2013). *Fundamentals of information systems* (7th ed.). Boston, MA: Cengage Learning.

Stefanou, C. (1999). Supply chain management (SCM) and organizational key factors for successful implementation of enterprise resource planning (ERP) systems. In W. D. Haseman & D. L. Nazareth (Eds.), *AMCIS 1999 Proceedings*. Paper presented at the annual Americas' Conference on Information Systems, Milwaukee, WI, 13-15 August (pp. 800-802). Atlanta, GA: AIS.

Storøy, J., Thakur, M., & Olsen, P. (2013). The TraceFood Framework–Principles and guidelines for implementing traceability in food value chains. *Journal of Food Engineering, 115*(1), 41-48.

Trienekens, J., & Wognum, N. (2009). Introduction to the European pork chain. In. J. Trienekens, B. Petersen, N. Wognum & D. Brinkmann (Eds.), *European pork chains-Diversity and quality challenges in consumer-oriented production and distribution* (pp. 19-36). Wageningen, the Netherlands: Wageningen Academic Publishers.

Trienekens, J., & Wognum, N. (2013). Requirements of supply chain management in differentiating European pork chains. *Meat Science, 95*(3), 719-726.

Trienekens, J., & Zuurbier, P. (2008). Quality and safety standards in the food industry, developments and challenges. *International Journal of Production Economics, 113*(1), 107-122.

UB (2008). *D-4.1.1: Case study reports per selected chain Germany.* Bonn: University of Bonn (unpublished manuscript, contact D. Brinkmann).

Umble, E. J., Haft, R. R., & Umble, M. M. (2003). Enterprise resource planning: Implementation procedures and critical success factors. *European Journal of Operational Research, 146*(2), 241-257.

Van der Vorst, J. G. (2006). Product traceability in food-supply chains. *Accreditation and Quality Assurance: Journal for Quality, Comparability and Reliability in Chemical Measurement, 11*(1), 33-37.

Van Plaggenhoef, W. (2007). *Integration and self regulation of quality management in Dutch agri-food supply chains: a cross-chain analysis of the poultry meat, the fruit and vegetable and the flower and potted plant chains*. Wageningen, the Netherlands: Wageningen Academic Publishers.

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences, 39*(2), 273-315.

Verbeke, W., Frewer, L. J., Scholderer, J., & De Brabander, H. F. (2007). Why consumers behave as they do with respect to food safety and risk information. *Analytica Chimica Acta, 586*(1), 2-7.

Verdecho, M.-J., Alfaro-Saiz, J.-J., Rodriguez-Rodriguez, R., & Ortiz-Bas, A. (2012). A multi-criteria approach for managing inter-enterprise collaborative relationships. *Omega, 40*(3), 249-263.

Verwijmeren, M. (2004). Software component architecture in supply chain management. *Computers in Industry, 53*(2), 165-178.

Vickery, S.K., Jayaram, J., Droge, C., & Calantone, R. (2003). The effects of an integrative supply chain strategy on customer service and financial performance: an analysis of direct versus indirect relationships. *Journal of Operations Management, 21*(5), 523-539.
Volkoff, O., Strong, D. M., & Elmes, M. B. (2007). Technological embeddedness and organizational change. *Organization Science, 18*(5), 832-848.
Wailgum, T. (2009). 10 Famous ERP Disasters, Dustups and Disappointments. Retrieved from http://www.cio.com/article/486284/10_Famous_ERP_Disasters_Dustups_and_Disappointments.
Walsham, G. (1997). Actor-network theory and IS research: current status and future prospects. In S. Lee, J. Liebenau, & J. I. De Gross (Eds.), *Information systems and qualitative research* (pp. 466-480). London, UK: Chapman & Hall.
Want, R. (2006). An introduction to RFID technology. *Pervasive Computing, IEEE, 5*(1), 25-33.
Webb, J. (2004). Tracking pork from pen to plate. *Advances in Pork Production, 15*, 33-41.
Webster Jr, F. E. (1992). The changing role of marketing in the corporation. *The Journal of Marketing, 56*, 1-17.
Wever, M., & Wognum, P. (2008). *D-4.1.1: Fresh pork meat chain in The Netherlands.* Wageningen: Wageningen University (unpublished manuscript, contact J.H.Trienekens).
Wever, M., Wognum, N., Trienekens, J., & Omta, O. (2010). Alignment between chain quality management and chain governance in EU pork supply chains: A Transaction-Cost-Economics perspective. *Meat Science, 84*(2), 228-237.
Wilkinson, M. A. (2001). Information sources used by lawyers in problem solving: An empirical exploration. *Library & Information Science Research, 23*(3), 257-276.
Williamson, O. E. (1979). Transaction-cost economics: the governance of contractual relations. *Journal of Law and Economics, 22*(2), 233-261.
Williamson, O. E. (1985). *The economic institutions of capitalism: Firms, markets, relational contracts.* New York, NY: The Free Press.
Williamson, O. E. (1991). Comparative economic organization: The analysis of discrete structural alternatives. *Administrative Science Quarterly, 36*, 269-296.
Wolfert, J., Verdouw, C., Verloop, C., & Beulens, A. (2010). Organizing information integration in agri-food—A method based on a service-oriented architecture and living lab approach. *Computers and Electronics in Agriculture, 70*(2), 389-405.
Yao, D.-Q., Yue, X., & Liu, J. (2008). Vertical cost information sharing in a supply chain with value-adding retailers. *Omega, 36*(5), 838-851.
Yin, R. (2003). *Case study research: Design and methods* (5^{th} ed.). Beverly Hills, CA: Sage Publications.
Yordanov, D., & Angelova, G. (2006). Identification and traceability of meat and meat products. *Biotechnology & Biotechnological Equipment, 20*(1), 3-8.
Yu, Z., Yan, H., & Cheng, T. E. (2001). Benefits of information sharing with supply chain partnerships. *Industrial Management & Data Systems, 101*(3), 114-121.
Zachmann, K., & Østby, P. (2011). Food, technology, and trust: an introduction. *History and Technology, 27*(1), 1-10.
Zhang, X., & Aramyan, L. H. (2009). A conceptual framework for supply chain governance: An application to agri-food chains in China. *China Agricultural Economic Review, 1*(2), 136-154.

Zhu, X., Mukhopadhyay, S. K., & Kurata, H. (2012). A review of RFID technology and its managerial applications in different industries. *Journal of Engineering and Technology Management*, *29*(1), 152-167.

About the Author

Janne Marcel Denolf was born in Roeselare, Belgium on 3 March, 1987. He obtained his degree in business engineering specializing in operations management from the University of Ghent (Belgium). During his studies, he was interested in improving and optimizing business processes through better information provision. Therefore, in 2010, he joined the Management Studies Group at Wageningen University as a PhD candidate, part of the project TIPO (Traceability and Identification of Pigs within the Organic meat supply chain). Later, in January 2013, he started working at Deutscher Raiffeisenverband (DRV, Germany), where he was involved in the EU 7th Framework project Quarisma (QUality And RISk MAnagement in meat chains). Janne's interests lay in the general fields of supply chain management, information sharing, and traceability. He is specifically interested in the complexities of implementing supply chain information systems, particularly in food supply chains. The main contribution of his PhD work is the identification of critical success factors governing the success of such implementations in pork supply chains.

Completed Training and Supervision Plan

Janne M. Denolf
Wageningen School of Social Sciences (WASS)

Name of the learning activity	Department/ Institute	Year	ECTS*
A) Project related competences			
Writing research Proposal	WASS	2010 - 2011	5
“Towards a Supply-Chain Instrument to Monitor an Information Technology Implementation”	Fooddynamics conference, IGLS, A	2011	1
“Towards a Supply-Chain Instrument to Monitor an Information Technology Implementation”	Wicanem conference, Wageningen, NL	2012	1
Workshop “To learn from crises”	GIQS	2012	1
Workshop “QUARISMA-Workshop on Pig Health Management Systems”	GIQS	2012	1
Information systems (INF 31306)	WUR	2011	6
B) General research related competences			
Academic Writing II	WGS	2010	3
Scientific Writing	WGS	2012 - 2013	1.7
Research Methodology: From Topic to Proposal	WASS	2010	4
Cambridge course: Certificate in Advanced English (CAE)	WGS	2013 - 2014	4
Qualitative Data Analysis: procedures and strategies (YRM 60806)	WUR / RME	2010	6
Techniques for writing and presenting a Scientific paper	WASS	2011	1.2
C) Career related competences/personal development			
Teaching and supervision activities	WUR / MST	2011-2014	2
Total (30 - 45 ECTS)			**36.9**

*One credit according to ECTS is on average equivalent to 28 hours of study load

The research described in this thesis was partially funded by the Province of Gelderland (the Netherlands) and the European Fund for Regional Development (EFRO), through the project TIPO (Traceability and Identification of Pigs within the Organic meat supply chain). Furthermore, the research was also financially supported through QUARISMA (QUality And RISk MAnagement in meat chains), a project of European partners from Industry and Academia. It is funded by IAPP (Industry-Academia Partnerships and Pathways), which is an element of the specific Programme Marie-Curie Actions of the EU 7th Framework Programme. The content of the thesis reflects only the views of the author. The two funding parties did not have a role in the process of conducting interviews, analysis, and interpretation of the data.

Cover design & layout | Jana Mangels & Janne Denolf

Print | GVO drukkers & vormgevers B.V.